

PROCEEDINGS
OF THE
LOUISIANA
ENGINEERING SOCIETY

VOL. VI. 1920

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PROCEEDINGS OF THE LOUISIANA ENGINEERING SOCIETY

CONTENTS

EDITORIAL NOTES AND COMMENT:	PAGE
Address of the Retiring President.....	7
Affiliation with the Federated American Engineering Societies.....	197
Annual Reports.....	7
Changes in the Rules of the State Board of Engineering Examiners.....	71
Chemical Engineers, The.....	198
Dredging the Industrial Canal.....	69
Electric Transmission Lines.....	161
Ethics of the Engineer, The.....	171
Fabricated Steel Ship, The.....	70
Federated American Engineering Societies, The.....	162
Foundations of the Custom House Building.....	194
Honor for Mr. Garsaud.....	262
Hurricane Movement as Related to Storm Tides.....	193
Individual Element, The.....	263
Lock Foundation, The. Inner Harbor Navigation Canal.....	129
New Members.....	131, 176, 197
New President of the Society, The.....	4
Open Mouth for the Mississippi River, An.....	5
Prevention of Automobile Accidents.....	265
Question of Temperature in Creosoting Cylinders, A.....	5
Recent Additions to the Library.....	132, 177, 198, 264
Red and Atchafalaya Divorce Case, The.....	261
Removal of the Poydras Market.....	75
Smoker, The.....	4
Sewerage, Water and Drainage in New Orleans.....	259
To Counteract Shorter Hours.....	176
Westinghouse Turbine Makes a World's Record.....	271
Word of Appreciation, A.....	132
OBITUARY.....	77
PAPERS AND DISCUSSIONS:	
"Dredging New Orleans Inner Harbor Navigation Canal" By <i>Walter J. White</i>	80
"Existing Status of the Sewerage, Water and Drainage System of New Orleans." By <i>George G. Earl</i>	274
"Fabricated Steel Ship Construction as Handled by the Doullut and Williams Shipbuilding Co., Inc." By <i>J. P. Erwin</i>	103
"Lock Foundation, Inner Harbor Navigation Canal, New Orleans, La. The Problem and the Solution." By <i>Geo. R. Goethals</i>	134
"Open Mouth for the Mississippi River, An." By <i>Allan F. Washburn</i>	17
Discussion.....	32

"Natural Gas Supply for the City of New Orleans." (Address of the Retiring President) <i>By Ole K. Olsen</i>	8
"Power Transmission Equipment." <i>By William Crooks</i>	181
"Proposed Separation of the Red and Atchafalaya Rivers from the Mississippi and the Probable Effect on Flood Heights." <i>By John Klorer</i>	300
"Relation of Changes of Storm Tides on the Coast of the Gulf of Mexico to the Center and Movement of Hurricanes." <i>By Isaac M. Cline</i>	200
BOOK REVIEWS.....	179
MEMBERSHIP LIST FOR 1920.....	42
MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY:	
Minutes of Board of Direction, December 8, 1919.....	53
" " " January 30, 1920.....	54
" " " February 9, 1920.....	127
" " " March 8, 1920.....	127
" " " April 12, 1920.....	159
" " " May 10, 1920.....	160
" " " June 21, 1920.....	191
" " " September 13, 1920.....	257
" " " September 30, 1920.....	258
" " " October 11, 1920.....	326
" " " November 8, 1920.....	327
Minutes of the Society, December 8, 1919.....	53
" " " January 10, 1920.....	55
" " " February 9, 1920.....	127
" " " March 8, 1920.....	128
" " " April 12, 1920.....	159
" " " May 10, 1920.....	160
" " " September 13, 1920.....	257
" " " October 11, 1920.....	327
" " " November 8, 1920.....	328
Annual Report of the Secretary for 1919.....	56
Annual Report of the Treasurer for 1919.....	63
Annual Report of the Library Committee.....	67

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PRESIDENT JOHN RIESS

PROCEEDINGS

OF THE

LOUISIANA ENGINEERING SOCIETY

VOL. VI

FEBRUARY, 1920

No. 1

CONTENTS

EDITORIAL NOTES AND COMMENT:	PAGE
The New President of the Society	3
The Smoker	4
A Question of Temperature in Creosoting Cylinders.....	5
An Open Mouth for the Mississippi River	5
Address of the Retiring President	7
Annual Reports	7
 PAPERS AND DISCUSSIONS:	
A Natural Gas Supply for the City of New Orleans, (Address of the Retiring President). <i>By Ole K. Olsen</i>	8
An Open Mouth for the Mississippi River. <i>By Allen F. Washburn</i>	17
Discussion	32
MEMBERSHIP LIST	42
MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY.....	53
ANNUAL REPORTS	56

EDITORIAL NOTES AND COMMENT

The New President of the Society. At the annual meeting, January 10, 1920, Mr. John Riess was elected President of the Louisiana Engineering Society. This is an honor which Mr. Riess has won through his continuous and earnest work for the welfare of the organization, and the Society honors itself in the bestowal of this office upon him.

Mr. Riess is a native of New Orleans, and received his early education and training in the schools of this city. He is a graduate of Tulane University in Civil Engineering, Class of 1904. After graduation he served the usual apprenticeship of the young engineer just out of college, as rodman, computer, draughtsman, instrument-man and assistant engineer with various engineering firms and contractors.

The contracting field was always an attractive one to Mr. Riess, and after two years of practical experience as stated above, he hung out his own shingle as Civil Engineer and Contractor. Construction work appealing most strongly to him, he soon gave up the engineering end and devoted himself to specializing in engineering and architectural contract work. Since 1909 he has had his brother, Oscar Riess, C. E., with him as associate and partner in the firm.

This firm has handled a number of very large contracts, particularly in connection with the improvements to the docks and harbor facilities in and about the port of New Orleans.

Mr. Riess brings to his new office a large measure of experience in the affairs of the Society, having been a member since 1906, and during all that period having taken an active interest in all that concerned the welfare and advancement of the Society. He has served for five years upon the Board of Direction, and has twice been Vice-President, in addition to having rendered most excellent service upon many standing and special committees.

The Smcker. Once again Walter Moses and Company, the company this time being Lester F. Alexander, Farrar P. Hamilton and E. Hunter Coleman, wrote the plans and specifications and let the contract for one of those very enjoyable functions which only they know how to produce. Their efforts to supply "pep" and enthusiasm to the occasion, and the great success with which they met, were particularly noteworthy in view of the fact that it was prohibition time. In fact, one was not even aware of the absence of the usual liquid refreshments, which are supposed to be a necessary part of such an entertainment, and towards the end of the evening the spirits of the party ran so high that even the old stagers were moved to remark that if this affair was a criterion for judgment, perhaps prohibition was not so bad after all. On the other hand, some of the more seriously minded members of the Society have expressed the opinion that we should drop the smoker and return to the somewhat more formal dinner or banquet, which was the custom several years ago. It appears to be an open question as to which form of entertainment the majority

of the members desire; possibly as a change it might be well to try again the original plan. Judging by the numbers of members who attend the smoker on the one hand and the dinner on the other, the smoker seems to be the more popular of the two.

The smoker this year was held at Francois' restaurant after the adjournment of the annual meeting. Mr. A. M. Lockett was master of ceremonies, and despite the best efforts of the cabaret artistes and the jazz-band to prevent him, managed to get in quite a number of very neat little speeches by way of introduction of the guests and speakers of the evening.

Chief among these were Mr. Bradley Stoughton, Secretary of the Mining and Metallurgical Engineers, who brought us greetings from the national engineering societies; Colonel Herbert Deakynne, who spoke for the Army Engineers; and Lieutenant Commander L. F. Bellinger, representing the Corps of Civil Engineers of the United States Navy.

A Question of Temperature in Creosoting Cylinders. Referring to the published discussion of his paper on Wood Preservation in the December (1919) number of the Proceedings, Mr. Rollins writes in to say that he was somewhat disappointed that none of the engineers touched upon the question of the possibility or the practicability of maintaining in the creosoting cylinder during the vacuum process a temperature higher than the temperature of the vacuum. This is quite frequently called for in the specifications for timber treatment. This is an interesting point, and we shall be glad to publish any discussions thereupon from members or others who may have had experience with this particular phase of the problem, or who may desire to discuss it from the scientific standpoint.

An Open Mouth for the Mississippi River. Under this title there is published in this issue a paper read by Mr. Allen E. Washburn at the December meeting of the Society. Mr. Washburn outlines in a very interesting manner the history of the various projects for the maintenance of a navigable channel at the mouth of the River from the time of the early French settlers of two hundred years ago down to the present develop-

ment of the Southwest Pass. A number of proposals were made to side-track the difficulties due to sedimentation of the natural channels and bar formations at the mouth of the river, as well as to shorten the distance to the city, by the construction of a ship canal. During a vigorous discussion of various canal projects in the early seventies James B. Eads became interested in the problem, and finally in 1874 made a proposition to Congress to build jetties at the mouth of Southwest Pass at his own risk and cost, he to be paid as results were accomplished. A bill was passed in 1875 authorizing him to build his jetties in South Pass, and the result is known to all—for the past forty years South Pass has been the navigable channel and entrance to the port of New Orleans.

New Orleans has shown a singular lack of gratitude in that it has never recognized the work of James B. Eads by any sort of memorial to him.

South Pass is still a very excellent channel with a depth of 32 feet, but owing to the natural formation of the bar the approach from the Gulf has been shifted so far to the eastward that vessels must make a rather difficult turn just at the mouth of the jetties. With the expiration of the Eads contract consideration was given the problem of providing a larger channel from gulf to river. It was then decided to make use of Southwest Pass and to provide it with jetties in order to have a channel with a width of 1,000 feet and 35 feet depth. Construction of these jetties was begun in 1905.

Mr. Washburn calls attention to the phenomenon of "sand waves" as a retarding factor in the improvement of Southwest Pass. The volume of material and the speed of advance of these sand waves is of such magnitude at times as to cause a shoaling of twenty feet in twenty-four hours. There is apparently need for considerable extension to the study of this problem of sand waves, for while some points were brought out in the discussion of the paper, there appears to be a lack of definite data as to the periodicity of the waves, which of course would be a very important item in the question of the control and maintenance of the depth in the channel. A paper upon this very interesting phenomenon of the Mississippi River would be of interest to many members of the Society.

Address of the Retiring President. The Louisiana Engineering Society as an organization and through its individual members has always come forward to lend its assistance in the solution of civic problems, particularly those calling for expert knowledge or technical experience. In the long-drawn-out attempts of this city to secure the advantages of a supply of natural gas, several of our members have taken a prominent part, notably Prof. C. S. Williamson, Mr. A. M. Lockett and Mr. Ole K. Olsen.

The latter has taken this matter of a Natural Gas Supply for New Orleans as the subject of his address on his retirement from the presidency. It was not read at the annual meeting, and is being published here as a matter of record for the Society. Mr. Olsen discusses the general features of the problem and presents his own views as to the most feasible solution. His close study of the subject and his knowledge of local conditions places him in a position to speak with authority upon the question.

Annual Reports. This issue of the Proceedings forms a sort of year book of the Society for the year just closed. In it will be found a complete list of the members, a report from the Library Committee, and the regular annual reports of the officers.

The total assets of the Society amount to \$4,001.59; the General Reserve Fund shows \$996.23; the Proceedings Fund, \$1,855.07; the Library Fund, \$872.58. The membership list shows a total of 273 names, a net gain over the previous year of 28.

There is some very interesting matter in the report of the Library Committee. You are urged to read it for your own personal enlightenment.

PAPERS AND DISCUSSIONS

ADDRESS OF THE RETIRING PRESIDENT

OLE K. OLSEN.

In February, 1919, Hon. Martin Behrman, Mayor of New Orleans, appointed a citizens' committee composed of the leaders of organized labor, bankers, presidents of the various commercial exchanges, contractors and professional men, with Hon. E. J. Glenny, Commissioner of Public Utilities, as chairman, to investigate the feasibility of getting natural gas to New Orleans from the Terrebonne gas field, located in Terrebonne Parish, near the town of Houma, a gas field which had recently been the scene of active development.

This area had been known for years to be underlaid with gas holding sands, and various attempts had been made to drill gas wells, but had failed, principally on account of the drillers being unfamiliar with the drilling in the kind of soils confronted with here and on account of the very high pressure met with in the gas sand.

Finally the Foundation Company of New York, later known as the Carpenter Syndicate, succeeded in bringing in gas wells which were estimated to produce at the rate of 60,000,000 to 70,000,000 cubic feet of gas per day, and offered the City of New Orleans to furnish natural gas for domestic and industrial consumption.

From reports of two noted geologists who have spent many years in investigations of oil and gas lands, I can state that what is now known as the Terrebonne gas fields comprises, according to one of them, an area of 15 to 18 square miles south of Houma in a swampy region at an elevation of 5 to 6 feet above sea level, with an underlying gas sand about 50 feet thick. The other geologist estimates the extent of the field approximately 100,000 acres.

At the time this committee was appointed there were three producing well with an estimated capacity of about 200,000,000 cubic feet of gas per day, of which, according to the Louisiana State Conservation laws, 25%, or 50,000,000 cubic feet, would be available for consumption. Since then other wells

have been brought in and capped until the market for gas will justify opening them.

Above mentioned geologists state that the "Lirette Pool," which is under development, should by itself be good for several years, judging by the texture and thickness of the sand, to the extent of 70,000,000 to 75,000,000 cubic feet per day consumed gas.

With such information and such quantities of gas actually in sight and located fairly at our very door—being only about 45 miles in an airline from New Orleans—it was only natural that our good city should come in for consideration, especially as the town of Houma and several sugar plantations in the vicinity had already then been furnished natural gas for a while.

From the general citizens' committee the chairman appointed a special committee, which cheerfully and laboriously set to work on what turned out to be a very difficult problem.

As stated previously, "The Carpenter Syndicate," which had gained control of the greater part of what was known to be gas land, and which in addition had secured leases on several hundred thousand acres of surrounding territory, offered to sell gas to New Orleans and made a proposition to deliver gas at the east bank of the river at prices ranging from 40 cents per 1,000 feet to begin with, 20 cents of which was to be used in amortizing pipe lines and other parts of the system, down to 20 cents per 1,000, until \$4,000,000 had been amortized, and 20 cents thereafter. The gas would then have to be distributed by the New Orleans Light Company through a separate agreement, or if no arrangement satisfactory to the city and the Gas Light Company could be agreed upon, then the Carpenter Syndicate or the city itself should distribute to the consumers through a pipeline system built for the purpose.

Such arrangement as the latter could apparently be made without interfering with the New Orleans Gas Light Company's franchise, which allows the company "to vend and distribute gas for lighting," and which franchise terminates in 1925.

It was found that the New Orleans Gas Light Company would be perfectly willing to undertake the distribution through its system, based on a fair return on their valuation, 7%, but, unfortunately, it developed that with the valuation placed upon the properties, using General Goethals' estimate of \$8,914,000.00, which is approximately average of the company's estimate and that of Mr. Lafaye, the distributing cost per 1,000 feet of natural gas would be about 90 cents, based on the consumption of artificial gas in 1918, which was 1,573,000,000 cubic feet, or a daily average of 4,320,00 cubic feet, with a maximum on one day of 9,400,00 cubic feet. To the 90 cents for distribution would have to be added the cost of the gas which was offered at 40 cents per 1,000 feet, and which would make the price to the domestic consumer \$1.30. No doubt the gas consumption would greatly increase, but it is doubtful that the volume would increase in a measure to cut the distributing price to any great extent during the first years, due to the fact that the artificial gas as delivered develops 600 B. T. U. as against 960 from the natural gas, or, in other words, the same heat and light developed by the artificial gas at 4,320,000 cubic feet daily would be produced by approximately 2,700,000 feet of natural gas, or it would be necessary to distribute 60% more heat units per day to produce the same income.

Various interviews with the officials of the New Orleans Gas Light Company led to an offer from the company to sell or lease the properties or to distribute natural gas, but all based on above-stated conditions—or upon another valuation by distinterested parties—and as it seemed impossible to get any further it was decided to ignore the Gas Light Company and provide a franchise which could be sold to the lowest bidder to furnish and distribute natural gas from Terrebonne or any other gas field.

A subcommittee was appointed, on which the writer served, with the result that an ordinance was drafted and which in substance was based on selling the franchise rights to the bidder, gas lease holder and operator, who would agree to furnish the necessary natural gas at the lowest price to the consumers, the franchise holder to develop the field and build pipe line to the city, and either distribute the gas through an en-

tirely new system or through arrangement of some kind with the New Orleans Gas Light Company through its system. The cost of gas to the domestic consumer would not exceed 80 cents as an absolute maximum, and with a sliding scale according to the volume of gas consumed—this price of 80 cents to be the maximum price at which the franchise could be secured, but there being prospects of having two or three bidders it was considered probable that a substantially lower bid would be received.

In the price of said franchise was provided certain percentages to be applied to amortization of field developments, main line to New Orleans, such distributing lines as might have to be constructed, or parts of such, and it was contemplated that in 17 years the entire system should have been amortized, but if not completely so, the city would take over the entire plant and system upon payment of such balance which might have been left unamortized.

It was estimated that by that time the cost of natural gas to consumers for domestic use would come down as low as 40 cents per 1,000 feet—the city owning the entire system, and, as was suggested, operating it as a separate department under the Sewerage and Water Board. Provisions were made for the entire system to include a sufficient number of gas wells to take care of the consumption, domestic and industrial, based on 15% of their open flow capacity, and, in addition, 10,000 acres of lease holds for the domestic consumption and another 10,000 acres for industrial consumption, this land to be selected by the city from the holdings of the natural gas company.

I am frank to state that personally I considered this a splendid ordinance, although it should have been worked out more in detail, and it is natural that such advantages cannot be gained without the city being responsible to some extent for part of the cost, but in this case our city authorities found that on account of the amortization problem there would be a certain gamble involved, and that it was not within the right or the power of the city to undertake it.

After the ordinance was withdrawn a resolution was adopted requesting that Engineer George G. Earl, General Manager of the New Orleans Sewerage and Water Board, take

the matter under consideration and act in the capacity of advisory engineer and have his staff of engineers prepare an estimate of the physical value of the New Orleans Gas Light Company's present plant with a view to the city buying or renting the entire system, or, if no deal could be made, that the committee might know approximately what it would cost to build a new plant and distributing system that would be capable of taking care of the city's requirements in every respect. And it should be stated that the entire committee is absolutely in favor of having a distributing system with a gas plant in working order as an emergency and with storage tanks to take care of fluctuations in the consumption during the peak hours and the slack hours of the day.

Engineer Earl went deeply into the subject and made a very exhaustive report, but it appeared impossible to bring the gas price down near the popular desire, especially if the city should undertake to construct an entire new system, including artificial gas plants and storage tanks.

It would be most unfortunate if the city should be unable to make satisfactory arrangement with the Gas Light Company to take over its holdings at a price that it would be justified at—partly on account of the franchise expiring in five years—and the system would apparently be almost a total waste—partly on account of the terrible disturbance to all our streets and the various lines of water, sewers, etc., and last, but not least, on account of the unhealthy conditions likely to prevail while the city is being dug up from one end to the other.

At the last meeting held during this week a resolution was passed that the Natural Gas Committee recommends to the City Council to buy from the New Orleans Gas Light Company its entire plant and distributing system at a price not to exceed \$5,250,000.00, as recommended by Engineer Earl to be maximum price based on the amount of capital stock of the company. Or if no such deal could be consummated it was recommended for the city to arrange to build its own new plant and distributing system, it being considered certain that if the city has a system to operate it would be a certainty that there would be operators and gas producers ready to sell.

As to the price of 80 cents mentioned in the ordinance above, which price received so much criticism, the writer wants to state that natural gas at 80 cents, which would be the absolute maximum, and the maximum at which we knew there was at least one interested bidder, would correspond to paying \$2.05 for the same quantity of heat in artificial gas based on the present rate of \$1.30 per 1,000 feet of 600 B. T. U., while the natural gas from Tererbonne develops 950 B. T. U. Even on the same basis at 80 cents per 1,000 feet for natural gas the heat units we now buy for \$1.30 would only cost us 51 cents or very much less than half of the present price. It is, therefore, easy to see how little we would pay for light and heat, as the price would have decreased during the amortization period, ending finally with natural gas at about 40 cents per 1,000, or correspondingly about 25 cents for the same amount of heat for which we are now paying \$1.30.

Much publicity has been given to the fact that other places, like Shreveport, Little Rock, Kansas City, etc., are getting natural gas for from 20 to 40 cents per 1,000 feet, and while there is no denying the fact that this is true, various factors must be considered which should make it useless; in fact, thoughtless and hurtful for anybody to keep agitating the subject of natural gas for New Orleans at 25 to 30 cents.

First, the cities enjoying this low-priced gas have had gas for several years. The wells were drilled and pipe lines constructed in days when material and labor cost but half, or less than half, of what it costs now, and often the well owners would run their wells as high as 75% of the open flow capacity to save boring new wells and thereby often drowning the gas fields by salt water coming in. Louisiana has a State law limiting the draft on the wells to 25% of their capacity.

In order to make up for small profits, if any, from domestic consumption, operators would sell gas at or near the wells at prices ranging anywhere from 1 to 5 cents, there being very small expenses connected with the delivery, and therefore practically all of this money being clear profit.

The result has been that glass plants, cement plants, zinc smelters, and, worst of all, carbon plants, have grown up around the gas fields, and, as a rule, the public which had a

short enjoyment of natural gas for domestic uses, the operators of the wells, and last, but not least, the manufacturers themselves.

These practices should be discouraged, if not totally forbidden, and I am not at this time certain that I myself am not an advocate of the theory that natural gas should be used exclusively for domestic purposes, as it will draw a larger population, which would have the comfort of the cleanest fuel, which will remain happy and satisfied as long as they have this comfort in their homes, but it does call for a price which will make it interesting for the operator to throttle the output and make the supply last, getting a reasonably good yearly income rather than try to get rich quick.

Besides, with fuel oil plentiful at our doors, and apparently for many years to come, partly from our own State and partly brought here from Mexico, this oil normally selling in New Orleans at about \$1.25 per barrel of 42 gallons corresponding to natural gas at 19 cents per 1,000, it would look almost a crime to allow our gas fields to be exhausted for the sake of competing with fuels as cheap as the oil mentioned. It has, for instance, been suggested to induce certain industries as a steel rolling mill to locate here, holding out as an inducement, among other things, natural gas. A rolling mill of all things—a small rolling mill would consume about one million cubic feet of gas per day, or figuring the average consumption of the 60,000 homes which used domestic gas in 1918 at 720 feet per day (same quantity natural gas would correspond to 1,140 feet artificial) we see where 1,400 homes could be happy and comfortable, as against, perhaps, a nominal saving to one certain industrial enterprise.

In this connection it might be of interest to note that using gas in internal combustion engines is far more economical than to fire it under boilers and develop steam, as will be seen in a table below, and if natural gas is used for industrial purposes at all, it should be urged by everybody interested that the gas be used principally in the internal combustion engine, rather than under boilers, for it will be noted that for development of the same horse power by gas engine and steam engine

it will take from three to twelve times as much gas through the developing of steam, all depending upon the class of boiler and engine used:

Average amount of natural gas required to operate gas engines or to supply a steam engine plant using natural gas as fuel under the boilers, in cubic feet per indicated horsepower per hour:

	Cubic feet.
Large gas engine, highest type.....	9
Ordinary gas engine.....	13
Triple-expansion condensing steam engine.....	16
Double-expansion condensing steam engine.....	20
Single-cylinder steam engine with cut-off.....	40
Ordinary high-pressure steam engine without cut-off.....	80
Ordinary oil-well pumping steam engine.....	130

From 10 to 12 cubic feet of air is necessary for the complete combustion of 1 cubic foot of natural gas.

As to the consumption of fuel in New Orleans, the following quantities approximately were used in 1918:

For industrial plants across the river with a main line from the field touching or passing, fuel oil and coal were used corresponding to a total per day of 10,390,000 cubic feet of gas.

The City of New Orleans, not including the American Sugar Refinery, used fuel oil and coal corresponding to a total per day of 65,850,000 feet, and, as most of these plants would be within easy reach not less than two-thirds of this quantity would be consumed if the prices were made considerably lower than the corresponding values of oil or coal, or approximately 44,000,000 cubic feet.

These two, together with the domestic consumption, amounts to approximately 58,700,000 cubic feet, and, if prices are made low enough, this consumption would unquestionably be very much increased, consequently our natural gas, whether from Terrebonne or from other nearby fields, would play out correspondingly earlier—and no matter how economical and watchful, they must play out sooner or later, for there are no deposits holding infinite supplies.

It is to be hoped when the day comes—and may it come soon—when New Orleans gets its supply of natural gas, and

if this gas is allowed to be used for industrial purposes, that prices and conditions will be made so that no ruthless waste of this, one of nature's most valuable commodities, can be perpetrated; in fact, the writer would be in favor of excluding its use for developing of steam and have it be used in gas engines only wherever it is used for industrial work; that is, provided we do not go to the extreme by allowing the natural gas for domestic consumption exclusively, such as is being urged more and more by geologists and national economists.

AN OPEN MOUTH FOR THE MISSISSIPPI RIVER.

BY ALLEN E. WASHBURN.

Read Before the Society December 8, 1919.

Natural phenomena met with at the mouth of the Mississippi River offer a variety of interesting subjects from the scientific viewpoint. A paper such as this could be devoted wholly to the measurements of the discharge, which have been made here on a larger scale than anywhere else in the world; "Mud-lumps," their cause, activity and effect on the shore line and mouths of the river, furnish a subject for endless study; "Sandwaves," the masses of material which, too heavy for suspension, are moved along the bottom by the current—are queer freaks of nature, and no successful method has yet been devised to prevent these sudden shoalings from causing serious interference with the navigable channels.

These corollary subjects can be but lightly touched on, as it has been suggested that a general review of the 200 year battle for the maintenance of a navigable entrance to the Mississippi River is of timely interest just now. With a deep connection to the sea, New Orleans has gained and held the rank of second seaport of the United States. Its population is probably four times as great as it would be without the link to the "big water." The public wharves, warehouses and dock facilities are the pride and boast of New Orleans. River commerce is being revived and enlarged, and the business interests of the entire Mississippi valley share in the welfare of New Orleans. Let the outlet to the sea be removed and the result would be economic stagnation. The work of past decades must be continued and enlarged to meet the increasing bulk of our exports and to accommodate the larger vessels in which the ocean commerce is now moved.

This review involves both history and technical detail. First let us get the local geography clearly in mind. For 90 miles below New Orleans, the Mississippi River is an unexcelled roadstead and harbor. It need not be feared that the size of ships will ever outgrow this part of the route. But at Head of Passes the difficulties begin. The present delta is formed by three main outlets or passes (see Coast Survey

(Chart No. 94). Pass a l'Outre, flowing northeast, has no present commercial value. South Pass, smallest and shortest of the three, has served as the ship channel for forty years, and is still the gateway to the Gulf of Mexico. Southwest Pass, a fine natural canal of ample dimensions, has barriers at its head and its mouth. This delta formation is the tool with which the river has built itself far out into the Gulf, leaving a narrow strip of land on each side to impound the mighty flow of water.

The French settlers used Pass a l'Outre as the entrance to the river. This pass was then only half its present length, and it was adequate, without improvement, for the toy ships of those days. A French map of 1722, four years after the founding of New Orleans, shows that Pass a l'Outre branched about one and a half miles from its mouth. The southerly branch was a bold channel with a minimum thalweg depth of 14 feet, and with practically no bar to obstruct its mouth. *Balize* settlement grew up there and became known the world over. The map referred to shows two converging lines which would seem to be a suggested location for jetties, but as it would antedate even the jetties at the mouth of the Dwina River in Russia, it can safely be assumed that the jetty lines were drawn on the map at some later date. Another map, dated 1724, shows the disintegration of this outlet, it having been divided for its full length by a middle ground shoal, although a depth of 12 feet still prevailed. Efforts were made in 1726 to deepen by dragging harrows over the bars, but without results. Another map, of 1731, shows this outlet reduced to a very narrow channel with 10 feet depth. Preponderance had passed to the other mouth of Pass a l'Outre, but "The Balize" continued to be used for navigation until after 1815. Now it is shown on the maps merely as Southeast Pass, which is far advanced in decay. Of the historic old settlement, only an iron tomb and some brick work of an old magazine can now be found.

As "The Balize" fell into decay in the first half of the nineteenth century, Southwest Pass became the entrance to the Mississippi River and was used almost exclusively until the South Pass jetties were completed. These were the palmy days of clipper ships, which were towed to sea by steam tugs. The ships were often loaded to 2 or 3 feet more depth than

was known to exist on the bar at the mouth of Southwest Pass, and they were pulled through or over this bar by "main strength and awkwardness." Mishaps and delays were frequent, and at times large fleets of ocean vessels would be held up for varying periods by the blocking of the channel. Dissatisfaction naturally resulted, and relief was demanded of the national government. Between 1839 and 1873, the United States spent nearly a million dollars on work to deepen the channel through the Southwest Pass bar, none of this work being of permanent nature. Dredges were operated, but the favored method was that of towing large harrows and leaving the current to carry off the material thus stirred up. A depth of about 18 feet was maintained over the bar. In 1852 a flimsy jetty was built, but it fell an easy victim to the waves without having produced results. In 1856, a contract was let for constructing pile dikes obliquely to the current at the mouth of Southwest Pass and Pass a l'Outre. These dikes, which were to confine the current and concentrate its scour where most required, proved an expensive failure. Then blasting with explosives was tried, but harrows and dredges continued the main reliance. With the opening of South Pass to commerce, Southwest Pass was abandoned, and was not again considered until the growing demands of commerce made necessary a larger connection between river and gulf.

A great controversy has been waged between the advocates of a ship canal outletting from the river and those who advocated jetties to maintain a sufficient depth through a natural mouth. The relative merits of canal and jetties were fiercely contended in the early 70's. The South Pass jetties have been successful from their construction to the present time, but, like Banquo's ghost, the lateral canal project will not down. By some it is argued that the success of the South Pass jetties was merely a fortunate accident, and that the feat cannot be repeated elsewhere or on a larger scale. The immense advantage of a shorter connection from New Orleans to the Gulf, avoiding many miles of swift current, has been sufficient incentive to keep alive the agitation for a ship canal.

A deep channel entrance through Lake Pontchartrain would be a huge project, but it may still be given serious considera-

tion. In nearly all suggestions of a canal, the location selected was from the river near Fort St. Philip to Breton Island Sound, where the length of the canal would be only six and a half miles. A reconnaissance of this sound by British naval officers in 1775 appears to have been the first attempt to find a shorter approach to New Orleans. The first suggestion of a ship canal of which there is authentic record was that made about 1832 by Major Benj. Buisson, State Engineer for Louisiana. His plan of a \$5,000,000 canal just below Fort St. Philip was pressed on Congress by the commercial interests of the Mississippi valley, the Louisiana Legislature and the New Orleans Chamber of Commerce. Investigation of the project authorized by Congress was made in 1837 by Capt. Wm. H. Chase, Corps of Engineers. He gave much weight to the military protection which the forts would give, and reported favorably on the project. Further investigation was ordered and was made by Capt. Andrew Talcott, Corps of Engineers. As the result of a report based on this survey, the project was abandoned.

While engaged on his survey of the Mississippi River, about 1851, Major Humphreys was attracted by the idea of a ship canal opening out from the river at Fort St. Philip.

In 1858, the canal project was revived by Mr. R. Montague, civil engineer. He made an examination of the proposed route and published a voluminous pamphlet as the result of his investigation. He was raising funds for the work when his death and the outbreak of the civil war put an end to the agitation.

In 1869, the Coast Survey extended its work to cover Breton Island Pass, and the canal project was brought before Congress during the winter of 1869-70. Again surveys and reports were ordered, and these were made by Capt. C. W. Howell of the army. He reported that the plan was feasible, and his estimate was \$7,400,000 for a canal with jetties at the seaward end and with a lift-lock 400x80x27, which could be completed in three years. In January 1874, a Board of Engineers reported that this project, with some modifications, was feasible and would cost \$10,273,000, but that further examination should be made before deciding on the exact line of the canal.

Col. J. G. Barnard of this Board dissented and argued for "more attentive consideration of the superior advantages of natural mouths." He preferred Pass a l'Outre to Southwest Pass for jettying. The majority report of this Board was endorsed by Gen. A. A. Humphreys, then chief of engineers. In New Orleans, the sentiment was nearly unanimous for the canal.

During this controversy, James B. Eads became interested. Lacking educational advantages, he had learned much from experience. As a diver and contractor for salvaging wrecked boats, he had gained a wide knowledge of and love for the Mississippi River. His bridge across the river at St. Louis was an engineering triumph though a financial failure to him. He had made a close study of erosion by current and he ardently embraced the theory of a natural mouth of the river which should be kept open by jetties. Eads was a man of force and daring—a "plunger" if you will—and in February 1874, he proved the courage of his convictions by a formal proposition to Congress. He proposed to build jetties at the mouth of Southwest Pass at his own cost and risk, being paid only as results were accomplished. For a channel of 28 feet depth, he would receive \$10,000,000 in specified installments. This was \$6,000,000 less than the cost as estimated by the Board of Engineers. Eads' proposition aroused bitter opposition. New Orleans regarded him as an outsider who would meddle for the love of experiment. There was rivalry between river and railroad traffic and Eads, builder of the bridge, was suspected of wanting to ruin the river in order to aid the railroads. All manner of dire calamities were predicted if he were allowed to attempt his jetties.

At this time an \$8,000,000 appropriation for constructing the Fort St. Philip canal was favorably reported in the House, but it was delayed in the Senate, pending the report of a special commission which was sent to Europe to study existing jetties. Eads accompanied this commission, which was composed of three army engineers, three civil engineers and one engineer from the Coast Survey. They studied the jetties at the Sulina mouth of the Danube in Roumania, which was analogous to the Mississippi in many respects. They also ex-

amined jetties in Russia, Prussia, Holland and Denmark. They then recommended, as cheapest, jetties at the mouth of **South Pass**, to cost \$8,000,000, but also reported as feasible the **Port St. Philip canal**, estimated at \$11,500,000, and jetties at **Southwest Pass**, estimated at \$16,000,000. They wisely recommended that, whatever plan be adopted, the whole sum required be immediately available, so that the work could be pushed to completion as rapidly as possible.

Eads was greatly disappointed at the offer of **South Pass**, and protested that this would be more difficult than **Southwest Pass** because of disadvantageous conditions at the **Head of Passes**. He even reduced his **Southwest Pass** proposition to \$8,000,000, with \$150,000 per year for maintenance. This offer was accepted by the House with but two adverse votes, but the Senate insisted that the work be done at **South Pass**. Eads reluctantly accepted permission to jetty **South Pass** for \$5,250,000, with \$100,000 for each of twenty years of maintenance. The bill was passed on March 3, 1875. We now know that the adoption of **South Pass** was fortunate for Eads as well as for **New Orleans** and the **Mississippi Valley**, for with his financial difficulties and the unrelenting opposition which he met, he could not have succeeded with the larger **Southwest Pass** project.

New Orleans has not yet recognized its debt of gratitude to **James B. Eads** by any kind of a memorial.

How Eads did the work is another story, too well told in **E. L. Corthell's** "**Mississippi Jetties**," for any repetition here. With the aid of **Corthell's** engineering genius, each obstacle was met and surmounted. It was a body blow to the calamity shouters when the schooner **Mattie Atwood**, drawing 13½ feet, passed to sea through **South Pass** on March 4, 1876, one year after the work was authorized. A few weeks later, the **Cromwell Line** steamship **Hudson**, drawing 14 feet 7 inches, passed in from the Gulf, and the **South Pass** jetties were an assured success. The channel was officially opened to navigation on July 8, 1879, with a navigable depth of 26 feet. The twenty years of maintenance, plus the periods when there was

any deficiency of channel, terminated on January 29, 1901. The total payments made to Eads and his heirs aggregated \$8,000,000.

The east and west jetties at South Pass were built with foundation lengths of 12,070 feet and 7,820 feet, respectively. They consist of concrete parapets built on superposed tiers of brush mattresses. A much discussed feature of these jetties is that the seaward 3,600 lineal feet of them was built on a one-degree curve, in order that the current might debouch from the pass at a more favorable angle with the littoral current. These jetties are parallel, with a width of 1,000 feet between them. The average width of South Pass is but 700 feet. Spur dikes were built to reduce the width of the channel between the jetties, and inner jetties were built by connecting the channelward ends of these spur dikes. All interior works are simple pile and brush structures, which have required constant renewal. At the head of South Pass the channel was divided by an island. The easterly of these channels was closed by cross dikes. Eads operated a side wheel hopper dredge with centrifugal pump, beginning dredging while the jetties were under construction.

Since the expiration of the Eads contract, the United States has maintained the South Pass channel by direct labor and government plant. By more dredging and larger expenditures for maintenance, the navigable depth has been increased to 32 feet. Except for limitations of its size, South Pass is still an excellent ship channel. However, the natural bar advance, aided by mud-lump formation, has rendered maintenance more difficult and has shifted the approach from the Gulf so far eastward that vessels have to make a difficult turn at the mouth of the jetties. The crest of the bar is about 2,000 feet from the jetties. The rate of advance of the bar since 1838 has averaged about 50 feet per year. The seaward slope of the bar is about 1 in 100. The volume of discharge has increased more than 60 per cent, and the quantity of sediment deposited just outside of the jetties has been proportionately increased. The location of South Pass, being the shortest distance to deep water in the Gulf, has been an important factor in the longevity of the pass.

When the term of the contract with Eads was nearing its end, consideration was given towards providing a larger entrance from the gulf to river. It was then decided that South Pass could not be sufficiently enlarged, and a project for improving Southwest Pass was adopted. This project contemplated a channel 1,000 feet wide and 35 feet deep. Construction of jetties was begun in 1905. Spur dikes and inner bulkheads have been constructed for the purpose of confining the flow and securing greater scour. All lateral outlets have been closed, and the channel has been dredged deeper at the head and at the mouth of the pass. To hold them in restraint, mattress sills have been placed across the other outlets from the river, viz: The Jump, Cubit's Gap, Pass a l'Outre and South Pass. At the Head of Passes, spur dikes and a submerged deflecting dike have been constructed to throw more water away from Pass a l'Outre and into Southwest Pass.

As Southwest Pass discharges nearly three times as much water as does South Pass, the problems encountered have been much larger. The larger quantity of sediment brought out has caused the bar to advance as rapidly as the jetties were built seaward. The jetties, being on a much larger scale, cannot be completed as rapidly as were those at South Pass, and the appropriations for the work have been tardy or too small to enable most rapid construction when required. The desired dimensions for the Southwest Pass channel have not yet been obtained, and an extension of the jetties is necessary. The Gulf currents at the mouth of Southwest Pass are less favorable than were those at South Pass. Unstable foundation and rapid subsidence have been met with where it was necessary to place great weight.

"Sand waves," previously referred to, have been a retarding factor in the Southwest Pass improvement. Portions of the channel which had been dredged out have been refilled time and again by these immense bodies of sand. Sand waves have become more frequent as mattress sills were placed across the other outlets, because the heavy sand always travels by the more open channel which is offered. In quantity, a sand wave activity frequently is the movement of several hundred thousand cubic yards of material. A rate of travel as great

as 150 feet in 24 hours has been measured, and shoaling of 20 feet on a given spot has been observed in the same time period.

Mud-lumps have also increased the shoaling in front of the jetties. They are exudations of soft clay, caused by the weight of the new sediment which is deposited during the river floods. These eruptions occur at the points of least resistance within the radius of influence of the new sediment deposit, consequently they frequently form within the channel itself. Mud-lumps outside of the channel, however, sometimes reach a height of 9 or 10 feet above water surface before equilibrium is restored by the weight of their own mass. These mud-lumps serve to check the current and thereby cause more rapid sedimentation in that locality. They are of tenacious material, resisting wave erosion and difficult to remove by dredging.

Seaward extension of the South Pass jetties has been considered at different times. The bar has advanced to its normal distance beyond the jetties, and maintenance of a channel through this bar is difficult. In 37 years just prior to the construction of the jetties, the average annual advance of the bar was 75 feet. During the 24 years of Eads' work, the advance averaged only 44 feet per year. In the four years during which the channel was enlarged by the United States, the annual advance increased to 121 feet. Since that period the advance has been variable, but has averaged about the same as before the pass was jettied. An extension of the west jetty for 2,000 feet seaward would present no great problem from an engineering standpoint. But any extension of the east jetty would have to be built across the present deep channel, unless an angle of nearly 40 degrees be made in order to parallel the channel.

Equilibrium of discharge of the three main outlets—Pass a l'Outre, South Pass and Southwest Pass—is of utmost importance in maintaining a navigable open mouth to the river. For this reason, measurements of the discharge have been made periodically since 1908. In the volume of water dealt with and the length of time covered by the observations, these measurements have doubtless been on a larger scale than those

of other similar work. Whenever made, the observations are carried on throughout the full cycle of the annual flood stage of the river, the five-foot reading on the Carrollton gauge at New Orleans, La., being considered as the division between flood stage and low river. In 1915, the river flood was of longer duration than any previous one of which there is record, and complete observations were made during $10\frac{1}{2}$ months. While no entirely new methods have been evolved in this work, the duration of each series of observations and the experience of many years have resulted in fixing on the most practical methods to secure desired results. Many refinements have been introduced to secure greater accuracy and economy.

A complete observation for the three passes is made where possible in a single day. The first systematic measurements were made in 1898, when 80 complete observations were made by measuring South Pass, Southwest Pass and Pass a l'Ouvre. The period of time covered was from April 30 to August 18, inclusive, or 110 days. In 1905, the discharge through the three main outlets was measured from March 10 to September 15, inclusive, or 190 days. Sixty-seven complete observations were made. In 1909, the same work was carried on from March 6 to August 23, inclusive, or 171 days. Sixty-two complete observations in the same day were made in the three main outlets, and the sequence was changed each time so as to minimize the effect of the tidal influence. As a verification of results, the discharge of the main river was measured nine times on a cross-section abreast of Pilot Town. This proved quite satisfactory, as the rate of total discharge under the same conditions of tide agreed within the limits of 0.1 to 1.1 per cent with that found by summing up the three passes. Widely different conditions of tide and wind, however, caused the individual observations to differ as much as $6\frac{3}{4}$ per cent.

Beginning in 1917, the measurements have been made throughout every river flood. In 1915, one hundred and twenty-four complete measurements were obtained, and experimental work was done for the purpose of studying the velocity of current at different depths. The apportionment of water and relative velocities of currents into the three passes were also studied by means of floats.

The soundings and current observations are taken from two self-propelled survey boats. After taking the soundings necessary to compute the partial areas of the cross-section, the boats are then held as nearly stationary as possible on each velocity station for a period of 200 seconds. The current velocities are determined by the use of Haskell and Price current meters, equipped with electric registers or revolution recorders. Both wet and dry batteries have been successfully used and the installation of a spark coil in the electric circuit gave good results. The meters are attached to a $\frac{3}{8}$ -inch cable with insulated core, and the cable is handled by means of a hand-windlass with a drum six feet in circumference. On each velocity station the meter is suspended at six-tenths of the actual depth at that station, and the number of revolutions registered in a period of 200 seconds is recorded. The velocity at six-tenths of the depth is taken as the mean velocity on that station, on authority of the Humphrey and Abbot experiments in the Mississippi River. From data obtained from experiments made by the United States Lake Survey Office with the same type of meter and size of suspension cable, it is known that the sag and inclination caused at a depth of 50 feet by a current velocity of five to six feet per second produces a loss of 1.0 to 1.4 feet in the depth at which the meter actually hangs. In practice, however, it was found that a foot or so either up or down made no appreciable difference in the velocity of current registered. Hence, no allowance is made to effect the loss due to sag or inclination. The conditions of wind and tides are noted while the observations are being made. The mean current velocity at each station is computed by using the formula $y=ax \times b$, in which x is the number of revolutions per second recorded at the six-tenths depth and a and b are constants derived by rating the current meter in still water. The mean velocity of current found at each station is applied to the partial area of cross-section which extended half way towards the next station on either side. The product of the mean velocity at each station by the area to which it is applied gives the rate of flow past that partial area, and the sum of the several products thus obtained gives the rate of flow for the whole section. The sum for all of the outlets is taken

as the rate of discharge of the river, thus neglecting wastage over the banks during the higher flood stages. The rates of discharge are computed in terms of cubic feet per second. Having obtained the rate of total discharge for the river, the percentage which is being discharged through each outlet is computed. The mean velocity of current in the main river and in each outlet is found by dividing the rate of discharge by the total area of the cross-section used. The rating constants of the current meter are reduced by moving the meter over a measured distance in still water, separate ratings being made for each propeller wheel with which the meters are furnished. This proceeding is repeated from 20 to 40 times at different rates of speed, so as to meet the range of all velocities dealt with in the work. From the known length of base, time of travel and recorded revolutions of the propeller, the speed and the revolutions per second are determined for each trip over the measurer base. These are averaged by the theory of least squares, and the values of the constants *a* and *b* in the formula $y=ax \div b$ are computed. As these constants are changed by any damage to the propeller, wear of the spindle, etc., not less than three ratings were made during each period that the discharge measurements were carried on. In 1898 and 1905, the ratings were made in Red Pass, a branch from the Jump which had been closed by a levee. The meter was suspended from the bow of a skiff which was drawn over a 200-foot base by men on shore. In 1909, 1914 and 1915, the ratings were made in the still water of Baptiste Collette's Canal on the river side of the dam. Subsequent ratings have been made in sheltered water behind new works at the mouth of Southwest Pass. The meter was suspended from a 20-foot scantling projecting from the bow of the survey boat, and a base line 600 feet long was used. This arrangement was much more convenient and the results more accurate.

In 1898, the measurements in the three main outlets were made as nearly daily as was practicable. All later work has been on the basis of three measurements per week in the three passes, and no fixed schedule for the minor outlets. It is believed that this gives a very dependable average of the rate of discharge when carried out through a long period. Ef-

forts towards further improvements in methods should be directed towards securing more nearly simultaneous measurements in all the outlets, but such improvement can be had only by using more than one current meter outfit. The rate of discharge through each outlet is affected by tidal change in the water level and by changes in the direction or force of the wind, this being true especially during the lower stage of the river. Again, it is believed, however, that a fair average for each outlet has been secured by the number of observations made and by having varied the sequence in which the several outlets were measured.

Comparison of areas found at different times shows variations between different days in the same year. Such changes are to be expected from natural causes. The more rapid changes have been due to "sand waves" or material too heavy for suspension which is moved along the bottom. Thus, in 1898, the maximum depth found on the Pass a l'Outre cross-section was 99 feet on May 10; on June 14 it was 93 feet; on June 15 and 17 it was only 73 feet and 72 feet, respectively, then again it deepened to the normal depth of about 90 feet. Similarly in 1905, a shoaling from 90 feet to 63 feet in depth was noted, and like results in other years. South and Southwest Passes have been affected in the same way, but in lesser degree. The area of cross-section and the rate of discharge were correspondingly varied by these changes.

The relative sizes of the outlets are shown by the following table of average areas, in square feet, below datum in 1915:

The Jump.....	7,061
South Pass	23,479
Pass a l'Outre.....	78,420
Cubits Gap	29,824
Southwest Pass.....	72,047

The following is the average per cent of the total discharge at Head of Passes:

Year—	South Pass	Southwest Pass	Pass a l'Outre
1898	8.6	41.4	50.0
1905	9.2	46.1	44.7
1909	11.2	43.9	44.9
1914	12.7	41.2	46.3
1915	14.1	40.9	45.0
1917	14.7	39.6	45.7
1918	13.7	38.7	47.6
1919	14.6	40.4	45.0

From all measurements made in 1915, the average rate of discharge of the whole Mississippi River above The Jump is computed to have been 687,877 cubic feet per second. Between January 12 and November 5, the period of the measurements and the flood stage of the river, there were 299 days or 25,833,600 seconds. Multiplying the rate by the time gives the enormous quantity of 17,770,338,775,510 cubic feet of water as having been discharged by the river. The amount discharged by each outlet was directly proportionate to the percentages as stated in the preceding paragraph. It should be borne in mind, however, that the duration of the river flood in 1915 was fully 50 per cent greater than that of the average annual flood.

Experiments in South Pass from 1879 to 1901 showed that the proportion between the total discharge and the volume of sediment carried in suspension was 1 to 0.0007. These experiments, being continuous, included the period of low water, when practically no sediment was being carried in suspension. During the high water periods, a proportion of 1 to 0.001 is more nearly correct. Applying this ratio to the volume of discharge from the river during the flood period of 1915, it is found that the amount of sediment carried in suspension was something like 658 million cubic yards, enough to build up an area 64 square miles to a height of 10 feet.

Humphreys and Abbot in 1860 (pp. 146 and 148 of their report) concluded from their observations that the Mississippi's mean total annual discharge at Carrollton was 19,500 billion cubic feet, or, including the three outlets above—Old

River, Bayou Plaquemine and Bayou Lafourche—about 21,300 billion cubic feet, with about 443,000,000 tons of sediment. This brings the mean annual discharge to about 675,000 second-feet, and an annual deposit of sediment one mile square and 263 feet high, or, including the deposits on the delta, 290 feet high.

The greatest discharge actually determined in 1915 in all the outlets at the same time was 876,048 second-feet. This, however, was not the maximum for the year. On another day a discharge of 843,037 second-feet was measured in the three main outlets. Adding the discharge through the minor outlets on the nearest date when determined, a total of 979,000 second-feet is obtained. Allowing for wastage over the banks below the levee system, the total may be stated as 1,000,000 second-feet, or more, as the maximum for that year.

The Mississippi River Commission observations for February 10, 1913, with a stage of 15.6 feet at Carrollton, was a discharge of 1,048,815 second-feet, or, including wastage, a total of 1,051,465 second-feet.

During the greatest flood on the lower river, that of 1912, the Mississippi River Commission determined on May 15 at Red River landing, with local standard gauge at 53.2 feet, a discharge of 1,305,606 second-feet, or, including banks, 1,499,462 second-feet. Also, on May 11, 1912, with Carrollton gauge at 20.7 feet (highest record), the determined discharge was 1,309,818 second-feet, or, adding wastage, 1,312,242 second-feet. This agrees for river proper very closely to Red River landing discharge on May 15.

In regard to the determination of the mean velocity. Humphreys and Abbot stated on page 211 of their report that the mean velocity varies from 0.85 to 0.89 of the maximum, and that its position is generally about three-fifths of the depth below the surface.

The discharges in recent years have all been measured with current meters, and the velocity taken at six-tenths of the depth was taken as the mean velocity. The method of taking the velocity at certain points of the depth (say, at two-tenths and eight-tenths of depth, or at a greater number of places), might give slightly better results. But, in dealing

with such large discharges, it has been considered more important to gauge all three mouths the same day, if possible, in each observation. To accomplish this, the current readings must be taken rapidly in each vertical section, and one reading at the six-tenths depth was considered the most advisable. The six-tenths depth is not only stated by Humphreys and Abbot, but also given by Merriman as one of the recognized methods, and is also used by the Mississippi River Commission.

DISCUSSION

The President: We have heard the very interesting paper of Mr. Washburn. We all appreciate it, I am sure, especially in view of the fact that he has come all the way from the mouth of the river to tell us about it. Now we would like to hear some discussion on the subject from all the members who are interested in the problem of controlling the river.

Major Shaw: I would like to ask what is the limit of the capacity of South Pass as to navigation. Is the navigation that is now available at that outlet so great that it cannot be added to with safety, or is there a difficulty in maintaining the present channel there, making it desirable to have an addition to that pass?

Mr. Washburn: The trouble is that South Pass has been enlarged to its limit. That is the principal difficulty. More so then the difficulty of maintaining it. The Eads contract provided that he was to be paid according to results obtained, and when he reached a navigable channel of 26 feet depth, he was content to stand on that. He found it to his natural advantage to maintain that 26 feet and lose a payment when there was any deficiency in the 26-foot channel.

Since that time the channel has been enlarged by dredging and also by natural forces so that the navigable depth is, I can say, always 30 feet or more. More often it is about 32 feet. And in deepening this pass, it has also widened itself slightly. But the banks of the pass are so very narrow that if it were widened to any considerable distance more than it is already, artificial banks would have to be built. The banks along the

entire pass consist of a very narrow ridge of material, just solid enough to stand as banks. Even 100 feet away from the edge of the water you find the customary soft salt march, which would not stand or serve as a bank. And also, the slope of the bank drops off very rapidly there. We have had some trouble with caving banks. It is not so much a question of the amount of material we lose as it is the losing of the higher part of the bank, which, on a small scale, is like a break in a levee; the retaining wall allows the water to escape. That is the necessity for a larger outlet. We can take care of, and have had, vessels loaded to a draft at 32 feet, or a little more, that have navigated with safety; and during the greater part of the time 32-foot ships can go through. We have a number of vessels going through that are 500 feet or more in length, but that does not provide for the monstrous trans-Atlantic passenger ships, the *Laviathan*, and others like that, and, as you know, the tendency is towards larger vessels, and in order that New Orleans may keep up and hold her own, she will have to have channels to accommodate those larger vessels.

Major Shaw: It is the depth, rather than the width, that is limiting us now, is it not?

Mr. Washburn: Well, the depth could be further increased by dredging, no doubt, but that would be endangering the embankments.

Mr. Coleman: What is the effective width?

Mr. Washburn: The effective width is about 300 feet.

Mr. Robert: Could two vessels pass each other at one time in that 300 feet?

Mr. Washburn: They do, very frequently. I have seen three vessels pass there. That should not be done, but two vessels pass without any hesitation at all.

There is another thing about South Pass, and that is that foundering of vessels inside of the pass is almost unknown. A large ship traveling through South Pass is moving in a groove, and it is almost impossible for that vessel to swerve aside enough to stick herself into the bank. She is guided by that groove, and before she actually touches the shore, the water cushions act and the vessel "smells the bank," as the pilots

express it, and makes towards the other side. In case of a vessel "taking a bolt," she is more apt to get aground on the side away from where she sheers first than on the side towards which she sheers.

Mrs. Nelson: What about the vessel taking an awful turn and getting into the jetty?

Mr. Washburn: At the mouth of the jetties the central axis of the channel makes a turn of about 40 degrees and as an inbound vessel approaches, she has to come in at this angle, and just as she gets into the mouth of the jetties, where she encounters this strong curve, they have to swing the vessel up against that current. The current applies pressure on one bow of the ship, and consequently it often happens that the vessel has refused to respond to the helm and instead of making the turn gracefully, she "skidded" there until brought up against the west jetty, and had a little damage bill to pay.

Mrs. Nelson: Could not that be remedied by extending the jetty?

Mr. Washburn: That would require a very large expenditure. It would require an extension of both jetties. It has been considered, but the *desideratum* was to get a larger pass, and Southwest Pass offered advantages on which to work, being a natural ship channel, and requiring improvements only at the head and the mouth.

Mr. Robert: What is the effective depth of Southwest Pass now?

Mr. Washburn: The effective depth is a very variable quantity. The work of improvement is still going on over there. They have had an available depth of as high as 33 feet, I believe. At other times that has been choked up by the arrival of "sand waves," and the depth has fallen off to as low as 19 or 20 feet.

Major Shaw: Does it appear as though the formation at the mouth of South Pass, to bring it more nearly parallel to the littoral current, has been of assistance in carrying the deposit from the mouth of the pass, so as to prevent the formation of bars as readily as would be the case if the littoral current were at a sharper angle? I understand that was the reason given for it.

Mr. Washburn: That was the reason given. I think Eads got expert advice from abroad, and built that curve at the end as a result of that advice.

The question you ask is a much mooted one. My idea is that there was a gain by putting that curve there; that it served to give a long life to South Pass. It was predicted when Eads was doing the work that incessant prolongation of his jetties would be required, but as a matter of fact, they were completed in 1879, some forty years ago, and there has not been one foot of extension on the jetties to the present day. There have been a few feet lost by storms, however. By mathematical rules it was demonstrated that frequent prolongation of the jetties would be required, but in actual practice the jetties have done the work for forty years, and I think it is only fair to assume that some part of that was due to the curve which was put in there to give an easier angle of impact.

Major Shaw: Is the velocity of that littoral current at all comparable with the velocity in the Southwest Pass?

Mr. Washburn: Not during the time of a high river. It is even discussed whether there is any true littoral current along the mouths of the passes. It is known that the Gulf current flows eastward, but at the mouths of South and Southwest Passes it is westerly. The littoral current is an eddy from the main current, and until the shoal outside of the jetties built up to its present dimensions (that on the westerly side), the littoral current across the mouth of the jetties was very pronounced; not so much now as it was years ago. There was a time when a current of two or two and one-half knots. I think, across the mouth of the jetties was not unusual. It is to be understood, however, that the currents as well as the tides in the Gulf are greatly affected by the winds. The tides can be entirely obliterated by a stiff wind, and the conditions of the currents out there depend very materially on the conditions of the wind for the previous few days.

Mr. Coleman: Are you familiar with another ship canal project of later date which proposed to come in on the west side of the river, I think to pass near Grand Isle, east of Grand Isle and come up through Bayou Barataria, striking the

river at about Harvey's Canal, with locks at that point, so that vessels might enter the Mississippi River at that point?

Mr. Washburn: I have heard of such a canal, but I have nothing authentic on it. In fact, I recently read a suggestion about it in the newspaper under "Letters from the People." At different times back, canals have been suggested as outlets from the Mississippi River, but it seems to have nearly always been taken for granted that such canals would have to be to the eastward. The suggestion of a canal to the westward, as a rule, has not been taken seriously.

Mr. Coleman: In connection with the project I speak of, about 10 or 12 years ago there was an engineer here who maintained a force in the field for several months, and his plan involved not only the excavation of such a canal from the Gulf, at the east end of Grand Isle to Harvey's Canal, but also the excavation of a ship basin and the development of ship terminals on the west side of the river. It was not to be an outlet in any sense, for the reason that they also proposed to construct locks through which vessels might enter the Mississippi River, if need be, and reach the city of New Orleans. The project, as it was outlined, was more ambitious than that: it was apparently designed to take away from the city the business which was being done here.

Colonel Dent: While I am not familiar with that project, I know that the question of a canal has been raised. I got here last March and I know that it has been raised twice since then, but it is a big excavation and means an expensive lock at the river side.

The question of a canal going through Lake Pontchartrain and into the Industrial Canal has also been raised. Then it has been suggested that we put a canal on the west side and put the locks well down. There is a place down there where superficial foundations are as good as anywhere on the river. But none of those projects have been investigated sufficiently and I believe Congress has not been called upon to investigate them.

Mr. Washburn: They were to start just below Fort St. Philip?

Colonel Dent: They were simply considering a canal, and that is where it was to start.

Mr. Washburn: I am glad Mr. Coleman reminded us of that project. I do recall now some such work having been mentioned, but I did not know that so much had been done in that line as he points out.

Mr. Coleman: I do not think it ever reached the stage of presenting the plans to the government officers of the War Department officially, but the plans were formulated by an engineer named LeBaron, and he had an office on Rampart street, not very far from Beauregard Square. I saw a great many of the maps and plans which he had worked out, and I remember distinctly the large ship basin and very ambitious terminals which he was projecting. Who was backing the project I do not know, but he was not the type of man likely to expend his own time and money to conduct these rather elaborate surveys and maintain an elaborate engineering office. I thought possibly some news of it might have come to you and that you might enlighten us as to just what it was.

Mr. Washburn: No; the information that you give is more than I ever knew of it before. There have been various visionary schemes on that line. I recall, a few years ago, that some promoter was going to acquire land around here and was going to build something (he did build two cabins) that would put New Orleans out of business. He was going to have the terminals at Head of Passes. I don't know how he succeeded with his sale of land, which was, of course, at the bottom of it.

Major Shaw: It might be of interest to Mr. Coleman for him to know Mr. J. Francis LeBaron wrote a paper, which was published by the American Society of Civil Engineers, shortly after his investigations here, and it was through that paper that I got in touch with him ten years ago when I came here. I had some correspondence with him and he was then on the Pacific coast. It seems that the scheme of building a ship canal through the Barataria region to the back door of New Orleans, as ambitious as it was, was only incidental to a still greater scheme he had on foot. The capital which was furnished to him was for the purpose of investigating the agricul-

tural possibilities of that entire section. His main scheme was to have the whole Barataria country developed agriculturally, principally for the purpose of irrigation and the growing of rice. The capital furnished was principally for the investigation of agricultural possibilities of the section, and this ambitious plan of a ship canal was only incidental to this main object.

Professor Anderson: Will the ultimate development of the Southwest Pass stop the use of South Pass?

Mr. Washburn: That has been the idea. When Southwest Pass shall have been completed, and proven itself, and shall be in active operation, the United States will not be justified in making further expenditures for the maintenance of South Pass.

Mrs. Nelson: Are not the sand waves in the Delta Pass or Southwest Pass more troublesome than those in South Pass? Are you troubled with sand waves in South Pass?

Mr. Washburn: No; at present we are not. We have had shoaling from sand waves in the past, but that sand, being quite heavy, is averse to climbing at all; it will take the easier way. There is now a mattress sill which gives a slight raise to the bottom across South Pass, and that has the effect of shunting the sand (nearly all of it) into Southwest Pass, it would seem.

Mrs. Nelson: Would you not have that same trouble at all times? Using the larger pass, you will have a larger quantity of sand passing there?

Mr. Washburn: Yes; naturally. Pass a l'Outre formerly was the pass which threw off the large number of sand waves. Reference is made in my paper here to a shoaling of 26 feet in three or four days' time in Pass a l'Outre, but the mattress laid across the bottom, at the head of Pass a l'Outre, served to turn the sand away, and it nearly all comes diagonally across the channel and is drawn into Southwest Pass.

Mrs. Nelson: My idea was that it would be a risky thing to do away with the narrower pass that had little sediment and therefore small chance of being affected by sand waves, and take up the use of a larger one, which has sometimes 20 feet of sand in 24 hours, I think you said?

Mr. Washburn: Yes; we have had very sudden shoalings like that. However, the opinion I give as to the discontinuance of South Pass is my own opinion. It has never been definitely announced what the policy would be.

Colonel Dent: I want to call attention to two points that have not been explained, as far as I know. The bar at South Pass has advanced something like 3,000 feet since the jetties were built and we have been able to maintain a channel through. So far we have not been able to do it at Southwest Pass. I don't know why. Another thing is the water coming out of South Pass goes in a straight line right across over this bar. Now what makes the channel take the direction it does?

Mr. Klorer: How great is the change in direction?

Colonel Dent: About 40 degrees, there. The line of entrance makes an angle of about 40 degrees to the curve of the jetties at that point.

Mr. Klorer: I was particularly interested in the statement about those sand waves shoaling up the channel as much as 26 feet in 24 hours. I believe, if I remember correctly, it was stated that they travel 150 feet a day.

Mr. Washburn: I have measured that rate of travel. I think that is the maximum rate of travel.

Mr. Klorer: The point I was curious about was whether the appearance of those sand waves was simultaneous with the high stages of the water.

Mr. Washburn: They seem to be very irregular. We have not been able to lay down any rule for that. One year we may have a very large river flood, practically free of sand waves, and the next year we may have this large amount of moving sand thrown down.

Mr. Klorer: But generally, you don't have them in low water?

Mr. Washburn: Not in motion, but when the river reaches a low stage the velocity dies down and the sand is left here and it remains there unless we get busy with dredges and move it out of the way.

Mr. Klorer: Do you get more than, say, two or three of those sand waves during the high water season? How many do you get?

Mr. Washburn: Well, considering the length of the confined channel, there is about only time for one sand wave to work its way through in the high water season. One year we had two to contend with. One flood had left sand wave conditions in the lower part of the restricted channel, and about the time we got rid of that, another was showing up. I have not found any definite cause for it, but it seems to me these sand waves are more frequent and more pronounced now than they were a few years back.

Mr. Klorer: I think you stated the reason was the closing of Pass a l'Outre.

Mr. Washburn: It must be that the sand waves did move down Pass a l'Outre and they passed by unnoticed.

Colonel Dent: That question was studied by Professor Johnson at Helena pretty carefully, and he found the bottom of the river there had a sort of saw-tooth form, and one wave followed another. I forget the distance between the teeth.

Mr. Washburn: Well, the distance between would naturally vary with conditions. But that is precisely the condition which we often find. We have sounded and we know the soundings all decreased as they rose up and dropped suddenly. The "saw-tooth" term expresses it correctly.

Colonel Dent: What was the distance between the "teeth?"

Mr. Washburn: That is very variable, but it is somewhere about 75 to 100 feet.

Colonel Dent: Then where tooth No. 1 is today you would have tooth No. 2 tomorrow?

Mr. Washburn: Yes; when they are moving so rapidly as that.

Colonel Dent: That is what Professor Johnson found at Helena. He also found that one would overtake another.

Mr. Washburn: I don't doubt that that often occurs, just as floods on the river may overtake each other, and give higher water at a point down the river than they do up above, traveling at different velocities.

Colonel Dent: I understand that Colonel Leach was unable to detect any large sand wave movement at Carrollton. He made quite an investigation there one year, with very little in the way of positive results.

Mr. Washburn. It may have happened that he was not there the right year. The movement of sand has been very irregular. We may escape it some years, and make up for it later by having it worse than usual.

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- VICTOR L. WILLOZ, (1900), Superintendent of Distribution, N. O. Ry. & Lt. Co., 201 Baronne St., New Orleans.
- J. NORMAN WILSON, (1911), Assistant Engineer, Sewerage and Water Pumping Stations Department, Sewerage and Water Board of New Orleans, 2425 Audubon St., New Orleans.
- R. C. WILSON, (1911), Consulting Engineer, 7011 Elm St., New Orleans.
- ALLAN L. WOLFF, (1919), 1522 Aline St., New Orleans.
- JAMES M. WOOD, (1919), 1304 Marengo St., New Orleans.
- DURAND F. WOODS, (1915), Civil Engineering, Litcher, La.
- W. B. WRIGHT, (C. M.), Division Engineer, Sewerage and Water Board of New Orleans, City Hall Annex, New Orleans.
- HENRY L. ZANDER, (1898), Parish Engineer for Jefferson Parish, Engineer 1st and 2nd Good Roads Districts, Engineer 2nd and 5th Unit 4th Jefferson Drainage District, 821 N. Rampart St., New Orleans.

NON-RESIDENT MEMBERS.

- EDWARD A. ARPIN, (1918), Florence, La.
- CHAS. D. BABBITT, (1911), Consulting Engineer and Real Estate, Florence, La.
- JOS. P. BERANGER, (1915), Secretary and Chief Engineer, West India Management and Consultation Co., Inc., 129 Front St., New York City, N. Y.
- M. E. BERANGER, (1918), Supervising Engineer M. E., 50 Port Royal St., Kingston, Jamaica, B. W. I.
- MERRILL BERNARD, (1917), Civil Engineer, Crowley, La.
- JOS. M. BING, (1917), Consulting Engineer, 53 Hamilton Terrace, New York City.
- A. L. BLACK, (C. M.), 58 Sutter St., San Francisco, Cal.
- EDWARD W. BRES, (1915), Mechanical Engineer, 1119 Short St., New Orleans.
- R. W. BRINGHURST, JR., (1912), P. O. Box 192, Alexandria, La.
- JOHN CALLAN, (1918), care Oakes Club, Maryville, Tenn.
- H. F. CAMERON, (1914), Vice-President and General Manager, Texas Gas and Electric Co., Houston, Texas.
- C. GLENN CAPPEL, (1915), Covington, La.
- JOHN J. CHISOLM, (1918), 71 VanWame Ave., Mariner's Harbor, Staten Island, New York.
- LEE A. CHRISTY, (1918), 738 Wilson Building, Dallas, Texas.
- JOHN DeM. CRAWFORD, (1916), 1410 Second St., New Orleans.
- L. C. DATZ, (1906), Engineer, American Cities Co., 2100 First Ave., Birmingham, Ala.
- JOHN J. DAVIDSON, (1918), care Avoca Post Office, Morgan City, La.
- A. D'HEUR, (C. M.), Manager Fuel Oil Department, S. P. Co., 65 Market St. San Francisco, Cal.
- WILLIAM F. EBLEN, (1916), Houston Light & Power Co., Houston, Texas.
- L. P. ELBERSON, (1911), Superintendent, Louisiana Irrigation & Mill Co., Crowley, La.
- S. WALLACE ELBERSON, (1911), Engineer, with A. M. Lockett & Co., Crowley, La.
- FRANK E. EVERETT, (1914), Civil Engineer, Crowley, La.
- BENJ. HARRISON FARQUHAR, (1919), Union Sulphur Co., Sulphur, La.
- CHARLES H. FENSTERMAKER, (1914), Chief Engineer, Industrial Lumber Co., and Engineer Road District No. 5, Allan Parish, Elizabeth, La.
- JESSE F. FONVILLE, (1917), Magnolia, Miss.
- FRANCIS T. FOOTE, (1909), Lumber Business, Kaplan, La.
- LOUIS J. FORTIER, (1914), Captain of Field Artillery, Alabama Polytechnic Institute, Auburn, Ala.
- JAMES McC. FOURMY, (1916), Consulting Highway Engineer, Hammond, La.
- FRED. I. GETTY, (1915), Manufacturer of Oil Well and Water Well Supplies, Strainers, Pumps, Etc., 603 Cutting Ave., Jennings, La.
- WINFIELD A. HALLER, (1913), President Haller Car and Locomotive Corp., 120 Broadway, New York.
- FLOYD HAMILTON, (1919), Lake Charles, La.
- ADOLPH E. HARTMAN, (1918), Geologist, Gypsy Oil Co., Tulsa, Okla.
- JOHN LOVEJOY HENNING, (1919), 525 Kirby St., Lake Charles, La.
- H. H. HOLLOWAY, (1919), Civil Engineer, Bunkie, La.
- CHARLES L. JACOB, (1911), 600 Kerlerec St., New Orleans.
- E. S. JARRETT, (1909), President, Jarrett-Chambers Co., Inc., Contractors, 30 East 42nd St., New York City.
- XAVIER A. KRAMER, (1911), Consulting Engineer, Magnolia, Miss.

- L. A. LOUSTALOT, (1913), Civil Engineer, Franklin, La.
- HENRY A. MENTZ, (1915), Principal Assistant Engineer, Xavier A. Kramer, Magnolia, Miss.
- A. ROGERS MIELLY, (1915), Assistant Engineer, Fort Worth & Rio Grande R. R. and St. L. S. F. & T. R. R. S., Majestic Bldg., Fort Worth, Texas.
- ROBERT MORRISON, (1919), Cut Off, La.
- CHARLES W. OKEY, (1911), Engineer, Elliott & Harmon Engineering Co., 144 Freedom Ave., Peoria, Ill.
- WILLIAM C. OLSEN, (1914), Consulting Municipal Engineer, Sumter, S. C.
- GUY OSBORNE, (1913), Engineer, Black River Cypress Co., Sardinia, S. C.
- BOYKIN W. PEGUES, (1907), Professor of Civil Engineering, Louisiana State University, Baton Rouge, La.
- H. N. PHARR, (1908), Sugar Planter and Manufacturer, Olivier, La.
- H. A. PHILIPPI, (1912), Civil Engineer, 213 New Orleans Court Bldg., New Orleans.
- OTTO F. REISZNER, (1916), General Engineering Practice, Lecompte, La.
- FRANK LOUIS REYNOLDS, (1919), Vice-President, Fox, Reynolds Company, Inc., Building Construction, 81 East 125th St., New York.
- W. B. ROBERT, (1911), Civil Engineer, Lafayette, La.
- FRANK L. ROE, JR., (1920), Omega, Madison Parish, La.
- ERNEST A. ROSE, (1915), Engineer for American Beet Sugar Co., Rocky Ford, Colo.
- JOHN A. SALMEN, (1911), Vice-President, Salmen Brick & Lumber Co., Ltd., Slidell, La.
- T. H. SAMPSON, (1900), Manufacturer of Sampson Process Gum Lumber, Helena, Ark.
- REGINALD McC. SCHMIDT, (1915), Inspector, U. S. Engineer Office, 1023 Leontine St., New Orleans.
- J. S. SHARP, (1915), Roadmaster, N. O. & N. E. R. R., Room 308, Ross Bldg., Hattiesburg, Miss.
- HOBART D. SHAW, (1917), City Engineer and General Practice, Gulfport, Miss.
- ELMER E. SHUTTS, (1918), Lake Charles, La.
- FRANK SHUTTS, (1913), Lake Charles, La.
- FRED N. SHUTTS, (1913), Parish Engineer, Calcasieu Parish, La., Lake Charles, La.
- JOHN A. SILSBEE, (1915), of Gilbert & Silsbee, Civil and Consulting Engineers, Okmulgee, Okla.
- FRED E. SMITH, (1916), 3149 Chartres St., New Orleans.
- THOMAS BAKER SMITH, (1919), Houma, La.
- JOHN Y. SNYDER, (1918), Engineer, 1210-1211 Merchants Bldg., Shreveport, La.
- IRA W. SYLVESTER, (1901), Consulting Engineer, City Hall Bldg., Alexandria, La.
- WM. F. TRIGGS, (1914), Gueydan, La.
- THOS. H. TUTWILER, (1898), President and General Manager, The Memphis Street Railway Co., Memphis, Tenn.
- WM. VON PHUL, (1908), President and General Manager, United Railroads of San Francisco, 58 Sutter St., San Francisco, Calif.
- BUFORD E. WALKER, (1919), Pascagoula, Miss.
- ALLEN E. WASHBURN, (1908), Port Eads, La.
- JOHN LESTER WHITE, (1920), Lecompte, La.
- W. S. WHITE, (C. M.), 918 Parkerson Ave., Crowley, La.
- MAYBIN H. WILSON, (1912), Captain, U. S. A., First Engineers, Co. B, (Railway Operating), Coblenz, Germany. Home Address, 1221 Constantinople St., New Orleans.

- PEYTON W. WOOD, (1911), Sales Engineer, Buda Co., Harvey, Ill.
A. A. WOODS, (1911), Chief Engineer, M. W. & S., Southern R. R. Lines West,
131 Ingalls Bldg., Cincinnati, Ohio.
SAMUEL YOUNG, (1911), Civil Engineer, P. O. Box 41, Little Rock, Ark.
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ASSOCIATE MEMBERS.

- WENDELL W. ARMOUR, (1919), Louisiana State Highway Department, 1722 Prytanla
St., New Orleans.
R. H. BAUMBACH, (1911), Manager, Eugene Dietzgen Co., 615 Common St., New
Orleans.
EDWIN C. BROWN, (1915), Sales Engineer, 4032 Prytanla St., New Orleans.
H. W. FLETCHER, (1914), Manager, Clyde Iron Works, 416 Carondelet St., New
Orleans.
EDMUND J. GLENNY, (1919), City Hall, New Orleans.
GEORGE J. GLOVER, (1916), General Contractor, 1022-23 Whitney Bank Bldg., New
Orleans.
JULES GODCHAUX, (1899), Godechaux Bldg., New Orleans.
WALTER F. JAHNCKE, (1920), 814 Howard Ave., New Orleans.
A. A. KEITHER, (1919), 234 S. Scott St., New Orleans.
JOHN McINERNEY, (1920), 3205 St. Charles Ave., New Orleans.
EDWIN L. POWELL, (1914), President, New Orleans Coffee Co., 1531 Exposition
Blvd., New Orleans.
JOHN J. STEADHAM, (1912), Supervisor of Bridges and Buildings, N. O. & N. E. R. R.,
1228 Music St., New Orleans.
F. W. STEVENS, (1909), Manager New Orleans District Sales Office, Allis-Chalmers
Mfg. Co., 719 Maison Blanche, New Orleans.
J. M. VANDERVEER, (1916), General Manager, American Creosote Works, Inc., Pry-
tanla and Jena Sts., New Orleans.
STILLMAN W. WHELOCK, (1914), Manager of Sales, Carnegie Steel Co., 1030
Maison Blanche, New Orleans.
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RESIDENT JUNIOR MEMBERS.

- JOHN APPLEBY, JR., (1918), Assistant Engineer, A. M. Shaw, 617 Common St., New
Orleans; 1518 Melpomene St., New Orleans.
HENRY HESTER BATE, (1919), Civil Engineer, 1330 Pine St., New Orleans.
J. J. BULLING, (1915), Market Street Power House, New Orleans.
ASHLEY CALONGNE, (1914), Assistant Engineer with S. A. Calongne's Sons, 630
Gravier St., New Orleans.
EMILE C. FREELAND, (1919), 931 Henry Clay Ave., New Orleans.
HORATIO L. GILBERT, (1917), 7930 Sycamore St., New Orleans.
EUGENE C. GRAVELEY, (1919), 1302 Marengo St., New Orleans.
H. M. HAYNE, (1914), 3222 Prytanla St., New Orleans.
E. M. HORNOT, (1914), 2011 Prytanla St., New Orleans.
MAURICE F. HUNT, (1919), Manager A. Marx and Sons, Machinery Department,
3629 Chestnut St., New Orleans.
S. DOUGLAS JACKSON, (1916), Sales Engineer, A. M. Lockett & Co., 521 Baronne
St., New Orleans.
JOSEPH W. JOACHIM, (1919), 636 Second St., New Orleans.
WILHELM EMIL KOCH, (1913), Civil Engineer, 2627 Coliseum St., New Orleans.

- R. B. KOHNKE, (1911), Civil Engineer for Island Refining Corporation, P. O. Box 22, Sellers, La.
- ALEX. H. McCOMISKEY, JR., (1919), 2837 Carondelet St., New Orleans.
- SHEPARD F. PERRIN, (1915), Mechanical Engineer, Doullut & Williams Shipbuilding Co., 3804 Chestnut St., New Orleans.
- ROBERT A. PIERPONT, (1915), 1036 Napoleon Ave., New Orleans.
- CLIFFORD HOEY STEM, (1914), Office Assistant Engineer City of New Orleans, 7933 Poplar St., New Orleans.
- STEPHEN A. THEARD, (1920), 43 Neron Place, New Orleans.
- ANDREW J. WILD, JR., (1918), 9 West 32d St., Savannah, Ga.
- CHARLES J. WYLER, (1919), 530 Jackson Ave., New Orleans.

NON-RESIDENT JUNIOR MEMBERS.

- GEORGE O. ALLAIN, JR., (1916), Instructor, Tulane University, 6214 St. Charles Ave., New Orleans.
- G. C. BADGER, (1913), 453 Mission St., San Francisco, Cal.
- F. R. DUVIC, (1916), Engineer, with U. S. Engineer Office, Q. & C. Bldg., New Orleans.
- JACOB F. MULLER, JR., (1912), Engineer American Cast Iron Pipe Co., Birmingham, Ala.
- HERBERT P. NATHAN, (1913), 4138 Second Ave., Los Angeles, Calif.
- CARL SCHNEIDER, (1916), Superintendent, Mechanical Plant, Bureau of Standards, Washington, D. C.
- LUCIAN J. TROXLER, JR., (1915), Radio Division, Bureau of Steam Engineering, Navy Department, 1919 Eye St., N. W., Washington, D. C.
- CHARLES SPOONER ZIMMER, (1918), Ash St., Birmingham, Ala.

STUDENT MEMBERS.

- WALTER COOKE, 1025 Alvar St., New Orleans.
- JOSEPH M. GWINN, JR., 7405 Burthe St., New Orleans.
- EUGENE C. HAWKINS, 617 Common St., New Orleans.
- JOHN A. O'BRIEN, 919 Eleonore St., New Orleans.
- FRANK A. TURNER, 1230 Park Ave., Alexandria, La.
- VENNARD WILSON, First Lieutenant, 10th U. S. Field Artillery, A. E. F.; at present on detail at Watertown Arsenal, Watertown, Mass.; Home Address, 1221 Constantinople St., New Orleans.

SUMMARY.

Honorary Member	1
Resident Members	144
Non-Resident Members	77
Associate Members	15
Junior Members	21
Non-Resident Junior Members	8
Student Members	6
Total.....	272

PAST OFFICERS.

Presidents.

Sidney F. Lewis.....	1898	J. T. Eastwood.....	1909
Thos. L. Raymond.....	1899	W. B. Gregory.....	1910
Henry J. Malochee.....	1900	J. C. Haugh.....	1911
Frank M. Kerr.....	1901	D. S. Anderson.....	1912
Alf. F. Theard.....	1902	A. M. Shaw.....	1913
Alf. Raymond.....	1903	W. H. Williams.....	1914
J. F. Coleman.....	1904	L. C. Datz.....	1915
W. B. Wright.....	1905	Samuel Young.....	1916
W. H. Hoffman.....	1906	A. T. Dusenbury.....	1917
G. W. Lawes.....	1907	John Klorer.....	1918
C. W. Wood.....	1908	Ole K. Olsen.....	1919

Vice-Presidents.

C. H. Chamberlain.....	1898-1899	John Rless.....	1909-1910
Alf. F. Theard.....	1900	A. M. Lockett.....	1911-1912
J. F. Coleman.....	1901	Wm. H. Williams.....	1913
W. B. Wright.....	1902-1903	Ole K. Olsen.....	1914
W. T. Crotts.....	1904	Samuel Young.....	1915
J. M. Ordway.....	1905	A. T. Dusenbury.....	1916
G. W. Lawes.....	1906	John Klorer.....	1917
C. W. Wood.....	1907	R. S. Manley.....	1918
J. T. Eastwood.....	1908	John Rless.....	1919

Secretary and Librarian.

J. F. Coleman.....	1898-1899	L. C. Datz.....	1910
Gervais Lombard.....	1900	L. C. Datz, Jas. M. Robert.....	1911
John F. Richardson.....	1901	James M. Robert.....	1912
G. W. Lawes.....	1902-1903-1904-1905	James M. Robert.....	1913
Marcel Garsaud.....	1906	W. T. Hogg.....	1914-1915-1916
L. C. Datz.....	1908	J. M. Robert.....	1917
L. C. Datz.....	1909	J. M. Robert.....	1918-1919

Treasurers.

Alf. F. Theard.....	1898-1899	J. M. Robert, Ole K. Olsen.....	1911
Walter H. Hoffman.....	1900-1901	Ole K. Olsen.....	1912-1913
R. E. DeBuys.....	1902	E. H. Coleman.....	1914-1915-1916
W. H. Hoffman.....	1903-1904-1905	John Klorer.....	1916
J. C. Haugh.....	1906-1907-1908	Ole K. Olsen.....	1917-1918
J. C. Haugh.....	1909-1910	Walter B. Moses.....	1919

Directors.

Thos. L. Raymond.....	1898	A. M. Lockett.....	1910
A. C. Bell.....	1898-1899	A. M. Shaw.....	1911-1912-1914
F. T. Llewellyn.....	1898	L. C. Reed.....	1910-1911-1912
Frank M. Kerr.....	1899-1900	D. S. Anderson.....	1911-1913
Alf. Raymond	1901-1902	W. B. Gregory.....	1912-1913-1914-1915-1916
Ernest D. Ivy.....	1900-1901-1902	L. C. Datz.....	1912-1913-1914-1916
T. H. Tutwiler.....	1900-1901	A. T. Dusenbury.....	1913-1914
Henry J. Malochee.....	1899	Ole K. Olsen.....	1915-1916
John M. Ordway.....	1902-1903-1904	W. H. Williams.....	1915
A. C. Duval.....	1903-1904-1905	R. S. Manley.....	1916-1917
W. McCorkindale.....	1903	Samuel Young	1917
C. W. Wood.....	1904-1905-1906	J. M. Robert.....	1917
E. L. Jahncke.....	1905-1906-1907	H. L. Hutson.....	1918
John Riess	1907-1908-1917	John Riess	1918..
W. B. Gregory.....	1909	J. S. Barelli.....	1918
Marcel Garsaud	1908-1909-1910	R. T. Burwell.....	1919
J. W. Armstrong.....	1909-1910		

DECEASED.

CHARLES H. DICKINSON, C. M., December 13, 1898.
 EDGAR L. LAMBERT, R. M., March, 1901.
 H. BOLIVAR THOMPSON, C. M., July 10, 1901.
 THOS. L. RAYMOND, C. M., November 15, 1901.
 GEO. A. LEDERLE, R. M., March 27, 1905.
 JOHN T. NORTON, R. M., July, 1905.
 FRANCIS V. PELLERIN, R. M., March 31, 1908.
 JUDGE JOHN CLEGG, Assoc. M., October 5, 1908.
 JOHN MORSE ORDWAY, Hon. M., July 4, 1909.
 HENRY B. RICHARDSON, C. M., August 22, 1909.
 CHARLES W. WOOD, R. M., April 3, 1911.
 BENJAMIN MORGAN HARROD, C. M., September 7, 1912.
 JOHN D. WHITE, N. R. M.
 JAMES C. HAUGH, R. M., July 6, 1913.
 J. C. HENRY, N. R. M., December, 1914.
 REINNIER SWART, N. R. M., August, 1917.
 FOSTER OLROYD, R. M., October, 1917.
 C. W. BOCAGE, N. R. M., August, 1918.
 A. A. DIETTEL, N. R. M., August 6, 1918.
 ROBERT W. NOITE, R. M., October 9, 1918.
 DAVID W. WEIDMAN, Jr. M., October 18, 1918.
 C. H. GILLEAN, N. R. M., November 9, 1918.
 W. J. HARDEE, C. M., November 17, 1918.
 GAIL H. BROWNE, N. R. M., December 7, 1918.
 A. HAROLD DELBERT, Jr. M., January 6, 1919.
 HENRY L. HUTSON, R. M., January 10, 1919.
 C. T. RAYNER, JR., R. M., January 20, 1919.
 CHARLES O. BABIN, R. M., February 13, 1919.
 E. B. MCKINNEY, R. M., March 30, 1919.
 ALFRED RAYMOND, R. M., January 13, 1920.

MINUTES OF MEETING AND BUSINESS OF THE SOCIETY.

Regular Meeting of the Board of Directors, December 8, 1919.

The meeting was called to order with Mr. Olsen in the chair, and the following present: Messrs. Moses, Riess, Klorer, Williamson, Robert.

A communication from Captain Louis Fortier was read and he was ordered placed on the roll as non-resident member, dues to commence January 1. The status of Mr. J. F. Coleman was changed from non-resident to resident member, to be effective from January 1, 1920.

The applications of Messrs. John McInerney, Frank L. Roe, Jr., Stephen A. Theard, were ordered to the ballot, subject to the approval of the Membership Committee.

The following applications approved by the Membership Committee were ordered to the ballot:

Resident Members—Orlando P. Adams, Ben H. Bell, Olivier A. Billion, Lester H. Rayner, George Arthur Seaver, David W. Stewart, Roger B. Stevens.

Transfer from Junior to Resident Member—Alvin M. Fromherz.

Associate Member—Walter F. Jahneke.

The report of the Secretary was read and approved and bills ordered paid.

There being no further business, the meeting adjourned.

JAMES M. ROBERT, Secretary.

Regular Meeting of the Society, December 8, 1919.

The regular meeting of the Society, December 8, 1919, was called to order with President Olsen in the chair and 49 members and guests present. The minutes of the previous meeting were read and approved.

Upon motion, duly seconded, it was decided to hold a smoker following the Annual Meeting of the Society, Saturday, January 10, 1920. Upon motion, duly seconded, the nominations for officers for the ensuing year were left until after the discussion.

The technical exercises of the evening were then held and Mr. Allen Washburn delivered a most interesting paper entitled "An Open Mouth for the Mississippi River." There was a great deal of discussion following the reading of this paper, which was most interesting and instructive.

The nominations for officers were then held for the ensuing year, with balloting as per the following table:

President—John Riess, 24; John Klorer, 1; J. S. Barelli, 1; J. F. Coleman, 1; Blank, 1. Total—28.

Vice President—

First Ballot—J. S. Barelli, 2; W. H. Williams, 3; R. S. Manley, 8; M. Kokosky, 1; J. Klorer, 3; L. Alexander, 2; F. P. Hamilton, 2; B. S. Nelson, 2; J. M. Robert, 3; O. K. Olsen, 1; D. S. Anderson, 1. Total—28.

Second Ballot—J. S. Barelli, 2; W. H. Williams, 2; R. S. Manley, 21; H. Kokosky, 0; J. Klorer, 0; L. Alexander, 0; F. P. Hamilton, 0; B. S. Nelson, 1; J. M. Robert, 2; O. K. Olsen, 0; D. S. Anderson, 0. Total—28.

Secretary—James M. Robert, 28.

Treasurer—J. F. Coleman, 1; W. B. Moses, 20; E. H. Coleman, 3; O. K. Olsen, 1; A. M. Scott, 2; B. S. Nelson, 1. Total—28.

Director—

First Ballot—J. S. Barelli, 6; O. K. Olsen, 2; J. Klorer, 2; J. F. Coleman, 6; A. M. Shaw, 4; Hortenstein, 2; B. S. Nelson, 3; D. S. Anderson, 5; Blank, 1. Total—31.

Second Ballot—J. S. Barelli, 9; J. F. Coleman, 9; A. M. Shaw, 5; B. S. Nelson, 1; D. S. Anderson, 4. Total—28.

Third Ballot—J. S. Barelli, 16; J. F. Coleman, 5; A. M. Shaw, 7; D. S. Anderson, 3. Total—31.

According to the above balloting, the following officers were nominated for the ensuing year: President, John Riess; Vice-President, R. S. Manley; Secretary, James M. Robert; Treasurer, Walter B. Moses; Director to serve three years, J. S. Barelli. The other two members of the Board of Direction held over in the order of their retirement are—C. S. Williamson, Jr., G. W. Lawes.

There being no further business the meeting adjourned to the usual collation.

JAMES ROBERT, Secretary.

Regular Meeting of the Board of Direction, January 30, 1920.

The meeting was called to order with Mr. Olsen in the chair and the following present: Messrs. Burwell, Williamson, Lawes, Riess, Robert.

Ballots for new members were then opened, there being 75 ballots cast, and as a result the following were elected to the respective grades of membership:

Resident Members—Orlando P. Adams, Ben H. Bell, Olivier A. Billion, Lester H. Rayner, G. Arthur Seaver, Roger B. Stevens, David W. Stewart.

Transfer from Junior to Resident Member—Alvin M. Fromherz.

Non-Resident Members—Frank L. Roe, Jr., John L. White.

Associate Members—Walter F. Jahneke, John McInerney.

Junior Member—Stephen A. Theard.

An application from Mr. David B. H. Chaff, Jr., was presented to the Board, but since Mr. Chaff had been dropped from the Society previously, the Secretary was instructed to ask Mr. Chaff to apply for reinstatement.

The following applications were ordered to the ballot provided they are approved by the Membership Committee:

Student Members—Clarence L. Jones, Louis L. Wyler.

The resignation of Mr. Solomon Finkenstein was accepted, to take effect January 1, 1920.

Upon application, the status of Messrs. J. F. Coleman and J. H. O'Neill was changed from non-resident to resident membership. Mr. J. P. Kemper was reinstated to membership.

The Annual Reports of the Secretary and Treasurer were read and approved.

There being no further business the meeting adjourned.

JAMES M. ROBERT, Secretary.

The Annual Meeting of the Society, January 10, 1920.

The Annual Meeting of the Society was called to order with President Olsen in the chair, and 51 members and guests present. The minutes of the previous meeting were read and approved. The annual report of the Secretary, the report of the Treasurer, also of the Library Committee were read, received and filed.

Ballots for officers for the ensuing year were then opened. There were 83 ballots cast and as a result the following were elected for the year 1920:

President—John Riess.

Vice-President—R. S. Manley.

Secretary—James M. Robert.

Treasurer—Walter B. Moses.

Director for Three Years—J. S. Barelli.

The new President having been escorted to the chair by the retiring president, he promptly adjourned the meeting to Francois Restaurant, where the Annual Smoker was held:

JAMES M. ROBERT, Secretary.

ANNUAL REPORT OF THE SECRETARY.

Year 1919.

January 10, 1920.

To the Board of Direction, Louisiana Engineering Society:

Gentlemen: As Secretary of the Society, I beg leave to submit the following report for the year 1919:

During the year the Board of Direction held ten regular and two special meetings with an average attendance of six. The Society held ten regular meetings with an average attendance of 42; maximum 72, minimum 22. Two special meetings of the Society were held with an average attendance of 26.

The membership record for the year is as follows:

GRADE.	On Roll Jan., 1919	Elected	Reinstated	Transferred To	Transferred From	Dropped	Resigned	Died	On Roll Jan. 1, 1920
Honorary	1	0	0	0	0	0	0	0	1
Resident	124	22	3	9	3	7	0	3	145
Non-Resident	71	7	0	4	3	2	0	0	77
Associate	12	4	0	0	0	1	0	0	15
Junior	17	4	1	3	3	0	1	0	21
Non-Resident Junior	9	0	0	0	1	0	0	0	8
Student	11	0	1	0	6	0	0	0	6
	245	37	5	16	16	10	1	3	273

It is with regret that we report the deaths of Messrs. Charles O. Babin, E. B. McKinney and C. T. Rayner, Resident Members of the Society.

Submitted separately is the Treasurer's Report, which shows a balance January 1, 1920, of \$1213.79. Add to this amount checks received since January 1st, 1920, \$499.05, and not yet transferred to the Treasurer, and the total is \$1712.84. Take from this amount \$243.21, outstanding bills, and cash on hand is \$1469.63.

Dues amounting to \$285.50 were remitted for members in active military service.

Our investment account stands as follows: Hibernia Bank & Trust Co., Metropolitan Bank, New Orleans National Bank and Interstate Bank & Trust Co., \$250.00 each; Liberty Bonds, \$500.00; New Orleans Building Louisiana State Fair, \$100.00; total, \$1600.00.

Attached are statements showing the financial condition of the Society.

The following technical exercises were held:

February 10, 1919—Major A. M. Shaw gave a most interesting discourse on "The Construction Division of the Army."

March 10, 1919—Discussion by Mr. L. C. Datz of Mr. W. T. Hogg's paper on "The New Orleans Railway System."

April 14, 1919—"Pumping Machinery Used by the American Army in France," by Major W. B. Gregory.

May 12, 1919—Professor John S. Kendall gave a most interesting talk on "The History of Jackson Square."

June 9, 1919—"Refuse Disposal," by Mr. T. S. Willis, City Engineer.

September 8, 1919—"Organization of the Oil and Lubricating Branch of the Air Service," by Mr. W. M. Davis.

October 13, 1919—"Dredging Inner Harbor Navigation Canal for the Port of New Orleans," by Mr. Walter J. White.

November 10, 1919—"The Relation of Wood Preservation to Engineering," by Mr. Henry M. Rollins.

December 8, 1919—"An Open Mouth for the Mississippi River," by Mr. Allen E. Washburn.

Your Secretary desires to thank you for your kind co-operation during the year. It has been an honor and a privilege to serve you. I thank you.

Respectfully submitted,

JAMES M. ROBERT, Secretary.

FINANCIAL CONDITION OF THE SOCIETY, JANUARY 1, 1920.

Assets:

Cash on hand.....	\$1,213.79
Membership accounts receivable.....	699.00
Advertisers accounts receivable.....	488.80
Investments	1,600.00

Total assets	\$4,001.59
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Liabilities:

Library Fund	\$ 872.58
Proceedings Reserve Fund.....	1,855.07
1920 Dues	6.50
1917 Dues credited to 1920 dues.....	28.00

(On account of Military Service)

Accounts payable	243.21
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Total liabilities	3,005.36
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Balance in General Fund.....	\$ 996.23
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General Reserve Fund.

Balance from 1914.....	\$ 165.00
Balance from 1915.....	189.75
Balance from 1916.....	377.45
Balance from 1917.....	299.49
Balance from 1918.....	27.47
	\$1,059.16
Deficit for 1919.....	62.93
	\$ 996.23

Proceedings Reserve Fund.

Balance from 1915.....	\$ 112.20
Balance from 1916.....	546.13
Balance from 1917.....	568.14
Balance from 1918.....	587.52
Balance from 1919.....	41.08
	\$1,855.07

Proceedings Fund—Results for Year 1919.**Revenues:**

Advertisements	\$1,326.38
Subscriptions, Membership	503.00
Proceedings Sales	10.05

Total Revenues	\$1,839.43
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Expenses:

Salary of Editor.....	\$ 300.00
Salary of Secretary.....	60.00
Stenographer	52.50
Printing and Mailing.....	1,312.10
Miscellaneous Expense	73.75

Total Expense	1,798.35
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		\$ 41.08
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General Fund—Results for Year 1919.

Revenues:

Membership Dues	\$2,244.25
Smoker	157.50
Supper Dance	239.75
Outing	96.00
Entrance Fees	373.00
Total Revenues	\$3,110.50

Expenses:

Subscription to Proceedings.....	503.00
Appropriation to Library.....	480.00
Dues Remitted for Military Service.....	285.50
Delegate's Expenses	104.72
Misrellaneous Expenses	280.55
Serretary's Salary	300.00
Printing and Postage	328.13
Refreshments	118.70
Supper Dance	337.50
Outing Expenses	248.93
Smoker Expense	178.85
Exchange	7.55
Total Expense	\$3,173.43
Deficit	\$62.93

Annual Statement of Library Fund, January 1, 1920.**Revenues:**

January 1, 1919, balance.....	\$1,079.01
Revenue from General Fund.....	480.00
Fine	.30

Total Revenues	\$1,559.31
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Expenditures:

Jan. 9, Electrical World	\$ 3.00
Jan. 9, Concrete	1.13
Jan. 9, American Society for Testing Materials....	7.20
Jan. 9, S. D. Siler	11.50
Jan. 9, McGraw-Hill Book Co.	13.05
Jan. 9, Koskosky & Co.	.41
Jan. 9, Engineering and Contracting	3.00
Jan. 9, Electric Journal	2.50
Jan. 9, Miss Carrie Freret	10.00
Feb. 22, Library Bureau	5.05
Feb. 22, Electric Railway Journal	3.00
Feb. 22, Miss Freret	10.00
Mch. 7, Engineering Publishing Co.	2.00
Mch. 7, Railway Age	5.00
Mch. 7, Miss Freret	10.00
April 17, Tulane University Press	9.35
April 17, Southern Law Book Co.....	3.00
April 17, L. M. Wilson.....	.65
April 17, John Wiley & Sons.....	26.50
April 17, D. Van Nostrand Co.....	29.70
April 17, Railroad Commission of Wisconsin.....	.25
April 17, D. Appleton & Co.	7.06
April 17, H. W. Wilson Co.	1.80
April 17, Library Bureau	3.60
April 17, Miss Freret	10.00
May 13, S. D. Siler.....	18.27
May 13, Eugene Dietzgen Co.	48.23
May 13, McGraw-Hill Book Co.	10.50
May 13, American Society Mechanical Engineers..	.40
May 13, Trautwine Co.	6.30
May 13, Miss Freret	10.00
June 12, Library Bureau	21.00
June 12, McGraw-Hill Book Co.....	55.35
June 12, John Wiley & Sons.....	71.13
June 12, American Society for Testing Materials..	8.80
June 12, Eugene Dietzgen Co.	3.09
June 12, Miss Freret	10.00
Aug. 26, Miss Freret	20.00

Aug. 26, Eugene Dietzgen	2.40
Aug. 26, John Wiley & Sons.....	8.60
Aug. 26, Kokosky & Co.	35.27
Aug. 26, McGraw-Hill Publishing Co.....	41.50
Aug. 26, Library Bureau	2.48
Aug. 26, Power	4.00
Sept. 11, Professional Memoirs (1919)	3.00
Sept. 11, Moskau Cabinet Works	10.00
Sept. 11, Miss Freret	10.00
Oct. 15, McGraw-Hill Book Co.	2.25
Oct. 15, American Society for Testing Materials....	.80
Oct. 15, Kokosky & Co.	6.51
Oct. 15, Miss Freret	10.00
Nov. 14, John Wiley & Sons.....	2.56
Nov. 14, McGraw-Hill Book Co.	39.15
Nov. 14, Miss Freret	10.00
Dec. 12, International Magazine Co.	1.10
Dec. 12, Engineering and Contracting.....	3.00
Dec. 12, Concrete	2.18
Dec. 12, Railway Maintenance Engineer	2.00
Dec. 12, Professional Memoirs (1920).....	4.50
Dec. 12, Miss Freret	10.00
Dec. 12, H. W. Wilson Co.	1.61
Accounts payable	12.00
Total expenses	\$686.73
Balance on hand.....	\$872.58

Cash Account.**Receipts:**

1919 Dues	\$1,579.20
1918 Balances	370.00
1920 Dues	6.50
Entrance Fees	384.00
Members reinstated	46.75
Exchange	.30
Smoker	160.50
Supper Dance	156.60
Outing	78.00
Fine	.30
Advertisers in Proceedings.....	1,250.86
Proceedings Sales	10.05
Total Receipts	\$4,043.06
Deduct Exchange charges	7.85
Net Receipts	4,035.21
Add 1918 Balance	1,613.78
	\$5,648.99

Expenditures:

Total warrants this year.....	\$4,435.20
Balance January 1, 1920.....	\$1,213.79
Bills on Hand	243.21
	\$ 970.58
Add collections to date.....	499.05
Cash on hand January 10, 1920.....	\$1,469.63

JAMES M. ROBERT, Secretary.

ANNUAL REPORT OF THE TREASURER.

Year 1919.

New Orleans, January 9, 1920.

To the President, Louisiana Engineering Society, City:

Dear Sir: As per requirements of Article No. 4 of the Constitution, I have the honor to submit the following report covering Receipts and Disbursements for the period January 12, 1919, up to and including January 8, 1920.

Received from Secretary—	Deposited	Deposited	Exchange
	Citizens Bank.	Bank of Orleans.	
			Charged.
Feb. 12, Memo. 1 to 4.....		\$499.84	\$0.75
Mar. 19, Memo. 5 to 7.....		350.06	.55
Apr. 14, Memo. 8 to 12.....	532.91		1.25
May 12, Memo. 13 to 15.....		305.76	.25
June 30, Memo. 16 to 18.....	371.91		.70
July 31, Memo. 19 to 23.....		450.16	.60
Sept. 15, Memo. 24 to 27.....	246.01		.75
Oct. 9, Memo. 28 to 31.....		352.49	1.10
Nov. 7, Memo. 32 to 35.....	340.72		.75
Dec. 11, Memo. 36 to 39.....	367.95		.55
Dec. 30, Memo. 40 to 41.....		225.26	.60
	\$1859.50	\$2183.56	\$7.85
Total received February 12, 1919, to December 30, 1919.....			\$4,043.06
Less exchange			7.85
			\$4,035.21
Balance on hand as per Treasurer's Report January 11, 1919....			1,613.78
			\$5648.99

WALTER B. MOSES, Treasurer.

Disbursements from January 12, 1919, to January 8, 1920.

No.	Name.	Amount.
Jan. 15, 101.	Tulane University Press.....	\$ 141.85
102.	Electrical World	3.00
103.	Concrete	1.13
104.	A. S. for Testing Materials.....	7.20
105.	S. D. Siler.....	11.50
106.	McGraw-Hill Book Co.....	13.05
107.	Kokosky & Company.....	.41
108.	Engineering and Contracting.....	3.00
109.	The Electric Journal.....	2.50

	110. Mr. Uriah J. Virgin.....	10.00
	111. Metairie Ridge Nursery Co.....	10.00
	112. Mr. M. Clay Le Jeune.....	6.00
	113. Fabacher's Restaurant	8.40
	114. Miss Carrie Freret	10.00
	115. James M. Robert	34.50
Mea. 11,	116. Tulane University Press	567.10
	117. Engineering Publishing Co.	2.00
	118. Railway Age	5.00
	119. Miss Carrie Freret	10.00
	120. James M. Robert	38.00
May 14,	121. Major W. B. Gregory.....	104.72
	122. Frank M. Norman.....	1.10
	123. Fabacher's Restaurant	15.60
	124. S. D. Siler	18.27
	125. Eugene Dietzgen Co.	48.23
	126. McGraw-Hill Book Co.	10.50
	127. A. S. M. E.	.40
	128. L. Regenbogen	16.50
	129. Trautwine Company	6.30
	130. Maison Blanche	8.95
	131. Tulane University Press.....	292.15
	132. Miss Carrie Freret.....	10.00
	133. James M. Robert.....	35.50
June 10,	134. Tulane University Press.....	29.50
	135. Fabacher's Restaurant	10.40
	136. Parish Art Store	.85
	137. Mr. Wm. P. Menard.....	5.50
	138. Dr. Douglas S. Anderson.....	150.00
	139. James M. Robert.....	33.75
	140. Rowland & McRedmond.....	22.00
	141. H. B. Witherall.....	30.00
Oct. 17,	147. Citizens Bank & Trust Co.....	300.00
	148. McGraw-Hill Book Co.....	2.25
	149. American Society for Testing Materials.....	.80
	150. Kokosby & Company.....	6.51
	152. Miss Carrie Freret.....	10.00
	153. Tulane University Press.....	68.70
	154. James M. Robert.....	33.80
	155. James T. Mills	8.00
	156. James T. Mills.....	10.00
Nov. 18,	157. John Wiley & Sons.....	2.56
	158. McGraw-Hill Book Co.....	39.15
	159. Miss Carrie Freret	10.00
	160. Tulane University Press.....	144.80
	161. W. B. Gregory	2.55
	162. Fabacher's Restaurant	8.10

Annual Reports

65

	163.	Miss Edna Doll	7.50
	164.	James M. Robert	33.25
Dec. 17,	165.	Tulane University Press	24.80
	166.	Fabacher's Restaurant	21.60
	167.	M. Clay Le Jeune.....	15.00
	168.	International Magazine Co.	1.10
	169.	Engineering and Contracting.....	3.00
	170.	Concrete	2.18
	171.	Railway Maintenance Engineer	2.00
	172.	Professional Memoirs	4.50
	173.	Miss Carrie Freret	10.00
	174.	Douglas S. Anderson.....	150.00
	175.	Miss Edna Doll	15.00
	176.	James M. Robert.....	33.25
	177.	The Elliott Company.....	.83
	178.	H. W. Wilsons Co.....	1.61
Feb. 25,	201.	Walter B. Moses	134.75
	202.	R. J. Derbes, Jr.....	50.00
	203.	Palfrey-Rodd-Purcell Co.	17.25
	204.	James M. Robert.....	47.50
	205.	Miss Carrie Freret.....	10.00
	206.	Electric Railway Journal.....	3.00
	207.	Library Bureau	5.05
	208.	Herman Hustedt	7.50
	209.	Fabacher's Restaurant	8.10
	210.	Mr. N. L. Virgin.....	20.00
	211.	Tulane University Press.....	30.75
	212.	Tulane University Press	39.00
April 21,	213.	Tulane University Press	53.50
	214.	Fabacher's Restaurant	21.80
	215.	Whitney-Central National Bank	4.00
	216.	Garcia Stationery Co.	.75
	217.	Uriah J. Virgin.....	10.00
	218.	Southern Law Book Publishers.....	3.00
	219.	L. M. Wilson.....	.65
	220.	Jno. Wiley & Sons.....	26.50
	221.	D. Van Nostrand Co.....	29.70
	222.	R. R. Commission of Wisconsin.....	.25
	223.	D. Appleton Co.	7.06
	224.	H. W. Wilson Co.....	1.80
	225.	Library Bureau	3.60
	226.	Frank M. Norman.....	2.70
	227.	Miss Carrie Freret	10.00
	228.	James M. Robert.....	33.75
	229.	M. Clay Le Jeune.....	27.50
June 16,	230.	Library Bureau	21.00
	231.	McGraw Hill Book Co.....	55.35

	232. John Wiley & Sons.....	71.13
	233. A. S. for Testing Materials.....	8.80
	234. Eugene Dietzgen Co.....	3.09
	235. Miss Carrie Freret	10.00
Aug. 27,	300. Ole K. Olsen.....	317.85
	301. N. O. Building Louisiana State Fair.....	100.00
	302. Walter B. Moses.....	64.35
	303. Odenwald & Gros Co.....	166.03
	304. Schulze Stamps & Stencil Co.....	.90
	305. Fabacher's Restaurant	36.40
	306. Tulane University Press	190.24
	307. Miss Carrie Freret.....	20.00
	308. Eugene Dietzgen Co.....	2.40
	309. John Wiley & Sons.....	8.60
	310. Kokosby & Company.....	35.27
	311. McGraw-Hill Book Co.....	41.50
	312. Library Bureau	2.48
	313. Power	4.00
	314. James M. Robert.....	69.75
Sept. 15,	315. Tulane University Press.....	130.90
	316. Professional Memoirs	3.00
	317. Moskan Cabinet Works.....	10.00
	318. Miss Carrie Freret	10.00
	319. James M. Robert.....	35.00

\$4,735.20

Total receipts\$5,648.99

Total disbursements 4,435.20

\$1,213.79

Check account in Whitney Bank, Jan. 8, 1920.....\$ 412.53

Check account in Citizens Bank, Jan. 8, 1920..... 801.26

1,213.79

Deposit on 3% Certificates, Hibernia Bank.....\$ 250.00

Deposit on 3% Certificates N. O. National Bank..... 250.00

Deposit on 3% Certificates, Interstate Bank..... 250.00

Deposit on 3% Certificates, Metropolitan Bank..... 250.00

Interest accrued on these..... 45.00

One share stock, N. O. Building, La. State Fair..... 100.00

Five 4% Liberty Bonds, Citizens Bank..... 250.00

Coupons not deposited..... 14.50

Five 3½% Liberty Bonds, Whitney Bank..... 250.00

Coupons not deposited..... 21.85

\$1,681.35

Total balance\$2,985.14

Respectfully submitted,

WALTER B. MOSES, Treasurer.

REPORT OF LIBRARY COMMITTEE.

New Orleans, December 30, 1919.

Mr. Ole K. Olsen, President Louisiana Engineering Society,
New Orleans, La.

Dear Sir: The Library Committee submits this the report of the work accomplished by this committee during the year.

Number of books purchased 116, comprising 131 volumes besides a number of pamphlets. A list of the books purchased has been published from time to time.

About eight hundred cards have been made for the card catalog.

One hundred ninety-three books and a number of pamphlets have been catalogued and labeled and a list of books missing from the library is being made. This list of books covers those withdrawn without entry being made in the register.

The colored cards in the catalog which represent books in libraries in New Orleans, other than the library of this Society have been filed in a separate case.

A new bulletin board has been installed and thirty notices have been posted therein.

Twelve chairs have been re-caned and placed in good condition.

The committee appreciates the painstaking efforts put forth by the Librarian, Miss Freret, in her work in rearranging the cards and further simplifying the work of cataloguing the books and making it an easier matter to find books by additional cross-indexing. The committee realizes that considerable labor is involved in the work of the Librarian, although it is not evident on the face of it. The checking of the card catalog has been found necessary and the methods followed by the Librarian are showing results.

The committee begs to call attention to the large number of books that have been withdrawn without any record being made in the register as is shown on the accompanying list of missing books. Co-operation of the members is requested in endeavoring to have all books returned for which no record has been made in the register by the members who have withdrawn the books.

Respectfully submitted,

THE LIBRARY COMMITTEE.

F. A. MUTH, Chairman.

CHARLES KIRSCHNER,

G. W. LAWES,

WADE BARNETT.

PARTIAL LIST OF BOOKS MISSING.

- Tillson—Street pavements and paving materials, 1912.
 Pittsburg Filtration Commission. Report, 1899.
 Hayes—Public Utilities, 1913.
 Repton—Landscape Gardening, 1840.
 Rosenthal—Calculation of Transmission Lines for Distribution, 1909.
 Swain—Conservation of Water by Storage, 1915.
 Van Ornum—Regulation of Rivers, 1914.
 McBride—Handbook of Naval Architecture.
 Tomlin—American Engineers Behind the Lines in France, 1918.
 Ashburn—Elements of Military Hygiene, 1915.
 French—Steam Turbines, 1907.
 Frye—Civil Engineers' Pocket-Book, 1913.
 Greene—Wharves and Piers, 1917.
 Grieves—Military Sketching and Map Reading, 1917.
 Hiscox—Modern Steam Engineering, 1913.
 Hole—Distribution of Gas, 1912.
 Holms—Practical Shipbuilding, 1917 (two volumes).
 Hughes—Handbook of Ship Calculation, 1918.
 Hosmer—Principles and Practice of Surveying, Vol. 1, 1908.
 Hool—Concrete Engineers' Handbook, 1918.
 Jacoby—Navigation, 1918.
 Merriman—Test-book of Roofs and Bridges, 1914.
 Manly—Oxy-Acetylene Welding and Cutting, 1916.
 Parsons—Land Drainage, 1915.
 Spangler—Elements of Steam Engineering, 1914.
 Stirling—Fundamentals of Naval Service, 1917.
 Supino—Land and Marine Diesel Engines, 1918.
 Stirling—Floods of the Mississippi River, 1897.
 Spencer—Handbook of Cane Sugar Manufacture, 1906.
 Olmsted—Introduction to Astronomy, 1883.
 Miller—High Pressure Gas Main Under Mississippi River at New Orleans.
 Dickerson—Steam Engine, 1889.
 Faul—Short Treatise on Leveling by Vertical Angles, 1886.
 Daniels—Test-book of Free-Hand Lettering, 1907.
 Parsons—Landscape Gardening, 1891.
 Barton—Problems in Steam Engineering, 1884.
 Bell—Street Paving in Sydney, 1895.
 Case School of Applied Science. Program of Inauguration of President Howe, 1904.

PROCEEDINGS OF THE LOUISIANA ENGINEERING SOCIETY

VOL. VI

APRIL, 1920

No. 2

CONTENTS

EDITORIAL NOTES AND COMMENT:	PAGE
Dredging the Industrial Canal	69
The Fabricated Steel Ship	70
Changes in the Rules of the State Board of Engineering Examiners	71
Removal of the Poydras Market	75
OBITUARY	77
 PAPERS AND DISCUSSIONS:	
Dredging New Orleans Inner Harbor Navigation Canal, <i>By Walter J. White</i>	80
Fabricated Steel Ship Construction as Handled by The Doullut and Williams Shipbuilding Co., Inc. <i>By J. P. Edwin</i>	103
MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY	127

EDITORIAL NOTES AND COMMENT

Dredging the Industrial Canal. To the engineering profession of this city and community any new contributions to the literature of the important subject of Dredging are always welcome. We are, therefore, pleased at being able to present in this issue the paper, the outline of which was given by Mr. White at the joint meeting of the Louisiana Engineering Society and the Local Chapter of the A. S. M. E. Through the courtesy of the latter society we are able to print the paper as it appeared originally in their journal, and their editor has very kindly loaned us the cuts of the illustrations and diagrams which go with the article.

While we have become accustomed to calling this project "The Industrial Canal," Mr. White directs attention to the fact that for the immediate future, at least, the term "Inner Har-

bor" would be more appropriate, that feature being of much greater importance than its use as a navigation canal connecting the Mississippi River with Lake Pontchartrain. The best name, as he suggests, is "Inner Harbor Navigation Canal," as that calls attention to both the above functions.

During the construction of the canal or inner harbor it was found that the dredged material was of such unusual character that it necessitated a complete change in the construction of the dredge pumps. It is to the engineering features of this part of the problem that Mr. White desires to call special attention. The whole area to be excavated was underlaid with large cypress stumps, and over a large portion of the route there was a heavy surface growth of cypress and other timber. It soon became evident that progress would be slow and the work would be very expensive, due to stoppages and delays caused by clogging of the pumps.

The problem of designing a pump which would handle successfully the kind of material described above was turned over to Mr. A. B. Wood of the Sewerage and Water Board engineers. He designed an impeller for the 22-in. dredge *Texas*, and the very remarkable results obtained with this new pump are set forth and discussed in the paper.

The Fabricated Steel Ship. Mr. Ewin, Chief Engineer of The Doullut and Williams Shipbuilding Company, traces for us in his very interesting paper the original inception, the development and the final successful consummation of the project of the company to establish a plant and to build in New Orleans steel fabricated ocean going vessels of the first class. One of the most interesting points brought out in the paper is the method used to secure correct fitting and smooth lines in spite of errors and discrepancies which would inevitably occur in the fabrication of the various members of the structure.

To secure this result a certain number of the most difficult plates on each ship were selected and certain fabrication omitted from each one. Some of the plates were shipped in without fabrication of any kind, no holes being punched and edges being left to the same dimensions as the raw material. In other plates the rivet holes were all punched an eighth inch small to allow

for adjustment. The plates and steel work were then loosely bolted up, adjusted and no riveting was done until the vessel agreed as closely as possible with its theoretical lines. Mr. Ewin states that this plan was thoroughly justified in the smoothness of lines secured in the hulls, and in the fact that not a single plate was lost on any of the four vessels.

To secure economy and efficiency further in the fitting and installation of piping and auxiliaries it was decided to erect close to the pipe fitting and coppersmith shop a complete unit of all machinery which was to go into the boiler and engine room. This plan resulted in a very great economy of time, material and labor.

Changes in the Rules of the State Board of Engineering Examiners. At the March meeting of the Society, Col. Garsaud made a statement setting forth and explaining certain changes in the regulations concerning the licensing of engineers and the practice of civil engineering in this state, which had been suggested by the State Board of Engineering Examiners. These changes have been incorporated in the form of amendments to the original act and will be submitted to the next Legislature for enactment. The Board has requested the endorsement of this Society, and at the March meeting the changes were endorsed unanimously. They will have to be brought up again at the next meeting for final endorsement as required by the By-Laws. A copy of the Act as amended has been mailed to each member of the Louisiana Engineering Society, and it seems well to reprint it here as a part of our permanent record.

AN ACT

To amend and re-enact Act No. 200 of the General Assembly of the State of Louisiana for the year 1914, entitled "An Act to Amend and Re-enact Act No. 308 of the General Assembly of the State of Louisiana for the year 1908, entitled 'an Act to regulate the practice of Civil Engineering and Surveying; to create a State Board of Engineering Examiners, and regulate the fees and emoluments thereof; to prevent the practice of the said callings or professions by unauthorized persons; and to provide for the trial

and punishment of violators of the provisions of this Act by fine or imprisonment; and to repeal all laws or parts of laws in conflict or inconsistent with this Act.' "

Be it enacted by the General Assembly of the State of Louisiana, That Act No. 200 of 1914, entitled "An Act to amend and re-enact Act No. 308 of 1908, entitled 'an Act to regulate the practice of Civil Engineering and Surveying; to create a State Board of Engineering Examiners, and regulate the fees and emoluments thereof; to prevent the practice of the said callings or professions by unauthorized persons; and to provide for the trial and punishment of violators of the provisions of this Act by fine or imprisonment; and to repeal all laws or parts of laws in conflict or inconsistent with the Act,' " shall be, and the same is hereby amended and re-enacted so as to read as follows:

Section 1. Be it enacted, by the General Assembly of the State of Louisiana, That from and after the promulgation of this Act, no person shall practice the profession of Civil Engineering or Surveying within the State of Louisiana, unless such person shall be duly registered and licensed in accordance with the provisions of this Act.

Section 2. Be it further enacted, etc., That after the promulgation of this Act, any person, before entering upon the practice of Civil Engineering or Surveying, shall present to the Board of Engineering Examiners, as hereinafter constituted, a diploma from an engineering college or school of good standing, said standing to be determined by the Board, or satisfactory evidence that such diploma had been granted to him, and such other data regarding character and experience as the Board may require, or shall pass a satisfactory examination before the Board upon the following, to-wit: For Surveying, Plane Trigonometry, Plane Surveying, Practical Use of Instruments; for Civil Engineering—same as surveying, in addition thereto Natural Philosophy or Physics, including practical problems in design and construction.

All examinations held by the Board, and answers of applicants, shall be in writing and shall be filed and kept as records.

The person shall also satisfy the Board that he is twenty-one years of age, and of good moral character. If said diploma or examination is satisfactory to the Board, it shall register such person and issue to same

a certificate in accordance with the facts, which certificate shall be received as prima facie evidence that such person is duly registered according to law.

Section 3. Be it further enacted, etc., That the Engineering examiners shall consist of a Board of five members, three of whom shall constitute a quorum. All members shall be appointed by the Governor of the State from a list presented by the Louisiana Engineering Society, and the Governor shall have the right to remove any or all members thereof for inefficiency or neglect of duty and to fill all vacancies occurring in the Board from similar lists presented by the Louisiana Engineering Society, provided, however, that in the event that said Society fails to present such list when requested, the Governor shall select appointees at his own discretion.

The legal domicile of the Board shall be the City of New Orleans.

Section 4. Be it further enacted, etc., That the first Board of Engineering Examiners appointed under this Act, shall meet and organize within thirty days from the date of their appointment, and shall name one member to serve two years, one to serve three years, one to serve four years, one to serve five years, and one to serve six years, to be decided by lot or agreement among themselves as to their respective terms.

At the expiration of the above terms, each member shall be appointed by the Governor for a term of six years, from names recommended by the Louisiana Engineering Society.

Section 5. Be it further enacted, etc., That the members of the Board of Engineering Examiners shall receive in compensation for their duties, ten dollars per day during the session of the Board, together with their hotel bills and their traveling expenses by the most direct route to and from their respective residences, the same to be paid out of any moneys in the treasury of the Board, upon the certificate of the president and the secretary. The Board is empowered to demand a fee of one dollar for issuing a certificate, twenty-five dollars for registration by diploma, twenty-five dollars for examination, and fifteen dollars for registration under Section 15 of this Act. Said registration fees to include fee for certificate and license fee for the current year.

Section 6. Be it further enacted, etc., That the Board shall have the right to adopt by-laws, rules and regulations for conducting its affairs not inconsistent

with the provisions of this Act, and to employ such clerical force and professional assistance as may be necessary.

Section 7. Be it further enacted, etc., That to prevent delay and inconveniences, any one member of the Board may grant a temporary permit to practice after a satisfactory examination of any applicant, and shall report thereon to the next regular meeting of the Board. Said temporary permit shall not continue in force longer than until the next regular meeting, and shall in no case be granted less than six months after the applicant has been refused a permit by the Board.

Section 8. Be it further enacted, etc., That every registered Civil Engineer or Surveyor in this State who desires to continue the practice of his profession in this State, shall annually, during the time he shall continue in such practice, pay to the Board, on or before the first day of February or within thirty days after his return in case of absence from the State, a fee of three dollars for Civil Engineer and one dollar for Surveyor, and the Secretary shall thereupon issue such registered Civil Engineer or Surveyor a certificate of renewal of his license for the current year. Any registered Civil Engineer or Surveyor, who shall fail to have his license renewed, as above provided, on or before the first day of February of each year, shall have his license revoked. But the failure to renew said license in proper time shall not deprive such Civil Engineer or Surveyor of the right of renewal thereafter, but the fee to be paid to the Board upon the renewal of license after the month of January or the expiration of the thirty days following his return to the State shall be ten dollars for Civil Engineer and five dollars for Surveyor.

Section 9. Be it further enacted, etc., That the Board of Engineering Examiners shall publish annually in pamphlet form not later than April first a complete list of licensed Civil Engineers and Surveyors, with their residences, and such published list, when properly attested by the Secretary shall be received as evidence in court that persons whose names appear therein are duly registered and licensed.

Section 10. Be it further enacted, etc., That any person who shall practice or attempt to practice the profession of a Civil Engineer or Surveyor, either as an individual, employee, or as a member of a company

or corporation domiciled in or out of this State, without out having complied with the provisions of this Act, shall be fined not less than one hundred dollars, nor more than five hundred dollars, or shall be imprisoned not less than thirty nor more than ninety days, for each offense by any court of competent jurisdiction.

Section 11. Be it further enacted, etc., That the Board is authorized to adopt and use an official seal.

Section 12. Be it further enacted, etc., That the Board may revoke any permit or license it has issued, when its holder has been convicted of immoral conduct before a competent court.

Section 13. Be it further enacted, etc., That this Act shall not apply to the Engineering Departments of the United States, nor to the Civil Engineers and Surveyors of other States and Territories, when in actual and bona fide consultation with registered Civil Engineers or Surveyors of this State.

Section 14. Be it further enacted, etc., That the Board of Engineering Examiners shall make annual report to the Governor of its transactions, with such recommendations for the advancement of the service as it may think best.

Section 15. Be it further enacted, etc., That the Board is authorized to accept in lieu of its own requirements, under Section 1 of this Act, certificates of registration of similar Boards or Engineering licensing authorities of other States, having similar registration laws, whose requirements for registration and enforcement thereof are satisfactory to the Board, provided said authorities of other States likewise accept the certificates of registration issued by this Board in lieu of their own requirements for registration under this Section shall be in good standing with the authorities in their own States and shall otherwise fulfill the requirements of this Board.

Section 16. Be it further enacted, etc., That all laws or parts of laws in conflict with this Act be and the same are hereby repealed..

Removal of the Poydras Market. The Society at a recent meeting expressed its approval of a resolution introduced by Mr. W. T. Hogg, calling for the removal of the Poydras Market from its present site in the middle of Poydras street and its

reconstruction within the property lines of one or more of the neighboring squares. As it now stands the market blocks off practically that portion of the street between Baronne and South Rampart and thus helps increase the traffic congestion in that section. If the market were removed and the whole roadway paved from Baronne to South Rampart, it would result in opening up one of the very best streets in the city for heavy commercial traffic moving across town from the docks to the railways and in the reverse direction.

OBITUARY

Alfred Raymond, resident member since 1900, and Past President of the Louisiana Engineering Society, died at his home in New Orleans, January 13th, 1920.

Born in New Orleans, May 13, 1865, the son of William Clapp Raymond and Mary Ann Laidlaw, Alfred Raymond saw and was closely identified with much of the progress and development along engineering and industrial lines of the life of his native city from 1885 to the time of his death. His early education was received in Mr. Preot's preparatory school and he graduated from Tulane University in 1885 with the degree of Bachelor of Science. In 1897 he received the post-graduate degree of Mechanical Engineer from the same institution. For several years after graduation from Tulane he served as chemist for the Louisiana Sugar Refining Company and also worked in the shops of the Louisiana Electric Light Company, both located in New Orleans.

From 1889 to 1890 he was electrician in charge of the Meter Department of the Edison Electric Illuminating Company, then located on Baronne Street. In the latter part of 1890 he was promoted to the position of Superintendent of the same company, which position he held until November, 1895. Closely identified with the Edison Company in those days was a local electrical manufacturing concern, known as the Southern Electrical Company, and Mr. Raymond served as Superintendent of Construction of this company from 1893 to 1895.

During the receivership of the Louisiana Electric Light Company, he was made Superintendent of same from November, 1895, to June, 1896. This concern furnished power for the city lighting, for a number of the street railways, and to private consumers. It was the forerunner in a sense of the present New Orleans Railway and Light Company, the great modern power plant of the present company being located upon the site of the old Louisiana plant.

From 1896 to 1899, Mr. Raymond was City Electrician, during which time he prepared the specifications for the new fire alarm system, costing \$75,000.00; made investigations and re-

ports with recommendations for underground systems of distribution for the electric companies then operating in New Orleans; and in conjunction with the City Engineer he supervised the installation of the first conduit system in New Orleans. While still City Electrician he co-operated with Major B. M. Harrod, Chief Engineer of the Drainage Commission of New Orleans, in the preparation of specifications for the power plant, pumping stations and transmission line for the new system of drainage.

Since 1899 Mr. Raymond has occupied the responsible position of General Manager of the Drainage Department of the Sewerage and Water Board of New Orleans, having thus immediate charge of operation, maintenance and additions to power and pumping stations of this important branch of the service. In addition to his regular line of duties he has always found time to devote his tireless energy to the solution of other problems which are constantly arising in the administration of the practical affairs of a large city.

He co-operated in the preparation of the plans and specifications for a municipal lighting plant when that proposition was under discussion. In conjunction with Mr. Willis, City Engineer, he prepared plans for a garbage disposal system for the city. He was also one of a committee of three who drew up the preliminary plans for the organization of the Delgado Trade School. He was a prominent member of the Board of Administrators of Tulane University, serving upon a number of its most important committees, and lending his influence very strongly toward the upbuilding of the College of Technology in that institution.

Mr. Raymond was a member of the Kappa Alpha fraternity and also a member of the Tulane Chapter of the honor fraternity of Phi Beta Kappa. He was a prominent member of the Chess, Checkers and Whist Club. During the war he did most excellent and arduous service as chairman of Local Exemption Board No. 13.

Married in 1893 to Miss Jeanie Newman Balfour he is survived by his widow and two daughters.

In the death of Alfred Raymond, his wife and children have lost a loving husband and kind father, who, after the long day's work was done, turned to his home and his family as his most cherished possessions, always sure of finding there the comfort and spirit of rest which belongs to every happy home; the members of this Society and others in the engineering profession have lost one of their most prominent associates and warm personal friends; the Sewerage and Water Board has lost one of its most efficient engineers; and the City of New Orleans has lost one of its best and most useful citizens.

DREDGING NEW ORLEANS' INNER HARBOR NAVIGATION CANAL

Performance and Tests of Centrifugal Dredging Pumps

By WALTER J. WHITE.

Presented at Joint Meeting of the Louisiana Engineering Society and the
Local Chapter of the American Society of Mechanical
Engineers, October 13, 1919.

The port of New Orleans has long been denied its natural growth by restrictions imposed by the civil code of the State of Louisiana, which declares that the banks of all navigable rivers are public property and as such cannot be sold nor used for factory sites, shipyards, or other industrial enterprises. Attempts have been made to overcome this industrial handicap by proposals to build a navigable canal which would not be subject to the restrictions just enumerated. Some fifteen years ago Mr. Walter Parker proposed that such a waterway be built connecting the Mississippi River with Lake Pontchartrain, but the task was not undertaken until shortly before the war.

It is not the purpose of this paper, however, to deal with the history of this canal nor to present the many industrial advantages which its creation will bring to the port of New Orleans, but rather to present some of the outstanding engineering features incident to the completion of the work.

It may be of interest to note in passing, that in spite of the prevalent belief that the civil code has been a handicap to the general development of New Orleans, even if there were no law standing in the way, manufacturing plants located upon the Mississippi would be exposed to many dangers occasioned by the encroachment of the river. Furthermore, any manufacturing plant due to the great range of level of the river would be burdened with the cost and inconveniences of loading and unloading of water craft and such fact would serve to make impracticable the operation of the plant. It is also generally conceded by experts in shipbuilding that operations of that kind could not be maintained on the banks of the river with any hope of success. It is of course obvious that an inner-harbor navigation canal (controlled by locks) would be entirely suitable for all such purposes.

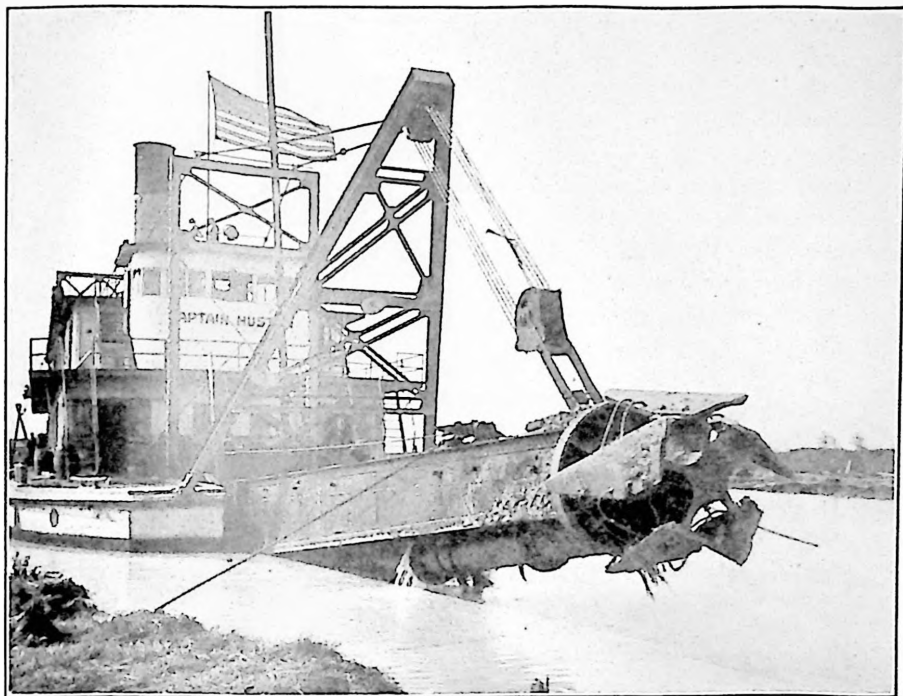


FIG. 1 THE DREDGE *Captain Huston*, USED IN THE EXCAVATION OF THE NEW ORLEANS INNER-HARBOR NAVIGATION CANAL

During the construction of the canal the very unusual character of the dredge material necessitated a complete change in the construction of the dredge pumps, and because the engineering features are particularly interesting, it is to this phase of the work that the writer wishes to direct attention; but before proceeding to examine the methods employed, a brief description of the canal itself will undoubtedly be of interest.

The surface elevation of that part of the city of New Orleans in which the canal is located is the same as mean gulf level. Occasional high tides, due to storms, occur when the water rises to an elevation of from three to five feet higher than the ground surface. It was therefore desirable that the dredge excavation be handled in such a way that the greatest benefit would be secured from the disposal of the material. This was accomplished by depositing the dredge material so as to form as nearly as

practicable a continuous fill, which thus serves as a levee along both banks of the canal and which prevents any possibility of overflow during storm tides. The dredge excavation furthermore provides high, well-drained sites for shipyards and other industries. The length of the Inner Harbor-Navigation Canal from deep water in the Mississippi River to the 14-ft. contour in Lake Pontchartrain is 31,800 ft. The completed project is to have a clear channel width of 150 ft. on the bottom with a depth of 30 ft. below low water. In the development of shipyards and other industrial sites no encroachment on the channel width will be allowed, such locations being provided with launching basins, slips, piers, etc.

While it is true that the Mississippi River and Lake Pontchartrain will be connected, it is believed that the use of the word canal is misleading and very likely to be misunderstood. It should be remembered that Lake Pontchartrain is a shallow body of water when compared with the depth of 30 ft. in the inner harbor. The present plan contemplates the construction of an inner harbor, or basin having a constant level and connected with the deep-water channel of the Mississippi River, entrance from the river channel to the inner harbor being by means of one lock. After the harbor feature has been considerably developed, it is quite probable that extensive dredging operations will be undertaken to establish a deep-water channel from the north end through Lake Pontchartrain and Mississippi Sound to the Gulf, thereby justifying, in the fullest sense, the name Inner Harbor-Navigation Canal—an *Inner Harbor* having a constant level and a *Canal* connecting deep water in the Mississippi River with deep water through Lake Pontchartrain to the Gulf.

During the construction of the canal, traffic had to be maintained over railroads, electric-car lines, and highways which crossed the line of the Inner-Harbor. This feature and the necessity of utilizing the excavated material in levees and fills along the banks, and also the requirement that all excavated material be deposited well back from the edge of the bank, prohibited the use of dipper dredges or other types of dredges which dispose of material by means of scows or by depositing along edge of cut.

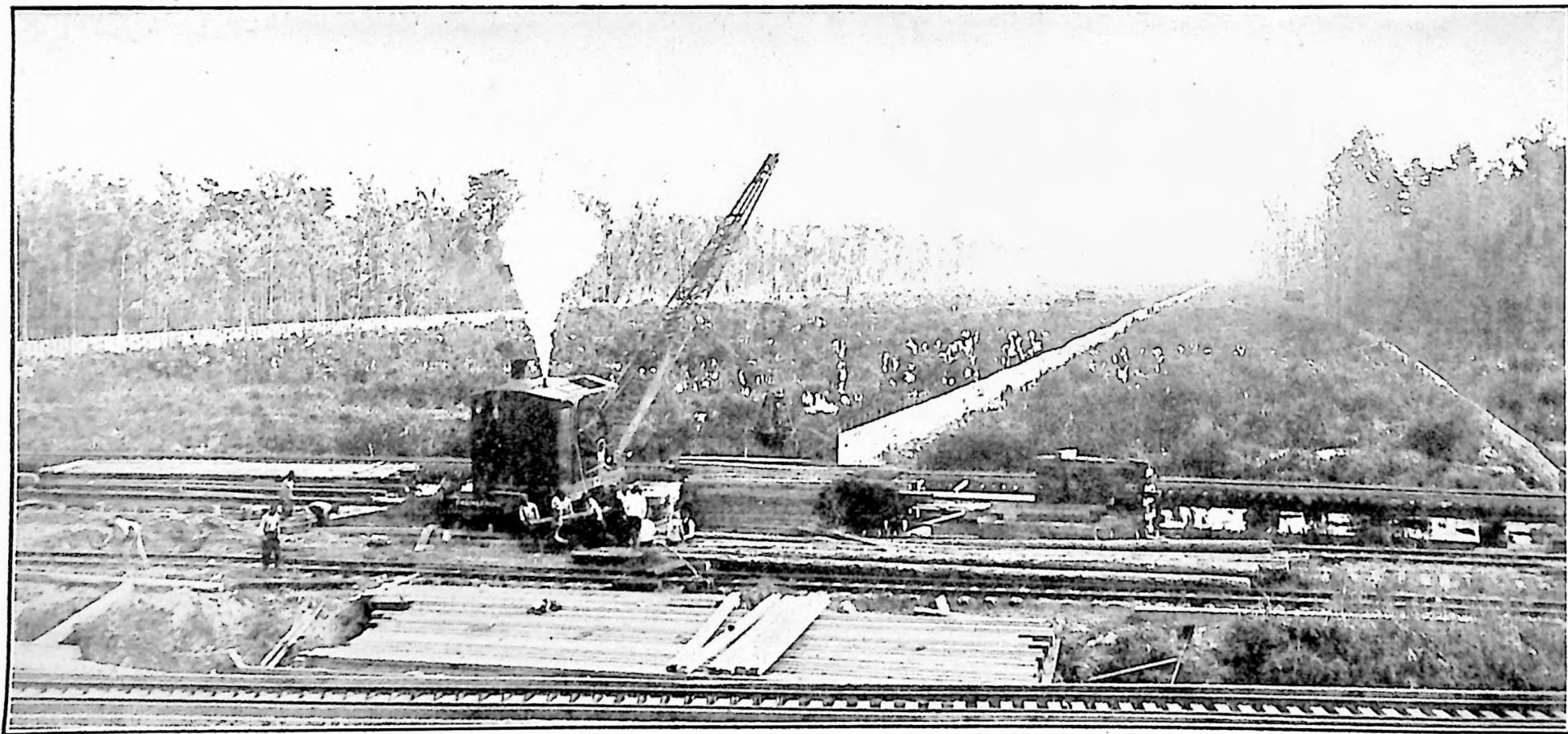


FIG. 2 VIEW OF CANAL SITE LOOKING SOUTH FROM THE RAILROAD



FIG. 3 VIEW OF CANAL AFTER EXCAVATION

While planning methods by which this dredging could be done economically, and at the same time rapidly, several test pits were excavated which confirmed the belief that about 80 per cent of the area to be excavated was underlaid with large cypress stumps which at some time in the past had either subsided or had been covered by deposit from overflow. In addition to the submerged stumps there was a heavy surface growth of cypress and other timber from Station No. 88 to Station No. 221. The topography of this country is best shown by Figs. 2 and 3. After clearing the standing timber from the area to be dredged tentative efforts were made to remove all stumps by shooting and grubbing, but it was found that this would greatly increase the cost of the work. During the progress of the work very little manual labor was expended on stumps and roots, although it was found to be advantageous to blast some of the larger surface stumps.

Notwithstanding the great number and character of stumps and roots, as evidenced by Fig 4, it was decided for the reasons mentioned that the work could best be done by hydraulic pipeline dredges of the cutter type and contractors were asked to submit bids on the work. Due to the difficulties mentioned, however, contract prices could not be secured and arrangements were therefore made to charter dredges, the Board of Port Commissioners accepting all responsibility for output. Four 20-in. dredges, and one 22-in. dredge were accordingly secured and work was commenced on May 15, 1918. Fig. 1 shows one of these dredges, the *Captain Huston*. The dredges were powerful machines of good design in all respects, but it was fully realized that much trouble was to be expected on account of stumps and roots.

By utilizing Bayou Bienvenu four of the dredges were brought in to a point on the canal near Station No. 88, where one was placed in operation headed toward Lake Pontchartrain and three were started toward the Mississippi River; one dredge was also started south from Lake Pontchartrain. On account of larger areas in suction and discharge pipes and pump, the 22-in. dredge *Texas* was placed in the most difficult section. After allowing a reasonable time for dredge and crew to become adjusted to conditions, it became evident that progress would be slow and the work would be expensive, due entirely to delays

and decreased capacity occasioned by stumps and roots clogging pump throat and suction. The soil itself was easily handled by a hydraulic dredge and the pipe-line conditions were not difficult, but the amount and character of roots encountered and later successfully handled is beyond description. Fig. 5 shows the character of the material actually pumped through the dredge *Texas*. It was thought that the solution of this difficulty would be found in a pump impeller designed with large and easy passage areas and having no projecting webs on vanes or hub. The writer learned that Mr. A. B. Wood, mechanical engineer for the Sewerage and Water Board of New Orleans, had designed and patented a centrifugal-pump impeller for handling sewage containing trash. An impeller for a 12-in. pump was inspected, and while none had heretofore been used on dredges of the cutter type it was believed that the root problem was solved and Mr. Wood was engaged to design an impeller for the 22-in. dredge *Texas*. All costs in connection with the manufacture of the impeller were to be borne by the Board of Port Commissioners regardless of whether or not it proved a success.

From the first the results obtained with the new impeller were remarkable, the increase in output being between two and three hundred per cent. The increased yardage excavated by the dredge *Texas* is shown by the following comparative statement, covering thirty days' operation immediately before and immediately after substituting Mr. Wood's impeller for the old type:

	Old Impeller	New Impeller
Excavating, hours	482.43	394.00
Clogged suction delay, hours.....	130.75	71.50
All other delay*, hours.....	106.82	254.50
Advance, feet	873	2,901
Excavated material, cubic yards.....	73,472	175,460
Average yardage per excavating hour.....	152	445

*The large number of delay hours after installation of new impeller was due to time lost cleaning boilers and raising a sunken fuel barge. For the period covered in the tabulation it will be seen that although the installation of new impeller decreased the number of excavating hours, the average advance in yardage was much greater. From observation of the dredge in operation it was seen that the ability of the impeller to pass stumps and roots insured the maintenance of a satisfactory output.

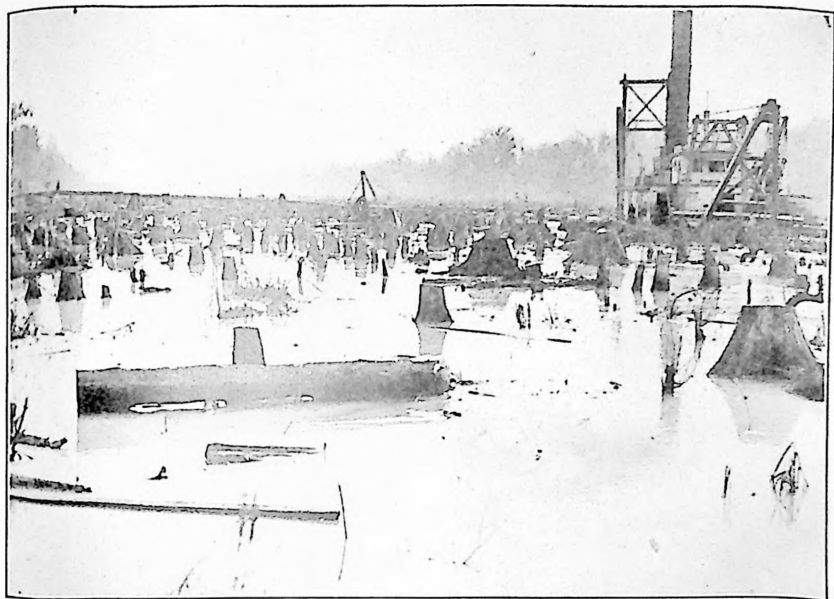


FIG. 4 CHARACTER OF EXCAVATION ENCOUNTERED

The operation and output of the 20-in. dredges *Captain Huston* and *Dirie* was very greatly facilitated and increased by certain modifications made in pump casings and impellers. Area in pump throat was increased by changing the shape of the throat ring and fitting a new piece of suction pipe. As previously mentioned, it was recognized that in order to secure maximum output in material of this character, it would be necessary to provide as large passages through pump and impeller as possible, and it was therefore determined that two-thirds of each alternate vane should be cut out of the impellers in these dredges, as shown in Fig. 6 and 7. The outer one-third of the vanes was left to preserve structural strength, but after observing the performance of the pumps it is the opinion of the writer that every alternate vane could have been entirely removed.

During the first three days that the dredge *Captain Huston* was in operation and prior to making alterations to the pump



FIG. 5 STUMPS AND ROOTS HANDLED AND ACTUALLY PUMPED BY
THE DREDGE *Texas*

the yardage output of the dredge was practically nothing. This was due to the fact that the pump-suction throat was continuously clogged with stringy roots and stumps, which it was impossible for the pump to handle. Conditions could not have been worse and it was felt that any method whereby the pump throat and impeller could be opened up would result in an increased output. It is admitted that some uneasiness was felt as to how these alterations might affect the performance of the pumps, but results have more than justified what at first seemed to be a drastic and hazardous measure. Pump and engine tests, typical curves of which are shown in Fig. 8, have shown that these alterations did not affect the capacity or efficiency of the pump, other than by greatly facilitating the passage of roots, etc., through the pump. While the writer understands that radical alterations should not be made without careful consideration, it is undoubtedly true that the performance of a dredge

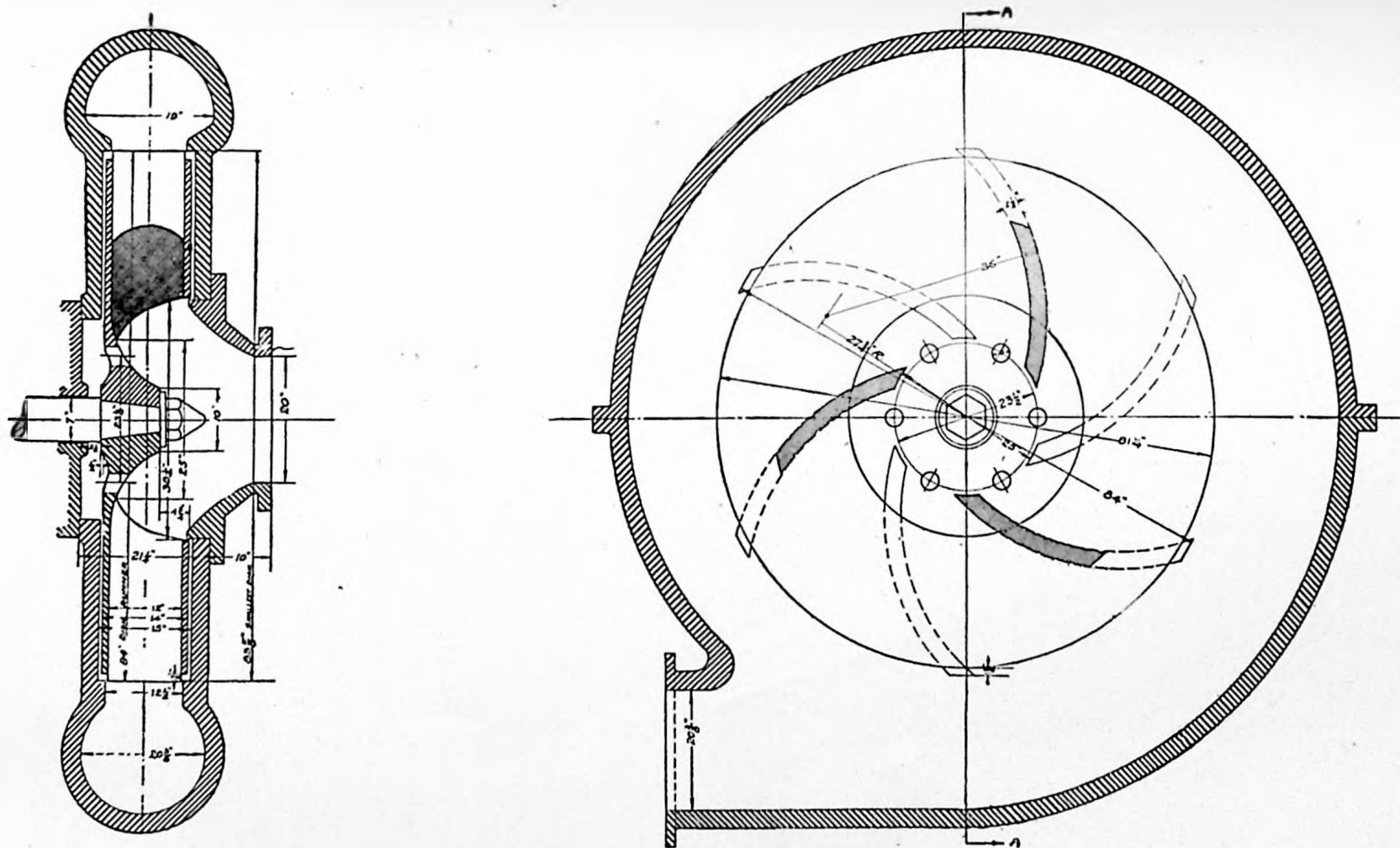


FIG. 6 DETAILS OF PUMP ON DREDGE *Dixie* SHOWING THE MODIFIED THROAT AND IMPELLER

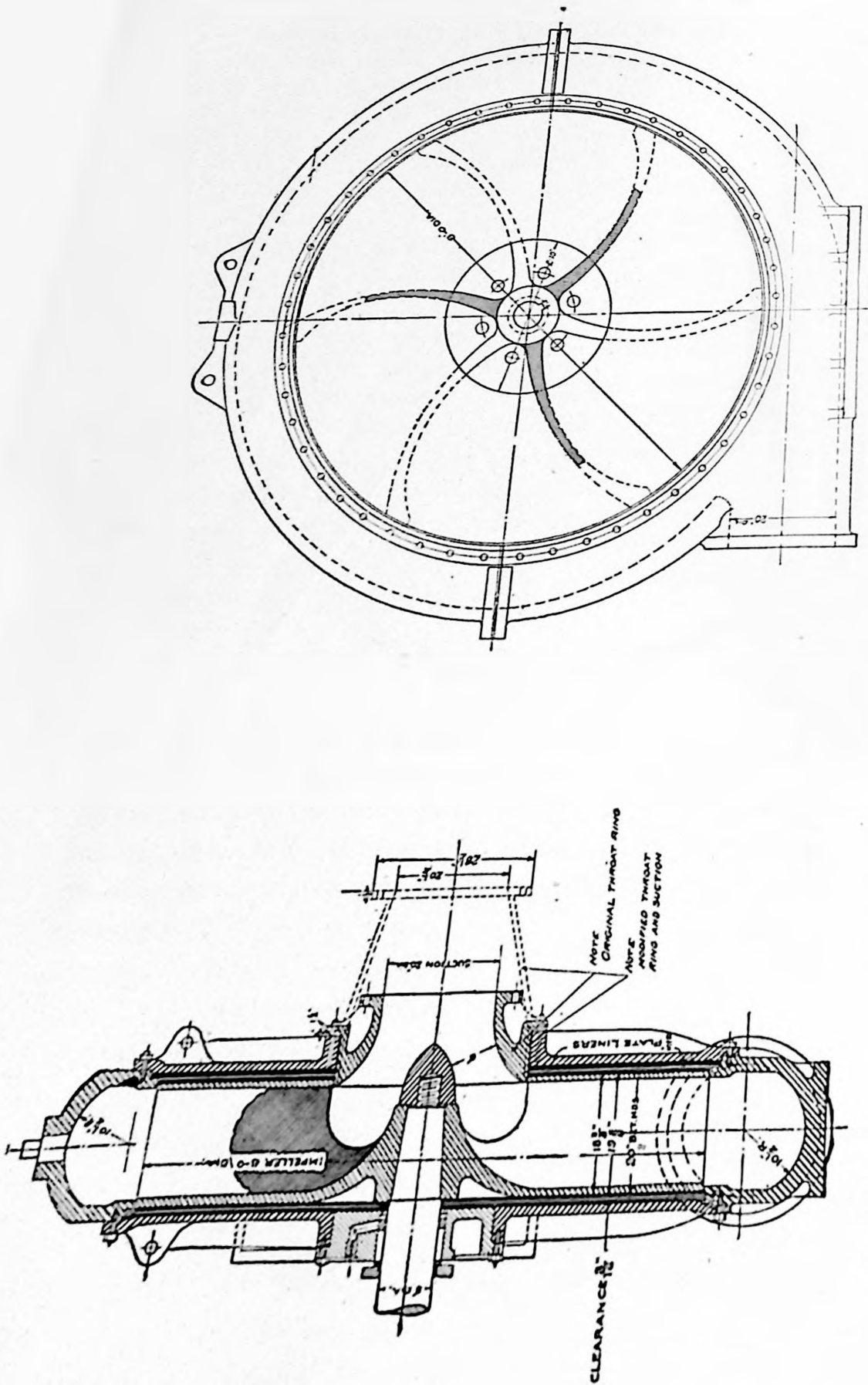


FIG. 7. DETAILS OF PUMP ON DREDGE Captain Huston SHOWING THE MODIFIED THROAT AND IMPELLER

is to be judged largely, if not solely, by the unit cost of output, and where for any reason output is not being secured any modifications of plant are justified, provided that the unit cost of output is controlled. In this particular instance there was involved the difference between failure and success. Assuming the same general character of excavation, a further modification along the lines indicated would, it is believed, result in a further increase in output.

The impeller designed for the 22-in. dredge *Texas* was of same diameter (80 in.) as that of the old impeller, but it had two instead of four vanes. An examination of Figs. 9 and 10 will show that, due to the peculiar shape of vane, the lodging or collection of roots or other material is made difficult, if not impossible, every encouragement being given by shape of vane and throat of impeller to the continuous flow of water containing irregular shape roots or other objects. The writer does not wish to convey the impression, however, that all of the large cypress stumps and roots were cut up by the cutters and handled through a 20- or 22-in. dredging pump. While suction ladders were built for heavy service and cutters were of good design and powerful, a great many of the stumps were undercut and allowed to sink to the bottom, where they were deposited below grade.

In general the operation and maintenance of the dredges followed the usual procedure for dredges of this type, and it is not believed that any novel feature other than in connection with modification of pump design can be presented. The 22-in. dredge *Texas* was equipped to use ball joints as connections between sections of pontoon pipe, and it is believed that the passage of roots was made easier than if rubber sleeves had been used.

Pump impellers having two, three, four, six, and even seven vanes and varying in diameter from 68 in. to 96 in. were used in the different dredges engaged on this work. While it is the intention to present methods and actual results secured rather than to discuss the design and performance of centrifugal pumps and impellers, it is thought that some comparative observations made of the different pumps will be interesting. Tests to determine certain centrifugal dredge-pump characteristics while pumping water were carefully made. The results of these tests

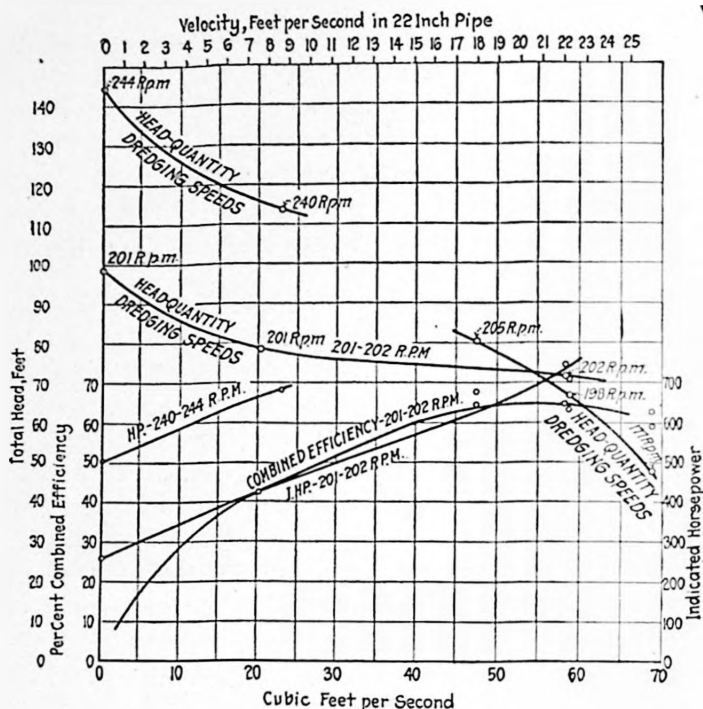


FIG. 8. CURVES OF DREDGE *Texas* EQUIPPED WITH IMPELLER DESIGNED BY A. B. WOOD

are given in Tables 1 and 2. Observers were selected and were rehearsed several times to make sure that they understood just what was required of them. All practicable precautions were taken so that accurate results would be secured. Readings were recorded as observed, the object being to eliminate any intention to interpret or analyze readings while test was in progress. A study of the readings does not reveal any wide range in any set of readings for a given condition. All the figures in Table 1 are a mean of a number of readings and the writer has confidence in the correctness of all observations and computations, and it is believed that the data presented will be of value in analyzing and studying the design and performance of centrifugal dredging pumps. At the time tests were made, the dredges were in good operating condition, but no special preparation of machinery was made. All of the pumps tested were of the single suction type and all impellers, with one exception, were

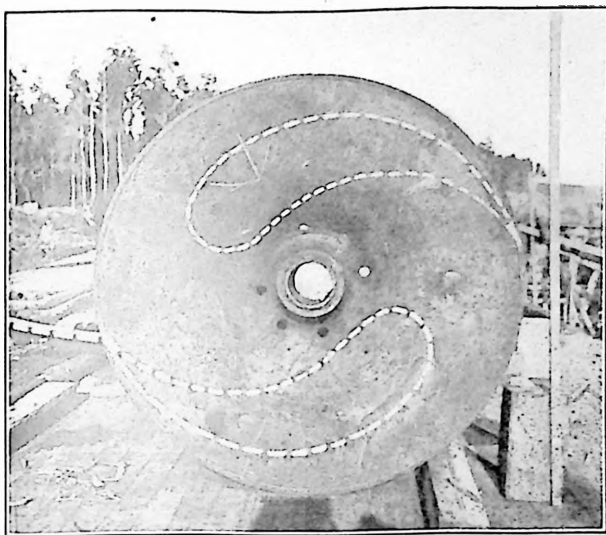


FIG. 9 REAR VIEW OF TWO-VANED IMPELLER DESIGNED BY A. B. WOOD

shrouded on both sides. The pumps were directly connected to vertical triple-expansion engines.

Upon the completion of the tests made on the dredges *Captain Huston* and *Dicie*, both of which were equipped with pumps having modified propellers, it was decided to test the pumps of the dredge *Pelican*, which was fitted with an open impeller. This pump, shown in Fig. 11, was tested with impeller in the pump in the normal manner with the vanes curved backward and also with the impeller reversed,* i. e., with the vanes curved in the direction of rotation. The results were surprising and are shown in detail in Table 1 and the curves of Figs. 12 and 13. So far as the operation of the dredge was concerned, both while pumping water and also while dredging, there was nothing to indicate to the closest observer that the pump was not assembled in the usual manner. After completion of tests it was found by comparison that there was a 10 per cent loss of efficiency due to increased consumption of power with the reversed im-

*In Trans. Am. Soc. C. E. vol. 50, page 505, Oct. 1905, Colonel C. W. Sturtevant, Mem. Am. Soc. C. E., mentions a centrifugal pump having been operated with impeller vanes curved forward instead of backward



FIG. 10 VIEW SHOWING THE LARGE PASSAGEWAYS OF THE IMPELLER
DESIGNED BY A. B. WOOD

pelled. As a matter of interest it might be stated that the dredge *Pelican* was operated from June 1 to June 14, 1919, with the reversed impeller, nothing unusual being noticed in operation and no diminution in yardage being apparent.

In the tests of dredges *Texas* and *Captain Huston* the quantity of water discharged by the pump was measured by pitot tube and venturi meter. While testing the dredge *Captain Huston* the pitot tube was bent and was not used in the tests of the other dredges. During tests the venturi meter was located just astern

of the dredge in a straight section of pipe, where it would not be influenced by elbows. Suitable arrangements were made so that the discharge pipe could be throttled, or closed off entirely, and in this way a variation in head and quantity was created. Piezometers were $\frac{1}{4}$ -in tee-handled pet cocks, which were screwed into the pipe. Indicators were not calibrated, but are believed to have been in excellent condition. Cards were taken simultaneously on the three engine cylinders. It was unfortunate that during the drop in pressure test made on dredge *Dixie* it was impossible to obtain comparable peripheral speeds due to valve of intermediate cylinder being improperly set.

From May 15, 1918, to August 1, 1919, there were employed in the construction of the Inner Harbor-Navigation Canal four 20-in. dredges and one 22-in. dredge. One of the 20-in. dredges was owned and operated by the Board of Port Commissioners, to which reference has already been made; one 20-in. dredge was chartered at a monthly rate for the bare dredge, all operating and maintenance costs being borne by the Board; and two 20-in. and one 22-in. dredges were chartered by the Board at a rate to include all operating and maintenance charges except fuel and shore pipe line, which were borne by the Board. In securing dredges for this work it was necessary too tow them to New Orleans from more or less distant points, two having been brought from Havana, Cuba, the Board assuming all towing charges and paying one-half the charter rate while dredges were in transit. A careful record of costs was kept and the total yardages by months and the total and the unit costs of the same will be found in Table 3, page 80. These costs are divided under three headings:

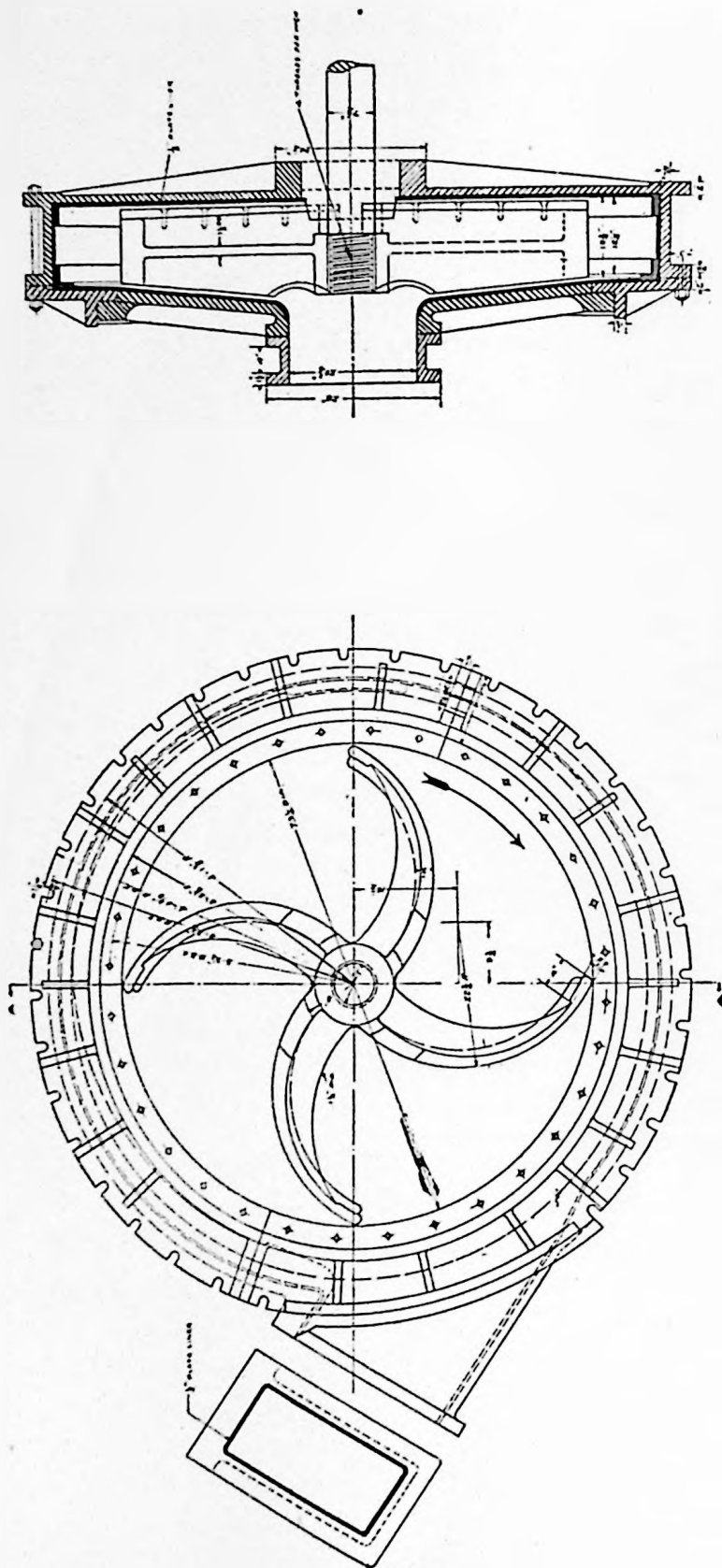
ARBITRARY

Cost of towing to and from New Orleans

One-half rental paid while in transit

Cost of 477,193 cu. yd. of preliminary and auxiliary dredging

Cost of design and manufacture of two-vane impeller for 22-in. dredge

FIG. 11 DETAILS OF THE IMPELLER OF THE DREDGE *Pelican*

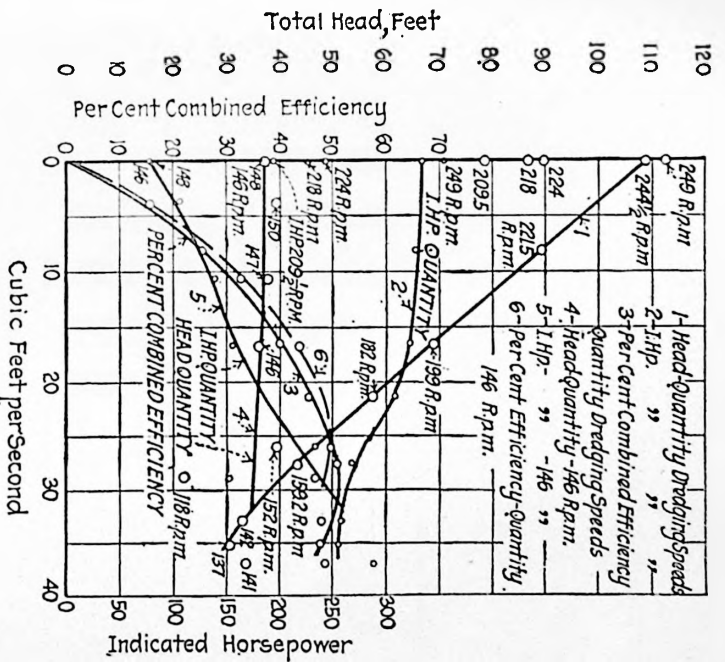


Fig. 13 TEST CURVES OF DREDGE Pelican WITH IMPELLER REVERSED

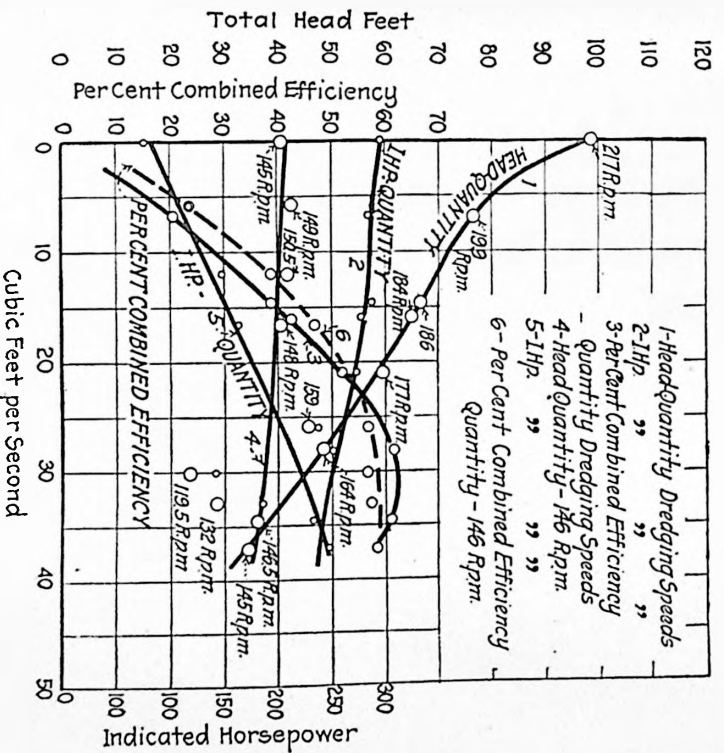


Fig. 12 TEST CURVES OF DREDGE Pelican

TABLE 1 DATA AND RESULTS OF TESTS OF CENTRIFUGAL DREDGING PUMPS

Steam Pressure, lb. sq. in. gage.	r. p. m.	Suction, ft. of water.	Discharge ft. of water.	Total, Including Difference of Velocity Heads.	Flow in ft. per sec. by venturi meter.	Indicated hp.	Water hp.	Combined Efficiency, Engine and Pump	Peripheral Speed, ft. per sec.
TEXAS									
February 14, 1919									
175	201	— .94*	76.02	77.03	20.16	423.4	175.8	41.5	70.16
175	201	+ .86*	99.34	98.48	0.0	254.45	0.0	0.0	70.16
173	202	— 12.94	57.57	71.18	58.37	742.5	471.0	63.3	70.51
170	240	— 1.34*	112.04	113.47	22.86	681.9	293.0	43.0	83.78
175	244	+ .86*	145.29	144.43	0.0	403.4	0.0	0.0	85.18
CAPTAIN HUSTON									
February 23, 1919									
200	141	— 30.20	25.82	54.26	52.38	657.9	322.1	49.0	59.06
198	161	— 15.23	85.11	99.56	35.17	706.7	397.8	56.3	67.44
200	165	— 12.74	93.65	105.69	33.05	729.5	396.0	54.1	69.12
200	166	+ .28*	99.89	99.61	0.0	292.7	0.0	0.0	69.54
191	168	— 10.06	98.96	108.49	28.87	682.8	355.8	52.1	70.38
200	174	— 10.97	104.97	115.33	30.78	742.8	403.0	54.3	72.95
200	182.5	— 6.56	123.67	129.88	23.47	756.8	346.0	45.7	76.48
200	184	— 6.40	122.22	128.27	23.47	759.6	341.7	45.0	77.00
200	221.5	+ .28*	186.94	186.66	0.0	426.0	0.0	0.0	92.78
DIXIE									
March 11, 1919									
158	158	— 25.99	28.52	54.70	49.55	559.55	307.50	55.0	57.91
155	160	— 22.98†	34.27	57.42	46.62	568.83	303.71	53.4	58.64
150	163	— 7.68	58.36	66.10	27.29	446.78	204.66	45.8	59.74
156	163.5	— 18.48†	44.22	62.85	42.0	551.42	299.56	54.3	59.92
145	166	— 8.16	60.21	68.44	27.81	471.47	215.94	45.8	60.84
152	174.75	— 9.32	66.68	76.08	30.35	545.4	261.8	48.0	64.05
155.7	175.5	— 10.74	64.71	75.54	32.33	577.42	277.25	48.0	64.32
154.5	176	— 2.68*	76.37	79.08	17.85	479.15	160.15	33.5	64.50
156	176	— .03	78.91	78.95	8.95	407.72	80.11	19.65	64.50
156	176.5	+ .92*	82.61	81.79	0.0	310.24	0.0	0.0	64.68
151	186	— 3.60	83.76	87.40	19.47	547.96	193.06	35.3	68.17
150	197	— .38*	99.46	99.85	10.21	552.39	115.39	20.95	72.20
154	219	+ .82*	127.17	126.35	0.0	578.31	0.0	0.0	80.26
PELICAN									
May 28, 1919									
174.5	119.5	+ 3.99	8.93	23.16	30.06	139.95	78.9	56.3	38.06
175	132	— 17.40	10.58	28.26	32.90	184.33	105.2	57.2	42.04
175	145	— 21.96	11.78	34.10	37.04	246.10	143.0	58.1	46.18
182.5	145	+ .88*	41.45	40.57	0.0	75.66	0.0	0.0	46.18
175	146.5	— 10.96	16.63	35.90	34.58	231.32	140.3	60.7	46.66
180	148	— 3.87*	36.38	40.32	16.61	162.82	76.0	46.6	47.14
175	149	+ .28*	42.88	42.61	5.74	117.93	27.7	23.5	47.46
180	150.5	— 1.57*	40.06	41.67	11.99	147.15	56.6	38.5	47.93
182.5	159	— 11.34	34.03	45.55	25.96	236.30	133.8	56.7	50.64
182.5	164	— 12.91	35.03	48.14	28.01	249.94	152.8	61.2	52.23
182.5	177	— 7.66	51.68	59.45	20.93	272.30	140.8	51.75	56.37
177.5	184	— 4.0	60.61	64.69	15.97	276.22	117.0	42.4	58.60
175	186	— 2.82*	63.63	66.51	14.65	286.53	110.2	38.5	59.24
175	199	+ .08*	76.78	76.71	6.79	283.2	59.0	20.75	63.38
177.5	217	+ .88*	93.41	98.53	0.0	295.22	0.0	0.0	69.11

TABLE 1—CONTINUED.

Steam Pressure, lb. sq. in. gage.	r. p. m.	Suction ft. of water.	Discharge ft. of water.	Total, Including Difference of Velocity Heads.	Flow in ft. per sec. by venturi meter.	Indicated hp.	Water hp.	Combined Efficiency, Engine and Pump	Peripheral Speed, ft. per sec.
PELICAN May 31, 1919 During this test the runner was reversed									
175	118	— 13.49	7.98	21.69	28.85	151.78	70.9	46.75	37.58
176	137	— 19.67	10.53	30.52	35.1	255.12	121.3	47.6	43.63
189	141	— 21.75	11.28	33.39	36.9	288.57	139.3	48.35	44.91
172.5	142	— 17.53	15.08	32.89	32.85	256.88	122.3	47.7	45.23
177.5	146	— 3.93*	31.88	35.88	16.65	154.56	67.70	43.8	46.50
175	146	+ .88*	37.98	37.10	0.0	75.85	0.0	0.0	46.50
175.5	147	+ 1.13*	36.68	37.84	10.60	138.93	45.5	32.7	46.82
172.5	148	+ .88*	38.18	37.30	0.0	79.48	0.0	0.0	47.14
172.5	150	+ .64*	40.08	39.44	3.76	106.66	16.78	15.73	47.78
181	152	— 10.63	28.58	39.38	25.90	233.58	115.3	49.4	48.41
181	159	— 11.84	31.18	43.22	27.54	266.79	134.7	40.55	50.64
177.5	182	— 7.14	50.18	57.44	21.38	307.91	139.0	45.2	57.97
187.5	199	— 3.88*	64.88	68.83	16.49	321.50	128.5	40.0	63.38
181	209.5	+ .88*	79.68	78.80	0.0	194.58	0.0	0.0	66.73
180	218	+ .88*	87.83	86.95	0.0	227.89	0.0	0.0	69.43
170	221.5	— .43	88.78	89.23	8.17	327.96	82.50	25.18	70.55
185	224	+ .88*	90.58	89.70	0.0	243.34	0.0	0.0	71.34
185	244.5	+ .88*	109.78	108.90	0.0	334.57	0.0	0.0	77.87
185	249	+ .88*	113.58	112.70	0.0	354.46	0.0	0.0	79.31

*Readings of suction gage incorrect because of whirl set up in pipe by pump impeller.

†Suction readings incorrect due either to pet cock being throttled down too much or getting temporarily choked up.

DISCHARGE-PIPE-LINE CONDITIONS FOR TESTS OF DREDGING PUMPS GIVEN IN TABLE 1

Texas: Tests 1 and 4, 8-in. valve on end of discharge pipe wide open. Tests 2 and 5, 8-in. valve on end of discharge pipe cut off. Test 3, pipe line 570 ft. pontoon and shore pipe.

Captain Huston: Test 1, Pipe full opening. Test 2, Iron plate bolted on discharge pipe. Tests 3, 7, and 8, 8-in. valve on end of discharge pipe wide open. Tests 4 and 9, 8-in. valve on end of discharge pipe cut off. Tests 5 and 6, Pipe line 3538 ft. pontoon and shore line.

Dixie: Test 1, Pipe full opening. Test 2, Wooden piece bolted on discharge pipe. Tests 3, 5, and 6, Pipe line 1583 ft. pontoon and shore pipe. Test 4, 2 pieces of wood bolted on end of discharge pipe. Test 7, Iron plate bolted on end of discharge pipe. Tests 8 and 11, 8-in. valve on end of discharge pipe wide open. Tests 9 and 12, 8-in. valve on end of discharge pipe partly closed. Tests 10 and 13, 8-in. valve on end of discharge pipe cut off.

Pelican: Tests 1, 2, and 3, Pipe full opening. Tests 4 and 15, 8-in. valve on end discharge pipe cut off. Tests 5 and 10, Wooden piece bolted on end of discharge pipe. Tests 6 and 11, 3 wooden pieces bolted on end of discharge pipe. Tests 7 and 14, 8-in. valve on end of discharge pipe partly closed. Tests 8, 12 and 13, 8-in. valve on end of discharge pipe wide open. Test 9, 2 wooden pieces bolted on end of discharge pipe.

Pelican: (with reversed runner): Tests 1, 2, and 3, Pipe full opening. Test 4, Wooden piece bolted on end of discharge pipe. Tests 5 and 12, 3 wooden pieces bolted on end of discharge pipe. Tests 6, 8, 14, 15, 17, 18 and 19, 8-in. valve on end of discharge pipe cut off. Tests 7 and 8, 8-in. valve on end of discharge pipe wide open. Tests 9 and 16, 8-in. valve on end of discharge pipe partly closed. Tests 10 and 11, 2 wooden pieces bolted on end of discharge pipe.

In all cases where length of discharge pipe is not given the length was less than 100 ft. from the stern of dredge. In general, it should be stated that the figures in Table 1 are a mean of a number of readings recorded during tests, which explains why the figures are worked out of two decimal places. The venturi meter had an inlet diameter of 22 $\frac{5}{16}$ in. and a throat diameter of 18 in. For readings at cut off, the elevation of water at rest in suction pipe was taken as suction head and for other readings of low quantity the suction head was taken from loss of pressure curve plotted from high quantity readings.

TABLE 2 DATA ON CENTRIFUGAL DREDGING PUMPS

	Texas	Capt. Houston	Dixie	Pelican	Pelican†
Diameter of impeller, in.....	80	96	84	73	73
Number of vanes.....	2	3*	3*	4	4
Diameter of suction pipe at suction gage, in.....	23 $\frac{3}{8}$	19 $\frac{3}{8}$	20 $\frac{1}{8}$	20 $\frac{3}{4}$	20 $\frac{3}{4}$
Diameter of discharge pipe at discharge gage, in.....	22 $\frac{1}{8}$	20 $\frac{3}{8}$	20 $\frac{1}{8}$	25 $\frac{1}{2}$ x 12 $\frac{1}{8}$	25 $\frac{1}{2}$ x 12 $\frac{1}{8}$
Triple expansion engine, in.....	14 x 21 $\frac{1}{2}$ x 35	14 $\frac{3}{8}$ x 22 $\frac{1}{2}$ x 40	14 $\frac{3}{8}$ x 22 $\frac{1}{2}$ x 36	11 $\frac{1}{8}$ x 18 x 29	11 $\frac{1}{8}$ x 18 x 29
Length of stroke in.....	18	20	18	18	18
Water at rest in canal above center-line of pump, in.....	10 $\frac{3}{8}$	3 $\frac{3}{8}$	9 $\frac{3}{8}$		
Water in river above center-line of pump, in.....				10 $\frac{1}{2}$	10 $\frac{1}{2}$
Zero of suction gage below center-line of pump, in.....	19	20	16.68	1.68	At Center line of pump
Zero of discharge gage above center-line of pump, in.....	20			7	7
Zero of discharge gage below center-line of pump, in.....		53 $\frac{1}{2}$	47.66		

*Originally 6, parts of 3 vanes removed. †This test made with impeller reversed.

CHARTER

Charter cost of four dredges.

ALL OTHER CHARGES

Fuel

Shore pipe lines

Labor, subsistence, repairs, material, insurance and supervision.

The writer was present and assisted in the very complete test of hydraulic dredges made for the Mississippi River Commission by Colonel F. B. Maltby, Mem. Am. Soc. C. E., and a careful study of the latter's paper in Vol. LIV, *Trans. Am. Soc. C. E.*, has been of material assistance in the preparation of this paper, Colonel Maltby has also very kindly offered suggestions and criticisms during the preparation of this paper.

In a hydraulic pipe-line dredge of the cutter type it is believed that all passages through pipes and pump should be designed so that clogging at any point by more or less irregularly shaped solids will be reduced to a minimum. As a result of tests and also based on observation of the dredges in operation, it is the conclusion of the writer that the modifications described did not decrease the efficiency or capacity of the main engines and pumps, but did greatly increase the output of the dredges as excavating machines.

TABLE 3 DREDGING YARDAGES AND COSTS

Year 1918-1919	Yardage Excavated	COSTS							
		Arbitrary	Unit Cost	Charter	Unit Cost	All Other Charges	Unit Cost	Total	Unit Cost
May, June and July.....	383,643			74,887.19	.196	12,143.72	.031	87,030.89	.227
August	291,256	9,524.07	.015	90,547.20	.245	11,053.66	.031	111,124.93	.294
September	578,065	18,902.72	.022	63,993.60	.183	44,602.56	.054	127,498.88	.259
October	734,056	24,003.63	.027	62,486.40	.147	53,717.97	.061	140,208.00	.235
November	427,522	13,979.97	.028	54,566.40	.143	77,431.04	.082	145,977.41	.253
December	597,488	19,534.82	.028	66,628.80	.138	61,053.99	.086	147,217.61	.252
January	498,340	15,295.72	.029	64,145.76	.136	80,726.85	.097	160,168.33	.262
February	455,159	14,883.70	.029	57,874.80	.136	45,607.02	.096	118,365.52	.261
March	222,508	7,266.01	.029	24,807.55	.133	35,857.67	.101	67,931.23	.263
April	167,481	5,476.63	.029	19,027.80	.133	22,203.91	.102	46,708.34	.264
May	94,777	3,099.20	.030	12,724.80	.133	6,028.60	.101	21,852.60	.264
June	130,386	4,263.62	.030	13,915.20	.132	8,376.64	.100	26,555.46	.262
July	141,233	4,618.32	.030	14,275.20	.131	3,528.24	.098	22,421.76	.259
Preliminary & Auxillary	477,193								
Total	5,199,107	140,848.41	.027	619,880.68	.119	462,331.87	.089	1,223,060.06	.235

All Yardages Computed from Sections Plotted from Soundings. Above Total Yardage is 70% of Estimated Yardage for Entire Project. Unit Costs Apply for Total Yardage Through Month Shown.

FABRICATED STEEL SHIP CONSTRUCTION

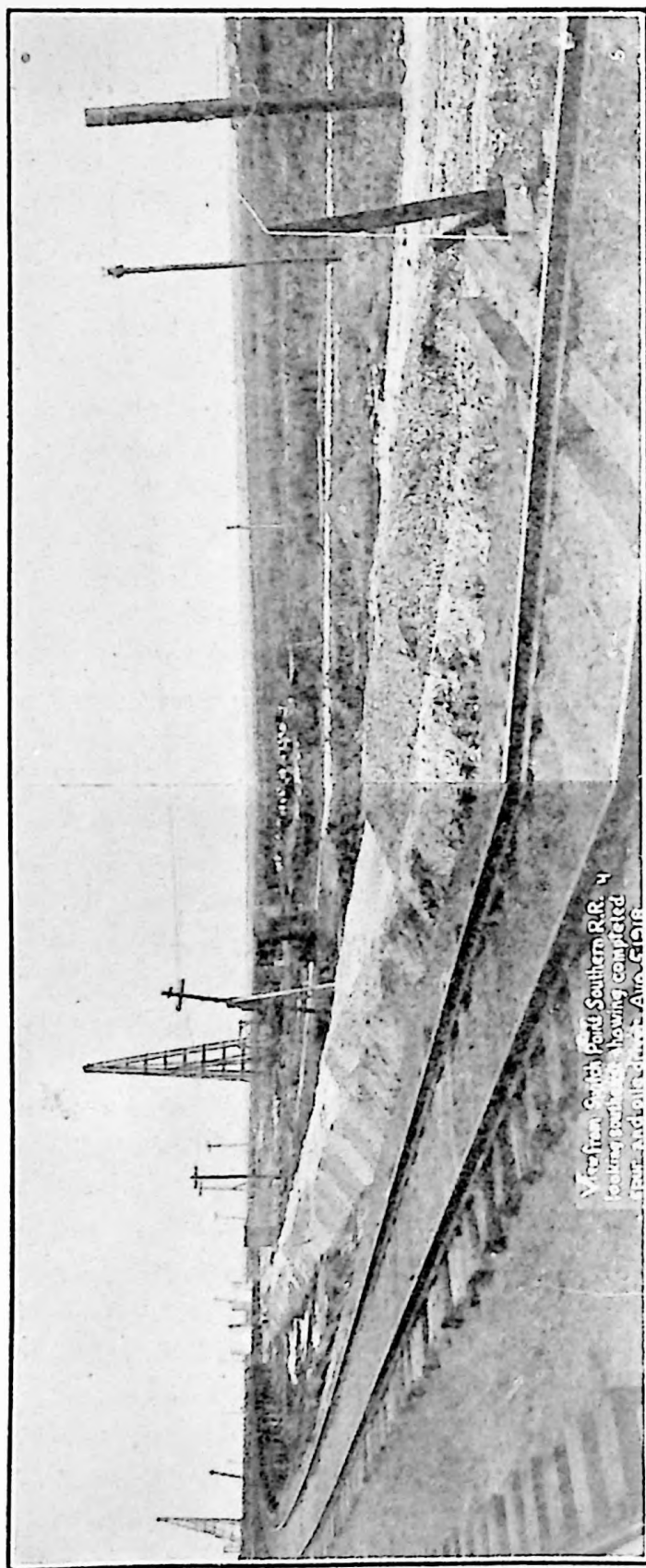
As Handled by the Doullut & Williams
Shipbuilding Co., Inc.

By J. P. EWIN, *Chief Engineer.*

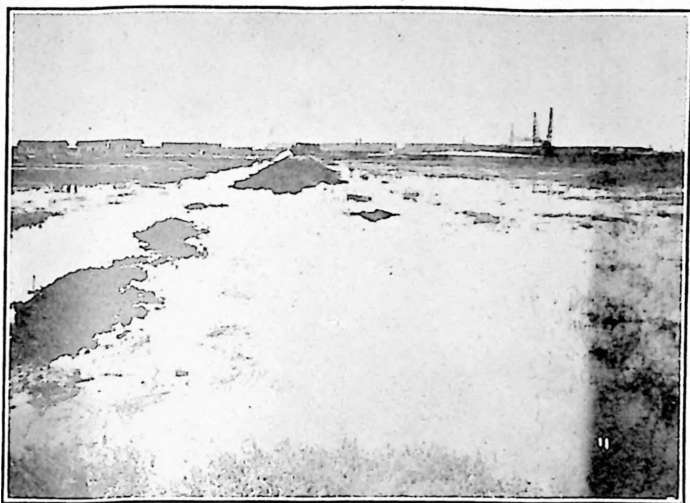
Read Before the Society, February 9, 1920.

Some of you will recall that in the early Spring of 1918, there was considerable agitation in the New Orleans daily papers concerning the lack of activity of this city in the industrial development necessary to carry the war to a successful conclusion. Ship yards were springing up in every available locality where suitable sites could be provided, and where housing facilities, transportation facilities, power and some of the many other necessary utilities could be had. Quite a number of corporations with contracts for the construction of vessels of one kind and another secured from the Emergency Fleet Corporation, and involving the expenditure of millions of dollars, made inquiries of our Association of Commerce and city officials for available sites, and investigated the possibilities of constructing ship-yards in this vicinity. New Orleans realized her need for sites on tide water with a deep channel to the Gulf, took up and discussed the feasibility of building the Industrial Canal, quickly matured her plans and began construction. I will not attempt in this paper to outline the many advantages which New Orleans held out to an industry of this kind, provided suitable sites could be found. In spite of the arguments used by Mr. Milton H. Smith, of the Louisville & Nashville Railroad, in his many pamphlets, letters, etc., which appeared in the daily press, it was apparent to every one with any intimate knowledge of the subject that New Orleans was not a suitable location for a large shipyard unless proper launching facilities and outlets to deep water could be provided. This subject was amply covered by statements which appeared at that time, a paper on the subject being presented, I believe, to the Louisiana Engineering Society.

Following promptly upon the decision of the Board of Port Commissioners to undertake the construction of our present Industrial Canal there were two firms which applied to it for



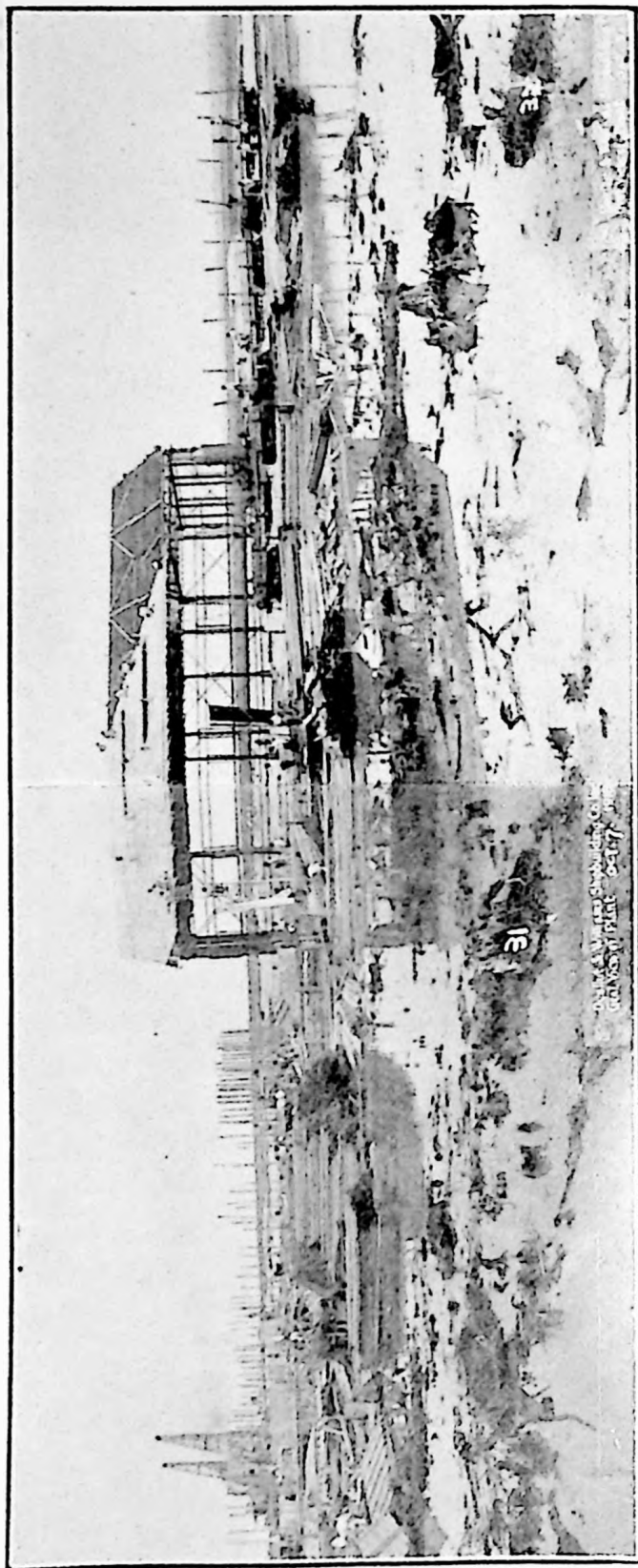
PLANT SITE AT BEGINNING OF CONSTRUCTION



ANOTHER VIEW OF PLANT SITE

sites for shipyards— The Foundation Co., of New York, and Doullut & Williams, Inc., of this city. In as much as the writer is familiar only with the work as handled by the latter firm, this paper will deal only with the ship construction at the Doullut & Williams plant.

At this time the Shipping Board had adopted the policy of letting no more contracts except to established yards, where the facilities for building vessels were in operating condition. The firm of Doullut & Williams, therefore, realized that it was an extremely difficult matter to convince the Shipping Board of their ability to do such work as was required and needed by the country, within a length of time short enough to be of service. However, having had quite a bit of experience in shipyard construction through the performance of several contracts on plants building on the Gulf Coast, and believing firmly that the fabrication of all steel entering into the construction of the hull could be undertaken, if properly handled, by long established fabricating plants, they obtained in writing, assurance from the Dock Board and the city officials, that should a contract be awarded them, they would be given the necessary site, transpor-



CONSTRUCTION WORK ON MACHINE SHOP AND POWER HOUSE

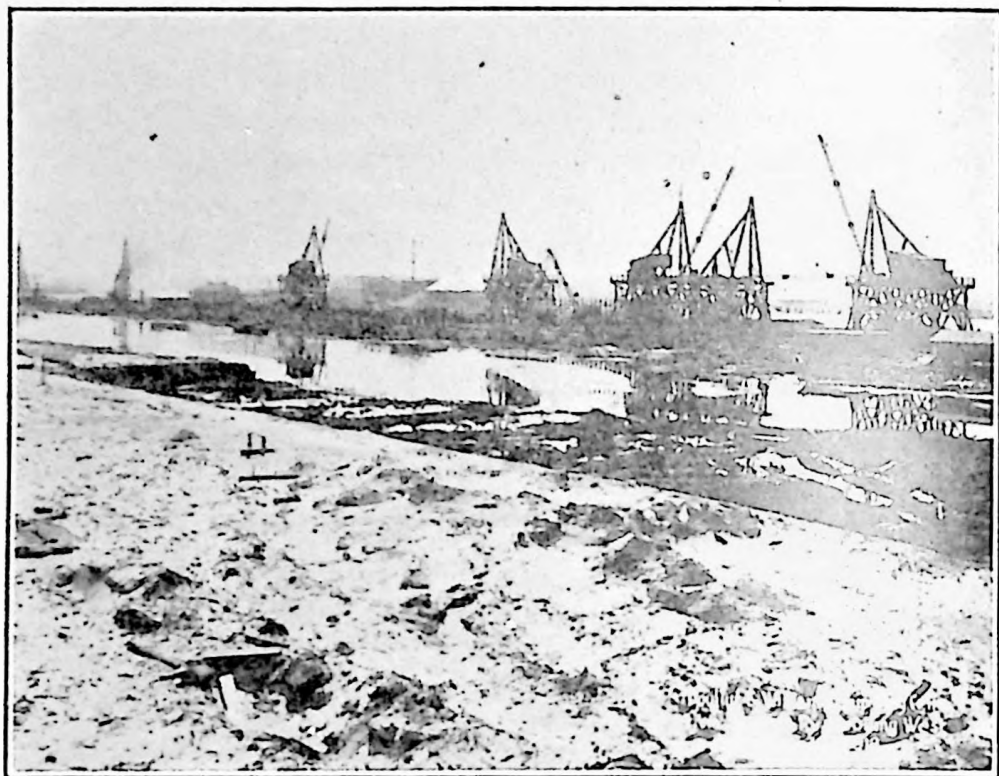
tation facilities, water supply, power, etc., which they would need in their operations. They obtained letters from various prominent men who had knowledge of their financial standing and ability to carry out their contracts, with many letters of recommendation and entered into preliminary negotiations with the Emergency Fleet Corporation for the construction of steel vessels. They also proceeded to organize a corporation, at present the Doullut & Williams Shipbuilding Co., Inc.

The bid was made by Captain M. P. Doullut, Mr. Horace Williams and Mr. L. H. Guerin, who came into the new corporation to act as Chief Engineer. After negotiations lasting some sixty days in Philadelphia and Washington, a lump sum contract was finally let for the construction of eight 9,600 ton vessels Isherwood type to be built to the highest class and special survey for ocean service under the American Bureau of Shipping. The general dimensions of these vessels are as follows:

Length between perpendiculars.....	395' 6"
Breadth moulded	55' 0"
Depth moulded to shelter deck.....	34' 11"
Height of 'tween decks at side, top of beam to top of beam	7' 11"

The vessels are single screw with straight stem and elliptical stern, shelter deck type, built on the Isherwood system of longitudinal framing. There are two complete steel decks with raised poop, bridge and forecastle; they are rigged with two steel masts and two derrick posts; have five cargo hatches and cargo handling gear, consisting of ten five ton steel booms, and one thirty ton boom. The machinery is located amidships and consists of one 2,800 S. H. P. Parsons Marine Turbine with Falk Reduction gear; three water tube boilers equipped to burn either coal or oil, built for a working pressure of 225 pounds per sq. in. with 75 degrees superheat; and the necessary auxiliary machinery consisting of main and auxiliary condensers, miscellaneous pumps, rado jets, feed water heaters, evaporators, refrigerating plants, etc.

Prior to the securing of this contract, the Company had entered into negotiations with the Virginia Bridge and Iron Company of Roanoke, Virginia, which company agreed to undertake



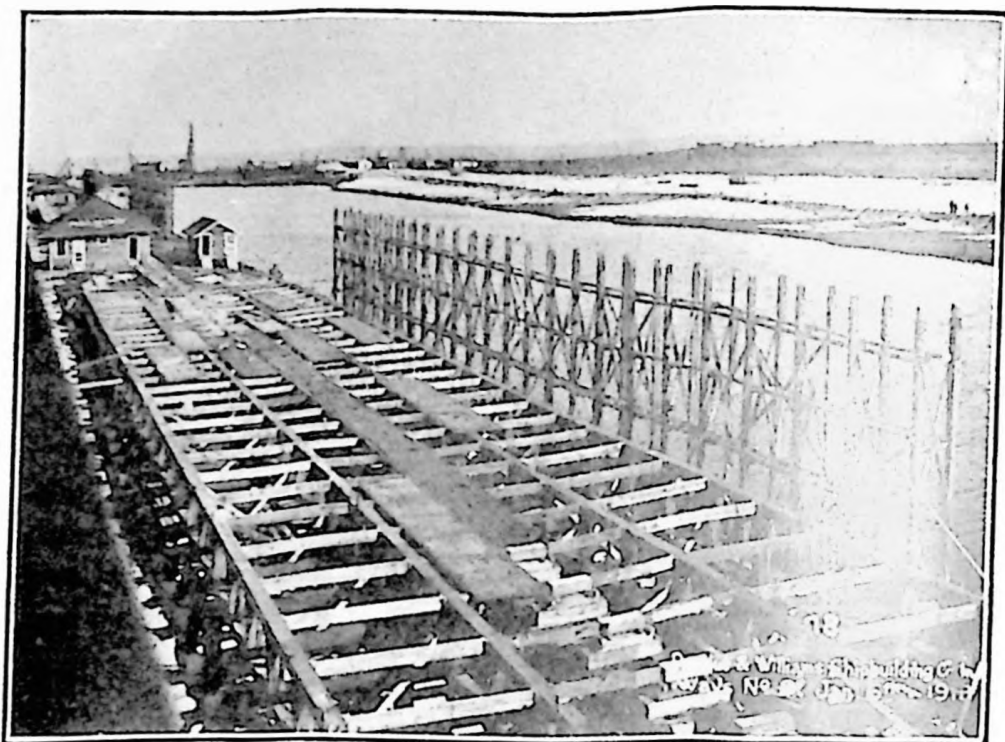
WAYS 1 AND 2 READY FOR STEEL.



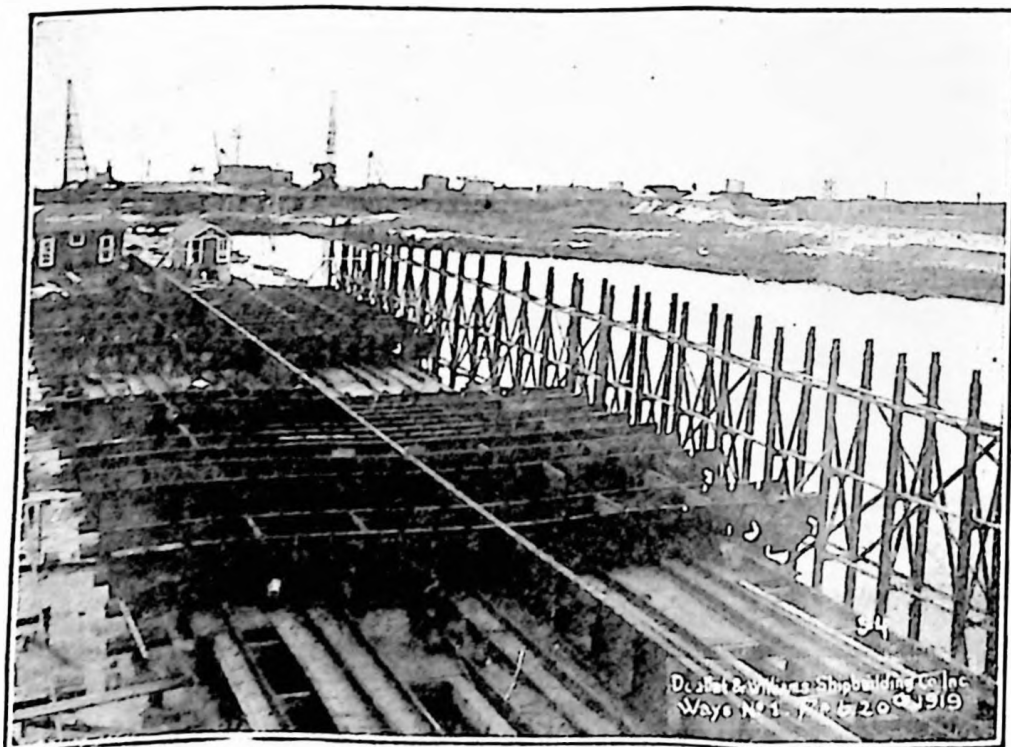
TRACK LAY-OUT AT NORTH END OF YARD

the fabrication of all hull steel entering into the construction of the vessels. Their facilities were at that time believed to be ample to meet all requirements. The officials of that company having done quite a bit of work for the Submarine Boat Corporation, of Newark, New Jersey, the Mobile Shipbuilding Company, and the Carolina Shipbuilding Company, were convinced, as were the officials of the Doullut & Williams Shipbuilding Co., Inc., that all work including the fabrication of the rolled and furnaceed plates, joggled longitudinals, and so forth, could be performed in their shop, sent to the ship and erected without undue difficulty. Working upon this basis, it was decided, in order to make required progress, to so construct the shipyard as to make it only an assembling plant. This decision was made for several reasons, chief among which were: 1. There was, as you gentlemen are aware, great delay in the delivery of all machinery at that time, and as speed was an essential element in the performance of this contract, it was imperative that the facilities of existing plants throughout the country be utilized in order to obtain quickly the various parts which enter into the construction of the vessel. 2. From a financial standpoint, it was undesirable to undertake the construction of a plant which would entail the expenditure of an unnecessarily large sum of money and which might prove a great loss to the investors should post-war conditions prove disadvantageous to the continuance of construction of vessels of the type which might be built in New Orleans upon a competitive basis.

The two questions of paramount importance which presented themselves to the corporation after the necessary funds were provided for the work, were: (A) the construction of the plant, and (B) the simultaneous development of the plans for the ships and the fabrication of the hull steel. In order to carry on these two branches of the work simultaneously, it was thought desirable that the work should be divided, Mr. Guerin going to Roanoke, Virginia, to undertake the laying out of the lines of the vessel on the mold loft floor, provided by the Virginia Bridge & Iron Company, the development of structural details, the purchase of the main machinery and the drawing of plans for the machinery and piping, outfitting, joiner work, rigging, etc.; while the plant construction was left in the hands of the local



SHORES AND SCAFFOLDING FOR BOTTOM PLATES

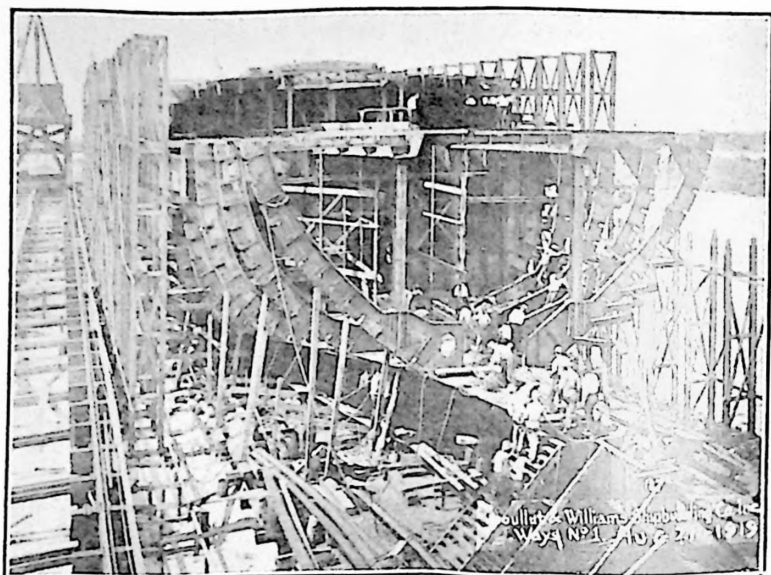


VERTICAL KEEL AND FLOOR PLATES

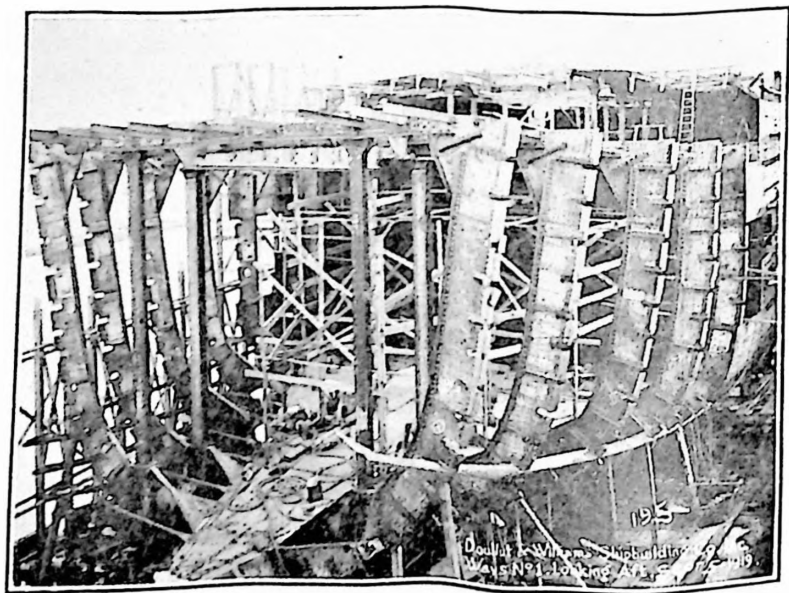
office to be carried out entirely at this point according to the rough plans submitted by him.

The work of the plant construction was promptly gotten under way, and some of the difficulties which were encountered can best be illustrated by the accompanying photographs. It was necessary, first of all, to pump approximately 600,000 cubic yards of fill upon the site. This was undertaken by the dredge which started operations at the Lake end of the Industrial Canal and which was recently described in the paper presented by Mr. White. Owing to the difficulties encountered by this dredge in its operations, it quickly became apparent that sufficient fill would not be available from this source, and the Dock Board, in order to carry out its promises, sent a larger dredge to be operated from the Lake and to assist the smaller dredge in pumping on to the site of the plant. It being imperative that the plant construction go rapidly forward, it was necessary that the construction of the various buildings be started while the dredging operations were in progress, and accordingly, practically all of the buildings on the plant were built in from 6 inches to 2 feet of water.

The general layout of the plant is as shown on the accompanying plan. The equipment of the fabricating shop is very meager, consisting of plate and angle furnaces with bending slabs, purchased and installed with the idea in view of correcting poorly formed plates, three punch and shears, two radial drills, a 600-pound steam hammer, and necessary overhead cranes. The equipment of the power house consists of three Sullivan air compressors with a capacity of 2,000 cubic feet per minute each, 75kw. generator, 1,000 H. P. water tube boilers in two batteries and one 1,000-gallon fire pump. The machine shop, though not able to handle any vast amount of work, is the best equipped unit of the plant. It contains all necessary appliances for the repair and maintenance of pneumatic tools, of which the Company has some \$60,000.00 worth, shapers, lathes, planers, drills, drill posts, milling machines, hack saws, bolt and pipe threading machines—in fact, all tools required to handle the many items necessary for the maintenance of the plant and for ship construction.



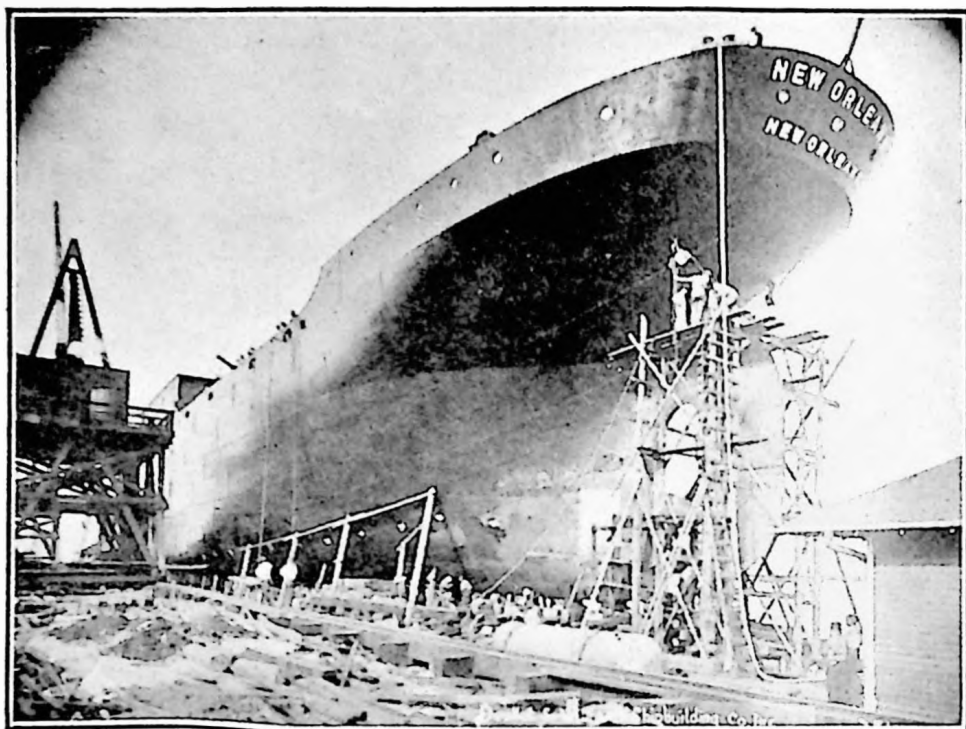
STERN VIEW, SHOWING SIDE FRAMES AND COLUMNS



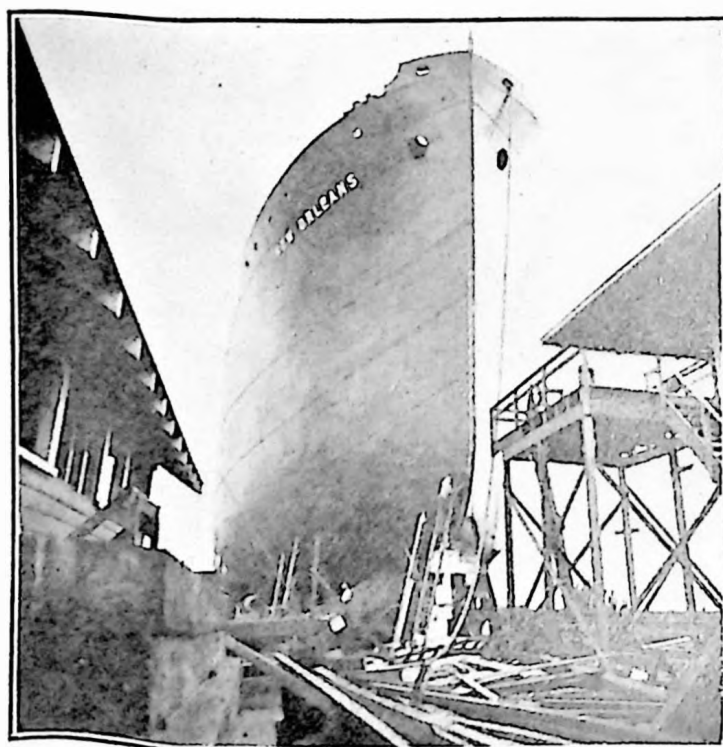
BOW VIEW

With the development of the detail plans for the hull work, it became apparent that certain plates could not be handled by the rolls which the Virginia Bridge and Iron Company had on hand, and that corporation entered into agreement with the Sun Shipbuilding Company of Chester, Pa., to roll the bilge plates for midship section for all eight vessels; with the Federal Shipbuilding Company of Kearney, New Jersey, to furnace and stamp the flat keel plates at the extreme fore and aft ends; and with the Submarine Boat Company of Newark, New Jersey, to roll and furnace some eighty-four plates at the fore and aft end of the ship. This work being performed at plants which, located at a considerable distance from Roanoke, had not access to the mold loft, it was essential that the utmost care be taken in the preparation of drawings and in furnishing the most complete information on all points, in order to insure the proper fit of the plates, when they ultimately went in place. The company was extremely fortunate in securing the services of a chief draughtsman, who attended to the details of the work with the greatest interest and care, whose accuracy and continued effort resulted in securing workmanship of the highest quality.

In November, 1918, the work at the plant of the Virginia Bridge and Iron Company, having been gotten well under way and left in competent hands, Mr. Guerin returned to New Orleans, leaving in Roanoke only the structural detailers, and established here his offices for the continuation of the development of machinery and outfitting plans. It was expected, at this time, that we would very shortly be getting steel from the fabricators in sufficient quantities to begin erection, and it was desirable that this work be started under the personal supervision of the Chief Engineer. However, in the discussion of the performance of this contract, it is pertinent to note here that it became apparent, about this time, that it would be an impossibility to obtain from the Virginia Bridge and Iron Company fabricated steel in the quantities in which we were prepared to erect it. This was due to a number of causes, some of which are entirely beyond the control of the fabricators. Heart-breaking delays had occurred one after another in the delivery of necessary plans and information from the Fleet Corporation, specifications not being delivered until some seventy-six days had elapsed after



"NEW ORLEANS", ONE DAY BEFORE LAUNCHING



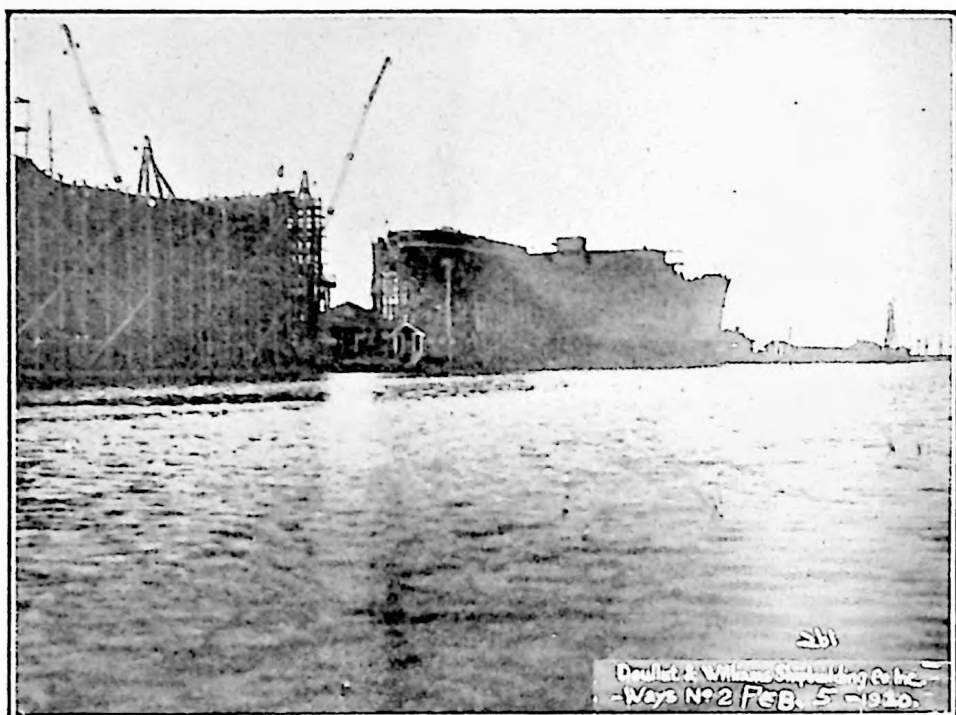
BOW OF "NEW ORLEANS"

the signing of the contract; also, raw material, which the Fleet Corporation was furnishing, and over which it had complete control, could not be obtained in anything like adequate quantities, and although we received, as early as October, 1918, a considerable tonnage, it developed, in many cases, that the fabricators could not undertake, at that time, to complete any particular piece of work, inasmuch as they would have on hand only certain parts necessary for making up a complete member. It also developed that the production of the shops, having been estimated on the basis of previous performances in straight structural work, could not come up to expectations. The fabricators had on their books, at that time, contracts with several shipyards which they had expected to finish before our plans were ready; but the other yards having met with difficulties as great, if not greater than our own, were far behind in their schedules, and as we had exceeded to a considerable extent our own expectations in the preparation of plans, the shops found themselves in quite a congested condition.

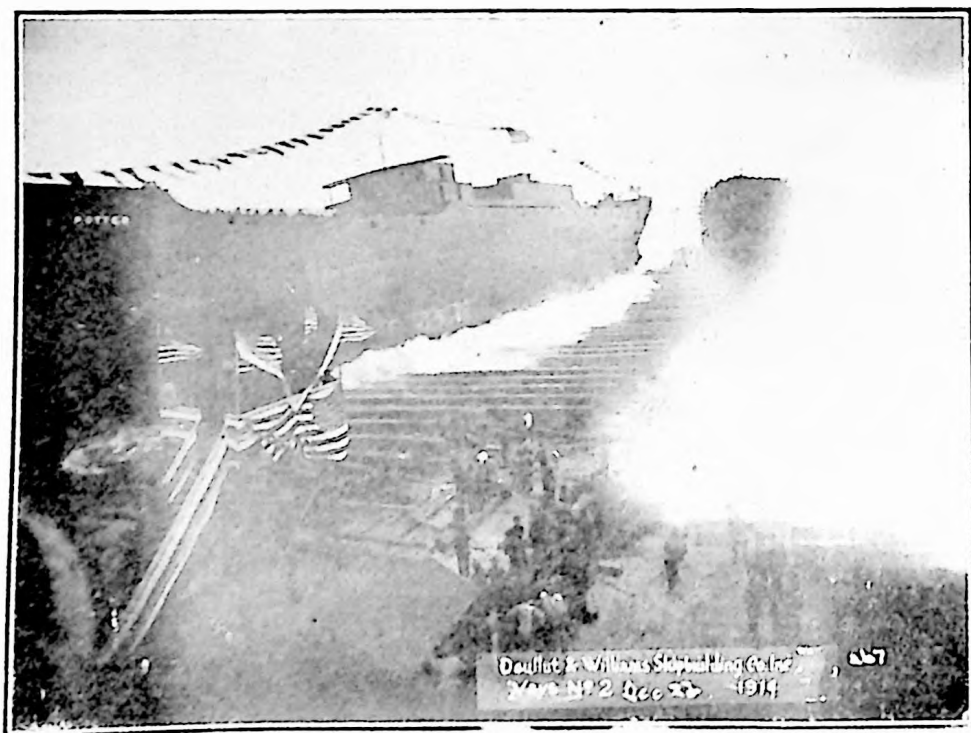
However, just as this situation was becoming apparent, it was somewhat relieved through the policy adopted by the Shipping Board after the signing of the armistice on November 11 of requiring of its contractors, not speed, formerly so vital, but rather workmanship of the highest class.

Fabricated steel in quantities began to arrive at the plant in January, and on January 30, 1919, the first keel was in place and so reported by the Shipping Board officials some eight months after the signing of the contract. However, the plant was ready and the first steel put on No. 1 Ways on November 21, 1918, only five and a half months after the contract was signed, the delay in keel laying being due to the fact that keel angles had not been delivered by the Fleet Corporation.

Going back to the statement made in the beginning of this paper concerning the belief that all steel could be completely fabricated and shipped to this plant before erection, reports from many yards concerning the difficulties being encountered and the great losses to which some of them were put through poorly fabricated work operated to a great extent in changing somewhat this policy. This matter was taken under discussion at length with the Chief Surveyor of the American Bureau of



VIEW OF THE "POTTER" FROM ACROSS THE CANAL

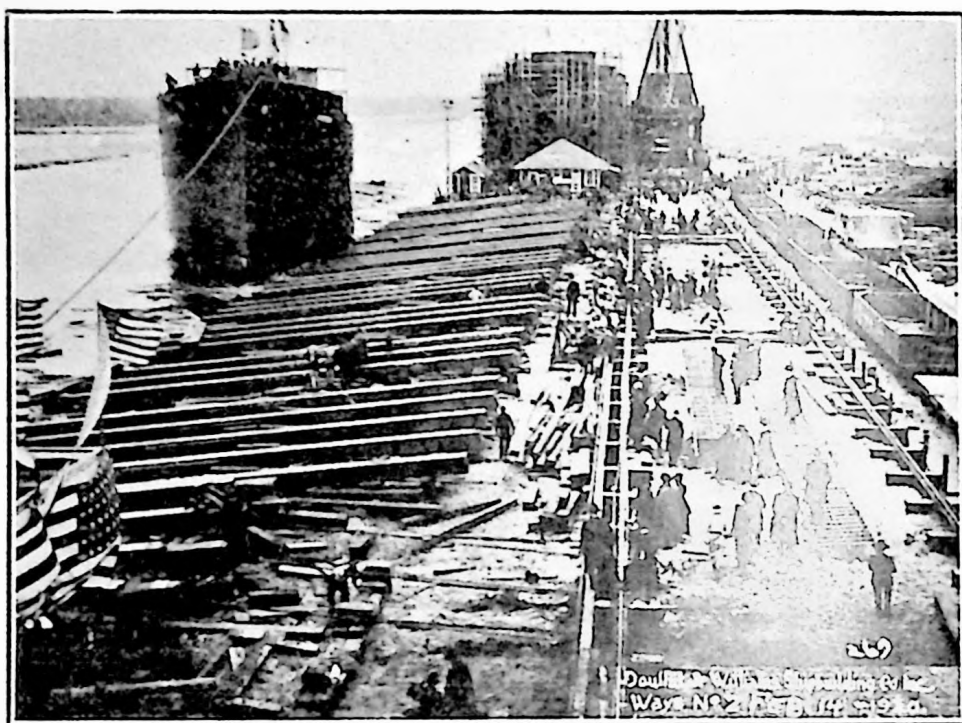


THE "POTTER" LEAVING THE WAYS

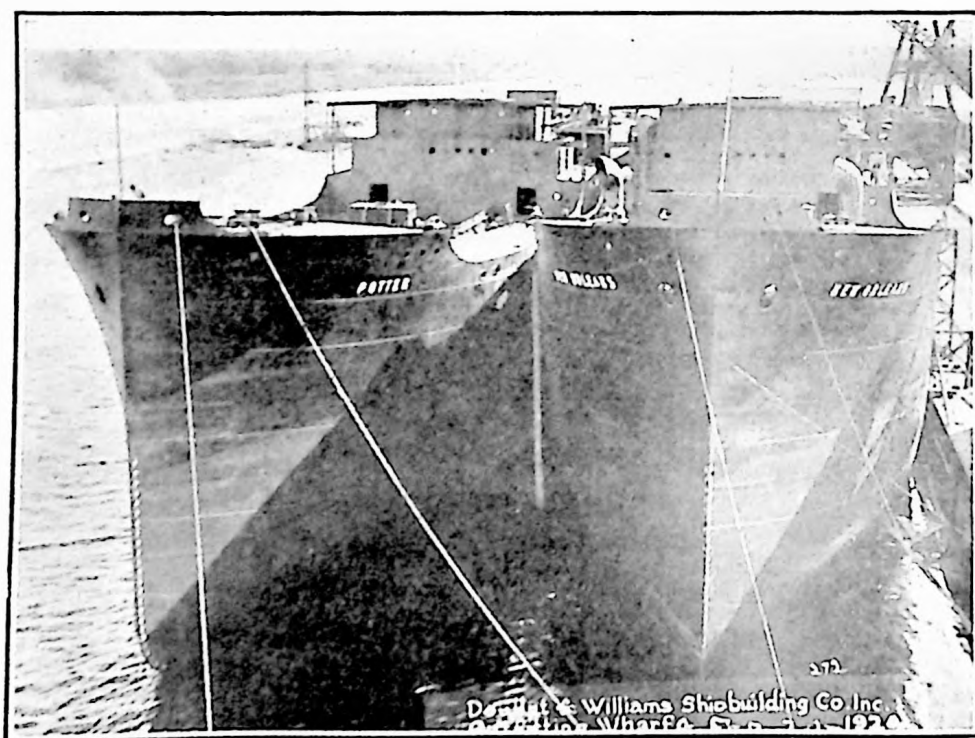
Shipping and his assistant. They advised strongly against having all plates completely fabricated, inasmuch as certain parts of the work could be performed at the shipyard and thereby we could be assured of some method of taking care of the discrepancies which were bound to creep in and exist between the theoretical lines to which the drawings had been made and the actual position of the framing when finally in place. Upon their advices and with the hearty concurrence of the Chief Engineer of the Company, some forty of the most difficult plates on each ship were selected and certain fabrication omitted from each one. Some of the plates were shipped to the plant without fabrication of any kind other than rolling or furnacing done, no holes being punched and edges being left to the same dimensions of the raw material. Other plates were shipped not sheared, but with all holes punched an eighth of an inch small so as to allow for adjustment, this necessitating an excessive amount of reaming, but giving the advantage of quite a bit of leeway on each plate. Proof of the wisdom of this move is amply demonstrated in the appearance of the ships which are now practically complete.

I do not believe that any vessel constructed according to the old pre-war practices has any smoother lines than those which are now finished, and it is a significant fact that not a single plate has been lost on any of the four vessels constructed, while other plants have lost quite a number,—one yard losing some ninety-odd plates on one vessel. Much credit is due to the fabricators, for although there have been numerous shop errors, they have, with but few exceptions, been inconsequential, and the work in general has been of a nature such as must command the admiration of all who have any knowledge of the difficulties encountered in the fabrication.

As the hull department was being organized we received applications from many men who had been connected in prominent positions with the Eastern shipyards. Desiring to use only experienced shipbuilders in the hull construction, we employed quite a few of these, only to find to our extreme chagrin that their war training had fitted them only for the performance of work in a haphazard, hit-or-miss manner. Practically all of them had been in the habit of putting up vessels where the mid-



THE "POTTER" JUST AFTER LAUNCHING



AT THE OUTFITTING DOCK

ship section, or "straight work," as it is called, had been fabricated from detailed drawings, and the end sections taken directly from the mold loft and from templates made in the field. They, therefore, could see no sense in attempting to hold the ship at midship section to its theoretical lines; but Mr. Guerin and the other officers of the Company, realizing that the end sections of these vessels were to be fabricated altogether from theoretical lines, insisted vigorously upon loose bolting up of steel work, adjustment and no riveting until the vessel was as close to its theoretical lines as it was possible to get it. To obtain these results, it was necessary to discharge practically every man connected with the hull department in responsible positions, during the course of the months immediately following the commencement of steel erection, and exceedingly difficult to obtain the services of efficient erectors who were willing and conscientious enough to carry out instructions given them. As in the case described above, the wisdom of sticking close to theoretical lines is also apparent in the completed vessels, and in the small amount of trouble encountered in the fore and aft sections where the difficult work was met. The writer, who personally investigated the reasons for the loss in the fore and after plates in other shipyards is convinced that this trouble was due, to a large extent, not to poor fabrication or imperfect workmanship, but rather to the method adopted of premature riveting and making completely rigid the midship section, before it had been properly adjusted and bolted up.

To those of you who are familiar with the side-launching of vessels, the following comments on the launching will not be of particular interest. However, to the builders of a hull the three to five seconds in which time the vessel leaves her position and goes overboard, are possibly fraught with more anxiety and concern than is ever the case on any other class of construction work. The result of practically a year's ceaseless effort can depend upon the developments which take place in this brief space of time, and although unsuccessful launchings are rare indeed, they sometimes do happen, and it behooves the builder to make a most careful study of the conditions entering into launching before the vessel is put overboard. I regret very much that I was unable to make slides showing the drawings

of blocking, cribbing and triggers used in launching. However, with slight variations depending upon the weight of the vessel and the supporting value of the foundation, the plans used are typical of general practice in side launching. Any accurate data concerning the stresses which are set up in side launching under the varying conditions which must be met as the vessel leaves the ways, and the several rows of cribbing drop from under it, does not seem to be available.

Realizing that the piling under their ways were spaced sufficiently far apart to warrant a careful investigation of the strength of the timbers over which the vessel had to travel, the company had an investigation of the strength of the ways made by several persons. Quite a bit of help was offered us by outside parties, and the consensus of opinion seemed to be that the only dangerous weakness lay at a point about ten feet back of the ends of the launching timbers. Theoretically, at this point when the line of cribbing under the keel of the vessel drops out practically the entire load is thrown upon the fourth row of cribbing from the out-board end, and the vessel immediately begins to turn about this point, all supports having fallen from under her center of gravity. However, this conditions, if it ever exists, exists only for the briefest space of time, for a very large portion of the weight, as soon as the vessel begins to turn, is falling and simultaneously going forward, and the pressure on the fourth row of cribbing from the out-board edge is relieved in large part, practically as soon as it is applied. The vessel being in place, it was considered hazardous to attempt to provide additional piling for further reinforcing the ways, inasmuch as it would be necessary to use a jet, which, in conjunction with the action of the steam hammer, might cause a cave in the bulkhead supporting the fill under the vessel, with the consequent danger of the foundation giving way completely. In the judgment of the officials of the Company, among whom is included one with a lifetime experience in side launching, it was not thought hazardous to launch the vessel without additional foundations other than the piling originally driven in the ways, inasmuch as the sand-fill behind the bulkhead, pumped well up around the caps, gave considerable support to the launching timbers in addition to that furnished by piling. The successful



HULL NO. 5. THREE WEEKS AFTER THE LAUNCHING OF THE
"NEW ORLEANS" FROM THESE WAYS

launching of the "NEW ORLEANS" on Saturday, January 24, has demonstrated the fact that the ways were sufficiently strong to carry their load. A careful investigation of the timbers made by the writer immediately after the launching revealed the fact that only in a very few instances was there any indication of failure from overload. Our investigations prior to the launching had led us to believe that the only danger lay in the crushing of the caps due to the small area of the pile heads on which the caps rested. However, this point was thoroughly tested prior to the launching, inasmuch as it was necessary in order to put the launching timbers and eribbing in place, to support the weight of 32 lineal feet of the vessel at midships section on one cap, this load being distributed over three caps, though the cribbing and sliders, when the vessel was launched. The writer carefully investigated these caps to which the maximum load was applied both prior to and subsequent to launching; and although several of the caps under the machinery space were crushed to an extent beyond which it might have been dangerous to go, there was no

indication of weakness sufficient to cause uneasiness. It is regrettable that the arrangement of keel-blocking, cribbing, etc., prevents the securing of any accurate data concerning the loads transmitted through the shores to the caps and the unit stress to which the timbers were subjected, as it is the writer's opinion that some very interesting figures would be arrived at, as regards the crushing strength of all-heart, long-leaf yellow pine were it possible to compute accurately the loading.

A brief description of the propelling machinery has been given heretofore in this paper, but those of you who are familiar with marine machinery will realize the important part which the auxiliaries and the piping play in the construction of a first-class vessel. They are expensive and their installation involves no inconsiderable part of the cost of outfitting. It is significant to note that the pipe work for the heating of fuel oil carried in double bottom compartments in the vessel and the pipe necessary for the proper installation of trimming pumps, service pumps, etc., for fuel oil burning apparatus alone is worth approximately \$15,000 per vessel. It was realized early in the development of this contract that a large portion of the costs for outfitting would arise from the necessity of having a great deal of the pipe work done in a very congested space. To our knowledge, several yards has attempted to make drawings of all pipes and have them fabricated by such manufacturers as the Crane Company, but this method proved extremely expensive and resulted in the loss of a large per cent of fabricated pipe. This was due to several reasons, chief among which were the inability of erectors to get foundations in exactly the proper location, with resulting discrepancies between units which had to be connected by pipe lines; to the many changes and alterations required by the Fleet Corporation and the various inspection bureaus from time to time; and to the fact that many pieces of machinery as received at the plants did not agree with drawings and specifications furnished. Doullut & Williams Shipbuilding Company, Inc., realizing that they had several months ahead of the prior to the time that they would be able to begin outfitting, decided that it would be an economical and valuable move from many standpoints to erect close to their pipe-fitting and copper-smith shop, a complete unit of all machinery which was to go

into the boiler and engine room. This was done, and as rapidly as the pipe plans were gotten up, passed upon, revised and approved by the several interested parties, the fabrication of the pipes was gotten under way. It is an extremely difficult matter to make drawings which will, in all cases, give proper clearances and good arrangement for pipe lines in a space as congested as is the engine room of a vessel. The installation of machinery on "THE NOGO", as it has been christened by the mechanics at the plant (the man in charge being called "Admiral Nogo") has brought out quite a number of necessary variations from original plans and has enabled us not only to view the work as it will actually be, but has also given opportunity for the inspectors to criticise the arrangement from a working standpoint, and to make suggestions for improvements which they demand, and which would be extremely costly if made at a later date. It has also enabled us to familiarize the "green" crews which we had to train for this work with the way in which machinery and piping is to be installed; but by far the most advantageous feature of this installation lies in the fact that it enables us to take down pipe, bent and difficult to work, and fabricate according to the one which has been fitted, for eight vessels at one time in the shop. This eliminates in a large degree the necessary loss of time for taking measurements on the ship, and the constant travel back and forth of highly paid mechanics between the outfitting basin and the shop. For every line in every vessel there is left one piece of straight pipe to be cut from measurements on the ship, thus giving us the necessary leeway in making the final fittings and adjustment.

Up to the present time quite a bit of work has been done on the installation of machinery. When the "NEW ORLEANS" was launched, her anchor handling gear and deck winches were all in place, as were practically all of the auxiliaries, including condenser, feed water heater, generators, pumps, etc., in the engine room, only the heavier parts, such as boilers, reduction gear and turbine being left out prior to launching.

One feature of the work which was particularly interesting to the writer was that in connection with the erection and boring of the stern frame. Difficulties are naturally to be expected in handling this part of the construction, and the methods used to

obtain the proper fits must be very accurate. When the first machined casting was received at the plant and checked up, it was noted that there existed quite a number of discrepancies between the drawing and the casting. The casting was out of alignment in some places, but as this was a discrepancy which could be corrected by proper heating and bending, it was not of considerable moment. The point which was most important was the fact that the distances between the rudder gudgeons varied considerably from the drawing, inasmuch as the upper and lower rudder stocks were to be machined and the rudder arms shrunk on at shops, located away from the city, according to dimensions shown on original drawing. Here we again adopted a safe policy and held up the work in the shop which was finishing the rudder stock until such time as the stern frame might be erected and riveted in place. We then obtained the actual dimensions between the gudgeons, and working from this information, made up separate drawings for each hull, and had the rudder arms shrunk on to the stock in exactly their true position. The boss of the stern frame was bored with a ten-inch boring-bar, having an automatic feed and driven by a $7\frac{1}{2}$ H. P. Single Phase motor. Inasmuch as the fit of the stern tube into the boss on the frame is of vital importance, this boring was not done until after the tubes were received at the yard and callipered. The boss was then bored to approximately 2-1000 of an inch larger than the outside dimensions of the tube, and the stern tube forced into place by the use of long $2\frac{1}{2}$ -inch machine bolts to pull and a 50-ton hydraulic jack to push from the rear. A proper fit of the stern tube thus depended only upon the accuracy with which the shaft was assured, inasmuch as the finishing work on the tail shaft was done by the same company which furnished the propellers; propeller hubs were fitted to the propeller shaft, a Prussian blue impression fit being made in the presence of our inspector, as well as inspectors of the American Bureau of Shipping, before leaving the shops of the manufacturer.

It was originally intended to do the facing on the connecting flanges for the line shafting at this plant, but as it developed that we had quite a bit of time after the hull was erected it was decided to take accurate measurements of the over-all dimensions of the vessel between the point where the shafting connected

with the reduction gear and the propeller shaft. When these measurements were made it was found that on two hulls now erected the discrepancies between the actual and theoretical measurements were only one-eighth of an inch, and on the other two less than one-sixteenth of an inch. It was accordingly decided to have the flanges faced in the shop of the Hardie-Tynes Manufacturing Company of Birmingham, where the other work was being performed, there being sufficient room for adjustment both at the stern end and at the reduction gears to take care of this small difference.

There has been from time to time quite a bit of discussion, I believe, concerning the proposed route by which the Doullut & Williams Shipbuilding Company, Inc., intend to take their vessels to open water. We have never had the faintest hope that the locks of the Industrial Canal would be completed by the time we were ready to deliver a vessel. Our belief that the Canal with its many difficult problems of construction would not be completed in time to serve our ships was the prime factor which appealed to us in locating the plant at the Lake end. It is proposed to take the ships out from the Canal through the channel made by the dredges between the Southern tracks where they cross the Canal at the Lake and the North draw on the Southern Railway; from which point the vessel will follow the route used by the Slidell and Jahneke boats to the Big Rigolets. They will go from this point through the Rigolets, but instead of passing through the L. & N. draw will turn to the east through the East Pass of Pearl River and "Little Lake," thence into Pearl River and out through that stream. How much difficulty will be encountered is not known at present, inasmuch as the channel may have shifted considerably since that time when vessels drawing more water than these being built by the Doullut & Williams Shipbuilding Company, Inc., have passed over this route. It is believed that owing to the length of the vessels it will not be possible to take them through the channel used by other vessels between the Rigolets and Pearl River, and that it will be necessary to do a comparatively small amount of dredging in "Little Lake," but it is not thought that the dredging will involve any serious difficulty. The vessels can be trimmed

to about 9 feet 6 inches on an even keel when completely finished and outfitted.

There is also available another route—that used by the Foundation Company recently, through Bayou Bienvenue and Lake Borgne. The bridges on the Industrial Canal, as well as the Canal itself, are practically completed between the Doullut & Williams plant and Bayou Bienvenue; and the vessel which the Foundation Company recently took out draws practically the same amount of water as will the "NEW ORLEANS" when she is ready for sea.

In conclusion, it is the writer's belief that the successful carrying out of ship construction as planned and developed by the Doullut & Williams Shipbuilding Company, Inc., is due in large part to the several reasons enumerated below:

1. High efficiency and accuracy in the original laying down of the lines of the vessel and preparation of steel details.
2. Insistence that the work on the hull construction follow as closely as possible the theoretical lines in the early stages of hull work.
3. Departure from original scheme of operations and making every instance where close fits were necessary and discrepancies likely to creep in, provision for performing the finished work at the plant.
4. Care on obtaining prior to the undertaking of any part of the construction, the entire criticisms and approval by the customs officials, the American Bureau of Shipping and the Emergency Fleet Corporation, and—
5. Ceaseless effort to turn out a finished product of the highest class of which the Corporation, as well as the community, might be proud.

MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY

Regular Meeting of the Board of Direction—February 9, 1920.

The meeting was called to order with President Riess in the Chair, and Messrs. Barelli, Olsen, Lawes, Moses, Williamson and Robert present. The minutes of the previous meeting were read and approved. A letter from the Frederick Courtenay Barber Company was read and the Secretary instructed to make further inquiry.

The application of Mr. D. B. H. Chaffe, Jr., for reinstatement as Student Member was approved. A letter of resignation from Mr. F. E. Sprague was read. Before accepting the same, however, it was decided to write Mr. Sprague requesting him to remain in the Society as a Non-Resident Member. The resignation of Mr. James Wood was accepted as of January 1, 1920.

The Secretary's report was read and approved and the bills ordered paid. There being no further business the meeting adjourned.

J. M. ROBERT, Secretary.

Regular Meeting of the Society—February 9, 1920.

The regular meeting of the Society was called to order with President Riess in the chair and 56 members and guests present. The minutes of the previous meeting were read and approved. The President then read to the meeting a list of the committees for the ensuing year.

Professor Gregory then made a short statement concerning the National Department of Public Works Association, and upon motion of Mr. Dusenbury, seconded and carried, a sum of \$150.00 was appropriated to further the interests of this department. Mr. Marcel Gausaud made a statement concerning the relation of engineers and contractors and moved that with a view of closer co-operation and harmony between these two, a committee of five be appointed to look into the matter and report its findings at the next meeting. This motion was promptly seconded and carried. There being no further business to come before the meeting, Mr. James P. Ewin, Chief Engineer, read a paper entitled "Fabricated Steel Ship Construction as Developed by Doullut & Williams Shipbuilding Company, Inc." This paper was most interesting and was thoroughly enjoyed by all present.

The meeting was then adjourned to the usual collation.

J. M. ROBERT, Secretary.

Regular Meeting of the Board of Direction—March 8, 1920.

The regular meeting of the Board of Direction was called to order by President Riess, in the Chair, and the following present: Messrs. Olsen, Lawes, Moses, Robert. The Secretary's report was read and approved and the bills ordered paid.

The resignation of Mr. Frank E. Sprague was accepted as of January 1, 1920. A letter from the Secretary of the State Board of Engineering Examiners was read, calling attention to vacancies on the Board, and

asking that the Society recommend nominees to fill these vacancies. Upon motion, it was decided to write the Governor recommending to him that those members of the Board whose terms had expired be reappointed to fill their own vacancies. These men are B. W. Pegues and W. B. Robert.

A letter from the New Orleans Association of Commerce was read soliciting our assistance in making an industrial survey of New Orleans. It was decided to refer this letter to our Industrial Committee.

The following applications were ordered through the ballot:

Resident Members—Marion J. Epley, Thomas P. Johnston, Errol E. Kelly, Solis Seiferth, Lewis Campbell Smith, Theron H. Tracy.

Transfer from Junior to Resident Member—Ashley Calongne.

Transfer from Student to Resident Member—D. B. H. Chaffe, Jr.

Non-Resident Members—John M. Jenks, John H. McConnell, Herbert H. McGehee.

Associate Member—Arthur T. Gomilla, Sr.

Student Members—Robert Lee Atkinson, Clarence Leonard Jones, Ralph H. Mann, Louis J. Wyler.

There being no further business, the meeting adjourned.

J. M. ROBERT, Secretary.

Regular Meeting of the Society—March 8, 1920.

The regular meeting of the Society was called to order with President Reiss in the Chair and 25 members and guests present. The minutes of the previous meeting were read and approved.

Mr. Gausaud brought up for approval changes the State Board of Engineering Examiners desire to make in the License law. These changes were presented at this meeting in their final form and upon motion, duly seconded, it was decided that we endorse these changes. This endorsement must be passed a second time at the next meeting.

Mr. W. T. Hogg then presented the following resolution:

“Whereas, the continual growth in the vehicular traffic of our city is creating more and more congestion in Canal and adjacent streets between Magazine and Rampart streets, and

“Whereas, the width of Poydras street offers a logical route by which through traffic can move out to South Rampart street and avoid the congested area,

Be it resolved, That it is the sense of this meeting of the Louisiana Engineering Society that the present Poydras Market should be removed from the roadway of Poydras street, and be reconstructed within the property lines of one or more of the neighboring squares, and

Be it further resolved, That a wide paved roadway should be constructed on Poydras street between Baronne and South Rampart streets.”

Next in order was the Technical exercise, and Mr. J. F. Coleman read a most interesting and instructive paper on the Port of New Orleans. After some little discussion, which was enjoyed by all, the meeting was adjourned to the usual collation.

J. M. ROBERT, Secretary.

PROCEEDINGS

OF THE

LOUISIANA ENGINEERING SOCIETY

VOL. VI

JUNE, 1920

No. 3

CONTENTS

EDITORIAL NOTES AND COMMENT:	PAGE
The Lock Foundation. Inner Harbor Navigation Canal.....	129
New Members	131
Recent Additions to the Library	132
A Word of Appreciation.....	132
 PAPERS AND DISCUSSIONS:	
The Lock Foundation, Inner Harbor Navigation Canal, New Orleans, La. The Problem and the Solution. <i>By Geo. R. Goethals</i>	134
MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY.....	159

EDITORIAL NOTES AND COMMENT

The Lock Foundation, Inner Harbor Navigation Canal.
Under this title we present in this issue a very interesting and instructive paper by Col. Goethals dealing with the problems arising in connection with the construction of the lock which connects the Industrial Canal with the Mississippi River.

This lock will have a usable length of 600 feet, a width of 75 feet, and a minimum depth on the gate sill of 30 feet, the maximum drop between river level and lake level being 19 feet. It is interesting to note that it may at times happen that the high level pool may be on the north or lake side of the lock, due to the fact of the backing up of the water in Lake Pontchartrain at times of hurricanes or severe southeast storms. While this paper deals primarily with the problem of the lock foundation, the design of the lock as a whole differs materially from any heretofore constructed, both walls and floor having been designed on the principle of an integral unit somewhat analogous to the hull of a ship, thus producing a practically uniform loading of the piles, rendering local settlement practically impossible.

Substrata conditions were determined by the method of driving 10-inch iron pipe casings, two or three feet at a time, excavating, then repeating the process until the desired depth was reached. Information thus gained showed that the successive strata of clay and quicksand were practically continuous and of constant thickness over considerable areas.

Excavation was handled by means of two hydraulic dredges working simultaneously on either side of the center line of the lock, the cutting being as handled on the sides as to produce a stepped bank with a resultant slope of $1\frac{1}{2}$. While this dredging was in progress a wooden sheet piling cofferdam was driven, completely surrounding the lock in order to cut off the first quicksand stratum. The dredges were removed through the north end, and a temporary cofferdam and earth dyke thrown across at this point, thus leaving the lock site as an isolated pool of water cut off both from the river and the canal end.

The paper then proceeds to discuss the most important part of the problem, the unwatering of the lock, in the course of which many new problems were met and solved in novel and ingenious ways. One of the most interesting of these was the use of artesian wells in the form of ten inch steel pipes for the purpose of relieving the static head in the third stratum of quicksand, which was always a possible source of danger tending to cause a blow up of the bottom.

This paper constitutes a valuable contribution to the records of this Society and to the general literature of the subject of foundations in alluvial soils. It is to be hoped that Col. Goethals at some later date will contribute other papers upon the general construction of the lock.

In his final summing up Col. Goethals makes this interesting observation: "The whole problem has been an interesting one and unique in the way material of the class encountered has been dealt with. It merely goes to furnish another forcible illustration of the fact that the profession of engineering still remains an art, in which imagination and some new application always plays a part, and that the day when this same profession shall be called an exact science, is, fortunately or unfortunately, in the future."

New Members. Since the first of the year the following new members have come into the Society:

RESIDENT MEMBERS:

O. P. Adams, Boiler Room Engineer, N. O. Rys. & Light Co.

B. H. Bell, Chief Electrician, N. O. Rys. & Light Co.

O. A. Billion, Chief Inspector for French Government in N. O. Foundation Co. Shipyard.

M. J. Epley, President and General Manager, Toyoh Valley Sulphur and Railroad Co.

T. P. Johnston, Research Engineer, Southern Pine Association.

E. E. Kelly, General Engineering & Designing, Jahneke Drydock Co.

L. H. Rayner, Sup't Myrtle Grove Factory of T. S. Wilkinson.

G. A. Seaver, Chief Engineer with George J. Glover.

Solis Seiferth, Ass't. Engineer with A. M. Shaw.

L. C. Smith, General Engineering.

R. B. Stevens, Appraisal of Chalmette Refinery.

D. W. Stewart, Chief Engineer, Central Power Station, N. O. Ry. & Light Co.

T. H. Tracy, President & Genl. Manager, Tracy Engineering Co., New York City.

TRANSFER FROM JUNIOR TO RESIDENT MEMBERS:

Ashley Calongne, Paving Contracting and General Engineering.

A. M. Fromherz, with Jos. Fromherz, General Contractor.

TRANSFER FROM STUDENT TO RESIDENT MEMBER:

D. B. H. Chaffe, Jr., Mechanical Engineer, Doullut & Williams Shipbuilding Co.

NON-RESIDENT MEMBERS:

J. M. Jenks, Bay St. Louis, Miss., Construction Work for Dock Board.

H. H. McGehee, Arcadia, La., with Xavier A. Kramer on Water and Light Plant Construction.

F. L. Roe, Omega, Madison Parish, La., Parish Surveyor.

J. L. White, Lecompte, La., General Engineering Work.

ASSOCIATE MEMBERS:

A. T. Gomila, Sr., with Doullut & Williams.
W. F. Jahneke, Jahneke Interests.
John McInerney, Manager, Geo. A. Fuller, New Orleans.

JUNIOR MEMBER:

S. A. Theard, General Contracting Business.

STUDENT MEMBERS:

R. L. Atkinson, Senior Class, Tulane University.
C. L. Jones, Senior Class, Tulane University.
R. H. Mann, Senior Class, Tulane University.
L. J. Wyler, Senior Class, Tulane University.

Recent Additions to the Library. The Chairman of the Library Committee submits the following list of books which have recently been added to our Library:

Morrison. Oil Engines, Details & Operations.

Kimball. Principles of Industrial Organization.

Meron. Human Elements in Organization.

Rogers. Erecting and Operating Machinery.

Rogers. Machinists Guide.

Burghardt. Machine Tool Operation.

J. E. Aldred. Lectures on Engineering Practice, 1916-17, 1917-18, 1918-19.

Marine Engineers' Guide.

Millions from Waste.

Bassett. When Workmen Help You Manage.

A Word of Appreciation. The Society is to be congratulated upon the very excellent service during the past season of the Committee on Technical Papers, under the Chairmanship of Professor W. B. Gregory. There have been uniformly good programs for each meeting, and the papers which have been published in the Proceedings have been of a very high character, and have attracted the attention of the engineering world in many quarters.

With the great strides in material development now being made by New Orleans and the surrounding territory, and the many projects actually under way or being designed, there

would appear to be many excellent opportunities to secure papers and discussions for the coming season after our Summer adjournment.

It is to be hoped that our members will bear this in mind and that many of them will be inspired to prepare articles or papers and thus bring before the Society some of the problems and solutions therefor which they have met with in the progress of their work.

THE LOCK FOUNDATION, INNER HARBOR NAVIGATION CANAL, NEW ORLEANS, LA.—THE PROBLEM AND THE SOLUTION.

BY GEO. R. GOETHALS.

Lieut. Col. U. S. Army, Retired. Associate Member, American Society of Civil Engineers.

Read before a joint meeting of the Louisiana Engineering Society and the Local Section of the American Society of Civil Engineers, May 12, 1920.

Introductory.

The construction of the lock for the New Orleans Inner Harbor Navigation Canal has involved some interesting problems in engineering. The methods employed to solve the problems of the lock foundation, so far as authentic records are concerned, are up to the present time unique in this part of the United States wherever material of like character is encountered. It is thought the methods pursued may be of sufficient interest to the engineering profession to warrant making a permanent record, not only of what has been done, but also of the reasons leading to the various successive steps.

A brief resumé of the physical characteristics of the canal will first be given. The waterway, 5 1-3 miles in length, is to connect the Mississippi River with Lake Pontchartrain. See Fig. 1. This will afford ample opportunity to increase, to an unlimited degree, the facilities of the port by affording an inner harbor, capable of indefinite expansion between the lock and the lake. It is also to be hoped that eventually a deep water channel through Lake Pontchartrain and Mississippi Sound may be realized, thereby bringing New Orleans much closer to the open sea than is now the case through the tortuous river route. A lock is essential in order to overcome the difference in level between the river and the lake. The lock is located 2000 feet, measured along the canal channel from the river. The canal prism, between river and lock will be 125 feet wide, with 30 ft. minimum depth; and between lock and lake, a bottom width of 150 feet and a minimum

NOTE.—All elevations given in this article are referred to Cairo datum

floor to which they (the walls) are securely tied. This gives not only a single unit structure but in addition results in practically a uniform, instead of a variable pile loading, thus rendering local settlement practically impossible. To obtain such a relation and condition, the floor of the lock is 9 feet thick in typical sections and 12 feet thick at the gate sections. This brief explanation has been given to outline the reason for the unusual thickness of the floor and the necessity for carrying the excavation down to -20 , and at the comparatively short gate sections, to -23 .

Substrata Conditions.

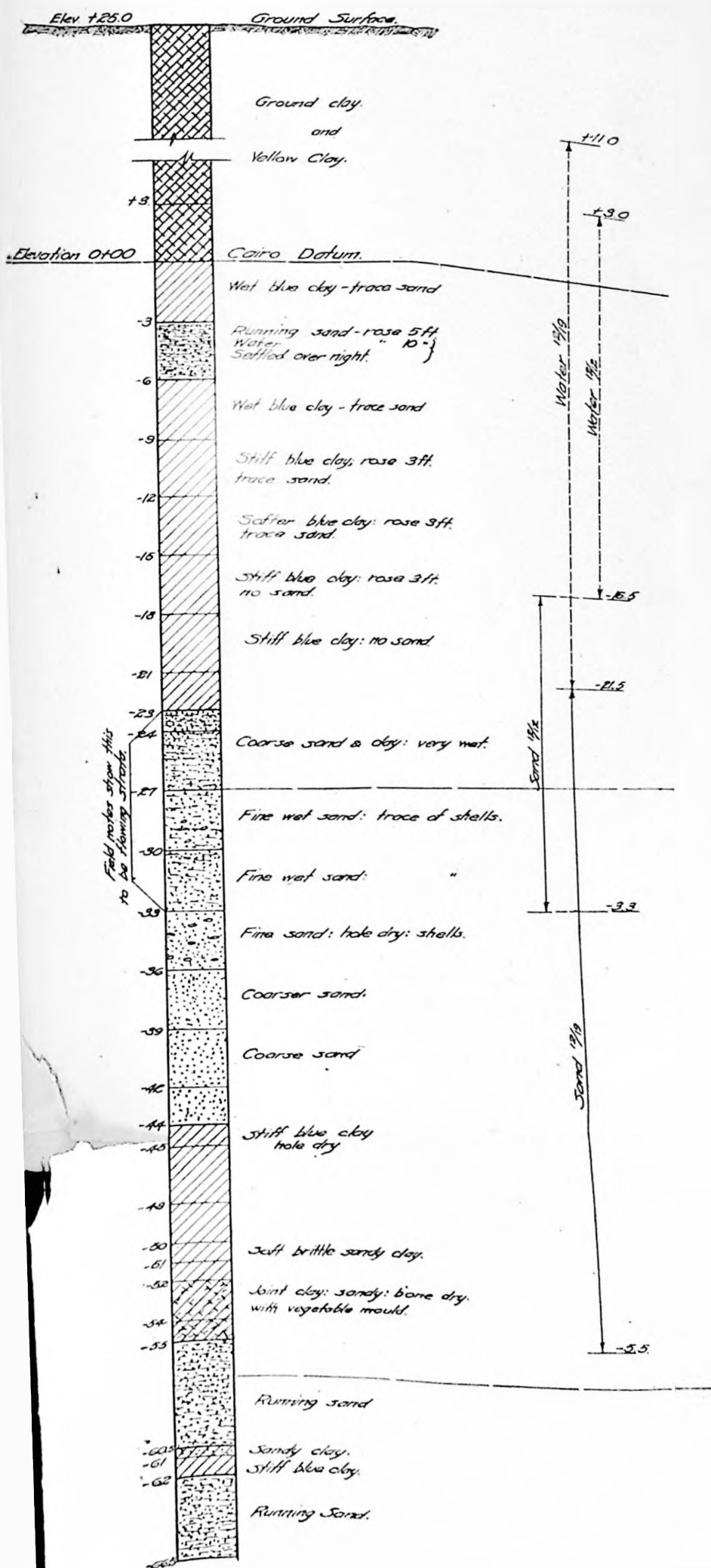
The natural surface of the ground at the lock site is at elevation $+25$. From the surface down, investigations made show an alternate series of clay and quicksand strata. It was also determined that the same conditions found at the lock site are true all the way to the river and for some distance north of the lock. Certain planes of demarkation between strata vary somewhat as to elevation, and the strata vary slightly in thickness, but in the main, conditions are uniform and as shown in the accompanying plate, figure 2.

Wash drill borings proved to be worthless as a means of determining subsurface conditions. The only reliable method was found to be that obtained by driving 10 inch pipe casings, two or three feet at a time, excavating, then repeating the process until the desired depth was reached. Figure 2 shows the information thus obtained at a point 270 feet west of the center of the lock.

Other such pipe sunk in a similar manner and at other localities checked the results here shown. It is interesting to note the behavior of the quicksand while the casing was being driven. When the cutting edge reached -33 , sand immediately filled the pipe up to -16.5 , and water rose to $+3$. It was then evident that the pipe could not be further excavated unless or until the cutting edge should reach and penetrate another clay blanket, thus sealing the bottom of the pipe. Accordingly the casing was driven further down and on reaching an elevation of -47 it was found possible to bail the water out of the pipe without the latter immediately refilling. This resulted in

Test Bore -10" Casing N^o 2.

Made Dec. 1918.



the development of a second blanket of stiff blue clay, beginning at —44, as noted, and extending to —55, and it was now possible to remove without further difficulty the quicksand lying immediately above elevation —44.

The sand and water flow just described was repeated when the cutting edge reached —55. In this instance, sand rose in the pipe to —21.5 and water came up to +11. The thickness of this quicksand stratum has never been determined. It can only be said that it extends below elevation —66.5 because the cutting edge of the casing was driven to this point without obtaining a seal. It was necessary to prove that this stratum was at least ten feet thick for the reason that it was desirable to have the foundation piles bring up in a material other than clay and highly resistive to penetration. Having obtained this information, however, the further extent of the stratum was of no interest to the problem involved, since the question of its eventual isolation by means of cofferdams was neither practically possible nor necessary in the development of the work.

The data obtained by this investigation is of considerable interest, in that they prove conclusively that the strata encountered are continuous, unbroken, and of practically constant thickness for considerable areas. The results obtained, described and illustrated in Figure 2 were not only checked by another casing similarly driven in a different location, but have since been verified by the driving of 130 ten inch artesian wells completely surrounding the outer masonry line of the lock, and which will be referred to hereafter. In this large area the position of the planes of separation between material of different character varies only a matter of a few inches. The same holds towards the river and towards Florida Walk. At the siphon, the same conditions are found, although the strata at this distance vary in thickness from what obtains at the lock. At the L. & N. bridge piers and the N. O. & N. E. bridge piers, the same general characteristics hold, but the relative thickness and position of the strata are quite different. These variations, however, result from a gradual sloping of the planes of separation and the changes are nowhere abrupt.

Excavation of the Lock Site.

Local practice and advice indicated that material of the character here found could be excavated and the banks made to stand on a slope of $\frac{1}{3}$. However, no attempt had ever been made, as far as could be found, to excavate a prism to a depth of 47 feet below the natural surface of the ground, either in the dry, or in the wet with the ultimate intention of pumping out the water. Accordingly, it was decided to excavate so as to leave the banks on a slope of $\frac{1}{4}$.

Excavation was handled in the wet. Two hydraulic suction dredges were brought in from a partially finished section of the canal north of the lock site. The dredges worked on either side of the center line of the lock. Starting at the north end and working towards the south, a dredge was advanced the entire length of the lock prism making a cut about twelve feet in depth, leaving the bottom of the excavation at about +12. This process was repeated so that with four advances the length of the lock the final desired depth was obtained. By means of carefully set ranges, the side swings of the cutter against the sides of the excavation on each advance were so controlled as to produce a stepped bank whose resultant slope was $\frac{1}{4}$. The handling of the canal dredges was under the immediate direction of Mr. Walter J. White^{*}, former Superintendent of Dredging for the Dock Board, who has described in detail the interesting methods employed, in a paper written by him and presented to the Louisiana Engineering Society in October, 1919.

While the dredges were at work, a wooden sheet pile coffer dam was driven completely surrounding the lock and about 125 feet from the edge of the bank. The purpose of this cofferdam was to cut off the first quicksand stratum extending from -3 to -6, as it was expected, once the water in the lock prism was lowered, that this stratum would flow out causing settlements and breaks in the bank. The latter tendency would be minimized with the stratum of quicksand thus cut off. This cofferdam, the outer one indicated on figures 3 and 4, also served the purpose of maintaining the water table in the adjacent

^{*}Associate Member, American Society of Mechanical Engineers.

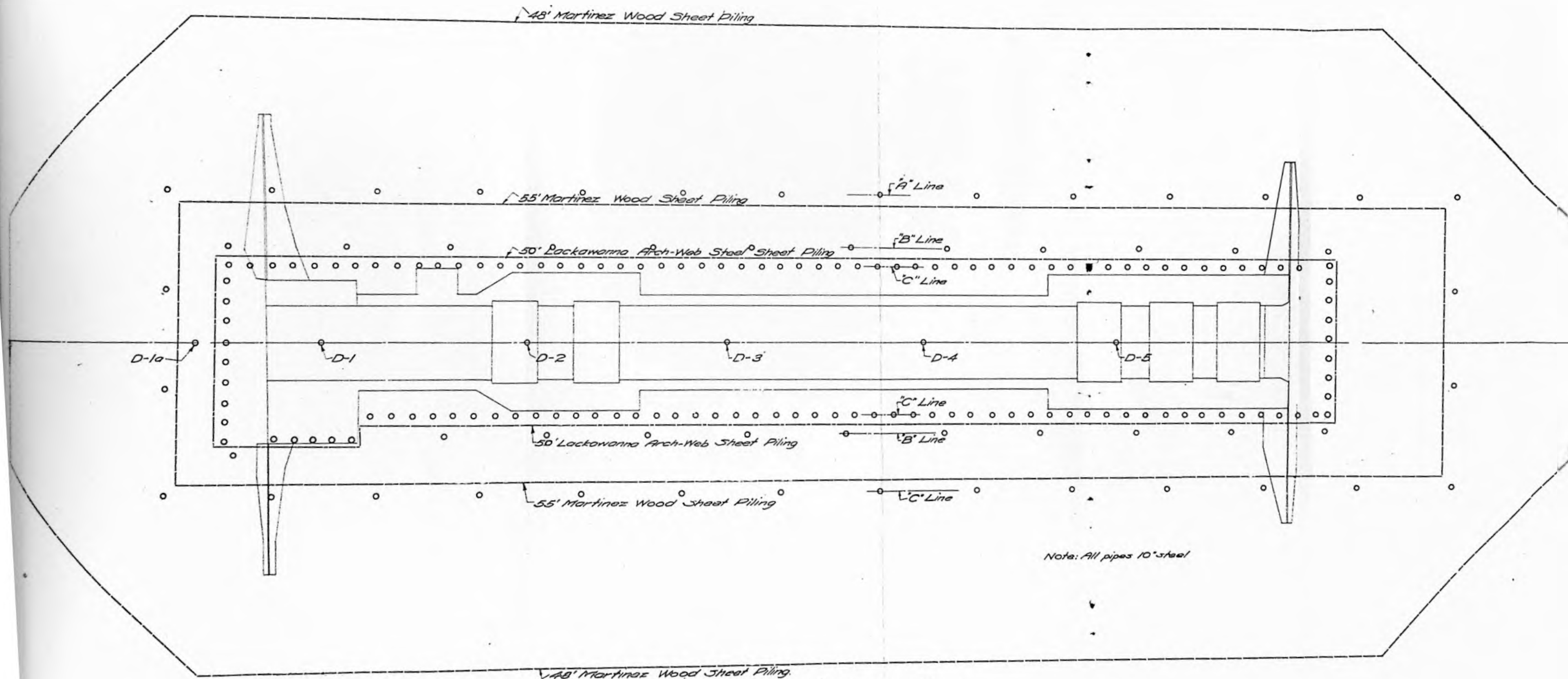


FIG. 3. PLAN OF COFFERDAMS AND ARTESIAN WELLS

ground, a condition which was essential to prevent settlement of the foundations of nearby buildings when the water in the lock prism was lowered.

The dredges having finished their task at the lock, withdrew to take up additional work in the canal prism to the north. The ground to the south of the lock remained untouched, so that from this direction the prism was naturally shut off. A temporary cofferdam and earth dyke was thrown across the north end of the lock after the dredges moved out, thus isolating the pool of water remaining in the lock prism from the water in the canal section to the north.

General Conditions of the Problem.

The problem now remaining was to get the water out of the lock prism and in so doing avoid both the possibility of the collapse of the banks and the danger of the pressure in the quicksand strata blowing up the bottom. The necessity of having a lock floor of reinforced concrete has already been explained. It was essential that this floor should be laid in the dry. To construct a floor of this design under water would have involved an expense not only prohibitive but one which it would have been next to impossible to estimate upon or execute.

At this point, (See Fig. 4), let it be remembered that the second quicksand stratum (from —23 to —44) carried a static pressure head of 55 feet, as obtained from the investigation made while sinking the casings aforementioned; while the third quicksand stratum carried a static head of 75 feet. It was essential that the former stratum, occurring, as it does, only a foot or so below the floor of the lock, be entirely cut off by a cofferdam. All thought of attempting to cut the third layer off was abandoned practically from the start. It was also possible that some means would have to be devised to relieve the pressure in the quicksand strata.

Accordingly various tentative successive steps, including two cofferdams and means for relieving the pressure in quicksands were worked out, always having in mind that while the problem was so uncertain a one all might eventually be necessary; yet realizing at the same time that in order to

save all expense possible, the later steps would not be resorted to until it was proved that they were absolutely essential; and never forgetting that the most extreme care was demanded from the outset in order to avoid any serious blow from the bottom which would destroy the integrity of the clay blanket lying between the second and third quicksand strata. It will readily be appreciated that a rupture of any considerable size in this blanket would permit the up-flow of quicksand from the third stratum whenever the water in the lock might be lowered; that it would be practically impossible ever to shut off a large flow once created, and that such an accident would make the construction problem along the lines being attempted practically unsolvable.

The First Step.

It was decided, then, that the second quicksand stratum must be shut off. From the standpoint of expense, a cofferdam to serve this purpose must enclose an area as small as possible; and not only that, but the individual piles must be as short as possible. To drive this cofferdam at the elevation of the natural ground outside the edges of the bank would have required piles over 70 feet in length, as it must be remembered the points of the piles would have to bring up in the clay blanket next below the second quicksand stratum. The question then was, how far could the water in the lock prism be safely lowered at this time, or, in other words, how far down the banks could the cofferdam be located and yet make it possible to handle the driving so that final pile cut-off would be just above the surface of the water?

The readings taken on the 10-inch easings thus far sunk indicated that the water would rise in the pipes, when the second quicksand layer was pierced, to about +3. It was, therefore, believed safe to lower the water in the prism to about this point. In doing so, the behavior of the bank slopes was carefully watched. When an elevation at +3 had been reached, several small breaks occurred near the southeast corner of the excavation. They were not serious, but indicated clearly that the point of stability was being approached, possibly due to the fact that the first quicksand layer, from -3

to -6 , was beginning to flow out into the prism, causing small settlements of the superimposed clay. The adopted slope of $1/4$ was none too gentle.

With the water at about $+3$, the inner wooden cofferdam shown in plan on Figure 3 and in section on Figure 4 was driven. It consists of Martinez sheet piling. The individual piles are 50 feet in length and are cut off at about $+4$. Assuming this cofferdam to be perfectly tight, the second quicksand stratum would thus be effectually cut off from the interior of the lockspur. It may be stated here that a wooden cofferdam was resorted to, first, because it was believed this type would be sufficiently effective; secondly, because it was cheaper than steel; and, finally, because steel piling in the quantity needed at this time was unprocureable on account of war conditions.

The Second Step.

The operations described above, from the time the dredges started their lock excavation task, to the time of completion of the inner wooden cofferdam, took from November, 1918, to May, 1919. It was hoped no further precautionary measures, already studied and decided upon in case of necessity, would be required, and that from this point the lock might be unwatered without difficulty. This was based on the experience already gained at the inverted siphon crossing under the canal at Florida Walk, where the same methods had been pursued under similar conditions. At this particular time the siphon excavation had been unwatered, although doubt had been expressed as to the success of the undertaking. Furthermore, the bottom of the siphon pit was three feet lower than the bottom of the lock pit. While the area involved at the siphon was very much smaller than that at the lock, it was now believed worth while attempting to resume the unwatering of the lock slowly and carefully.

With the water in the lock prism at about $+3$, unwatering operations were resumed, and the pumps were worked so as to lower the water level at the rate of about one foot per day. Favorable progress was made as far as -3 and the lowering continued. As soon as a level of -3.5 had been reached,

trouble developed. Cracks appeared along the top of the south and east banks. These rapidly widened and in a short while about one-third of the south bank and 300 feet of the east bank, measured from the southeast corner, were in motion. This was accompanied by violent boils of gas, sand and water which occurred in various parts of the lock prism. Water was immediately turned back into the lock and as soon as it had risen to -3 , the boiling stopped and the bank movement ceased. All this occurred in a space of about five hours.

The bank movement comprised, first, a vertical drop downward, causing a break, followed by a lateral movement towards the center of the lock. The enormous force exerted by this mass of material in motion was sufficient to shear off completely 300 linear feet of the inner wooden cofferdam near the southeast corner and to move this broken portion bodily about 30 feet towards the center of the lock. See Figures 5 and 6. What probably happened was this: As the water in the lock prism fell the upper quicksand stratum (from -3 to -6) began to flow out. Some of it worked its way through the inner wooden sheet piling. This left a void into which the superimposed clay proceeded to collapse vertically under its own weight. The stability of the bank now having been destroyed, a movement toward the center of the lock immediately followed, the great weight of the moving mass causing the rupture of the cofferdam, as well as a squeezing out, through the destroyed sheet piling, of some of the second layer of quicksand. The boils occurring in the lock prism undoubtedly had their source in this second quicksand stratum.

No serious damage had been done. The condition of equilibrium had been so slightly disturbed that by raising the water again only six inches, original conditions were at once restored. The experiment demonstrated the fact, however, that the additional safeguards planned must now be resorted to. In order to be on the safe side while these were being installed, the water in the lock was raised again to zero.

Preparations for the Third Step.

First of all, the damaged portion of the inner wooden cofferdam was redriven. It was then decided to construct a third cofferdam, which, with the water now at zero, could be driven

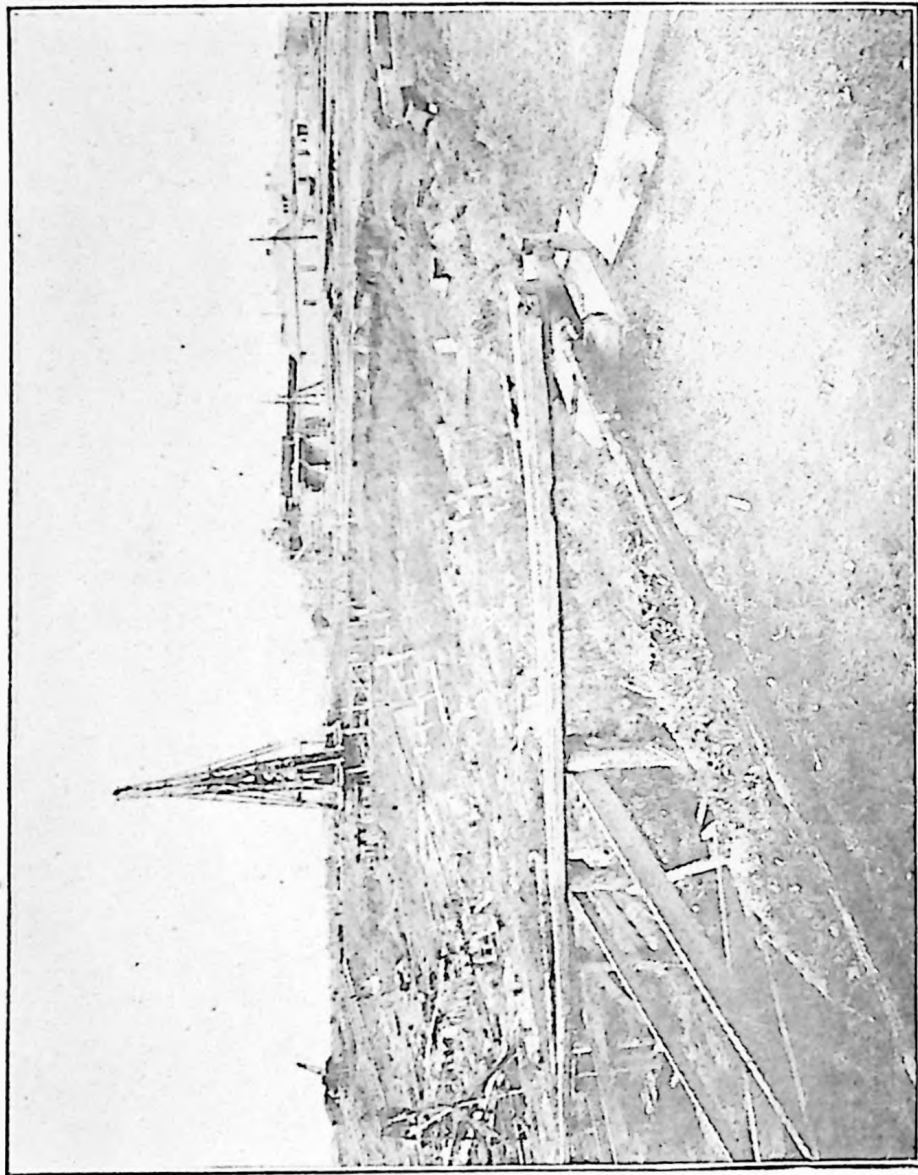


FIG. 5. SOUTHEAST CORNER OF LOCK EXCAVATION SHOWING SLIDE OF MAY, 1919

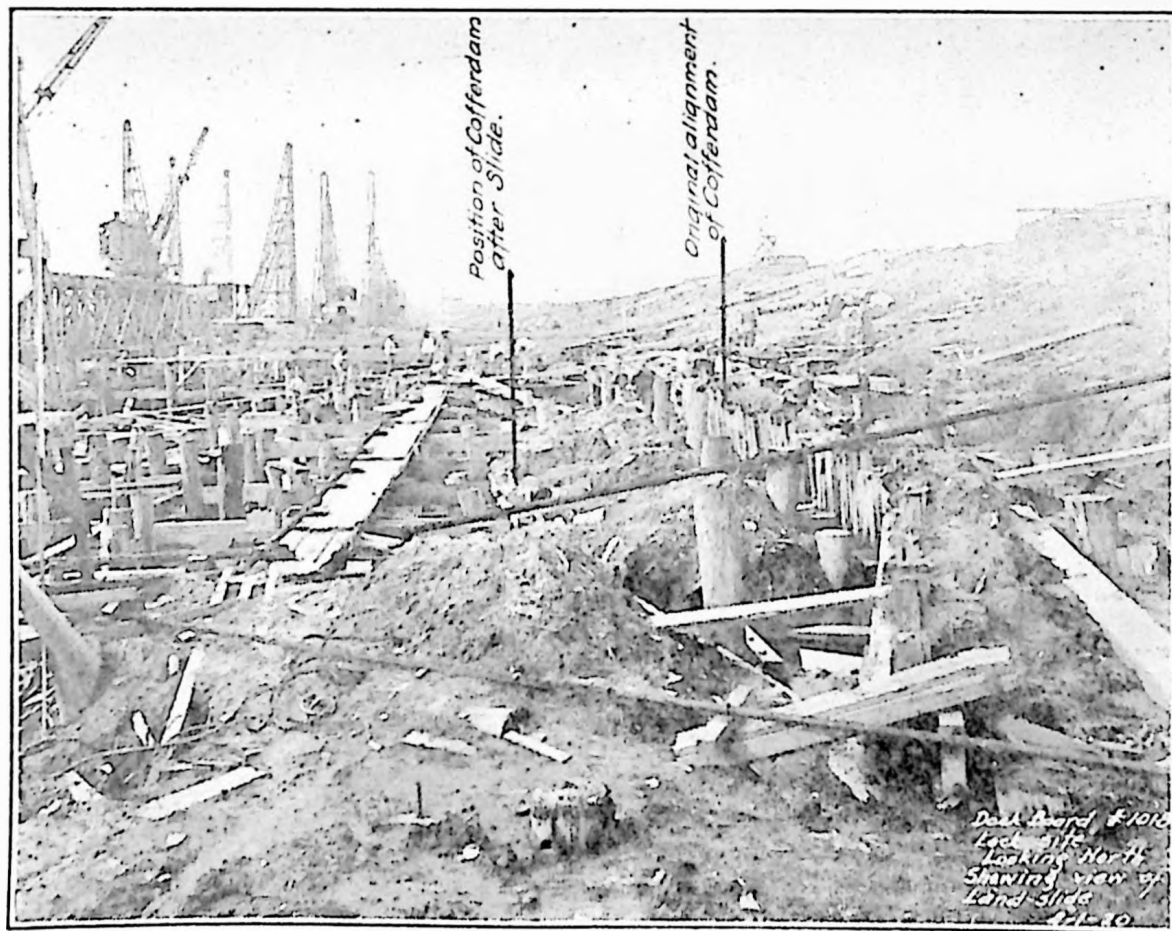


FIG. 6. SOUTHEAST CORNER OF INNER WOODEN COFFERDAM

just outside the outer masonry line of the lock. With such cofferdam enclosing a comparatively smaller area, it would then be feasible to install a system of cross bracing of sufficient strength to prevent a collapse of the coffer should any further bank movements occur. It was also decided to relieve the pressure in the quicksand strata by means of a series of small artesian wells.

(a) The Steel Cofferdam.

At this time it was now possible to procure steel piling, and accordingly, an order was placed for fifty-foot interlocked, arch web type, Lackawanna steel piles. These were driven so as to form the inner and final cofferdam shown in figures 3 and 4.

Of its type, this is one of the largest cofferdams of steel ever driven. A couple of points gathered as to methods of driving are worthy of mention. Wooden waling strips, with a slot between, were set up fastened to special wooden piles, for the purpose of guiding the steel piles while being driven. It was found, however, that in driving through material as compact as are the layers of quicksand when confined, the piles had a tendency to drift or slant sidewise in the direction of the groove between the waling guides. This tendency was cumulative. This would have necessitated the use of a great number of special wedge-shaped piles at frequent intervals in order to restore verticality. To overcome this and to minimize the purchase of special wedge piles, teams of two drivers were employed in setting the piles, as follows: One driver would back away and set up 50 to 100 linear feet of the cofferdam, the piles merely being placed in proper position and allowed to sink as far as they would of their own weight, without being driven. The second driver, moving forward, would then follow, always keeping at least 50 feet from the first driver, and drive the piles home. The resistance to drift afforded by the piles already set up, aided by the effect of those already in place, made it possible to maintain verticality with little further trouble, and as a result, in a cofferdam whose perimeter is 2,650 feet, only 30 wedge piles had to be used, or an average of one wedge pile per 88 linear feet of dam.

(b) The Artesian Wells.

With the static head in the third quicksand stratum always present as a source of possible danger tending to cause a blow-up of the bottom, it was decided to sink some ten-inch steel pipe into the quicksand for the purpose of relieving this pressure. There were no means of determining accurately the total quantity of water that would flow into that portion of the stratum below the lock, in any given time. Some sort of a rough guide was essential, however, in order to determine the approximate number of pipe that would be necessary to handle the greatest amount of water that might be expected. It was assumed for the moment that the flow of water through the third quicksand stratum, should the pressure therein be relieved from above, would be the same as would exist in a slow sand filter of the same material and operating under the same head. Mr. Allen Hazen gives a formula for the velocity of flow of water through sand.*

By making certain arbitrary assumptions to fit the conditions of the problem at hand, and believing that the static head in the quicksand was due to the river, an approximate value for V was obtained, which, when applied to the formula for discharge through a given area, gave a result showing that between 1,000 and 2,000 gallons per minute might be expected to flow into and from the quicksand stratum concerned. The higher limit was adopted for further development. Bearing in mind that the velocity of water in any pipe should not be sufficient to force up any sand through a gravel filter at the bottom of the pipe, it was then determined that 130 ten-inch pipe might be expected to accomplish the relief required. It is here desired to emphasize the fact that the result obtained was intended to furnish only a rough guide for future steps, and not a definite conclusion. It merely gave the *least* number of pipe that *might* fulfill conditions. This number was therefore

$$*V = \frac{cd^2h}{1} \left(\frac{10^6}{60} + 10^6 \right)$$

For application of this formula, see page 932, American Civil Engineers Pocket Book, Second Edition, 1912.

decided upon as a starter, to be increased later on, should conditions so demand.

Accordingly, 130 pipe were driven to penetrate the quicksand stratum beginning at —55. They were located just inside the steel cofferdam on 20-foot centers, with tops at about elevation zero. See Figures 3 and 4. After driving, the pipes were excavated, and gravel was forced down and beyond the bottom of the pipe, forming a bulb which acted as a filter. Gravel was also placed in the pipe proper for a distance of ten to twelve feet from the bottom. In each pipe about 10 cubic feet of gravel were thus employed, and the result, in all cases, has given a flow of absolutely clear water without any tendency toward clogging of the gravel filter below.

While the second quicksand stratum was now virtually cut off from the lock by two cofferdams, one of wood and one of steel, it was nevertheless deemed advisable to dry out the stratum by a similar system of artesian wells, in order to guard against possibility of further bank movements. The quicksand, if dry, will not flow, and all the breaks and slides which had previously occurred were undoubtedly caused, first of all, by the flowing out of quicksand from below. A similar method of approximating number of pipe required was employed, and 56 of them were driven in two rows, 100 feet center to center in each row, the pipes in one row being staggered with respect to the pipes in the other row. One line was placed between the inner wood and the steel cofferdam, and the other just outside the inner wooden cofferdam. See Figures 3 and 4.

For convenience of future reference, the row last named is called the "A" line; the row between the the wood and the steel cofferdams the "B" line, while the row inside the steel cofferdam is termed the "C" line.

It was found, after the three pipe systems had been installed, that the flow from the "A" and "B" pipe at elevation zero was very small. The average flow per pipe amounted only to 1.4 gallons per minute. It was necessary to induce a greater flow in order to dry out the second quicksand stratum to the desired degree. To accomplish this, small pumps were installed and connected up so that each pump served from 5 to 7 "A" and "B" pipe. These pumps were intended to keep the level

of water in the pipe at -18 , and under actual operating conditions there has been no difficulty whatever in maintaining this water level.

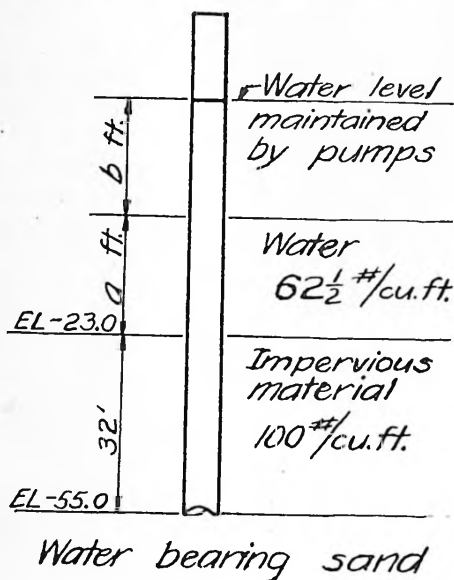
At this point, an experiment was conducted to ascertain whether, under the induced flow, there would be any danger of the gravel filters at the bottom of the pipes clogging. One "A" pipe and one "B" pipe were connected up to a pump, and the latter was operated for 10 consecutive days at a rate to keep the water in the pipe at -18 . The flow increased in the two-pipe to about 10 gallons per minute. At the end of the period the filters had proven adequate and indicated no tendency towards clogging. It was also interesting to note the sensitiveness of the artesian well system, which at once gave promise of the sufficiency of the relief measures provided. During the experiment mentioned, the water in the next adjacent "A" and "B" pipes, which, be it remembered, were not connected to a pump at this time, ceased to flow and fell ten feet; simultaneously the water in the "A" and "B" pipe next removed fell five feet. In other words, the effect of operating only one pipe in each line was felt to a distance of 200 feet on each side. The effectiveness of the system was established; and the conclusions that the quicksand stratum was continuous and that the static head therein could be satisfactorily relieved were further verified.

Naturally, the flow of water in the "C" line was greater than that in the "A" and "B" lines. It amounted when the C pipes were flowing at zero, to an average of 3.5 gallons per minute per pipe. The method of handling the "C" line did not require pumping. As the pipes were inside the steel cofferdam and driven on a line where they entered the ground at about -18 , this left about 18 feet of each "C" pipe exposed. It was intended to punch out holes in the pipe so that, as the water in the lock was lowered, the "C" line would flow at whatever elevation water in the prism might be. As a matter of fact, as soon as the flow in the entire "C" line had been satisfactorily established, the pipe were immediately punched at -10 , it being the intention, as will be explained, to call a halt here in order to complete the bracing system.

A scheme was now devised by means of which it would be possible to tell during unwatering of the lock, whether a point

was being reached which would bring the upward pressure of the water in the third quicksand stratum in equilibrium with the weight of the overlying material; in other words, whether the danger mark at which the bottom quicksand stratum might blow up was being approached. Five ten-inch pipe were sunk into this quicksand layer, 200 feet apart along the center line of the lock, excavated and provided with gravel filters just like the other artesian wells. This line is called the "D" line. See Figure 4. The pipe in this line were left open at the top, but were carried to such an elevation (about +4) that they would not overflow. In other words, a sort of barometer was thus provided in which the water could rise and fall, but not flow off.

The figure below illustrates one of these pipe.



The distance from the bottom of the lock excavation to the third quicksand stratum is 32 feet.

Let a = depth of water at any time in lock prism.

Let b = difference in elevation between water in pipe and water in lock.

Assume weights of material as indicated in figure.

The upward pressure at any time is equal to weight of water in pipe $= (32 + a + b) 62.5$

And downward pressure on quicksand stratum at any time $= 32 \times 100 + 62.5a$

For equilibrium, we have

$$(32 + a + b) 62.5 = 32 \times 100 + 62.5a$$

Whence, $b = 19.2$ and remains constant, a cancelling from the above equation. In this deduction, the fractional cohesion of the material acting as a further resistant element against a blow-up from the bottom was indeterminate and hence neglected. It undoubtedly would have had some favorable effect, but the error introduced is on the side of safety.

This showed that if, at any time, the elevation of the water inside a "D" pipe should be 19 feet above the elevation of water in the lock prism, a condition of equilibrium would exist between forces acting downwards and water pressure upwards. Stated in other words, if at any time the difference of elevation between the water in the "D" pipe and the water in the lock prism were less than 19 feet, there could be no danger of the bottom of the lock blowing up. It was to be expected that as the water in the lock prism fell and the "C" pipe were allowed to discharge themselves at successively lower elevations, the water in the "D" pipe would also fall. It was also to be expected that while the water in the "D" pipe would fall, it might lag somewhat behind the fall of water in the lock prism. Thus the "D" pipe were to serve as possible danger signals during the unwatering operation.

(c) The System of Cross Bracing.

It was now necessary to take steps to prevent collapse of the cofferdams, should any bank movements occur when the water should be further lowered. The steel cofferdam was braced transversely from side to side by means of 10" x 10" timbers, fastened to and partially supported by piles driven for this purpose. These braces were placed on about 15-foot centers, corresponding to unit monoliths decided upon for the construction of the concrete floor. In addition to bracing steel to steel, the steel cofferdam was likewise braced to the inner wooden cofferdam and provision was made for bracing the ends of both cofferdams against the system of transverse braces. The result was to form an incollapsible box, capable of resist-

ing any pressure likely to be brought about by small bank movement. This system of braces tied into the cofferdams at about zero elevation. See Figure 7. It was further intended when the water in the prism had been lowered to -10, to install a supplementary set of similar braces directly under the first set and trussed thereto by X members. This was to gain desired stiffness, it being impracticable, for later construction reasons, to employ horizontal stiffeners between braces.

(d) The Unwatering Plant.

The plant required for the unwatering operation comprises 12 Worthington duplex pumps, capacity 57 gallons per minute at a piston speed of 150 feet per minute for pumping out the "A" and "B" pipe. These pumps are all driven by compressed air.

The compressor plant was located near the north end of the lock and includes 8 steam-driven Westinghouse 10½" cross compound air compressor units handling 150 cubic feet per minute at 80 to 100 pounds per square inch. Compressed air is used for other features of constructive work, and a multiple, rather than a unit system, was installed in order that part might be cut out from time to time for repairs and adjustment. It must be remembered the pumps on the "A" and "B" line have been working continuously 24 hours a day, and must still be kept in service until the lock floor and part of the walls shall have been completed. Hence, possibility of interrupted air service could not have been countenanced.

Two unwatering pumps were installed at the north end of the lock. They are of the motor driven, centrifugal type, having a capacity of 2,200 gallons per minute, with 8" discharge and 10" suction lines.

In order to provide means for immediately refilling the lock in case of accident, another motor driven centrifugal pump, capacity of 2,200 gallons per minute, was installed north of the lock. The intake was from the water in the canal. Adjacent to this pump, two auxiliary siphons were installed, built of 10" pipe, to aid, if necessary, in refilling.

All of the operations described and required to prepare for the further lowering of the water in the lock prism, con-



FIG. 7. CROSS BRACING AND FINISHED SECTION OF LOCK EXCAVATION

sumed the time between May and November, 1919. During this interval the work was tied up six weeks on account of a strike of skilled labor.

The Third and Final Step.

On Nov. 18, 1919, the Worthington pumps were started and from that date on the water in the "A" and "B" pipes has been maintained at elevations varying from —15 to —18. For the first 10 feet, in anticipation of a possible movement of the banks, due to further oozing of the upper quicksand stratum, the water was lowered approximately one foot on alternate days, and the other days were reserved for observation. The following schedule indicates rate at which water was lowered during this first period. At the start, the water in the lock prism was at elevation —1.

Date.	Water elevation Reached in lock prism.
Nov. 19	—2.5
21	—3.5
23	—4.5
25	—5.5
27	—6.5
29	—7.5
Dec. 1	—8.75

At latter elevation pumping operations were discontinued to allow the supplementary line of bracing, already mentioned, to be installed. It took from Dec. 1st to Dec. 25th, 1919, to install these braces.

On Dec. 26th pumping operations were resumed and continued in accordance with the following schedule, it being regarded as unnecessary to suspend pumping on alternate days for observation purposes:

Date.	Water elevation Reached in lock prism.
Dec. 26	—11.4
27	—12.5
28	—13.6
29	—14.5
30	—15.5

At this point pumping operations were suspended for three days in order to determine whether the lag in fall of water in pipe D—1 was due to local influence or otherwise. This will be discussed below.

Pumping operations continued:

Date.	Water elevation Reached in lock prism.
Jan. 3	—16.5
4	—17.5

During the unwatering process, transit and level readings were taken twice daily on established points along the banks of the lock, and along the wood sheet piling; level readings were also taken on points established on piles in the lock prism. The former were for the purpose of determining any tendency of the banks to move, and the latter for the purpose of noting any tendency of the bottom to heave up. The inner line of wood sheet piling moved inward a maximum distance of three inches. Further movement was arrested by the braces. This movement was not accompanied by any bank movements visible to the eye and was noticeable by the transit readings only. But the installation of the bracing system was plainly justified.

Attention is now invited to Figure 8, which shows graphically the behavior of pipes in the D line during the unwatering program. It will be noted that the fall of water in the "D" pipe has practically been uniform with fall of water in the lock. In the case of pipe D—1, the peculiar performance noted between Dec. 12th and Dec. 20th is due to an abnormal condition resulting from disturbances around the bottom of the pipe produced by pile driving. The filter at the bottom of the pipe was undoubtedly affected on account of the sudden jets produced under the blows of the hammer, and the water would be impelled into the pipe under this jetting, but fail to fall of its own weight through the deranged filter as rapidly as it had driven. When pile driving in the immediate vicinity of this "D" pipe had been completed, the water gradually fell, since which time the pipe has been acting normally. This was the reason for putting into service and starting pipe D—1—A, as it was not known whether D—1 could be further relied upon.

Attention is also invited to the note at the top of this figure. This note explains the practically constant fall of the "D" pipe with respect to the water in the lock while the latter was above an elevation of -10 . On account of the mud line close to the steel sheet piling where the "C" pipe were driven, it has been impracticable to tap the "C" pipe below elevation of -14 . The tapping was done at about three-foot intervals and the irregular curves for the "D" pipe are thus explained.

Pumping operations were suspended when a water elevation of -17.5 had been attained, as noted. This was done so as to leave the bottom in a soupy, saturated condition, facilitating the clean up excavation to final grade. The methods employed to accomplish the cleaning up of the bottom cannot be described in detail within the limits of this paper. Suffice it to say that the material remaining was sluiced out by means of powerful hydraulic jets and the water, with material in suspension, removed by specially designed centrifugal pumps. With the completion of this clean-up work in certain sections, it is now gratifying to be able to state that the lock has been successfully unwatered as far as an elevation of -23 . In fact, at the north end, an elevation of -25 at one point has been reached without danger, where it was necessary to provide a temporary sump for collecting water. It is also interesting to note that the second quicksand stratum, so treacherous and difficult to deal with when unconfined, is now so hard in many sections inside the lock where it has been laid bare, that a man can walk on it without leaving as much as the imprint of his shoe.

It is unfortunate, in a problem as interesting and critical as this has proved to be, that laboratory methods cannot be carried to the field without undue cost. If this were possible, much of interest and value in the way of accurate data on the hydrostatics and hydraulics involved might have been gained. However, it may not be amiss to include here the following general observations made with reference to the flow of water in the various relief pipe systems.

During the unwatering operation, it was not possible to obtain any pipe flow data of sufficient value to go on record.

In the case of the pipes of the "A" and "B" lines, while effort was made to maintain the water level in these pipes at about -18, practically speaking it was almost impossible to regulate the speed of the pumps to make sure of uniformity in this respect. For these reasons, the flow from any individual pipe could not be measured with any accuracy. It may be noted in passing that the supply of water reaching the "B" pipes was more limited than that which got to the "A" pipes. This was to be expected, however, for the reason that the portion of the stratum relieved by the "B" line was supposedly cut-off by a wooden cofferdam. A phenomenon difficult to explain is the fact that the discharge from groups of "A" and "B" pipe at the north end of the lock—farthest from the river—is nearly double that from the groups at the south end.

Data on the "C" pipes is likewise lacking for the following reasons: When lowering the water in lock prism from -1 to -10, the "C" pipes were discharging through orifices punched at -10. Consequently the discharge could not be measured. During the second phase of the final unwatering program, the "C" pipe were punched every two feet or so. and above the water level in the lock, but there was not sufficient time to get discharge data. It is interesting to note that the "C" pipe system is now so sensitive, that punching a hole in any "C" pipe as much as one foot below the discharge orifices in the immediately adjacent "C" pipes practically stops the flow from the latter.

It should also be noted that during the majority of the time that the unwatering operation was taking place, the Mississippi river was at + 33, or within about 6 feet of maximum recorded flood stage.

Conclusion.

Continual vigilance is still necessary to guard against an accident. The water in the pipe of the "A" and "B" lines is still being maintained at about -18. The "D" pipe are being watched constantly. Points established along the banks are being read periodically by instruments. All this must continue until the lock has been so far completed that, with part of its backfill, its weight will be sufficient guarantee to war-

rant discontinuance of the safety devices being employed. The whole problem has been an interesting one and unique in the way material of the class encountered has been dealt with. It merely goes to furnish another forcible illustration of the fact that the profession of engineering still remains an art, in which imagination and some new application always plays a part, and that the day when this same profession shall be called an exact science is, fortunately or unfortunately, in the future.

The methods employed to unwater the lock were devised by Mr. Geo. M. Wells,* of Geo. W. Goethals & Co., Inc., Consulting Engineers for the Dock Board. Mr. R. O. Comer, Designing Engineer on the Dock Board, made many of the investigations and worked out many of the details in collaboration with Mr. Wells. To these two gentlemen the writer is indebted for data obtained prior to his connection with the work.

Mr. J. Devereux O'Reilly was Chief Engineer up to Nov. 1, 1919. Under his direct charge, 99% of the details and safety devices for unwatering the lock were installed.

General Arsene Perilliat became Chief Engineer Nov. 1, 1919, and under his administration the final unwatering operation took place.

Mr. James Cosgrove was Superintendent of Construction during the entire time and was in direct field charge of all the installations and operations herein described.

*Member American Society of Civil Engineers.

MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY.

Regular Meeting of the Board of Direction, April 12, 1920.

The regular meeting of the Board of Direction was called to order with President Riess in the chair and Messrs. Lawes, Moses, Robert, Barelli and Williamson, present.

Ballots for new members were opened. There were 73 regular ballots and 4 irregular ballots cast, as a result of which the following were elected to membership:

Resident Members—Marion J. Epley, Thomas P. Johnston, Errol E. Kelly, Solis Seiferth, Lewis Campbell Smith, Theron H. Tracy.

Transfer from Junior to Resident Member—Ashley Colongne.

Transfer from student to Resident Member—D. B. H. Chaffe, Jr.

Non-Resident Members—John M. Jenks, Herbert H. McGehee.

Associate Member—Arthur T. Gomila, Sr.

Student Members—Robert Lee Atkinson, Clarence Leonard Jones, Ralph H. Mann, Louis J. Wyler.

Upon motion duly seconded the New Orleans Item was placed on the mailing list of the Society.

The action of Mr. J. F. Coleman in extending an invitation to members of the American Society of Civil Engineers to be our guests on their way to the convention at Houston in October was ratified.

The report of the Secretary was read and approved and bills ordered paid. There being no further business, the meeting was adjourned.

JAMES M. ROBERT, Secretary.

Regular Meeting of the Society, April 12, 1920.

The regular meeting of the Society was called to order with President Riess in the chair and 91 members and guests present. The minutes of the previous meeting were read and approved.

The proposed changes in the license law for engineers were brought up for a second reading and upon motion of Mr. Coleman seconded by Professor Gregory, the motion was carried that the Society lend its endorsement to the proposed legislative action.

Mr. Marcel Gausaud reported that the Committee on the relations between engineers and contractors had held a meeting and decided that the material to be investigated would justify the continuation of this committee for investigation and recommended that the committee would consist of three engineers and three contractors. The motion was carried.

The Nolan Bill regarding Patent Legislation was brought before the meeting and a motion was made, seconded and carried that it was the sense of the meeting that the Nolan Bill be approved and the Secretary was instructed to write the two U. S. Senators to this effect.

This being a joint meeting of the Louisiana Engineering Society and the Local Section of the American Society of Civil Engineers, President Dusenbury of the Local Section was then called to the chair.

The technical exercises of the evening were then proceeded with and Col. G. R. Goethals read a most interesting and instructive paper en-

titled: "The Lock Foundation, Inner Harbor Navigation Canal, New Orleans, Louisiana—The Problem and the Solution." This paper was thoroughly enjoyed by all present and the meeting tendered a rising vote of thanks to Col. Goethals.

Dr. J. A. L. Waddill, the noted bridge engineer, was also present and made a few remarks.

There being no further business to come before the meeting, same was adjourned to the usual collation.

JAMES M. ROBERT, Secretary.

Regular Meeting of the Board of Direction, May 10, 1920.

The regular meeting of the Board of Direction was called to order with President Riess in the chair and the following members present: Messrs. Williamson, Barelli, Moses, Lawes, Robert.

The following applications for membership were ordered to the ballot subject to complete endorsement and the approval of the Membership Committee:

George B. Gibson, Meyer Godehaux, Lewis G. Heider, Allan J. Negrotto, Marion C. Huckaby, J. A. Brennan, Charles G. Lowe, Edward T. Malloy.

The Secretary's report was read and approved and the bills ordered paid. There being no further business, the meeting was adjourned.

JAMES M. ROBERT, Secretary.

Regular Meeting of the Society, May 10, 1920.

Meeting was called to order with President Riess in the chair and 42 members and guests present. Minutes of the previous meeting read and approved.

Profesor Gregory spoke of a moving picture lecture to be given by Mr. W. M. White in New Orleans on June 4th, and suggested that the date of the next meeting should be placed on that date.

President Riess called attention to the fact that President Dinwiddie of Tulane University had asked the co-operation of the Louisiana Engineering Society in a drive that was about to be organized to secure additional funds to meet the necessities of the University. On motion of Professor Anderson, seconded by Messrs. Crump and Garsaud, it was decided that this Society offer to heartily support the drive and authorized the President to appoint a committee of five men to co-operate with the General Citizens' Committee during this campaign.

The technical exercises of the evening were then proceeded with and consisted of a paper by Mr. William Crooks of Pine Bluff, Arkansas, entitled: "Power Transmission Equipment." In the absence of Mr. Crooks, Professor Anderson read the paper, which, with the discussion which followed was enjoyed by all. There being no further business to come before the meeting, same was adjourned to the usual collation.

JAMES M. ROBERT, Secretary.

PROCEEDINGS OF THE LOUISIANA ENGINEERING SOCIETY

VOL. VI

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No. 4

CONTENTS

EDITORIAL NOTES AND COMMENT :	PAGE
Electric Transmission Lines	161
The Federated American Engineering Societies	162
The Ethics of the Engineer	171
To Counteract Shorter Hours	176
New Members	176
Recent Additions to the Library	177
BOOK REVIEWS	179
PAPERS AND DISCUSSIONS:	
Power Transmission Equipment. <i>By William Crooks</i>	181
MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY	191

EDITORIAL NOTES AND COMMENT

Electric Transmission Lines. The efficient industrial development of any community or country is dependent almost entirely upon an adequate supply of mechanical energy, or as it is more often called, power. The supply of energy must be located either directly at the point of utilization, or it must be in such form as to permit of easy transportation or transmission to the place at which the industry is to be located. Thus one finds the older industrial communities of this country situated close to available sources of water power, near existing supplies of fuel, such as coal and oil, or at sea-ports closely connected by trunk lines of railways with coal fields. The electric transmission line is simply another method of transporting such supplies of energy to points at which they may be most conveniently and efficiently utilized.

The paper by Mr. William Crooks, Chief Engineer of the Arkansas Light and Power Company, read at the May meeting of the Society, and published in this issue, deals with the general problem of transmission line construction and equipment. The first points discussed are those of the standardization of voltages for transmission lines, with a suggestion as to the maximum values toward which current practice is approaching; the relation between distance of transmission and voltage and the relation between spacing of the wires and voltage. There is also a brief discussion of the principal factors to be considered in the location of the line, in somewhat the same way that such factors must be taken into account in the location of a railway.

Relative advantages and limitations of pin type and suspension type insulators are considered, and there is a general discussion of the problem of protection from lightning and other line phenomena of a similar nature, and there is a very brief statement concerning the types of transformers to be used.

The Federated American Engineering Societies. Below is given a brief outline of the actions of the Joint Conference Committee which convened in Washington, D. C., June 3-4, 1920, at which this Society was represented by Professor W. B. Gregory.

STATEMENT FROM THE COMMITTEE.

In response to the call issued April 19, 1920, by the Joint Conference Committee representing the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, 140 delegates representing 71 societies, having an aggregate membership of over 110,000, convened in Washington, D. C., June 3-4, 1920. The program of this Organizing Conference, an abstract of the proceedings, and a list of the societies represented and of their delegates, are appended.

The Organizing Conference was thoroughly representative as will be seen from the attached list. National, local, state and regional engineering organizations from Maine to California and from the Gulf to the Lakes had delegates in attendance. The gathering is unparalleled and marks a forward step in the history of the engineering and allied technical societies of this country. The Conference had two distinct characteristics, the business sessions which moved smoothly and harmoniously, voicing the unanimous desire of the engineering societies of this country for a comprehensive organization as planned by the Joint Conference Committee, and the sessions at which addresses of an inspirational character were presented. The deliberations were characterized by great harmony and form of organization, including constitution and by-laws, was adopted without a dissenting vote. Assuming that the delegates in attendance reflect the spirit of the organizations they represented, it is evident that there is a widespread and unanimous desire for some form of comprehensive organization that will represent the solidarity of these professions.

The Joint Conference Committee will issue to your organization a formal invitation to become a member of The Federated American Engineering Societies and to send delegates to the American Engineering Council, which is expected to hold its first meeting early in November, as well as the Constitution and By-Laws that have been adopted; the call for this meeting announcing the time and place will in due course be issued by the Joint Conference Committee. It will also send you at a later date the proceedings of the Organizing Conference including the addresses.

The Joint Conference Committee feels that it reflects the unanimous judgment of the representative body of engineers who attended the Organizing Conference in Washington when it states that at this historic meeting action of the greatest importance to the future of the engineering and allied technical professions was taken in the formation of a comprehensive organization that will represent these professions in a service dedicated to the city, state and nation.

The Joint Conference Committee would strongly urge the engineering and allied technical societies of this country to take immediate action in the matter of becoming members, appoint at an early date delegates to participate in the first meeting of the American Engineering Council and in all ways "do their bit" in making eminently successful the new organization which shall speak for these professions in all matters affecting the public welfare, wherever technical knowledge and engineering experience are involved, and on other matters of common concern to the public and to these professions.

FUNDAMENTAL PRINCIPLES OF THE ORGANIZATION.

Resolved, That it is the sense of this Organizing Conference that an organization be created to further the public welfare wherever technical knowledge and engineering experience are involved and to consider and act upon matters of common concern to the engineering and allied technical professions.

Resolved, That it is the sense of this Conference that the proposed organization should be an organization of societies or affiliations and not of individuals.

SALARIES OF ENGINEERING TEACHERS.

"Whereas, in order to maintain and improve the standing of the engineering profession, it is necessary that teachers in engineering colleges be competent, content and adequately paid;

And Whereas, the average of the salaries at present paid are insufficient to retain teachers of adequate experience, now therefore,

Be it Resolved, That it is the sense of this Organizing Conference that all those in responsible authority be urged to increase the salaries of such teachers to an amount that will attract and keep the best engineering talent."

DEPARTMENT OF PUBLIC WORKS.

"Whereas, the engineering societies of the country, through a conference which met in Chicago in April, 1919, did initiate an effort which has resulted in the demand for the organization of the administrative branch of the National Government

by creating a Department of Public Works to embrace the major constitutional and engineering activities of the Government;

And Whereas, a measure is now pending before Congress (H. B. 6649—S. 2232, 66th Congress, First Session), providing for the creation of such a Department; now therefore,

Be it Resolved, That this Organizing Conference endorse the bill in question and the efforts of the National Public Works Department Association in support thereof."

CLASSIFICATION OF TECHNICAL EMPLOYEES.

"Whereas, the Reclassification Committee heretofore appointed by Congress has now rendered a report containing among other things, a recommendation as to the classification of the technical employes of the various governmental departments and a schedule of salaries to be paid such employes; now therefore,

Be it Resolved, That it is the sense of this Organizing Conference that the necessary legislation should be promptly enacted by Congress to give effect to the principles of such report.

OPENING ADDRESS—ORGANIZING CONFERENCE.

By Richard L. Humphrey, Chairman,
Joint Conference Committee,
Consulting Engineer, Philadelphia, Pa.

I esteem it a high honor as well as a privilege, as Chairman of the Joint Conference Committee, to call this Organizing Conference to order.

We are met to consider some of the most important questions that have ever confronted the engineering and allied technical professions in this country; the results of our deliberations will have a far-reaching effect on the future of these professions.

We must decide whether there shall be formed a comprehensive organization that can speak for these professions in public affairs where technical knowledge and engineering experience are involved, as well as on other matters that are also of common interest,—or, whether our respective societies shall, as heretofore, pursue their separate ways and only occasionally co-operate in matters of common concern.

The problem is of national as well as of local importance and because of this importance, any decision reached shall reflect the judgment of all here represented.

The American Society of Civil Engineers was founded in 1852 for "the advancement of engineering knowledge and practice and the maintenance of a high professional standard among its members." Subsequently the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers and later the American Society for Testing Materials and the American Railway Engineering Association and other national engineering societies were formed. The activities of these societies are almost entirely technical. In addition to the numerous national societies that have been organized to care for special lines of engineering and allied sciences, local engineering societies and clubs, as well as state and regional engineering and allied technical organizations have been formed. These organizations carry on their activities, generally, independently of each other.

As these organizations increased in number it became evident that it was desirable to so federate them that there would be a representative body that could speak for these professions. The matter was under consideration prior to the war, and with its advent the desirability of this federation became more apparent.

Engineering is defined "as the art of organizing and directing men and of controlling the forces and materials of Nature for the benefit of the human race." The growth and development of this country has been largely a matter of engineering. The European war, because of the brilliant work of the engineer, brought the universal recognition of his importance in its successful prosecution; it awakened the public to a keener realization of the service of the engineer and awakened in the engineer a desire for greater service to the public—a desire to do his part in the successful administration of the affairs of the nation. The engineer has, therefore, changed his viewpoint from the somewhat narrow one of following his profession exclusively, to the broader one of unselfish devotion to the common cause.

This meeting marks the culmination of many years of efforts that have been made to bring about the formation of an all inclusive organization and these efforts have been crystallized during the last two years by the work of the Joint Conference Committee, representing the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers.

An all-inclusive organization of the engineering and allied technical professions has been advocated for a long time; the need for such a comprehensive organization in which all the engineering and allied technical societies of this country could be represented has been apparent for many years.

The first step toward meeting this need was taken June 27, 1917, when the representatives of the four above named Societies organized the Engineering Council "to provide for consideration of matters of common concern to engineers, as well as those of public welfare in which the profession is interested, in order that united action may be possible."

The American Society of Civil Engineers, June 18, 1918, adopted a resolution—which stated "Sociological and economic conditions are in a state of flux and are leading to new alignments of the elements of society." "These new conditions are effecting deeply the profession of engineering in its service to society, in its varied relationships to communities and nations and in its internal organizations,"—and authorized the appointment of a Committee on Development to make "a broad survey of the functions and purposes of the Society in order that an intelligent and effective readjustment be accomplished so that the Society may take its proper place in the larger sphere of influence and usefulness now opening to the profession." The relations of the Society to other Societies and to the profession generally were also included.

This action was followed by the appointment of similar committees by the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Mining and Metallurgical Engineers. These committees appointed conferees who met and organized the Joint Conference Committee; its purpose was to determine in

what manner these four societies could co-operate in non-technical or welfare work affecting the relations of the engineer to, and his services in public affairs. This committee presented a report to these societies in September, 1919; at the meeting held in New York, January 23, 1920, the governing boards of these societies of Engineering Council, the American Society for Testing Materials and the trustees of the United Engineering Society, unanimously requested the Joint Conference Committee to call, without delay, a conference of representatives of national, local, state and regional engineering organizations of this country, for the purpose of bringing into existence the comprehensive organization recommended by the Joint Conference Committee.

In compliance with this request the Joint Conference Committee issued an invitation to 110 engineering and allied technical organizations and societies; these represented an aggregate membership of over 120,000, who under the conditions of the call were entitled to send 184 delegates to this Organizing Conference. The list included all societies, organizations or affiliations, not associations, sections, chapters or branches of national societies, whose chief object is the advancement of the knowledge and practice of engineering and the application of allied sciences and who are not organized for commercial purposes.

This conference is thoroughly representative. There are in attendance delegates representing over 60 per cent of the organizations invited. These delegates, over 70 per cent of those who could attend under the conditions of the call, represent organizations having an aggregated membership of over 100,000, or 83 per cent of the membership of all the organizations and societies invited.

This splendid response from the engineering and allied technical organizations of this country to the invitation to attend this Conference, to consider the desirability of welding the engineers of this country, through their respective societies or organizations, into a comprehensive body for united action in non-technical or welfare work, is evidence that there is a general desire on the part of the engineers and allied technologists in this direction.

It is believed that this is the first attempt that has been made to hold a conference for the purpose of discussing the possibilities of such an organization; I think you will agree with me on the evidence of this representative attendance the organizations represented look with favor on the fundamental principles involved.

On behalf of the Joint Conference Committee and of the societies which it represents I desire to thank you and through you the societies and organizations that you represent for your co-operation in making this Conference so successful.

This is an auspicious occasion and is fraught with great potentialities for strengthening and advancing the engineering and allied technical professions in this country. It is one of the most important gatherings that has ever been planned; it can be considered a success—if harmony is its outstanding characteristic—for it is only through harmony that we may achieve the results that will ultimate in the greatest success.

We are met not to discuss details but to use our very best endeavors to reach an harmonious agreement as to fundamental principles involved and leave the working out of details of whatever plan that may be agreed upon to the governing board of the new organization.

I would suggest that this problem be approached with an open mind and that the discussion be on a broad, unselfish plane, having but one object, namely, the good of the engineering and allied technical professions.

The Joint Conference Committee may perhaps be criticised for having unduly usurped authority or taken action that may not be approved by this Conference, but I think you will agree with me that it was necessary for somebody to undertake to complete the arrangements, if the Conference was to be a success and in making these arrangements the Committee had of necessity to decide the many questions that arose in connection therewith. There was no desire on the part of any member of the Committee, of which I have the honor to be the chairman, to take any action or to be actuated by any other motives than those that were for the best interest of the cause. Action has always been taken by the committee with the undersanding that it would be subject to the approval of the

comes one of the noblest trees of the forest, so from this ethical germ a code expands to guide and direct both professional and lay people.

Moses brought down from Mount Sinai the tablets upon which were writ the ten commandments; eight of these are prohibitive and begin "Thou shalt not," and their observance is as wholesome today as when they were revealed to the tribes of Israel as they wandered in the wilderness. They designate the harm that one must not do to his fellowman, but do not suggest the good that one may do for or to him. After the promulgation of the Decalogue, fifteen hundred years elapsed before the good Samaritan answered for all time the question, "Who is my neighbor?" From "wells of ancient inspiration" we draw many undying truths, and none of these is truer than this: "No man liveth unto himself." The fact of being a man establishes kinship to the human family, and utter isolation from all the members of that family is impossible. The debt of service is a debt of honor, and how best to discharge that debt should be the desire and the effort of every honorable man.

THE ETHICS OF RIGHT LIVING.

This being true, why should engineers need more than the common, every-day ethics of right living, which are applicable to every avocation, calling or profession?

The honesty which is unswerving.

The truthfulness which abhors a lie.

The helpfulness which lightens the burdens of life.

The human sympathy which gladdens aching hearts.

The honor which scorns to take a mean advantage.

The courage which always dares to do right, and

The courtesy of kindliness.

These are the branches which the germ of ethics sends out.

The engineer has obligations, a few of which may be adverted to.

In accepting an engagement in any field of service in which he has not already proven his attainments to be equal to the task, he should be frank with his client and state just what his previous experience has been and give the reasons which, in his judgment, justify his undertaking the contemplated

work. Many a man has had responsibilities thrust upon him by clients who, though fully aware of his lack of previous experience in the field which they wished him to enter, recognized in him resourcefulness, good judgment, industry and frank honesty, which they believed fitted him to carry the new responsibility to a successful issue; and not often has he failed.

THE FUNCTIONS OF THE ENGINEER.

which is being done by a contractor, individual or firm, at once exercises two functions—one requiring engineering knowl-

The engineer, in responsible charge of construction work edge, skill and experience; the other, judicial fitness. He becomes the arbiter between the principal, man, firm or corporation for whom the work is being done and whose money is paying for it, and the contractor who is doing the work. He must be a just judge, executing righteous judgment between the parties to the contract, without fear or favor. The fact that his client, the principal or first party to the contract, pays him must not have the value of a pennyweight in tipping the scale in favor of the source of his income. The engineer owes his client an allegiance demanding intelligent, conscientious and diligent service. That he owes, but his debt demands for its liquidation no act, no word, which would compromise his integrity or offend his sense of justice and right.

The engineer's obligation to serve is not limited to the duties for which he is paid; he owes it to his equals in service, to his subordinates and to the public at large. His equals are his brothers, with whom he should share his knowledge and experience should they seek it. His subordinates should find in him the help of good example, the friend with whom they may take counsel, and the mentor who will impart of his knowledge of life, of men, of things, to aid them in shaping their conduct and their purpose.

THE PUBLIC AND PROFESSIONAL OBLIGATIONS OF THE ENGINEER.

To the public at large he owes good citizenship. With every other citizen he shares responsibilities for government, civic, state and national, and his efforts should be to make government good. He cannot hold himself aloof from those activities which our form of government imposes upon those

who live under it, and escape responsibility for its shortcomings and its failures. If an unworthy man represents him in any governing body, he shares that unworthiness unless he exercised the right and duty of good citizenship and tried to put a good man into the office that the weak or bad man holds. "They also serve who only stand and wait" may be true of those who, through misfortune, are cut off from life's activities, but the saying does not apply to any live engineer. "He must be up and doing." He must keep his mental equipment as fit for service as the soldier keeps his arms, and the guiding motives of his life true, lest they fail him when the hour of trial comes.

Moreover, an engineer owes a professional obligation to the public by reason of his special training along technical lines. Therefore, he should use his knowledge and experience to promote the general welfare by every means in his power. He stands upon the watchtower of progress to warn against danger and to show the way to better methods in dealing with problems of engineering. He should stand against the individual or group of individuals who try to exploit, for their own profit or advantage, forces of nature which belong to the nation, the state or the municipality, without making a just return therefor to the rightful owners of the potentiality.

Wherefore should an organization of honorable men present a code of ethics when each carries in his own mind and heart rules of right living and honorable action?

It is "Lest we forget."

The law-abiding are not conscious of the restraints of the law, but the lawless are made to feel its power. A code of ethics accepted by the great body of professional men in the declaration of their faith is the chart by which they direct their course in the voyage of life. To this chart one who is in doubt may turn for suggestion as to the right course in any time of perplexity, and by the principles laid down in this chart transgressors will be judged and disciplined by their fellows.

THE DECLARATION OF APPLIED ETHICS.

Any code of ethics must be predicated upon the basic principles of truth and honesty. "Whatsoever things are true,

whatsoever things are honest," are the things for which engineers must contend.

An engineer may not "go beyond and defraud his brother" by any underhand act or method. He may not do or say anything which will injure his brother's reputation or his business for the purpose of securing his own advancement or profit. This admonition carries with it no obligation to refrain from telling known and absolute truth about an unworthy brother, as a protection to others; but the truth so told must be such as can be substantiated, and he who tells it must have the courage which will not shrink from the consequence of his telling.

The engineer owes his client allegiance demanding his most conscientious service. But conscientious service to the client must never entail a surrender of personal convictions of truth and right.

An engineer who receives compensation from an employer may not receive gift, commission or remuneration of any kind from a third party with whom he does business for that employer.

An engineer seeking to build up his business may not resort to self-laudation in advertising. He may state briefly the lines of work in which he has had experience, and enumerate responsible positions which he has held and give his references.

An engineer who employs others, either in his own service or in that of the client who employs him, should recognize in his relationship to them an obligation of exemplary conduct, of helpfulness and personal interest in those with whom he is thus brought in contact, and he should discharge such obligation tactfully and kindly.

The honor of the profession should be dear to every engineer, and he should remember that his own character and conduct reflect honor, or the reverse, upon the profession.

If, then, he so lives that this own honor shall never be smirched by his own act or omission, he will thus maintain the honor of the organization to which he belongs.

To Counteract Shorter Hours. The installation of the most modern machinery, no matter how costly, is a justified and paying investment if it results in increased production with reduced man-power, shorter hours of labor, less efficiency of labor.

In fact, any method of cutting production costs and increasing plant output is receiving serious consideration nowadays by captains of industry—even the little things that they were wont to dismiss with a contemptuous wave of the hand a few years ago.

For instance, factory lighting wasn't considered a matter of much importance less than a decade ago. It wasn't realized and it didn't matter much anyhow if operatives did lose some time-stopping to rest tired, strained eyes, wearied by poor light on their work. They were mostly low paid people working long hours and even under bad lighting conditions production costs were low.

But now there is hardly any such thing as cheap help; hardly anybody works long hours and few exert themselves to produce a full day's output. Every possible idea of science, and ingenuity must be taken advantage of to counterbalance the modern attitude of labor.

New factory buildings are mostly windows; old buildings are generally too dark. But it has been found that they can be lightened up a great deal by painting the interior wood, brick, cement or plastered walls with a snow white, washable oil paint having a maximum of light reflecting properties.

And it is remarkable the influence a seemingly little thing like this has upon production. Eye strain causes headache. No operative will even try to produce to capacity when not in good physical condition. But his high wages go on just the same. Better lighting removes the cause. Increased output, more accurate work, less breakage and spoiling of materials pays for the painting many times over. (From Dupont Industrial News Service.)

New Members. Since the last issue of the Proceedings the following new members have been received into the Society:

RESIDENT MEMBERS.

Meyer Godehaux, Engineer with American Heating and Plumbing Co.

Lewis G. Heider, Engineer and Manager, Underwood Construction Corporation.

Allan J. Negrotto, Engineer, Emergency Fleet Corporation.

NON-RESIDENT MEMBERS.

Marion C. Huckaby, Covington, La., Engineer Goods Roads Commission, St. Tammany Parish.

ASSOCIATE MEMBERS.

George B. Gibson, Superintendent Southport Mill, Ltd.

Charles G. Lowe, Chief Clerk, Doullut & Williams.

Annual Meeting A. S. M. E. The following advance notice of the Annual Meeting of the American Society of Mechanical Engineers has been received:

The 1920 Annual Meeting of The American Society of Mechanical Engineers will be held in the Engineering Societies Building, 29 West 39th Street, New York City, from December 7th, through December 10th.

Sessions will be held on the subjects of Appraisal and Valuation and the Application of Engineering to Woodworking.

The newly founded Professional Sections on Management, Power, Fuels, Machine Shop, Railroads and Textiles will also conduct sessions to consider the vital problems in their field. In addition a number of valuable papers will be presented at General Sessions.

A memorial session for Dr. Brashear is planned, as a fitting tribute to his life and work.

Recent Additions to the Library. The Chairman of the Library Committee submits the following list of books which have recently been added to our Library:

Selling your Services—Pearson.

Developing Executive Ability—Gowin.

Engineering for Land Drainage—Elliott.

Practical Farm Drainage—Elliott.

- Fifty Years of Rapid Transit—Walker.
The Construction of Graphical Charts—Peddle.
Electric Power Transmission—Still.
American Machinist Shop Note Book.—Suverkrop.
Radio Engineering Principles—Lauer and Brown.
Punches and Dies—Stanley.
Practical Oil Geology—Hager.
Mineral Deposits—Lindgren.
Manual of Physical Measurements—Zeleny.
Engineering and English—Aydelotte.
The Composition of Technical Papers—Watt.
Rock Drills—Weston.
Wiring of Finished Buildings—Croft.
Wiring for Light and Power—Croft.
American Telephone Practice—Miller.
Principles of the Telephone—Smith and Campbell.
Bearings and their Lubrication—Alford.
Timbering and Mining—Storms.
Principles of Mining—Hoover.
American Mine Accounting—Charlton.
Principles of Radiotelegraphy—Jansky.
Business Finance—Lough.
New Collection Methods—Gardner.
Effective Business Letters—Gardner.
Examination of Hydrocarbon Oils and Saponifiable Fats—Holde.
Technical Writing—Rickard.
Railroad Structures and Estimates—Orrock.
Sewage Disposal—Kinnicutt.
Shore Processes and Shore Line Development—Johnson.
Graphical and Mechanical Computation—Lipka.
Railway Estimates—Lavis.
Timber, Its Strength, Seasoning and Grading—Betts.
Ports and Terminal Facilities—MacElwee.
American Sewerage Practice—Metcalf and Eddy.
Aerial Arm—Gill.
Airplane Design and Construction—Polilio.
Water Purification—Ellms.

BOOK REVIEWS

ENGINEERING FOR LAND DRAINAGE.

By Charles Gleason Elliot.

This new edition of Dr. Elliot's book has met with favorable criticism from the leading technical journals of the country and as they have treated the work as a whole, this review will be confined principally to the application of the book to local conditions.

The first five chapters contain matter which should be of especial interest to the student and to the beginner. The description of field equipment and methods usually found in books of this nature is included but this is relieved by a number of original suggestions as to methods to be employed in making drainage surveys. The great mass of elementary material that is so often found in the opening chapters of books written for the use of both students and practicing engineers is notable by its absence.

With a few minor exceptions, the arrangements of matter is excellent and logical, one exception being that in the opinion of the writer, the paragraphs on "Cross Sectioning" and "Keeping Cross Section Notes" (which are given on pages 208 to 210 under "Location and Construction of Open Ditches") might more properly be included in the chapter on "Engineering Technique" which describes other field methods and systems of note keeping. The form of cross section notes proposed departs from that which has been established by long usage in rail road construction and which the writer has found to be well adapted to drainage work. The advantages of the form proposed are not obvious.

Of especial interest to local engineers are the chapters dealing with artificial drainage by pumping, use of tidal gates, flow of water in open ditches and runoff from large areas. The diagram included as an insert at page 166 is deserving of special mention. Church's Diagrams and other short cuts for Kutter's formula have been a great relief to the engineer who has been compelled to use the tedious "cut and try" method of determining the most suitable proportions and gradient for

a ditch to meet certain conditions but the diagram given by the author goes a step further and makes it possible to determine all the variables at a single reading. It is true that the chart given is confined to one value of the co-efficient of friction ($n = .030$) and a fixed side slope of one to one but these values are so nearly universally applicable to ordinary drainage canal design that the diagram will be found to fit most conditions and furnish the desired information with the minimum amount of work.

Much of the data on the run off from large areas has been collected from the immediate vicinity of New Orleans, having been taken from the records of the "Drainage Investigations" of the U. S. Department of Agriculture. Concrete examples are given and these are liberally supplied with illustrations.

The matter of appraisal of benefits and damages in drainage districts is treated in an original manner and could be read to advantage by every engineer interested in drainage work. The principles involved are simple but their misapplication, both by engineers and by non-technical men is entirely too frequent. The application of the methods proposed would result in a more nearly fair distribution of the assessment than is usually secured.

While it is hoped that more data will be included in later editions of this book, especially on the subject of pumping plants and on the relative advantages of various methods of construction of canal systems, the book as a whole is well balanced and contains a large amount of data of value to the drainage engineer, which is not to be found in other reference books. The many illustrations are clear and complete and the typography is good. The author has been notably diligent in giving credit for material secured from published records and from other sources.

A. M. SHAW.

PAPERS AND DISCUSSIONS

POWER TRANSMISSION EQUIPMENT

By William Crooks.

Chief Engineer Arkansas Light & Power Co.

Read before the Society, May 10, 1920.

The development of the possibility of transmitting increasingly large amounts of electrical energy over large areas from central generating stations during the past generation has followed the better understanding, study, and development of the laws governing the phenomena of alternating current, together with the improvements and refinements in central station practice. It is a long step from the earlier 2300 volt city distributions to the present 110,000 volt transmission lines, and the inter connection of the large central generating stations, but it is certain that the next generation will see an even greater development. Even now it seems that the 220,000 volt transmission line will soon be an actuality.

In this paper it is not my intention to discuss central station generating problems. A study of the development of hydro-electric and steam turbine generating equipment, together with improvements in condensing and boiler equipment offer possibilities of unlimited interest to me and I hope to the members of this Society, but I will confine myself largely to the elements entering into the construction of transmission lines. The statements that I make in this paper are the results of studies made during the construction and operation of between four and five hundred miles of transmission and distribution lines carrying various voltages.

In speaking of transmission lines I refer to high tension lines of voltages of 22,000, 33,000, 66,000 and 110,000. Lines carrying voltages lower than this, namely 2300, 6600, 12,000 and 13,200 are properly distribution lines. There is every reason to believe that in the future development of transmission lines and in the universal standardization that is sure to come that 22,000 volts will be eliminated from general use and the steps from the generator up will be 2300, 6600, 12,000, 13,200, 33,000, 66,000, 110,000 and 220,000. In using the term

12,000 volt lines I have in mind the "Y" grounded neutral system using transformers rated at 6900 volts, which system is rapidly gaining favor where conditions are such that it is necessary to transmit power at distances greater than the limits of 6600 volts, but where conditions are such that it would not be economically profitable to install additional 6600 volt step down substations.

There is quite a similarity between transmission line systems and railroad systems, since 66,000 and 110,000 volt lines correspond to the main trunk railroads and the 33,000 volt lines to branch line railroads with the 6,600, 12,000 and 13,200 volt distribution lines as the feeders. There is also quite an analogy between the philosophy of location of both railroads and transmission lines. The same general laws apply to both. The successfully located railroad is the one for which the location and type of construction was so selected that its earning capacity is at a maximum or, in other words, the location and type of construction should be selected so that the annual traffic per mile divided by the cost per mile is a maximum. This rule applies as well to the location and selection of the type of construction of a transmission line except that it must be borne in mind that in selecting the type of construction that there is no interruption periods at which no traffic is coming over the transmission line as in the case of railroads and ample provision should be made to take care of any possible future growth in the loads that the transmission line will carry. In using the term location I mean the general term, which includes a consideration of both the financial and engineering features and takes into consideration the feasibility of serving or not serving certain load centers in the general territory under consideration.

In the matter of actually locating the transmission line upon the ground, as a general rule, as in the case of railroads the most direct line between two determining load centers is the most desirable. However, numerous physical features of topography intrude themselves in such a way that it becomes more desirable to deviate from a straight line. In actually locating a transmission line upon the ground consideration should be given to the ease of transportation during construction,

policing, maintenance and repair. It has been found just as advantageous to locate transmission lines with the aid of survey parties as it is in the location of railroads. To actually stake out the poles with a transit is the only way to secure perfect alignment in the pole line.

The voltages to be carried by transmission line conductors naturally enter into the preliminary engineering and financial studies of the feasibility of a proposed transmission line. The voltage and the size of conductors being determining factors of the cost of the line, while the length of the line and the probable load are the factors which determine the voltage. While in some cases of light load comparatively light voltages may be used for a considerable distance, good engineering practice requires the following limiting mileage:

13,200	16-20 miles
33,000	45-50 miles
66,000	70-75 miles
110,000	90-100 miles

Care should be taken to see that the saving in copper due to the use of a higher voltage is not overbalanced by the higher cost of standard equipment necessary when the higher voltage is used, such as larger poles, pins, insulators, switching equipment, transformers, and lightning arresters.

As between copper and aluminum conductors, the choice becomes largely a matter of equating costs, the weight of aluminum being 30.2 per cent that of copper. Consideration should also be given to the conductivity factor using hard drawn copper as unity the conductivity factor of aluminum wire is 63.2 per cent.

The steel cored aluminum cable, which has lately been put upon the market, has an advantage over copper in greater mechanical strength enabling the use of longer spans, in this way reducing the number of poles, insulators, line hardware, etc., required per mile of line.

The spacing of the three conductors is a function of the voltage and the requirements of good practice is as follows:

33,000 volts	36-40 inches
66,000 volts	72-74 inches
110,000 volts	120-130 inches

ment, and in the future we may hope to expect to see many improvements and refinements in the various types of apparatus whose function in that of protection against lightning discharges.

Probably the best protection against lightning trouble is to avoid those districts that are known to be subject to severe lightning disturbances. Where conditions are such that these districts cannot be avoided, continuity of service can best be secured by building two entirely separate lines, preferably located as many miles apart as possible.

For all lines carrying voltages higher than 33,000 it is unquestionably better to install an overhead ground wire. This wire should be placed as high as possible above the conductors. In using an overhead ground wire care should be taken to see that the actual grounding is properly installed. This last suggestion applies with equal force to the actual grounding of any piece of transmission line equipment or apparatus.

At the important grounding points upon any transmission line the cost of sinking test holes to study the subsoil conditions will be justified. If this study indicates that the subsoil is of a dry porous nature, or composed of gravel, it will be found advantageous to excavate the undesirable soil and to replace with some moisture holding substitute that will make a close and good contact with the ground terminal. The same result is sometimes obtained by sinking pipe of sufficient length to reach entirely through the undesirable subsoil. There are several forms of ground terminals upon the market that when used will materially aid in the grounding of various pieces of transmission line apparatus. Galvanized iron wire is usually used as a pole ground wire, one end of which forms a mat upon the bottom of the butt and the other extending a little above the pole. The iron ground wire will probably rust entirely through in a few years. As a safeguard in case this happens a short length of soft bare copper should be fastened to the iron ground wire in such a way that the copper wire extends at least two feet above and below the ground line.

Until lately electrolytic lightning arresters were the only type of arresters upon the market which could be relied upon to furnish a reasonable degree of protection in case of dis-

charges and surges upon high voltage transmission lines. A disadvantage to the use of electrolytic lightning arresters is that in order for them to function properly they must be charged once each day at practically the same time. As a rule 66,000 and 110,000 volt lines usually end at a large switching or sub-station, where an operator would be in attendance, and who can do the arrester charging along with his other duties. However, it is often the case that the end of a 33,000 volt line will be at some isolated distribution center where daily charging is difficult to secure. In such cases as this is has been customary to rely upon some form of horn gap arrester for protection. Horn gap lightning arresters cannot be relied upon for full protection and should be used only where no other form is available or where load conditions are such that interest cannot be earned upon the investment required for an electrolytic. In the last analysis a horn gap arrester is simply a weak place put in the line whose function is to break down before damage is done to other apparatus by surges and discharges.

Lately the oxide film arrester similar in type to the electrolytic lightning arrester has been brought out. This arrester does not require a daily charging as does the electrolytic. Where these arresters have been put in service they are apparently functioning properly and will undoubtedly come into general use especially at isolated sub-stations or distribution centers.

With an electrolytic arrester at each end of a transmission line, or an electrolytic at one end and an oxide film arrester at the other, I seriously doubt the necessity of protection at the intermediate sub-stations further than a good choke coil.

Several types of high voltage air break switches that will break successfully under small and medium loads are on the market. Where sub-stations or switching stations are operating under heavy loads, good engineering practice demands that the actual breaking be done by means of suitable oil switches, with air break switches as an emergency reserve. All air break switches that are intended to break under a medium load should have extra wide spacing between poles to

Transmission line development in the future will also be largely along the line of drawing public utility operators, and especially central station operators closer together, and enabling them to work towards conservation of fuel and towards more economical operation, due to the inter-connection of their power plants and the interchange of power, and enabling each operator to achieve as nearly as possible the maximum yearly load factor for his power plant, and to maintain a continuity of service in case of an accident or breakdown.

MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY.

Regular Meeting of the Board of Direction, June 21, 1920.

Meeting was called to order with President Riess in the chair and the following present: Messrs. Barelli, Lawes, Olsen and Robert. Ballots were opened, the following being elected to the respective grades of membership:

Resident Members—Meyer Godechaux, Lewis G. Heider, Allan J. Negrotto.

Non-Resident Member—Marion C. Huckaby.

Associate Members—Geo. B. Gibson, Charles G. Lowe.

A special mimeograph ballot was ordered on the application of Mr. Sexton Berg, subject to the approval of the Membership Committee.

The matter of obtaining assistance for the State Museum from the Louisiana Legislature was taken up and the Secretary was instructed to get in touch with Mr. Glenk on this and if the matter has not gone too far to get out a letter ballot concerning the same.

A letter from Mr. E. H. Coleman concerning application for membership, was read and the Secretary was instructed to write Mr. Coleman that the Board has not the authority to modify the requirements for membership, but if he so desires the matter will be placed before the entire membership for action.

The application for Mr. R. P. Rordam for reinstatement was approved and he was accordingly reinstated. The status of Mr. G. H. Davis and also that of Mr. R. B. Stevens was changed from Resident to Non-Resident membership. A letter from Mr. Thomas L. Willis resigning from the Society was read and the Secretary was instructed to write Mr. Willis calling his attention to the grade of Non-Resident membership, and ask him if he does not care to continue his membership in this capacity.

Upon motion duly seconded and carried, the salary of Miss Carrie Freret was increased from \$10.00 to \$15.00 per month.

A letter from Mr. F. C. Barber and Associates was read offering to conduct a campaign to increase the membership of the Society. The Secretary was instructed to write Mr. Barber thanking him for his interest, but to say that just at this time the Board does not think it wise to go into a campaign for membership.

The report of the Secretary was read and approved and the bills ordered paid.

There being no further business, the meeting adjourned.

JAMES M. ROBERT, Secretary.

PROCEEDINGS

OF THE

LOUISIANA ENGINEERING SOCIETY

VOL. VI

OCTOBER, 1920

No. 5

CONTENTS

EDITORIAL NOTES AND COMMENT:	PAGE
Hurricane Movement as Related to Storm Tides	193
Foundations of the Custom House Buildings	194
Affiliation with the Federated American Engineering Societies ..	197
New Members	197
The Chemical Engineers	198
New Books in the Library	198
 PAPERS AND DISCUSSIONS:	
Relation of Changes of Storm Tides on the Coast of the Gulf of Mexico to the Center and Movement of Hurricanes. <i>By Isaac M. Cline</i>	200
MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY	258

EDITORIAL NOTES AND COMMENT

Hurricane Movement as Related to Storm Tides. At its regular monthly meeting in September the members of the Society had the pleasure of hearing a very interesting and instructive lecture by Dr. Isaac M. Cline, District Forecaster for the Weather Bureau at New Orleans. The exact title of the paper upon which the lecture was based is "Relation of Changes in Storm Tides on the Coast of the Gulf of Mexico to the Center and Movement of Hurricanes." It is reprinted in this issue of the Proceedings in full from the MONTHLY WEATHER REVIEW for March, 1920.

This subject should be of the greatest interest to the engineering fraternity of this section of the country on account

of the effect of these tropical hurricanes and their resulting high tides upon many of the most important engineering projects, such as marsh land reclamation and drainage, the protection of exposed coastal areas and the control of channel approaches to the rivers and harbors of the Gulf Coast.

The conclusions and theories of Dr. Cline are based upon data covering all the big storms in the Gulf for the past twenty years, from 1900 to 1919. In every instance the water on the coast begins to rise in front of the cyclonic area one or two days before the storm is felt. Charts are made of the storm area by dividing it into four quadrants and in these are plotted the actual wind directions and velocities as determined from stations within the area. It is shown that in the right-hand rear quadrant the winds persist longer and blow with much greater velocity than in any other part. In this quadrant the wind has been found to blow for a period of 24 hours or longer with an average sustained velocity of 60 miles per hour, and for periods of 13 hours at from 70 to 85 miles per hour.

These winds produce waves in the Gulf the size and length of which bear a certain relation to the sustained velocity of the wind and the length of time it blows over the water. The largest and longest waves are produced in the right-hand rear quadrant, and as they move on through the storm area they cause an abnormal rise in tide at points along the coast which **lie in front of and to the right of the center line of advance of the hurricane.** As this rise begins when the center of the storm is 300 to 500 miles away and continues until it has moved inland, it may readily be seen that this affords a valuable means of predicting the points at which the hurricane will be most severely felt. The water at such times rises to heights of 8 to 15 feet above mean Gulf level.

Foundations of the Custom House Building. There is a fairly widespread tradition in this city that the U. S. Custom House was built upon bales of cotton. Mr. A. M. Shaw has sent the Editor a copy of a letter published four years ago in the Times-Picayune which gives some valuable information upon this subject with the suggestion that it be made a matter of permanent record by publication in the pages of the Pro-

ceedings. The letter was written by Captain Thomas J. Woodward, so well known in this city and community.

August 5, 1916.

Editor,
Times-Picayune,
New Orleans, La.

Dear Sir:

For many years there has been a contention in the minds of the people of New Orleans regarding the foundation of the Custom House, and many have believed that a portion of the foundation consisted of cotton bales, so when I took charge of the Post Office at New Orleans, I was determined, if possible, to find out what the original construction consisted of, and how it was laid, so I employed a man to go in the record room, fourth floor of the Custom House and overhaul, and if possible, find the record relating to the the foundation, which he found after a long search. Here is the substance of it in full, as it was reported:

Interesting Facts of the Custom House Building.

The land was ceded to the United States June 29, 1848, and building operations were commenced soon afterwards and continued until 1860. The walls were then 75 ft. high, and a temporary roof was constructed. Work was resumed from 1871 for a time, again in 1879, and from 1881 till 1883, when the third story was completed. During the work from 1881 to 1883, the ground floor was altered to accommodate the Post Office.

The building is constructed of Quincy (Mass.) granite. It measures 340 ft. on Canal street, 297 ft. on Decatur street, 252 ft. on Custom House street, and 309 ft. on North Peters street, its cubic contents are 6,085,000 feet.

The foundations rest on a plank flooring seven feet below the street line. On this flooring is a grillage of 12-foot logs, the first layer being side by side, and those of the traverse layer from 2 to 3 feet apart. The space between the logs is filled with concrete, which is carried about 1 foot above the grillage.

The exterior walls are 4 feet thick, $2\frac{1}{2}$ feet of which is brick and the remaining $1\frac{1}{2}$ feet stone masonry. The roof of the building is of copper.

The main stairway is of marble. The central portion of the second story is the MARBLE HALL. It contains fourteen marble Corinthian columns at the top of the capital of each are bas-reliefs of the Juno and Mercury. At one end of the hall is a panel with life size bas-relief of Sieur de Bienville, the founder of New Orleans; at the same end, with the Court of Arms of the State of Louisiana between them is a panel with life size bas-relief of General Andrew Jackson, the defender of New Orleans.

The total cost of the building, exclusive of repairs, Was \$4,412,551.35.

My first visit to New Orleans was in 1851 as a sailor on board of ship at \$12.00 per month. At that time they were just putting on the first large block of granite on the foundation of the Custom House, the trenches at that time being open.

I little thought at that time, as I viewed the workmen putting on those heavy granite blocks, that some time in my life, I would have charge of a part of that building, drawing an admiral's salary of \$6,000.00 a year, which I received as Postmaster under Roosevelt, for the four years I occupied it.

The old St. Charles Hotel was burned at the time I was here. 'Twas a heavy norther blowing and a terrible fire that took everything in its reach until Poydras street, where the fire was checked.

I have been here many times since that time as Chief Officer and Captain of ships up to the time I

went into business here—in 1868—in the old company of Woodward-Wight.

Thinking that the information in regard to the foundation plan of the Custom House might be interesting to our people, I beg to remain.

Very respectfully,

(Signed) CAPT. THOS. J. WOODWARD.

Affiliation With the Federated American Engineering Societies. This subject of affiliation is still in the hands of the Committee appointed by President Riess to consider the whole problem. This committee was appointed originally to report upon affiliation with the American Association of Engineers, and when the question came up of the Federation Societies, the committee was enlarged by the addition of two members and requested to consider the whole matter of affiliation. This committee has made a brief preliminary report asking for more time for the purpose of securing from headquarters some additional information concerning the advantages of affiliation with the Federated Engineering Societies. So far as has been set forth in the preliminary reports from the Federated Societies the advantages appear to be somewhat indefinite in character, especially in the case of a society such as this which is at such a great distance from the center of activities of such a federation. The expense to the Louisiana Engineering Society will be about \$300.00 per year, and the question arises very naturally in the minds of many of us as to just what are we to receive for this amount. Might there not be local activities in which the Society could engage and for which this amount of money might be expended to a greater advantage.

This is not intended in any way to prejudice the case, but simply to call attention to one of the features upon which the committee placed special emphasis in its discussion of the question.

New Members. The following new members have been recently into the Society:

Resident Members—Sexton Berg, Engineer with G. D. Von Phul; George R. Hammett, Sales Engineer with A. M. Lockett

& Co.; H. G. Martin, Director of the Isaac Delgado Central Trades School; Lester C. Smith, Engineer with Doullut & Williams.

Non-Resident Member—Harry D. Scott, Trujillo, Honduras, C. A., Superintendent of Trujillo R. R.

Associate Members—Joseph A. Brennan, Construction Superintendent, George A. Fuller Co., New Orleans, La.; Edward T. Malloy, 2621 Wisteria Ave., New Orleans, La.

Transfer from Student to Resident Member—John A. O'Brien, Asst. Supt., U. S. Lighthouse Service, Eighth District, New Orleans, La.

Student Member—John R. Dykers, Senior Chemical Engineering Student, Tulane University.

The Chemical Engineers. The American Institute of Chemical Engineers will hold its winter meeting in New Orleans, December 6 to 9. The Louisiana Engineering Society will cooperate with the local chemists by extending to them the facilities of its organization and in such other ways as may be necessary.

This is a comparatively young organization with a membership of between 300 and 400. Its president is Mr. David Weson of the Southern Cotton Oil Company, New York City, and the secretary is Dr. John C. Olsen, professor of Chemistry in the Brooklyn Polytechnic Institute. An attendance of from 60 to 75 members is expected. They will be taken on a trip to Lake Charles to see something of the salt and sulphur industries, and will also visit a number of sugar mills.

New Books in the Library. Since the last issue of the Proceedings the Library Committee has purchased the following books:

Kent—Bookkeeping.

Roberts—Track Formulae.

Fowler—Ordinary Foundations.

Goldman—Financial Engineering.

Harris—Soil Alkali.

Simons—Dredging.

Gillettee—Clearing and Grubbing.

Davis—Surveying.

- Schneider—Everyday Science.
Comstock—Matter and Electricity.
Soddy—Matter and Energy.
Murphy—Drainage Engineering.
Turneaure—Principles of Concrete Construction.
Merriman—Engineer's Handbook.
Codex—How to Make Graphic Charts.
Finch—Topographic Maps.
G. H. Thomas—Aerial Transport.
Sherbondy & Wardrop—Textbook of Aero Engines.
Woodhouse—Textbook of Aerial Laws.

PAPERS AND DISCUSSIONS

RELATION OF CHANGES IN STORM TIDES ON THE COAST OF THE GULF OF MEXICO TO THE CEN- TER AND MOVEMENT OF HURRICANES.

By ISAAC M. CLINE, District Forecaster.
(Weather Bureau, New Orleans, La.)

Presented before the Society, September 13, 1920.

(Reprinted from MONTHLY WEATHER REVIEW, March, 1920, 48:127-146.)

SYNOPSIS.

A brief summary of what is known bearing directly on this subject concerning wind and waves is given.

Hurricanes are in all instances preceded by storm tides. The water commences rising on the coast in front of the cyclonic area, one to two days before the storm is experienced.

The wind velocities and directions in different parts of the hurricane, as deduced theoretically, do not meet the requirements in this study to explain the rises in tides. Composite charts showing the actual wind directions and velocities determined from stations in the different parts of the cyclonic area are submitted. In the right-hand rear quadrant the winds blow with much greater velocity and persist in the same direction longer than in any other part of the hurricane. At stations in this quadrant the wind has been found to blow for 24 hours or longer with a direction in line with the advance of the hurricane, with an average velocity of 60 miles per hour, and for 13 hours at 70 to 85 miles per hour. In other parts of the cyclonic area the wind continues to blow over the water in the same direction for only a few hours.

Winds in the cyclonic area over water develop waves of a size and length which bear a relation to the sustained velocity of the wind and the length of time the waves are under the influence of the same wind direction. Waves of different sizes are developed in proportion to the winds which prevail in the different parts of the cyclonic area. The largest and longest waves are created in the rear right-hand quadrant; these waves pass on through the cyclonic area and move to shore where they cause a rise in the water in the front of and on the right of the line over which the center of the hurricane is advancing. This rise begins when the center of the hurricane is 300 to 500 miles distant, and continues until the hurricane moves inland. The heights of the water reached at shore near the center of the storm vary from 8 to 15 feet above mean Gulf level.

Changes in the position of the rise of the storm tide indicate changes in the course of the storm:

Bold-face figures in parenthesis refer to authorities preceded by the same figure in the bibliography at the end of this paper.

STORM WAVES AND SWELLS.

Waves and tides that appear along our coasts, many hours and at times one or two days in advance of hurricanes, convey some definite information regarding the position and direction of movement of the storm still many miles distant in the Gulf. Swells and waves break upon the shore and the water rises as the result of winds prevailing in the Gulf sometimes 400 to 500 miles distant.

The relations which the movements and actions of the waves and tides bear to the position and movement of the meteorological disturbances, which develop and carry these phenomena to shore, have not received the attention the importance of the subject justifies.

Ocean waves and their action under winds have received the attention of investigators, and we will summarize briefly the more important results obtained that bear directly on this subject. Their height, length, and speed have been carefully studied and recorded in both deep and shallow water. In the Atlantic and other oceans with 600 to 1,000 miles sea room it has been found in ordinary storms that waves of 35 to 40 feet in height are developed and in exceptional storms waves may exceed 45 feet. The crossing of two large waves will sometimes send up a peak of water which has been estimated to be 50 to 55 feet in height. The quotient obtained by dividing the wind velocity in miles per hour by 2.05 represents the average height in feet of the waves developed by that wind; however, this average will be exceeded when the wind has full opportunity to exert its force. Waves produced upon the deep sea communicate their motion to the water to a depth of about one-fourth the wave length; when the waves run into water which has depth less than one-fourth the wave length a reduction of the speed of the wave results and continues as shallower water is reached; the diminishing speed causes the wave crests to close up, the space separating them becomes less and less as

the depth of the water diminishes: but the interval of time between the arrival at shore of successive crests remains unchanged. The average storm wave in deep water moves forward with a velocity a few miles per hour less than the wind velocity that produces it. Long waves and swells that move through the storm and break upon the shore travel when in deep water with a greater speed than the highest waves in storms travel. In seas partly inclosed the speed and length of waves are less than on the open ocean, these being determined by the length of fetch as well as winds. (6).

In the Gulf of Mexico there is a distance or length of fetch over deep water for 600 miles from the Yucatan Channel to the middle Gulf coast and 800 miles to the west Gulf coast. From the Florida Straits to the middle and west Gulf coast the distance or length of fetch ranges from 600 to 1,000 miles.

In a cyclonic area with a progressive movement of 12 to 15 miles per hour large waves of considerable length are driven through and beyond the cyclonic area and by gravity and inertia are carried on far in advance of the area covered by the cyclonic circulation.

In discussing the propagation of waves of the sea in this connection Cornish says: (6).

The breakers which arrive (at shore) somewhat irregularly during storms do so at intervals which, as far as I have noticed them, do not differ much from the intervals observed on board ship in the deep sea during storms. When waves are driven outside the wind area and left to themselves to travel over considerable distances the originally complex and irregular waves are analyzed into a series of simple, regular waves of graduated lengths. The longer and swifter are in front, the shorter and slower in the rear; the shorter components flatten out very quickly as they travel, whereas the longer components preserve their height with but little diminution for long distances and reach places far distant from the windward shore, where the water will heave with a long period undulation. At a considerable distance from the windward shore the state attained by the sea during a storm does not depend only on what the wind does there but by the transmission by gravity, independently of the wind of the longer-period component of the irregular waves which the storm has created to windward. The greater the length of the fetch the greater is the distance from which the surface water draws the reinforcement of its long period heaving and the greater, therefore, is that part of the wave disturbance which is of greater wave length than the dominant wave.

Darwin says: (2)

The point we have to note is that an isolated disturbance will generate long waves and they will run ahead of the small ones; the long waves are more persistent, * * * but I do not understand how it is that the separation of the long from the short waves is so complete nor what governs the length of the wave.

Dr. George Stokes showed nearly half a century ago that there is a transfer of water in the direction in which the wave is moving. The speed of the transfer depends on the depth and diminishes rapidly as the depth of the water increases. (4)

Coast currents observed as resulting from cyclonic storms in the Bay of Bengal have a steady set or drift to the west. Eliot says: (1)

It is probable that the strength of a cyclone advancing to the northward coast of the bay could be roughly ascertained by the strength of the westerly set at the head of the bay. Data are, however, wanting to test this. * * * The drift near the center of the large storms in the Bay of Bengal may be so much as 6 to 8 knots. * * *

Observations of the construction engineers indicate that the effects of waves on such structures as rubble breakwaters are generally not appreciable beyond a depth of 15 to 16 feet below the water surface. This varies, however, in different localities. At Port Elizabeth, South Africa, blocks of rubble stone weighing 100 to 150 pounds, in 22 feet of water, were not disturbed by waves 15 to 20 feet high. At Colombo, stones weighing three tons, in water 10 to 14 feet deep, were disturbed by waves not exceeding 15 feet in height. At Algiers, Africa, stones 33 to 39 feet below the surface of the water were moved by waves or currents. (7)

The most destructive element in hurricanes is the breaking wave. A cubic yard of water weighs about 1,500 pounds and the waves, driven by the wind, break on the coast with the water moving forward at a speed of many feet per second, and cause destruction which exceeds description.

TIDE RECORDS.

The Port Eads tide gauge is about 2½ miles up the South Pass from the Gulf, and the Burrwood gauge in Southwest Pass is 5 miles from the Gulf.

The tide gauge at Galveston is at the foot of Twentieth street. The tide records used with the Mobile (Ala.) meteorological records are Pascagoula, Miss., 1909, and for the other years, Fort Morgan, Ala.

Mean low water at Port Eads, La., is 0.3 of a foot and at Burrwood, La., is 0.7 of a foot above mean Gulf level. At Fort Morgan, Ala., mean low water is 0.3 of a foot above mean Gulf level. For Galveston the United States Coast and Geodetic Survey gives mean low water (1917) 0.5 of a foot below mean Gulf level.

The zero of the tide gauge at Port Eads, La., is 3.16 feet and at Burrwood, 2.26 feet below mean Gulf level, and at Fort Morgan, Ala., the zero of the tide gauge is 1.22 feet below mean Gulf level; therefore, mean low water on the Port Eads gauge reads 3.46, on the Burrwood gauge 2.96 and on the Fort Morgan gauge, 1.52.

Darwin, in speaking of tides, says: (2) "The word 'tidal' should only be used when we are referring to regular and persistent alternations of rise and fall of sea level." He suggests that changes of water level due to wind and other atmospheric influences should be referred to as a "meteorological tide." The meteorological tide may be either low water or high water.

In referring to tides generally, mean low water as used by the United States Coast and Geodetic Survey will be used as the reference plane. The tide graphs shown with the graphs of meteorological conditions will give the tides above mean low water, in order that the records for Galveston, Burrwood, and Mobile, may be easily compared as the cyclonic area advances.

The term "Storm tide" will be used to represent the height of the water in excess of the predicted tide at a given hour. A study of the relationship existing between hurricanes and tides has been made possible through the complete records of tide conditions which we have had the good fortune to secure for this study.

Each hurricane, during the 20 years, 1900 to 1919, inclusive, will be taken up in chronological order, and we will deal

especially with the relation of the tides to the center and movement of the hurricane.

METEOROLOGICAL RECORDS AND HURRICANE TIDES.

September 1-12, 1900.—This disturbance reached the Florida Straits, September 5, and moved in a northwesterly direction, across the Gulf, a distance of nearly 1,000 miles, with its center passing inland over the western part of Galveston Island about 9 p. m., September 8. A graphical representation of the wind, barometric pressure, and tides at Port Eads, La., and Galveston, Tex., during the passage of this storm through the Gulf is shown in Plate I. At Port Eads the barometer commenced falling on the morning of the 6th and fell steadily until the night of the 7th, when 29.56 was recorded at the 8 p. m. observation. The wind was from the northeast during the 6th and until 8 a. m. of the 7th, with steadily increasing velocity, but not exceeding 44 miles per hour. The wind shifted to the east in the afternoon of the 7th, and the highest hourly velocity was 47 miles at 4 p. m. and 5 p. m. At 8 a. m. the wind was from the southeast and the velocity 30 miles per hour.

The tide gauge at Port Eads showed a slight rise in the water above the regular tides during the 6th, and the water continued to rise steadily, reaching 2.8 feet above mean low water at 9 p. m. on the 7th, the rise caused by the hurricane in 24 hours being 1.2 feet. The oscillations of the regular tides were not overcome, but the water at lowest tide on the afternoon of the 7th was 1.6 feet higher than the lowest water on the previous day. Port Eads was about 150 miles to the right of the line of advance of the center of the hurricane at the time of the highest water. In this instance the water at shore commenced rising at Port Eads 150 miles to the right of the line of advance of the hurricane, when the center was 400 miles distant and 36 hours before that place was on a line drawn through the center of the hurricane at right angles to the line of advance. The highest water occurred with the passage of the center of the cyclonic area and coincident with the lowest barometer and highest winds.

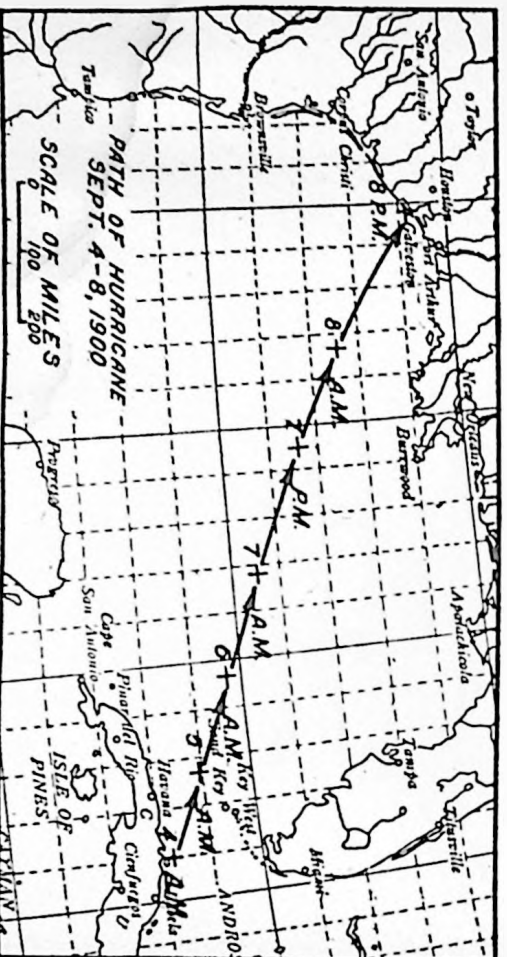
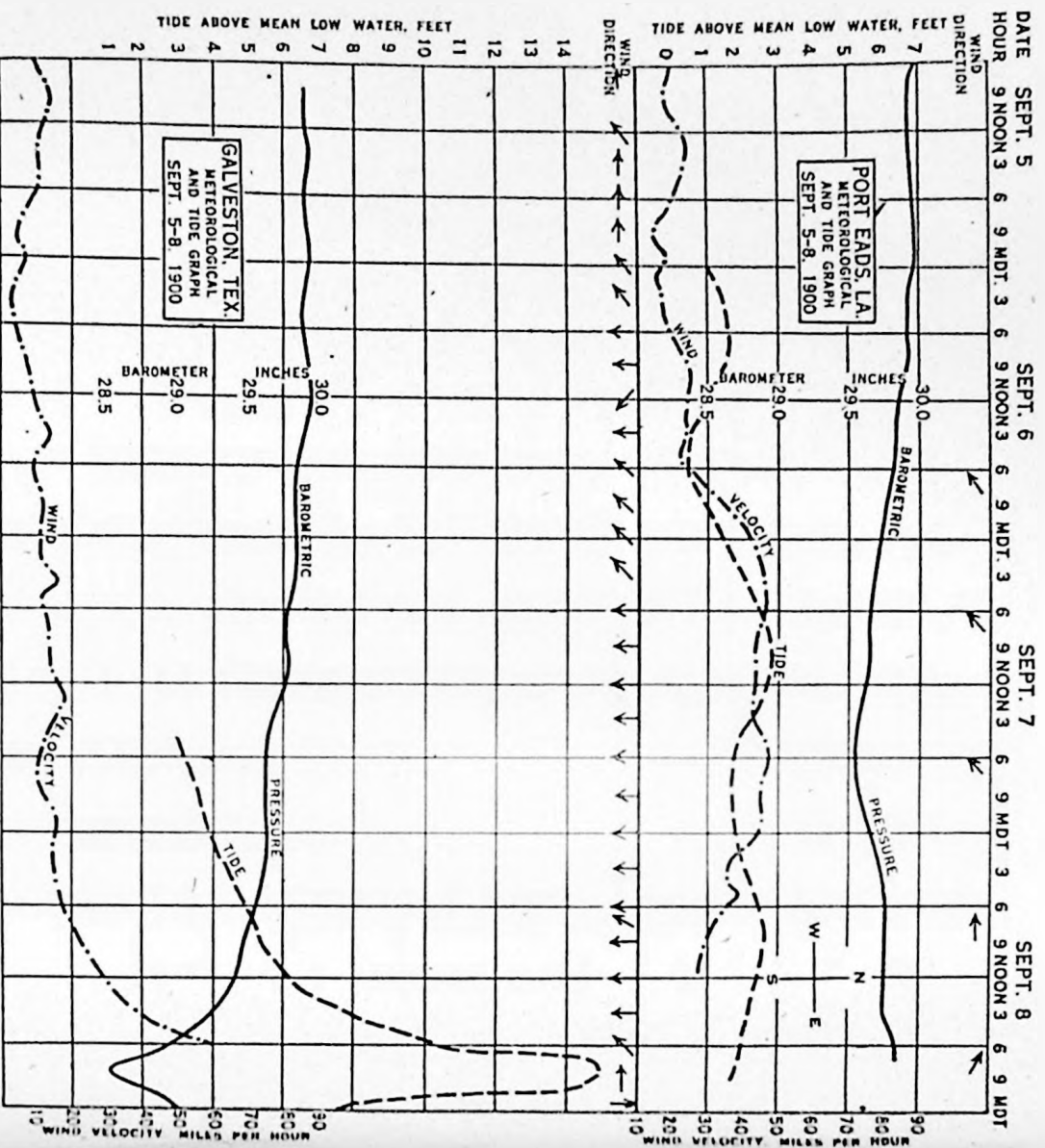


PLATE I.—I. M. CHINE

At Galveston the barometer commenced falling at 5 p. m. on 6th and continued falling steadily, but slowly, up to noon of the 8th, when it read 29.42 inches. The barometer then fell rapidly, recording 28.48 inches at 8:30 p. m. of the 8th, the lowest recorded up to that time at a Weather Bureau station. The wind blew steadily from the north from noon of the 6th until 3 p. m. of the 8th, except that it blew from the northeast during the hours ending at 9 a. m. and 10 a. m. of the 8th. The prevailing wind was from the northeast from 3 p. m. to 8:30 p. m., September 8: east from 8:30 p. m. to 10 p. m., southeast from 10 p. m. to 11 p. m., and after that time from the south. The wind velocity was less than 20 miles per hour up to 6 a. m. of the 8th, after which the velocity increased steadily, reaching 30 miles per hour at noon of the 8th, and was 60 miles during the hour ending 6 p. m. when the anemometer blew away. The velocity was increasing rapidly at that hour, 2 miles having been recorded at the rate of 100 miles per hour. It is estimated that a velocity of 120 miles per hour was reached about the time of the shift of the wind to the east.

There are no tide observations at Galveston prior to 4 p. m. of the 7th, when the water already stood 3 feet above mean low tide, showing nearly 2 feet of storm tide. At this time the center of the hurricane was 300 miles distant in space and 30 hours in time, and its line of advance was toward Galveston. The water stood one foot higher at Galveston at this hour than at Port Eads, which was only about 175 miles distant, from the cyclonic center, to the right of the line over which it was advancing. The crest of high water at Port Eads was 2.8 feet, and was reached at 9 p. m. of the 7th.

The water continued to rise rapidly at Galveston, and was 15 feet at 3 p. m. of the 8th, notwithstanding there had been up to this time a prevailing offshore north wind of 20 to 40 miles per hour; such winds ordinarily give a tide below low water. After 3 p. m. of the 8th, when the wind shifted to northeast and east the tide rose with phenomenal rapidity, reaching 15 feet at 8 to 9 p. m., a rise of 1.4 feet per hour. The rapid rise during the last five hours is attributed to the effects of the off shore north winds prior to 3 p. m. having

retarded the rise in the water as the storm approached, by forcing it back and banking it toward the storm center, and when the wind changed to northeast and east this water was forced in rapidly with favorable winds. The rise in the storm tide was not noticeable on the coast 50 miles to the left of the line of advance of the hurricane.

The destruction of property by the winds and waves in this hurricane amounted to about \$30,000,000 and 6,000 persons were drowned.

July 5-10, 1901.—A storm of small extent and moderate intensity moved through the Yucatan Channel into the Gulf of Mexico on the 7th and reached the Texas coast west of Galveston on the 10th. This disturbance gave a rise in water at Galveston of 4.5 feet at 3:30 a. m. No tide records of this disturbance are available. No damage of consequence resulted.

August 9-15, 1901.—This disturbance first appeared to the north of Cuba on August 9. It moved across southern Florida and into the Gulf of Mexico on the morning of the 11th, continued its course westward until the 90th meridian was reached, when, during the 14th, it recurved, and on the morning of the 15th passed northeastward between New Orleans and Port Eads. This disturbance was of small diameter, but of considerable intensity. Its course was unusual.

The barometer at Port Eads fell steadily, commencing about noon on the 12th and was 29.50 at 8 a. m. on the 14th, when the last observation was taken. The wind direction was northwest on the afternoon of the 12th and was northeast during the 13th; on the morning of the 14th it was southeast. The velocity increased steadily after 6 a. m. on the 14th, when the record was lost. The wind and pressure records at New Orleans are shown on Plate II, along with the wind, pressure, and tide records at Port Eads. (We have no automatic tide record for Mobile and Galveston for this storm. The highest wind velocity, 40 miles per hour at New Orleans, occurred at 11 a. m. on the 15th.

Tide records at Port Eads show the water rising before midnight on the 12th when the center of the storm was about

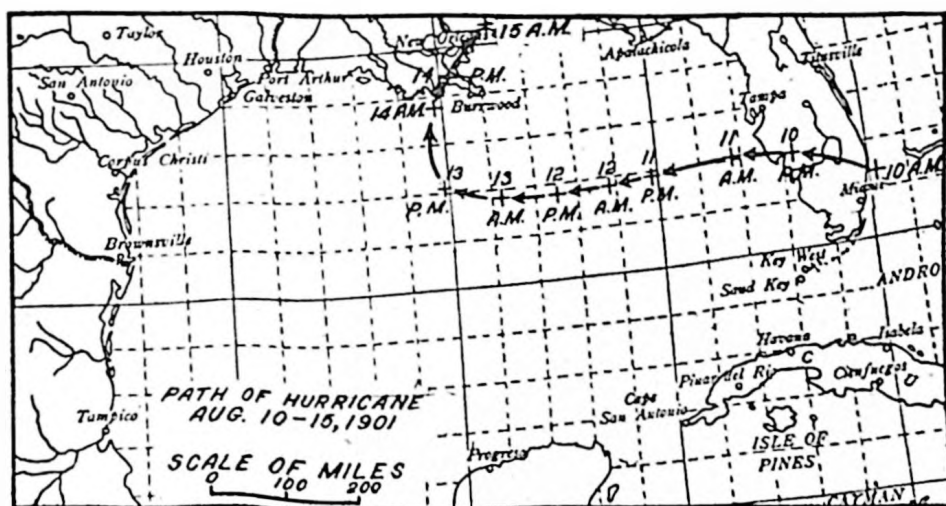
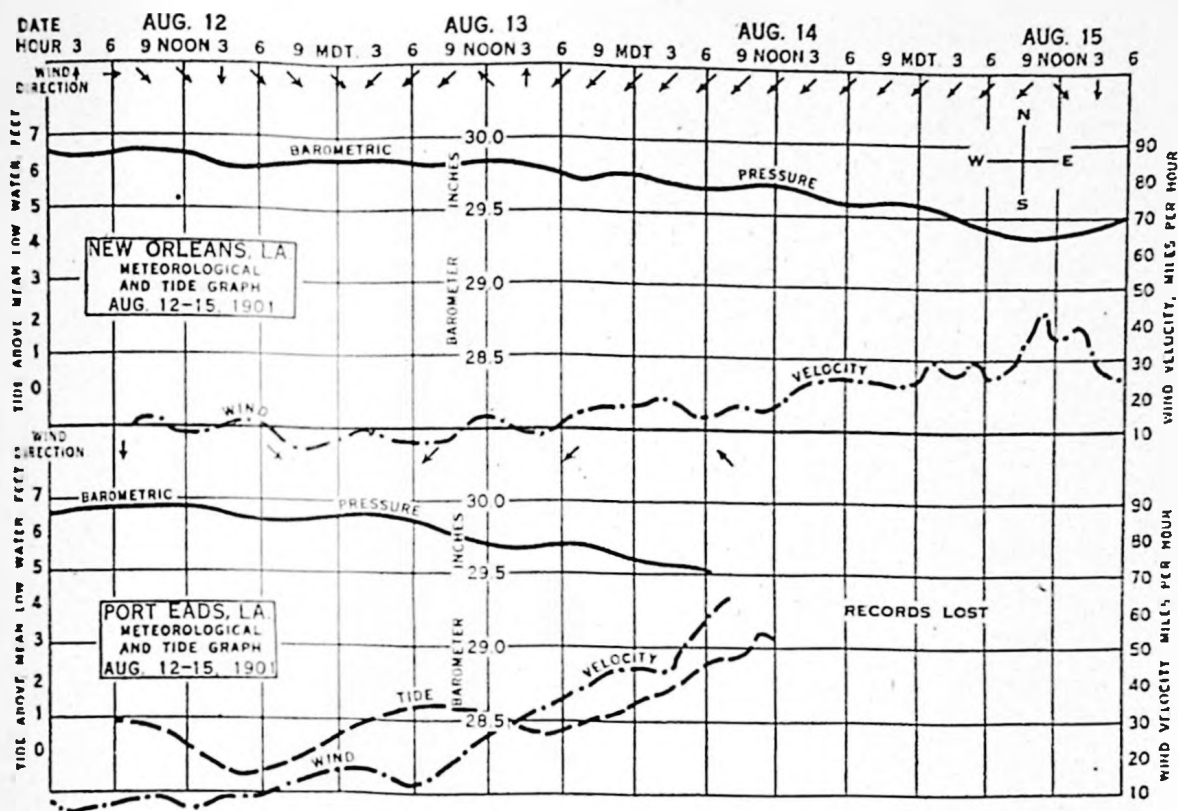


PLATE II.—I. M. Cline.

200 miles distant. The water reached a height of 3.2 feet above mean low water at 11 a. m. on the 14th, the record after that time being lost. The Mississippi River at New Orleans rose from 5.9 feet to 11.4 feet on the morning of the 15th, the water forced up the river by the hurricane winds amounting to 5.5 feet.

At Mobile the water was driven in and was awash of the wharves from 12 noon to 1 p. m. of the 14th. At 10 a. m. of the 15th the water began to come over the wharves, rising at the rate of nearly 1 foot per hour until 3:30 p. m., when it was 5 feet over the wharves and 8.2 feet above mean low tide.

Ten persons were drowned and the damage caused by the storm was \$1,000,000.

September 23-27, 1906.—This disturbance passed through the Yucatan Channel on the morning of the 24th, traveled in nearly a straight line, and moved in on the Mississippi coast on the morning of the 27th. The tide records at Port Eads, charted with the wind and pressure records of New Orleans (Port Eads meteorological records being missing) and the Galveston pressure, wind, and tide records during the storm are shown on Plate III. This was a hurricane of large extent and unusual intensity. The tide at Galveston during the passage of this disturbance through the Gulf showed only normal changes. At Port Eads, 50 miles to the left of the line of advance of the center of the storm, the storm tide commenced rising during the afternoon of the 25th, when the hurricane was 250 miles distant in space and 28 hours in time. The rise in water shown at Port Eads on the afternoon of the 25th must have started from the southeast Gulf during the afternoon of the 24th and traveled, during 20 hours, a distance of more than 500 miles, at the rate of about 25 miles per hour. The cyclonic area advanced at the rate of about 10 miles per hour. The highest tide at Port Eads was 3.8 feet at midnight of the 26th. There was a 3-foot rise in the river at New Orleans on the morning of the 27th as a result of the hurricane. Mobile and Pensacola were situated in the eastern segment of the cyclonic area, where they experienced the severest hurricane in their history. Unfortunately, we have no automatic tide records for either Mobile or Pensacola during this hurricane. The United States engineers at Fort Barancas on the bay below Pensacola, give the extreme storm tide at that place, 10.8 feet. At Mobile, the water was 9.9 feet above mean low tide. Thus we have the highest water at Port Eads, 50 miles to the left of the line of advance of the center of the

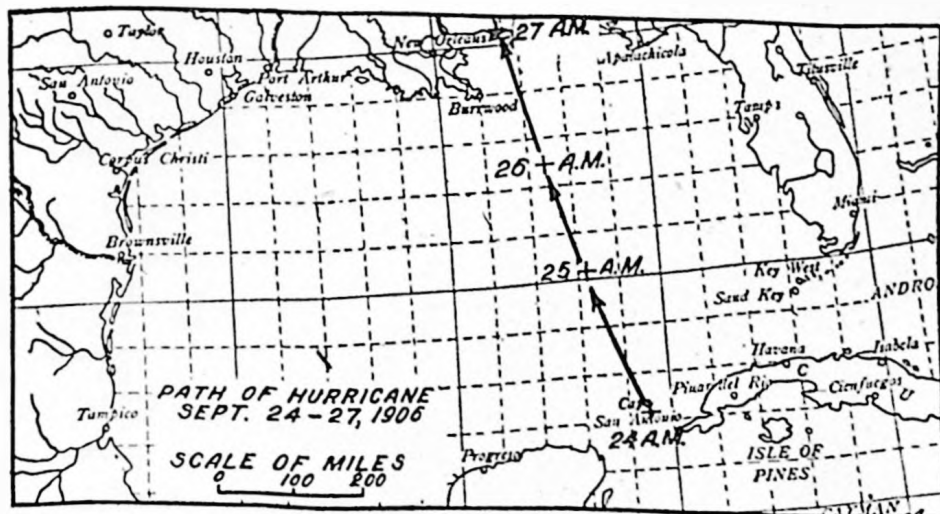
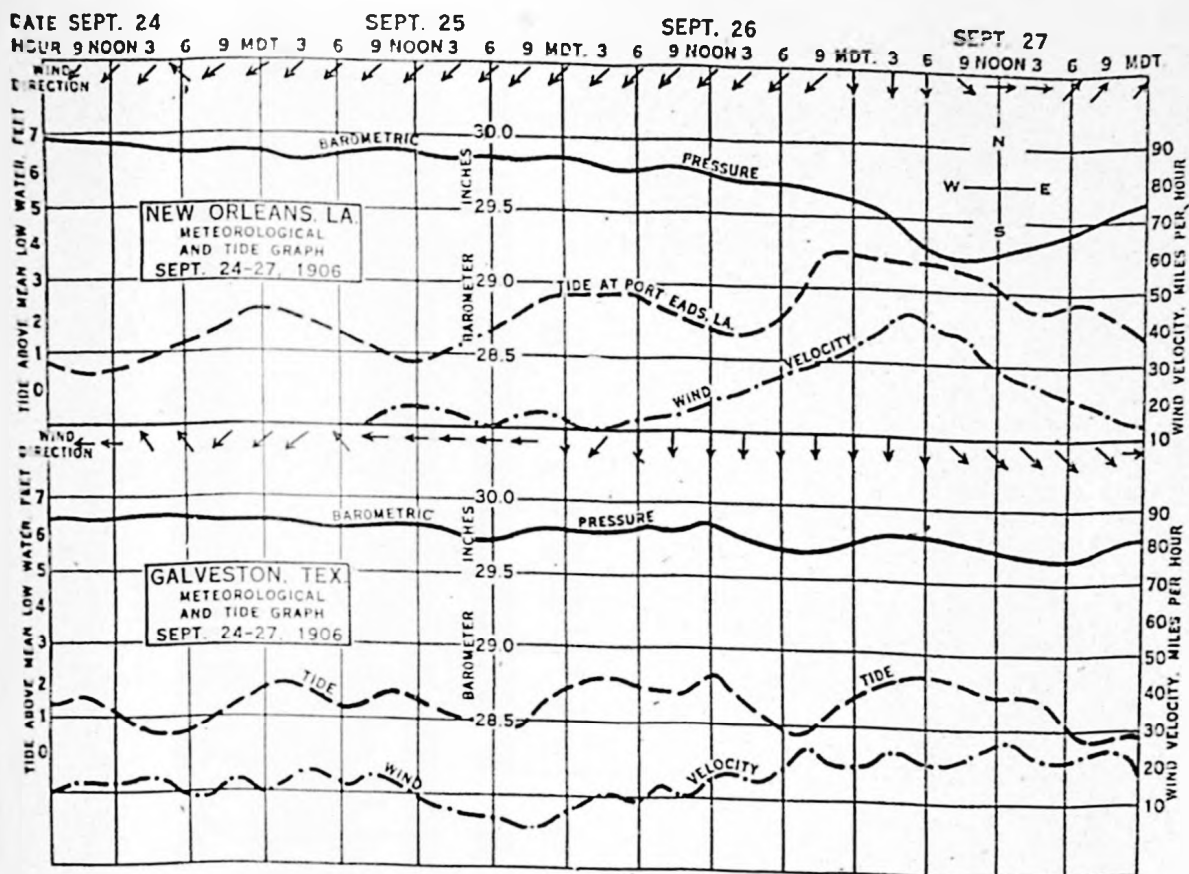


PLATE III.—I. M. Cline.

hurricane, 3.8 feet, and at Pensacola, 100 miles to the right, 10.8 feet.

The damage from the hurricane at Pensacola was \$2,120,000, and in the vicinity of Mobile, \$1,850,000. The total

known deaths at Pensacola were 32, and in the vicinity of Mobile 31 persons lost their lives.

July 18-21, 1909.—This disturbance moved from the Caribbean Sea through the Yucatan Channel on the 18th and moved inland on the Texas coast with its center near Velasco. The cyclonic area was about 100 miles in diameter and no hurricane winds attended it. High waves, swells, and tides prevailed as far to the right of the center as Galveston. We have no tide records for this storm.

The damage to property amounted to \$100,000 and 4 lives were lost.

September 12-21, 1909.—This was a storm of great intensity and a large extent, its effects being distinctly felt from east of Pensacola, Fla., to the west of Galveston, Tex. The disturbance passed through the Yucatan Channel during September 17 and moved inland on the Louisiana coast, its center a little distance to the right of the mouth of the Atchafalaya River, September 20. This disturbance advanced at the rate of about 8 miles per hour.

The meteorological and tide records at Mobile, Ala. (tide records from Pascagoula, Miss.), Port Eads, La., and Galveston, Tex., are shown on Plate IV. The storm tide began rising at Pascagoula, Miss., and Port Eads, La., about the same time on the afternoon of the 18th, when the center of the disturbance was nearly 400 miles distant in space and 40 hours in time. The rise which commenced at Port Eads and Pascagoula at 8 p. m. of the 18th had started from the southeast Gulf about 18 hours previously and had traveled about 500 miles at the rate of 28 miles per hour. By noon of the 19th there had been a rise at Pascagoula of 1.1 feet, and at Port Eads of 0.8 foot, and by midnight of the 19th the water had risen 2.4 feet at Pascagoula and 2 feet at Port Eads. No material changes in the tide other than the regular change were shown at Galveston until the night of the 19th. The storm tide from the forenoon of the 18th to the forenoon of the 20th at Pascagoula, Miss., was about 2.8 feet, and at Port Eads, La., 2.2 feet, and at Galveston, Tex., 1 foot. The rise in the tide at Galveston all occurred during the night of the 19th-20th.

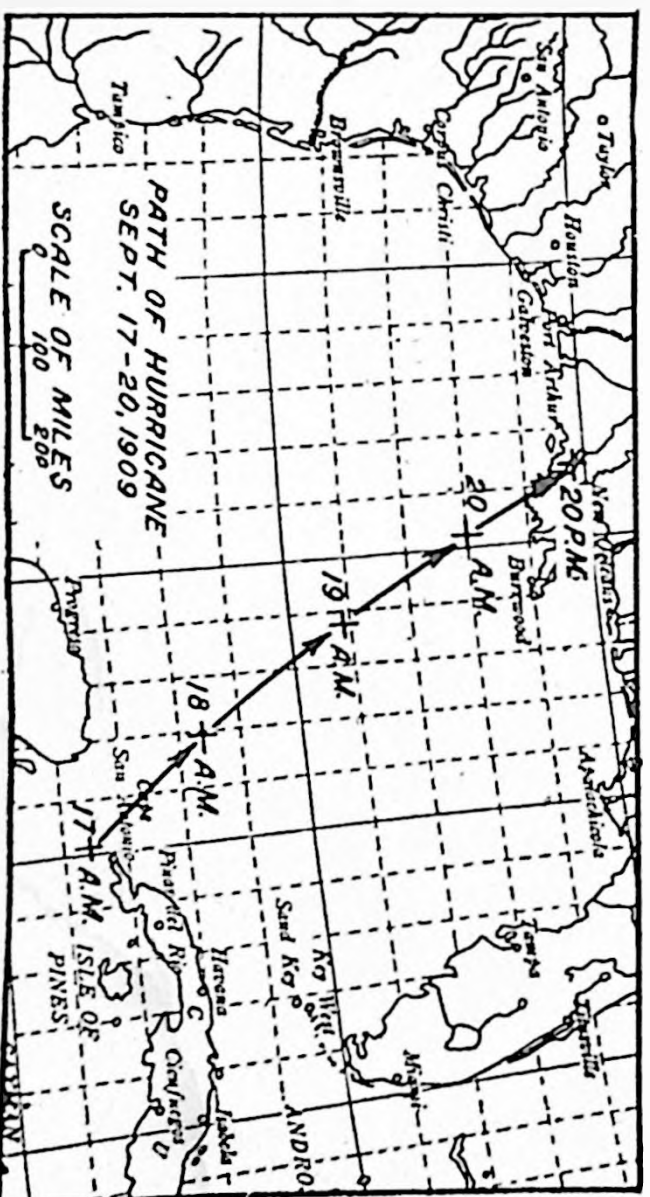
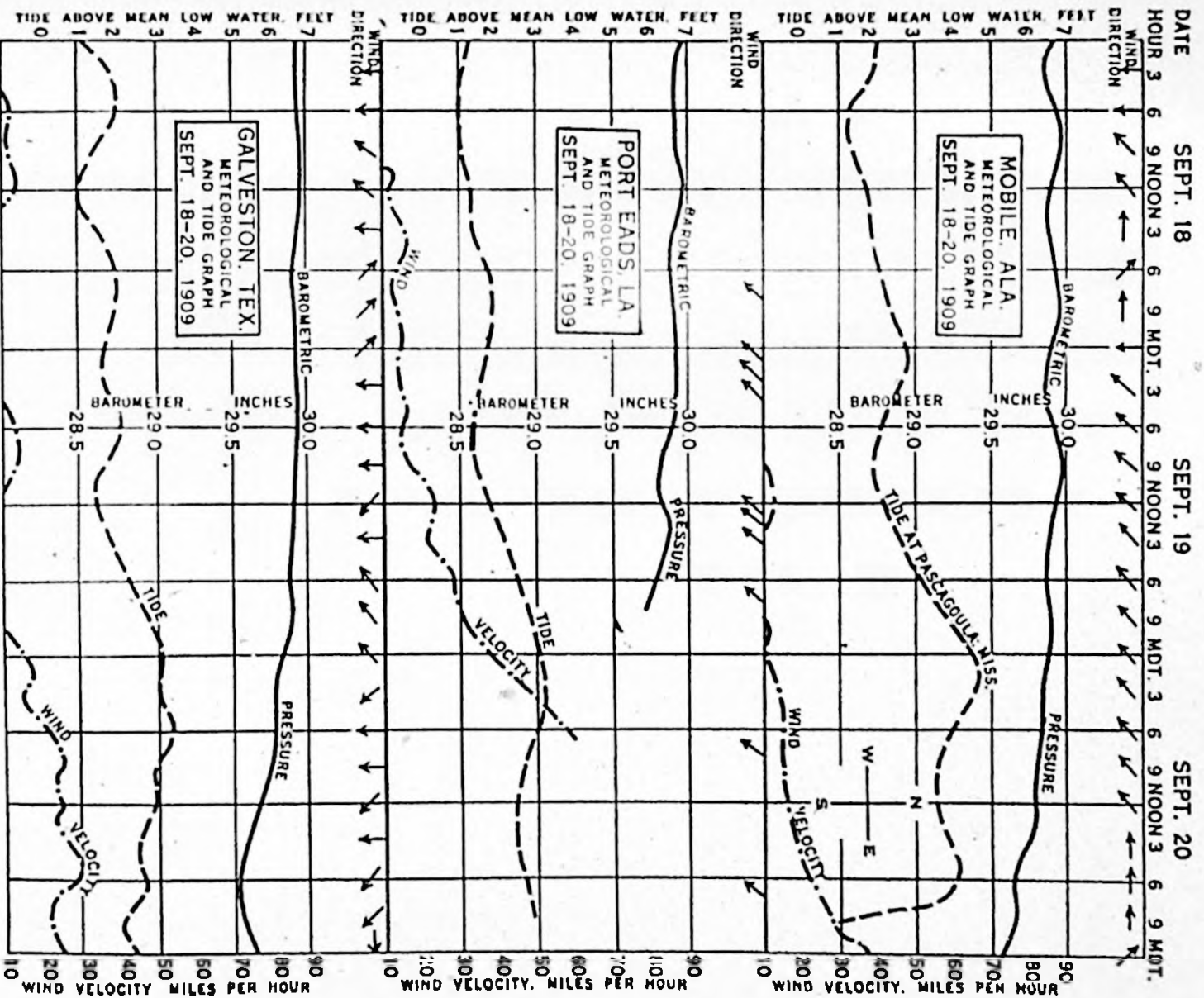


PLATE IV.—I. M. Cline.

The wharves at Mobile were overflowed and the water was within half a block of Royal street, the height of the water at that place being 8.7 feet.

The height of the water above mean Gulf level over the Louisiana coast region in the hurricane of September 20, 1909, has been determined by engineers of the Department of Agriculture in connection with the reclamation of marsh land (18). These records show the greatest height of the water in different parts of the hurricane with reference to the line of advance of the center, and from a study of these we may learn where to expect dangerous storm tides with the approach of a hurricane. The height of the water at several places in southeastern Louisiana during the hurricane of September 20, 1909, is shown in figure 1. Seven parishes were flooded, the height of the water being 6 to 10 feet over the greater portion of the area. The actual height of the water over the land in the right-hand segment of the cyclonic area resulted from the accumulation of water forced forward by the winds and checked in speed by the marsh lands, swamp forests, and levees. This is distinctly shown by the increased depth of 2 to 4 feet of water 30 to 50 miles inland from Burwood and Port Eads. The depths of 7 to 10 feet occurred at points where the greatest resistance to the advancement of the water, forced forward by the winds, was encountered. To the left of the line of advance of the center of the hurricane, the water did not get high enough at any point to attract attention and at Morgan City, La., near the center and in the left-hand segment of the cyclonic area, the water was 0.1 of a foot below mean Gulf level, while 75 miles to the right of the center the water was 5 to 7 feet above.

The damage to property by this storm amounted to \$6,400,000, and 353 lives were lost.

October 13-18, 1910.—This disturbance moved into the Florida Straits on the 14th, moved toward the northwest during the 15th, southward during the 16th, and then eastward to the Florida Straits by the morning of the 17th, after which it moved northward over Florida during the 18th. Barograph records of the French S. S. Texas from the 13th to the 17th



FIG. 1.—Height of storm tide above mean Gulf level in right and left hand segments of the hurricane, September 20, 1909. This shows the area overflowed when storm moves inland at nearly right angles to the coast line.—A. M. Shaw (18) and I. M. Chue.

confirm this movement.* We have no tide records for this disturbance. The official in charge, Weather Bureau Office, Tampa, Fla., reports the tide 6.6 feet below mean low water on the morning of the 18th, the lowest water of record, the cyclonic area at that time was moving northward with its center to the right of Tampa. After the passage of the center of the storm and its recurve northward, the water rose 10.1 feet, to 3.5 feet above mean low tide.

August 13-17, 1915.—This hurricane moved across the western end of Cuba into the Gulf of Mexico during the forenoon of the 14th, traveled in a direct line and passed inland on the Texas coast a short distance to the left of Galveston

*It is hoped at a later date to publish a full discussion of all reports of this remarkable storm.—EDITOR.

on the morning of the 17th. The disturbance advanced with a speed of about 12 miles per hour.

The wind, pressure and tides at Mobile, Ala., (tide at Fort Morgan), Burrwood, La., and Galveston, Tex., are shown on Plate V: The storm tide began rising slowly at Galveston,

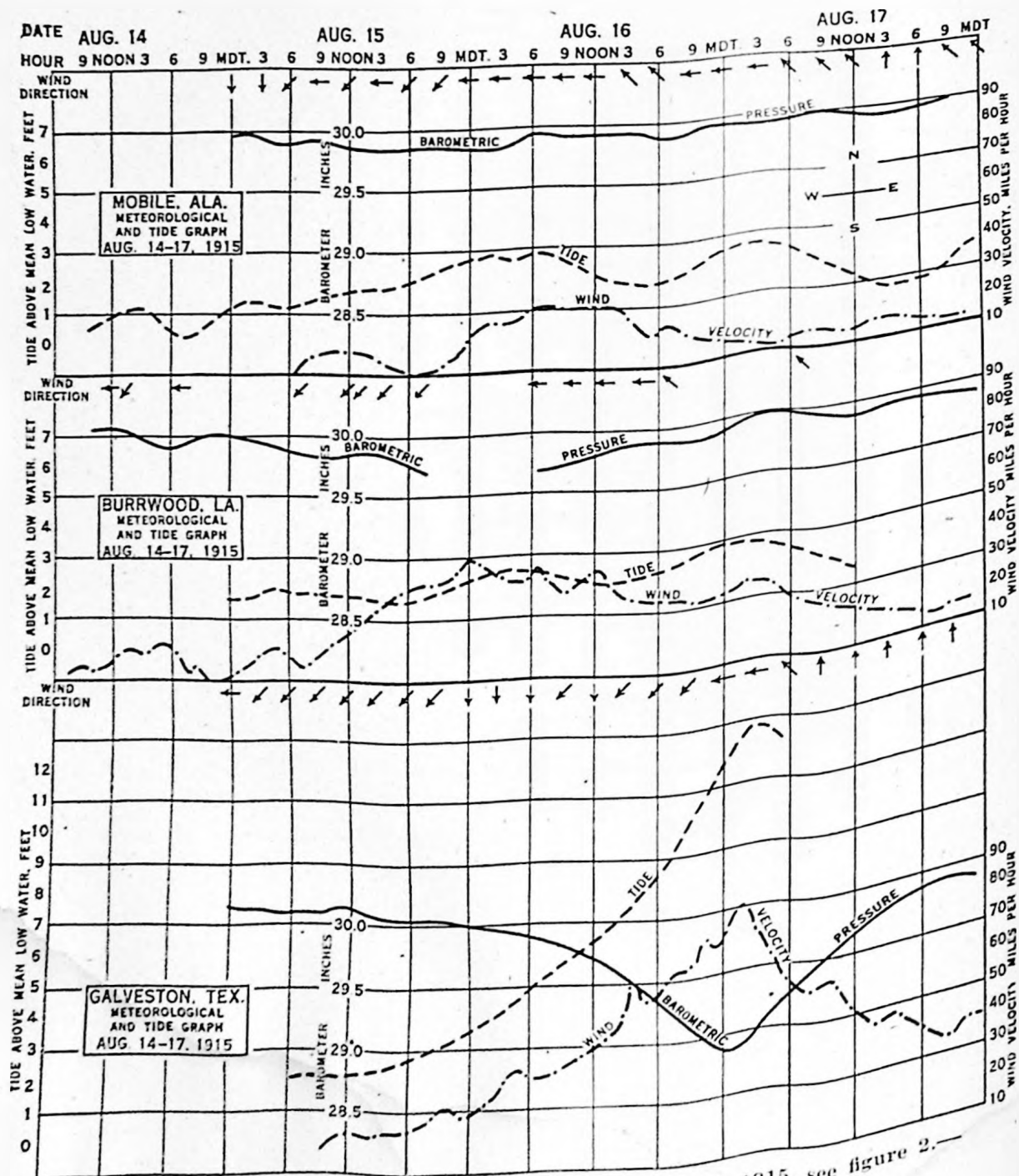
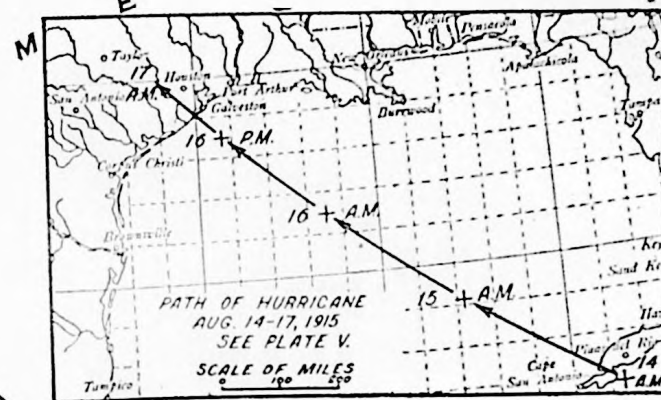
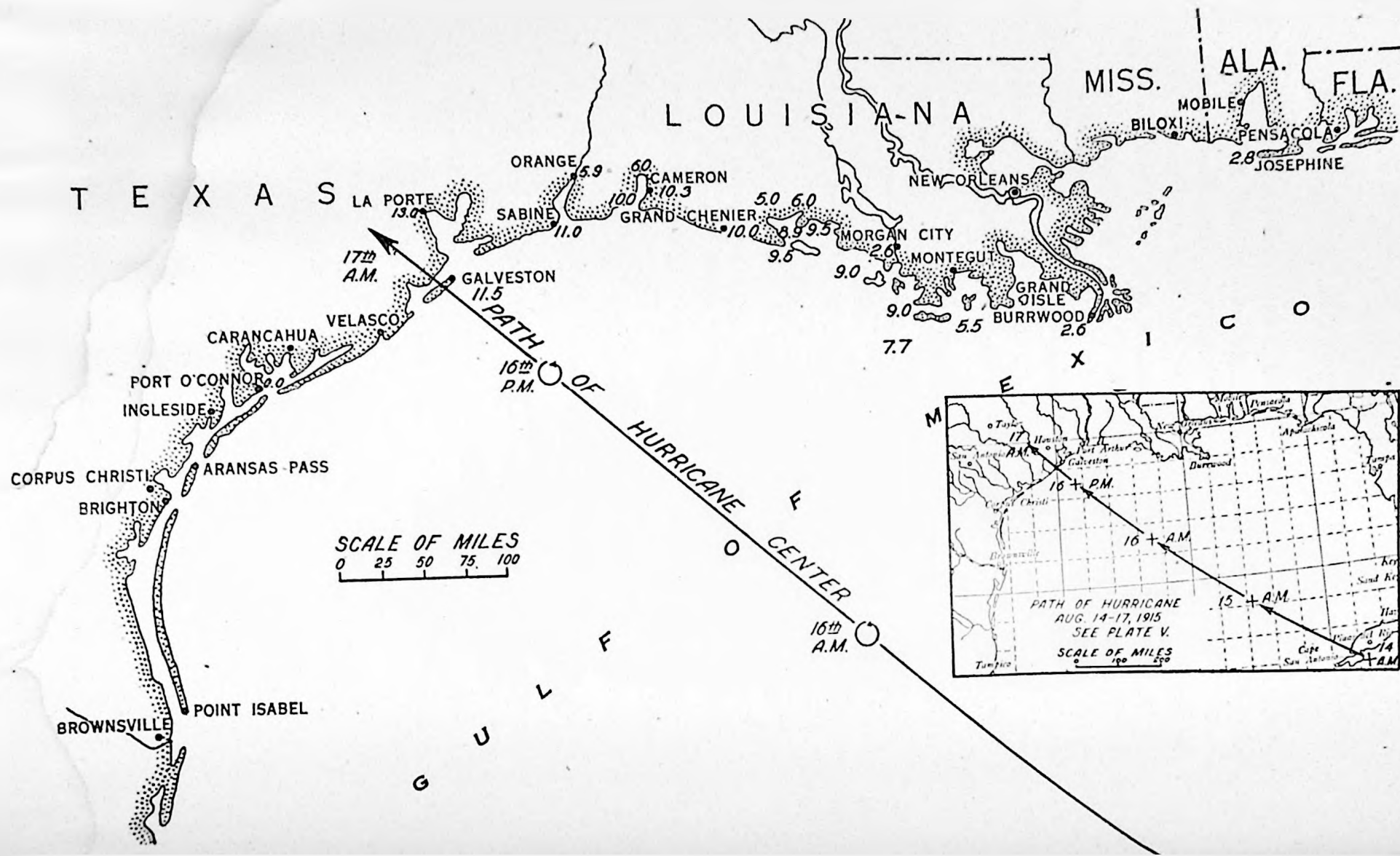


PLATE V.—For path and movement of hurricane, August 14-17, 1915, see figure 2.—
I. M. Cline.

Burrwood, and Fort Morgan during the forenoon of the 15th, just 24 hours after the disturbance had moved into the Gulf of Mexico. These rises in the water over a coast line more than 500 miles long all on the right of the line of advance of the hurricane resulted from waves started out from the region covered by the hurricane in the southeast Gulf during the 14th. The distance of the center of the storm at that time from Fort Morgan and Burrwood was 450 miles and from Galveston 700 miles. This would indicate that waves and swells were carried forward in the front of the right-hand segment in the line of advance of the hurricane at a velocity of 40 to 50 miles per hour and those going toward shore farther to the right of the line of advance traveled with a little less than half that speed. The highest water at Fort Morgan, 2.8 feet, was recorded at 6 a. m. on the 16th and showed a rise of 1.8 feet in 24 hours. At Burrwood, 2.6 feet was recorded at 1 a. m. of the 16th, a rise of 1 foot in 24 hours. The tide did not rise after that to any extent, at either of these places, but high water continued at Fort Morgan and Burrwood until the storm moved inland; the regular tides were not obscured.

At Galveston the tide continued to rise and was 4.1 feet at 6:30 a. m. on the 16th, a storm tide of about 3.1 feet in 24 hours. The center of the disturbance at this time was nearly 300 miles from Galveston and 21 hours distant in time. The rise in the water in front of the storm at this hour at Galveston was nearly twice the rise of 1.8 feet at Fort Morgan, 300 miles to the right of the line of advance of the hurricane, and was three times greater than the rise at Burrwood. The water continued to rise at Galveston until about 3 a. m. of the 17th, when it was 12 feet. The tide changed very little at Fort Morgan and Burrwood after 3 a. m. of the 16th and commencing at 3 a. m. of the 17th, fell to about normal on the afternoon of that date.

The heights of the water above mean Gulf level along the coast during this storm are shown in figure 2. This shows the height of the water in feet and tenths along the Gulf coast at different distances from the line over which the center of the hurricane advanced.



During the passage of this hurricane, the action of waves and currents in moving objects in the open Gulf was brought out by the movement of light and whistling buoys that were within its range. Trinity Shoals gas and whistling buoy, weighing 21,000 pounds, anchored in 42 feet of water, with 6,500 pound sinker and 252 feet of anchor chain weighing 3,520 pounds, was carried 8 to 10 miles westward of its proper location in latitude $29^{\circ} 07' N.$ and longitude $92^{\circ} 15' W.$ The shape and exposure of the buoy are shown in figure 3. The location of this buoy was 100 miles to the right of the line of advance of the center of the storm.

Galveston Bar gas and whistling buoy, same as shown, anchored at the end of Galveston Jetties in 36 feet of water was carried $4\frac{1}{2}$ to 5 miles in a southwesterly direction from its proper location. This buoy was about 20 miles from the center of the storm.

A buoy of the same class, with the same moorings in 42 feet of water, located on Heald Bank, 28 miles off the entrance to Galveston Bay, was not moved from its proper position, although its lights were extinguished. The Heald Bank buoy was a little to the left of the line of advance of the center of the hurricane. From the action of the water on these buoys we can get some information concerning the effects of currents and waves attending hurricanes.

The property damage in this storm was about \$21,000,000, and 275 lives were lost.

September 2-4, 1915.—A disturbance of considerable intensity crossed western Cuba, moved into the east Gulf and recurving lowly, moved inland near the mouth of the Apalachicola River during the early morning hours of the 4th. Pressure, wind and graphs for Mobile (tide, Fort Morgan), Ala., and Burrwood, La., are shown in Plate VI. These stations were located, Fort Morgan, 100 miles, and Burrwood, 200 miles to the left of the line of advance of the center of the storm. The tides at these stations were not influenced in any manner by the disturbance and there was no high tide at Pensacola. Along the Florida coast, to the right of the line of advance high water prevailed generally. At St. Petersburg, Fla., water was 4.9 feet above any previous high water.

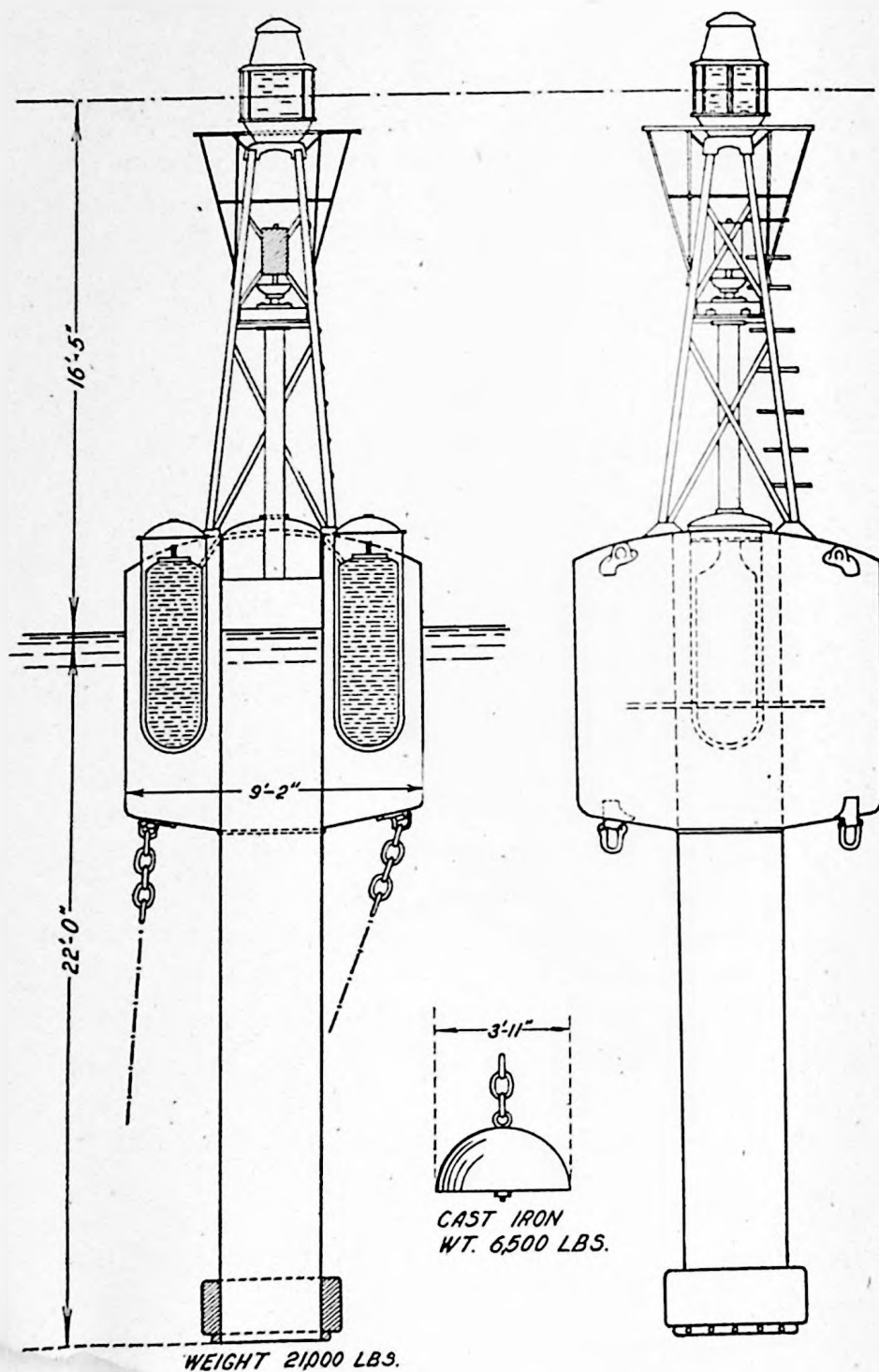


FIG. 3.—Design of gas and whistling buoy anchored at Trinity Shoals, Louisiana coast; Galveston Bar, off jetties and Head Bank, Tex. Trinity Shoals and Head Bank buoys are anchored in 43 feet and Galveston Bar in 36 feet of water.

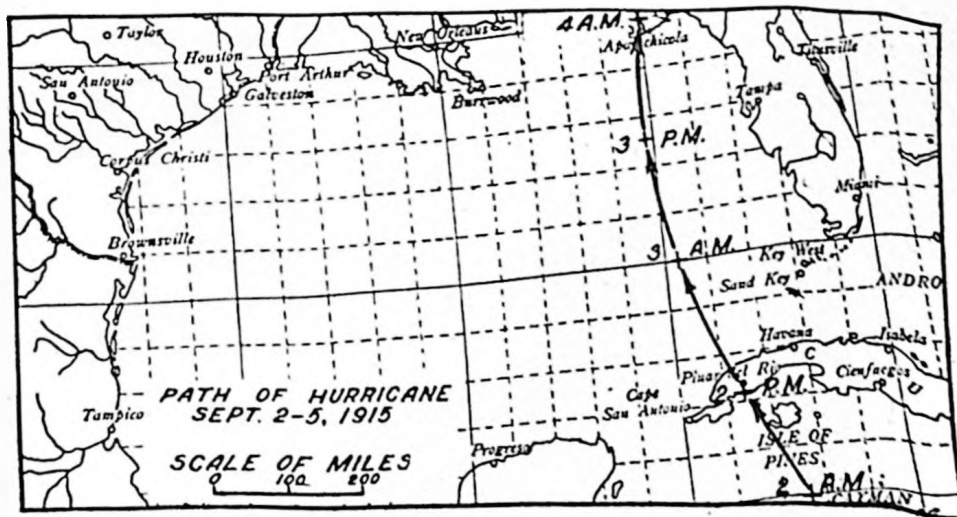
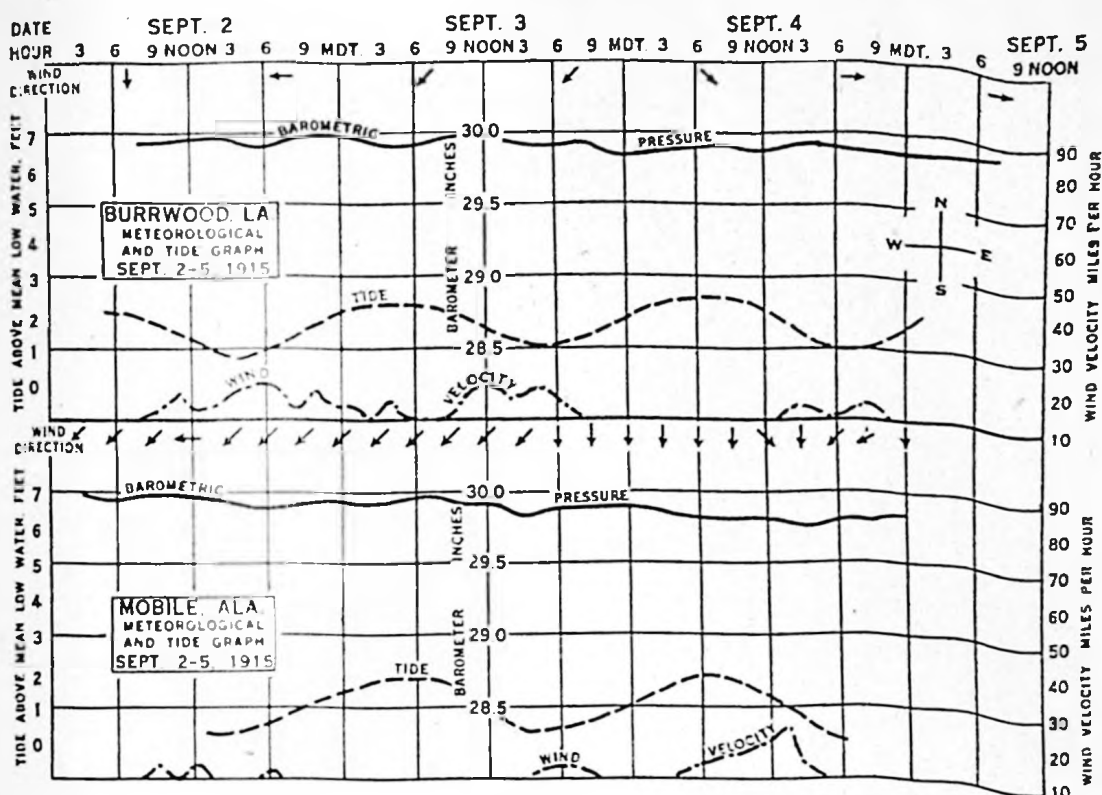


PLATE VI.—I. M. Cline.

September 22-30, 1915.—This was one of the most intense hurricanes in the history of the Gulf coast. The cyclonic area moved through the Yucatan Channel during the night of the 27th, and traveling northwestward moved inland on the Louisiana coast to the left of and near Grand Isle, La., during the

29th. This disturbance recurved slowly after crossing latitude 27° N. and moved slowly northward.

The pressure, wind and tides at Mobile (tide records Fort Morgan) Ala., Burrwood, La., and Galveston, Tex., are shown in Plate VII. The tide was about 0.8 of a foot above the predicted tide at 8 p. m. on the 26th. At 8 a. m. on the 27th the water had commenced rising at Fort Morgan and was 1 foot above the predicted tide on the Gulf coast from Burrwood to

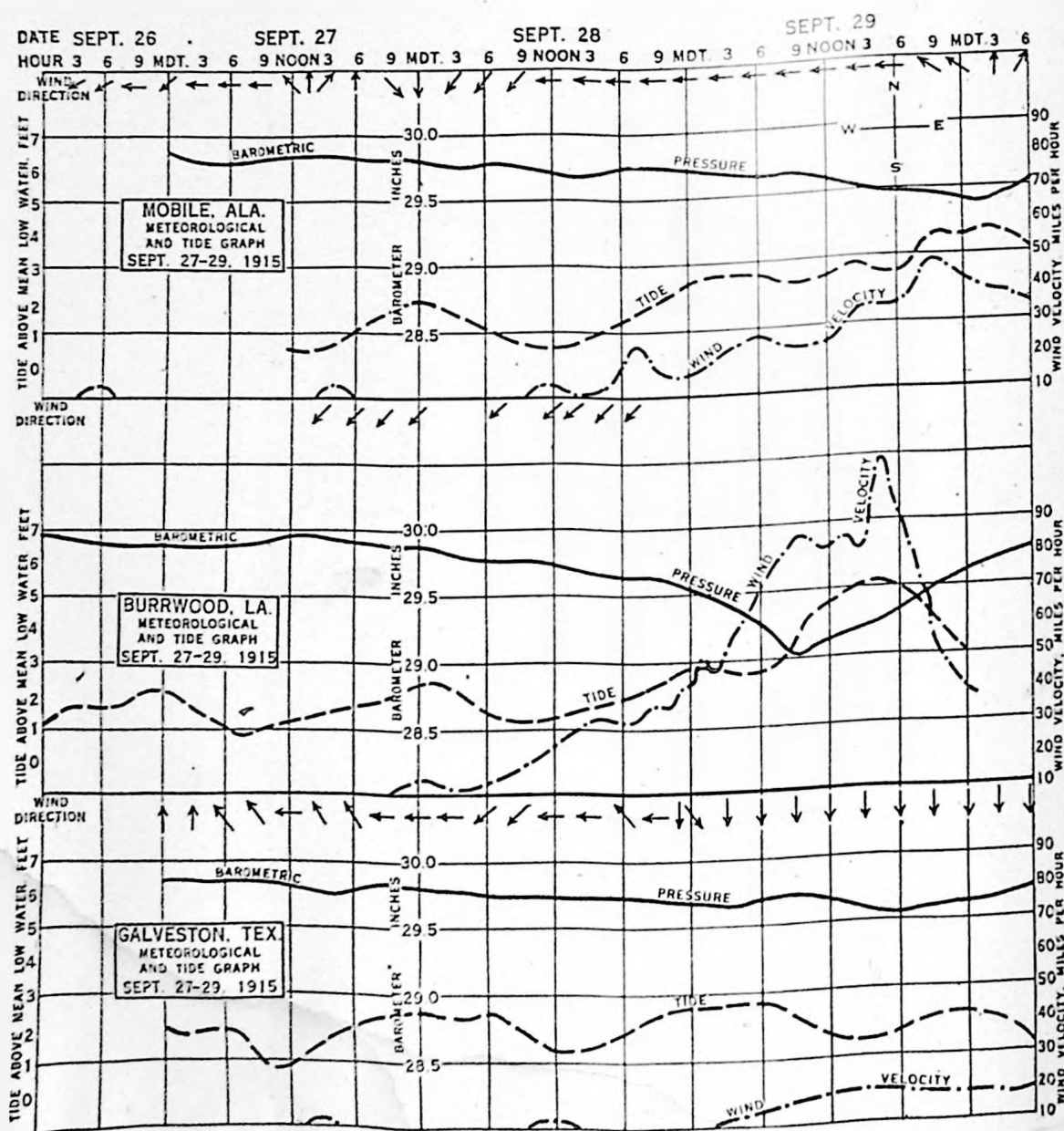


PLATE VII.—For path and movement of hurricane, September 27-29, 1915, see figure 1.—I. M. Cline.

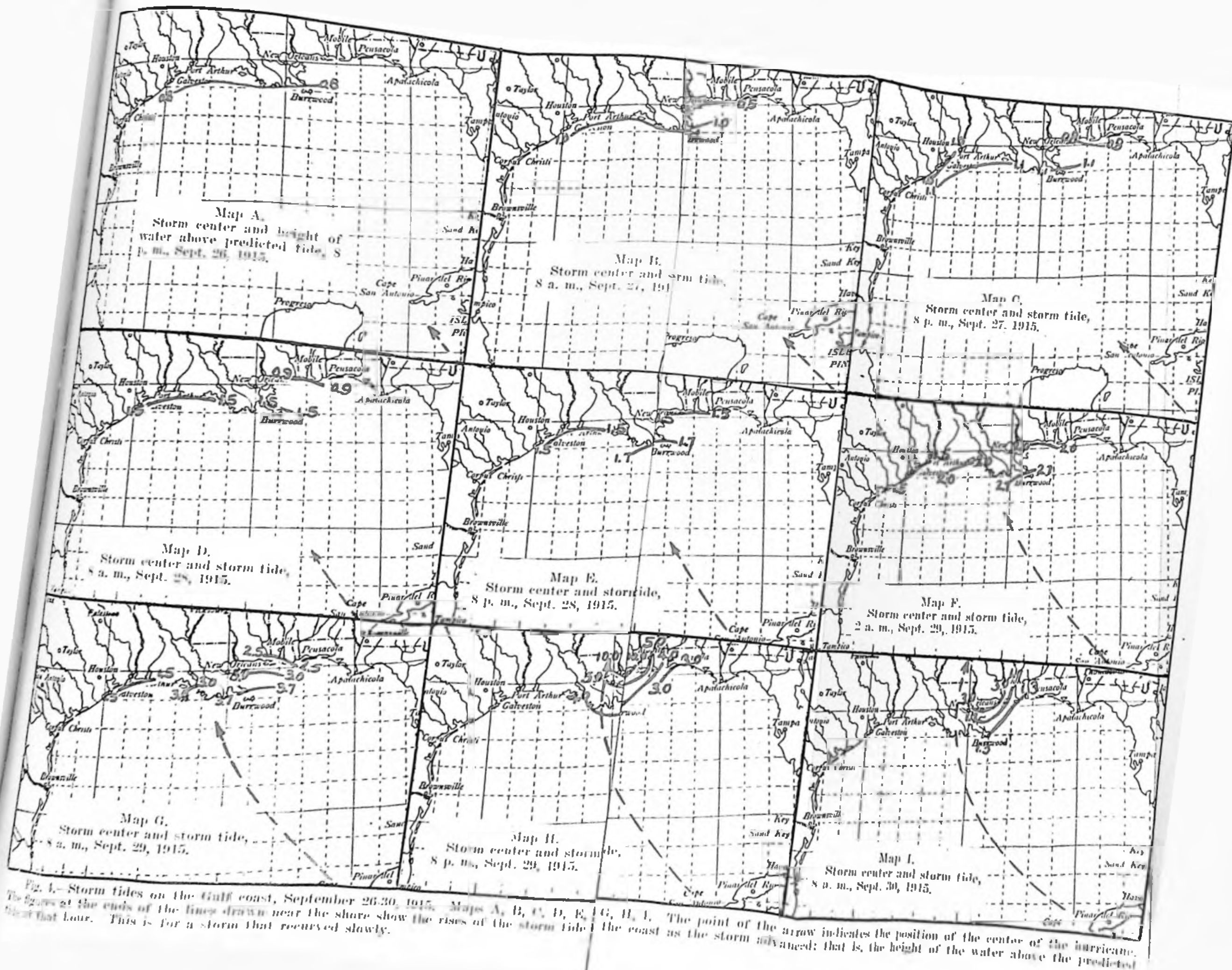


Fig. 1.—Storm tides on the Gulf coast, September 26-30, 1915. Maps A, B, C, D, E, F, G, H, I. The point of the arrow indicates the position of the center of the hurricane. The figures at the ends of the lines drawn near the shore show the rises of the storm tide above the predicted tide at that hour. This is for a storm that recurved slowly.

Galveston; at 8 p. m. the excess was 1.1 feet. At 8 a. m. of the 28th, there was 1.5 feet of water in excess of the predicted tide at Burrwood and Galveston and 0.8 foot at Fort Morgan. At 8 p. m. of the 28th, when the storm was about 250 miles distant, there was a storm tide of 1.7 feet at Burrwood and 1.5 feet at Fort Morgan. When the storm began recurving to the right, the water ceased rising at Galveston, and no storm tide was recorded there after 8 a. m. of the 28th. At 2 a. m. of the 29th, the tide had continued rising on the middle Gulf coast and showed 2.7 feet at Burrwood and 2 feet at Fort Morgan. At 8 a. m. of the 29th, the storm tide had risen to 3.7 feet at Burrwood and 2.5 feet at Fort Morgan. The rise of the storm tide is shown in figure 4.

The storm waters were carried over southeastern Louisiana and the depth was more than 12 feet on the shore of Lake Pontchartrain and 10 to 11 feet on the Louisiana and Mississippi coasts. High water prevailed to the right of the center of the hurricane to the eastward of Pensacola, where the water was 4 feet high, and at Mobile the storm water was banked up 7.2 feet. The distribution of the storm waters along the middle Gulf coast in the different parts of the hurricane are shown in figure 5. The height of the water in the open Gulf, as nearly as we can expect to get records, was 4.6 feet, 45 miles to the left of the center of the storm at a lighthouse about 40 miles out in the Gulf from Racoon Point; 8.4 feet at Timbalier Light, a few miles to the right of the center, which is 10 miles from land; and 5.8 feet at Burrwood, about 60 miles to the right of the center. No water was carried inland to the left of the line of advance of the center of the hurricane, and at Morgan City, 15 miles from the Gulf, the tide was 0.4 of a foot below mean Gulf level. At Pensacola, 175 miles to the right of the center, the tide was 4 feet; at Mobile, 150 miles, it was 7.2 feet; at Gulfport, Miss., 80 miles, it was 9.6 feet; at Bay St. Louis, 65 miles, it was 11.8 feet.

The center of the storm passed between Lake Pontchartrain and Lake Maurepas. In Lake Pontchartrain, to the right of, but nearly in the center of the hurricane, the water was 13 feet at Frenier, due to the wind forcing the water up against a dense growth of timber in that locality. A few miles farther



FIG. 5.—Height of storm tide above mean Gulf level, in left and right hand segment of the hurricane, September 29, 1915. This shows the distribution of high water on the middle and east Gulf coast with a slowly recurving hurricane.—C. W. Okay, (18) and I. M. Cline.

along the line of advance of the center of the storm, near the connection between Lake Pontchartrain and Lake Maurepas, where there was open space, the height of the water was 6 feet. At Frenier we find that the force of the wind, with about 25 miles open waterway, banked the water 13 feet against an obstruction of only a few miles extent, 7 feet higher than on either side.

The damage resulting from this hurricane is estimated at \$13,000,000, and 275 persons were drowned.

July 1-6, 1916.—This disturbance made its appearance in the Caribbean Sea on the afternoon of the 1st, moved almost in a straight line through the Yucatan Channel on the 3d and reached the Mississippi coast late in the afternoon of the 5th. The storm covered a considerable area and was of great intensity.

The wind, pressure, and tides at Mobile (tide records, Fort Morgan), Ala., Burrwood, La., and Galveston, Tex., are shown in Plate VIII. The tide at Mobile and Burrwood was rising at noon of the 4th when the disturbance was centered 400 miles distant in space and 26 hours in time. This rise of water had traveled from the Yucatan Channel a distance of 500 miles in 18 hours in the front and to the right of the line of advance of the center of the cyclonic area. At midnight of the 4th the water had risen 1 foot at Burrwood and 1.4 feet at Fort Morgan. At 8 a. m. on the 5th the storm tide was 2.8 feet at Port Eads and Burrwood and 3 feet at Fort Morgan. The highest water at Fort Morgan was 5.3 feet and occurred at 1 p. m. of the 5th; at Burrwood the highest water was 3.8 feet at 10 a. m. of the 5th. Burrwood was about 25 miles to the left and Fort Morgan about 75 miles to the right of the line of advance of the center. The distance traveled by the center of the disturbance after passing Burrwood before coming in a line with Fort Morgan was 50 miles.

The difference in time between the passage of the crest of high water at Burrwood and Fort Morgan, 3 hours, would indicate speed of about 15 miles per hour, which is the same as the progressive speed of the cyclonic area. The location of these stations is such that no great banking up of water by physical obstruction was likely to have taken place. Therefore, these records serve as a good illustration of the heights reached by storm tides on the different sides of the hurricanes where the open space of water represents as nearly the condition in the open Gulf as we can expect to find. Fort Morgan was three times farther than Port Eads from the center. As the shore was approached the water banked up much higher, this being due to physical obstructions. The height of the

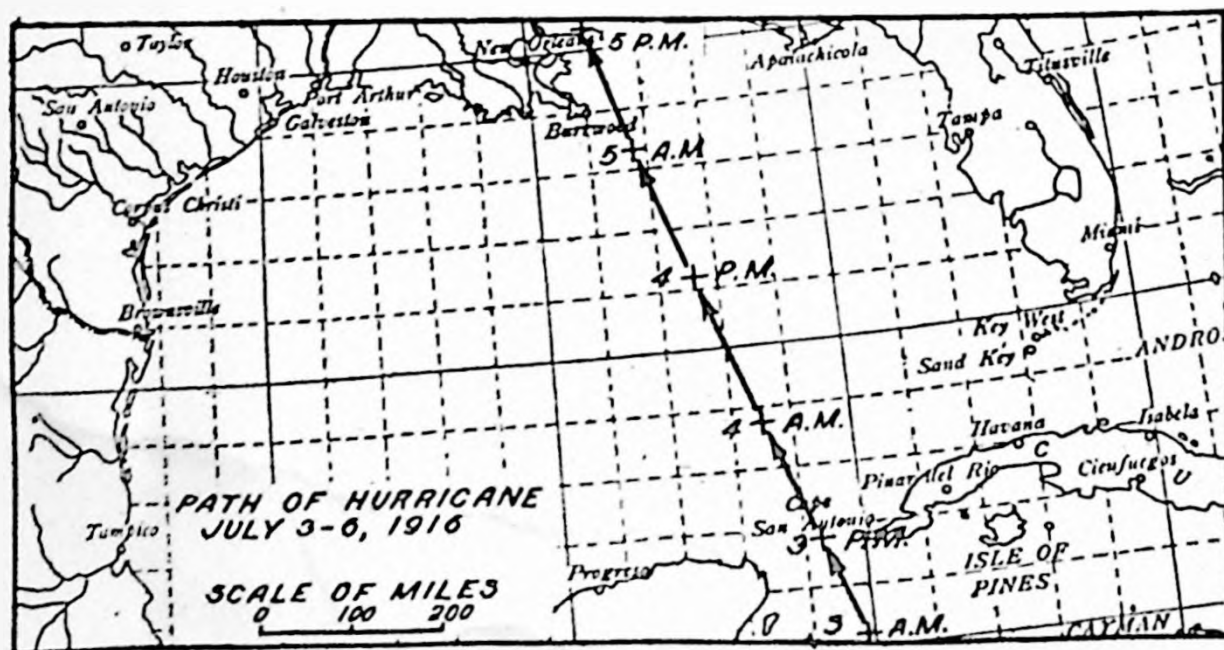
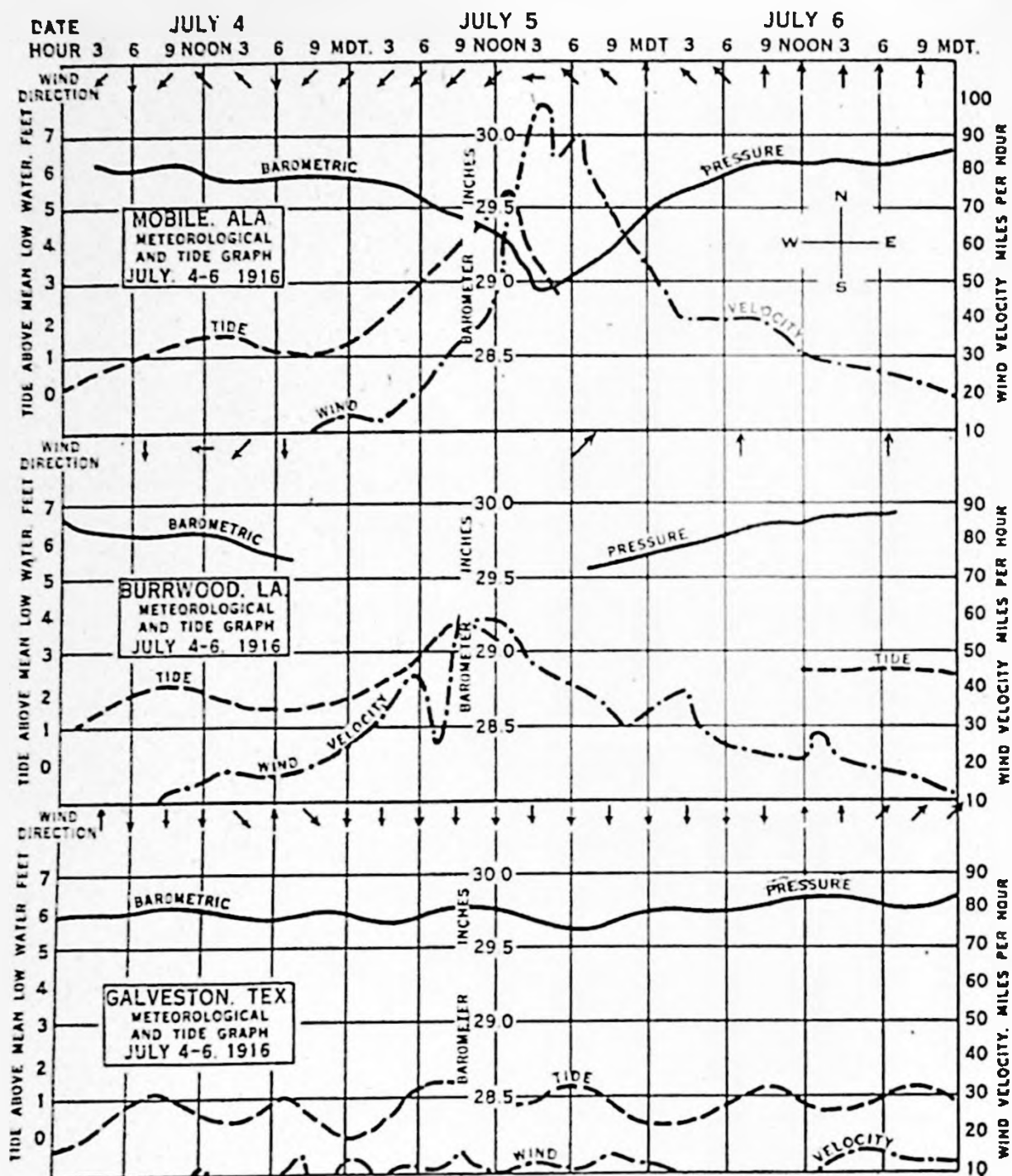


PLATE VIII.—I. M. Cline.

water at Mobile was 11.6 feet, which is 6.3 feet above the actual height reached by the water at Fort Morgan. High water did not occur as far west as Biloxi and Pass Christian. The damage at Mobile and on the Alabama coast amounted to \$2,500,000, and 12 persons were drowned. The height of the water at Pensacola, Fla., was 5 feet.

The damage at Pensacola amounted to \$1,000,000. The storm did not influence the tide in any manner at Galveston, Tex.

August 12-19, 1916.—This disturbance passed through the Yucatan Channel into the Gulf of Mexico during the night of the 16th, advanced northwesterly in nearly a straight line, and moved inland on the Texas coast midway between Corpus Christi and Brownsville during the afternoon of the 18th.

We have no tide records in the vicinity of the center of this hurricane, but wind, pressure, and tide records at Burrwood, La., 400 miles to the right, and Galveston, Tex., 250 miles to the right of the line of advance of the center of the hurricane, are shown in Plate IX. No appreciable influence was shown on the tide at Burrwood. At Galveston, 250 miles to the right of the line of advance of the center, the water commenced rising about 6 p. m. of the 17th, when the center of the disturbance was nearly 400 miles distant. The water that caused this rise must have started on its journey toward the Texas coast when the storm was passing through the Yucatan Channel and had traveled a distance of nearly 800 miles, showing a speed of about 40 miles per hour. The cyclonic area advanced at the rate of 18 miles per hour. The water at Galveston rose steadily from 6 p. m. of the 17th until 6 p. m. of the 18th, when the height of the water was 4 feet, about 3 feet being storm tide. Galveston, at the time of the occurrence of the highest water, was 200 miles from the center, and a line drawn through Galveston and the center of the storm at that time crossed the line of advance at right angles. The advance of the hurricane was more prominently shown in the rise of the water at Galveston than in the pressure or wind changes.

The damage caused by this hurricane was estimated at \$1,800,000, and 15 persons were killed or drowned.

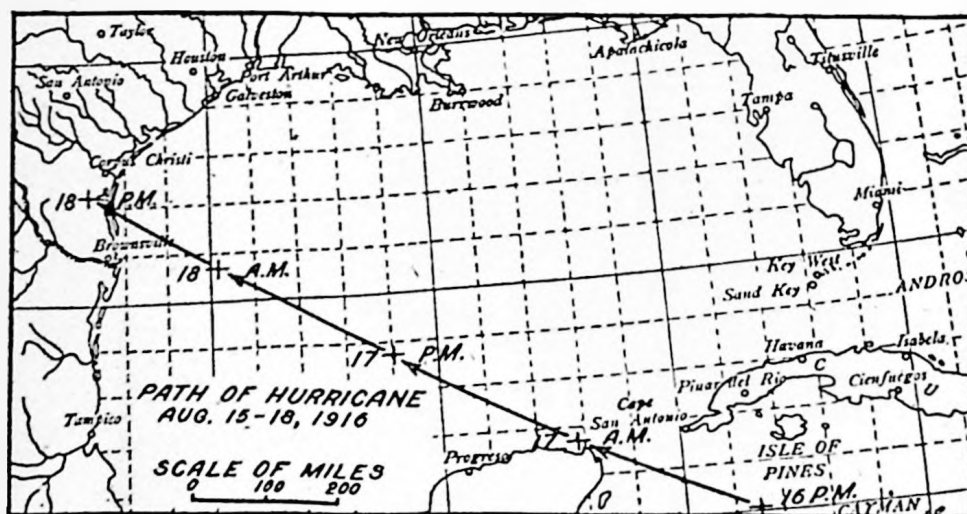
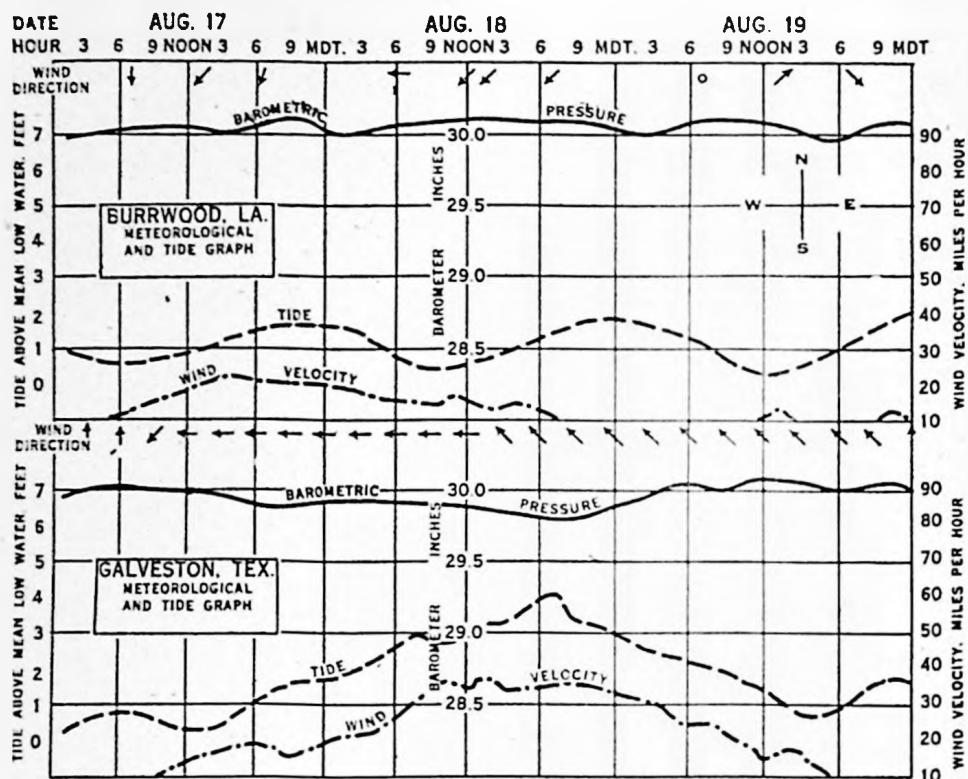
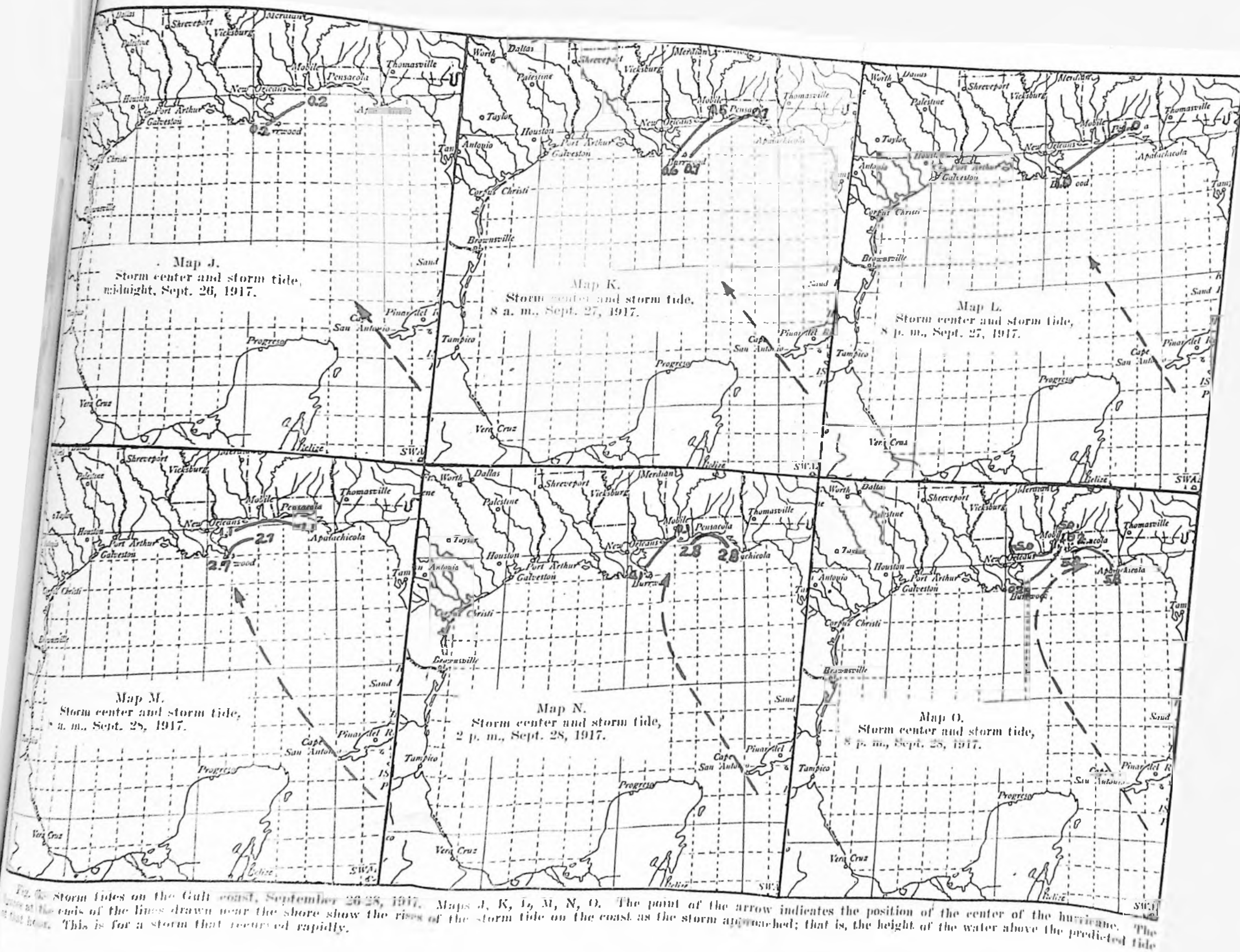


PLATE IX.—I. M. Cline.

September 21-29, 1917.—This disturbance moved through the Yucatan Channel into the Gulf of Mexico during the night of the 25th and advanced in a direction a little west of north toward the mouth of the Mississippi River. When within about 50 miles of Port Eads the storm began recurving to the right, and the center, passing about 50 miles to the right



of Port Eads, La., moved inland to the right of Pensacola, Fla.

The pressure, wind, and tides for Pensacola, Fla. (the tides are drawn from the observations made by the observer of the Weather Bureau except the highest stage, which was obtained from the United States Engineers, Burrwood, La. (tide Port Eads), and Galveston, Tex., are shown in Plate X.

The changes in the height of the water with the advance of the hurricane are shown in figure 6. The changes in the tide in a recurving hurricane are shown in this case. The tide

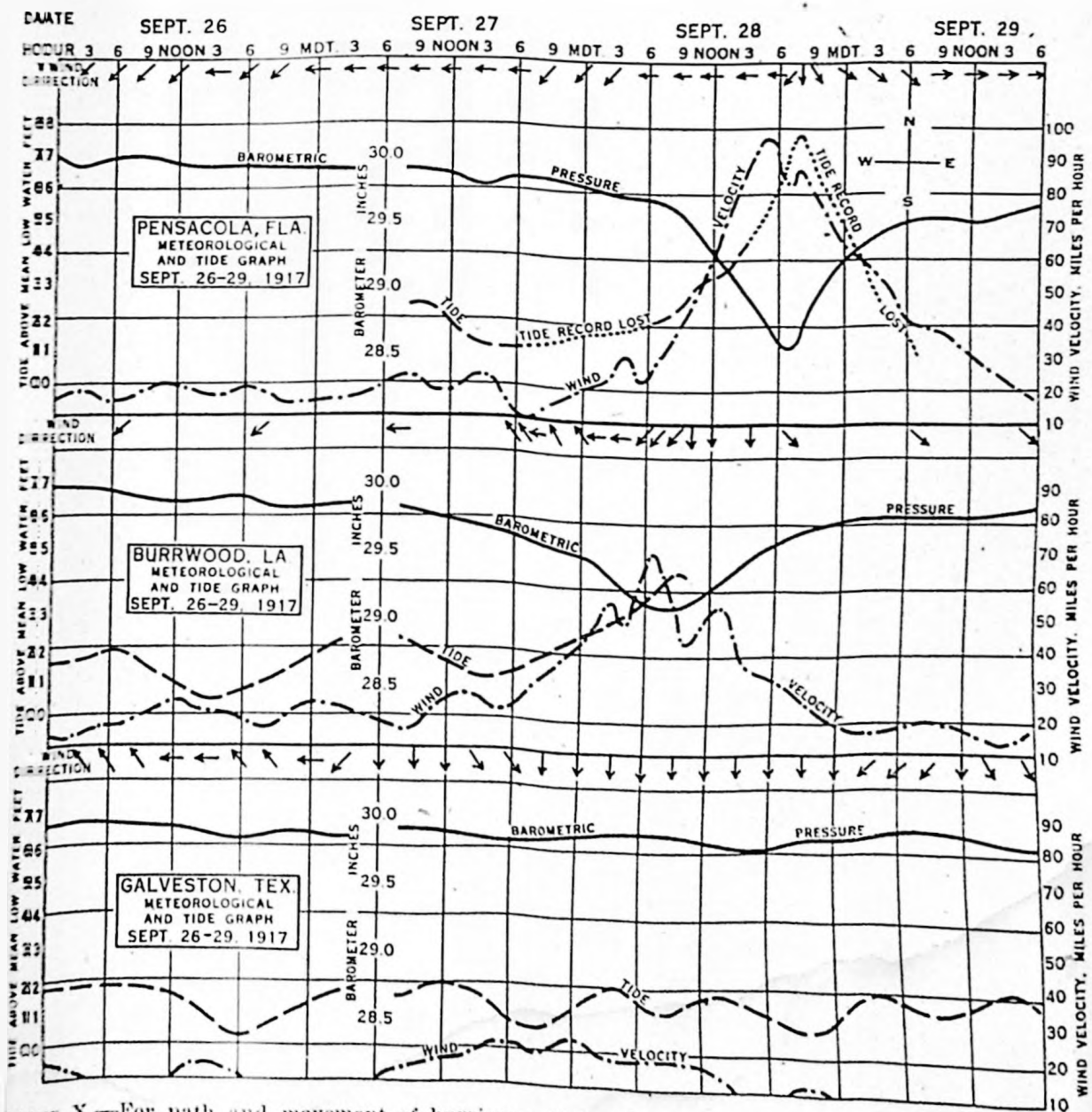


PLATE X.—For path and movement of hurricane, September 26-28, 1917, see figure 6.—I. M. Cline.

commenced rising at both Pensacola and Port Eads during the night of the 26th and was 0.6 to 0.7 of a foot above the predicted tide at 8 a. m. of the 27th, when the disturbance was centered about 200 miles from Port Eads and 300 miles from Pensacola. At 8 p. m. of the 27th there was 1.0 foot of storm tide at both Pensacola and Port Eads. On the morning of the 28th the line of advance of the center of the storm over Port Eads, which place had a storm tide of 2.7 feet, and Pensacola only 1.1 feet. At 10 a. m. reports from Pilottown showed the storm had shifted its course to the right. The tide began rising rapidly at Pensacola and by 2 p. m. the storm tide at that place was 2.8 feet. The storm tide about 8 p. m. on the 28th at Fort Barancas, Fla., was 5.8 feet, the height of the water being 7.8 feet. The water in the river at Mobile fell 5 feet below low water on the afternoon of the 28th.

The damage at Pensacola amounted to \$170,000. This place was near the center of the storm, but being to the left of the line of advance, suffered very little damage, notwithstanding the intensity of the hurricane.

August 1-6, 1918.—This disturbance moved through the Yucatan Channel into the Gulf of Mexico during the night of the 4th, traveled in a northwesterly direction and passed inland over Lake Charles, La., during the 6th. The hurricane was small but of marked intensity. We have no records for this storm, but at Morgan City, 150 miles to the right of the line of advance of the center of the storm the tide rose 3 feet, and 28 miles west of the center, at Johnsons Bayou, there was a tide of 2.8 feet.

The damage from the hurricane amounted to \$5,000,000, and 34 deaths resulted.

September 6-14, 1919.—This disturbance passed through the Florida Straits during the night of the 9th, moved very slowly during the 10th, 11th, and 12th, with its line of advance pointing toward the Louisiana coast west of the Atchafalaya River. On the 13th the disturbance changed its course to the westward, moved rapidly in almost a straight course, and passed inland with its center a short distance to the left of Corpus Christi, Tex., during the afternoon of the 14th.

The pressure, wind, and tides at Burrwood, La., and Galveston, Tex., are shown on Plate XI. The tire record at Galveston was incomplete after 12 noon of the 13th. The highest point reached by the water has been obtained from the United States Engineers and other records from tide heights telegraphed by the observer at Galveston with observations, and these data have been supplemented by other reports. We have thus been able to complete the tidegraph with a fair degree of accuracy. The long stretch of open water, more than 1,000

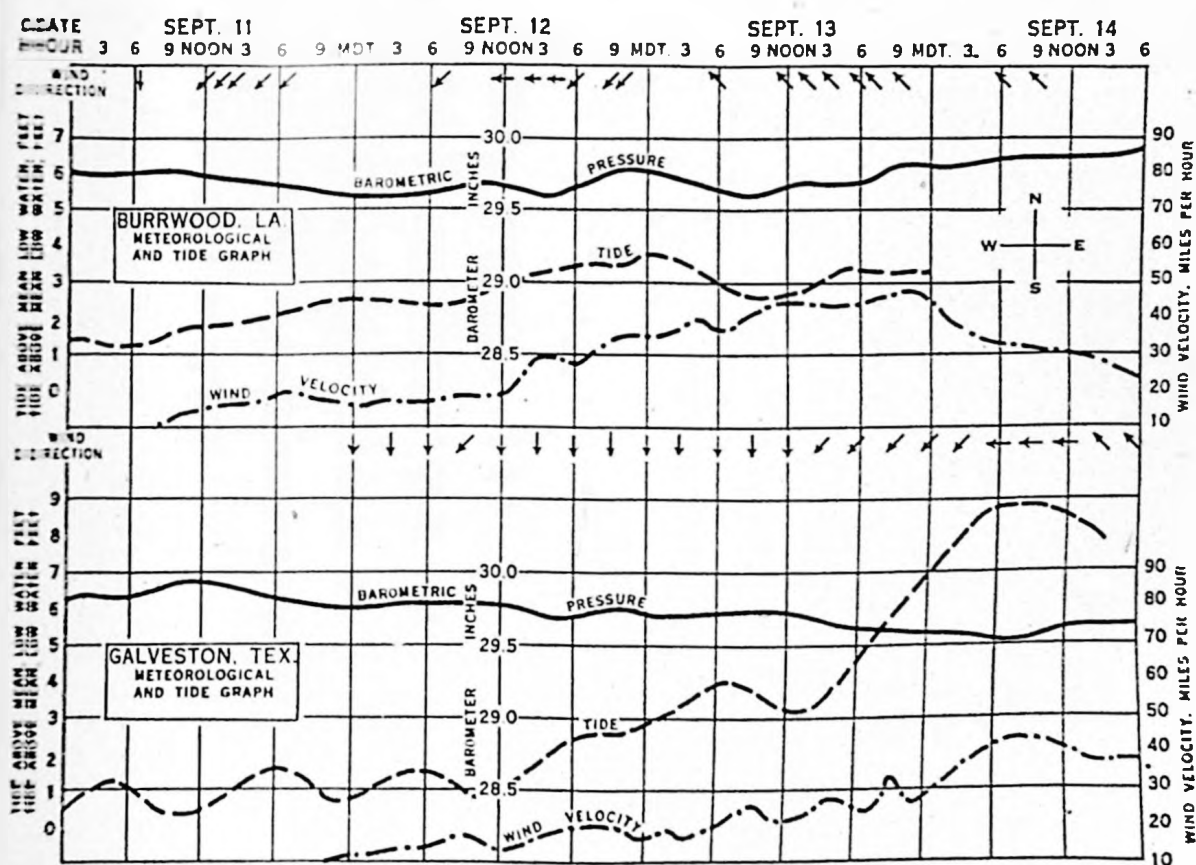


PLATE XI.—For path and movement of hurricane, September 11-14, 1919, see figure 7.—I. M. Cline.

miles, traversed by this hurricane after entering the Gulf of Mexico, furnishes a splendid opportunity to study the changes in the stages of the water along the coast both in front and along the line of advance of the center of the hurricane.

The storm tides and their changes with the advance of the hurricane from the morning of the 11th until the afternoon of the 14th, when the hurricane moved inland, are shown in figure 7. There was a rise of 0.3 foot above the pre-

dicted tide at Burrwood, La., at 8 a. m. of the 11th, when the center of the storm was 400 miles distant. At 8 p. m. of the 11th the rise of 0.3 foot had reached Galveston, traveling from the longitude of Burrwood, about 500 miles, in 12 hours, nearly 40 miles per hour, and the storm tide at Burrwood at this time was 1.1 feet. Galveston was at this time 600 miles distant from the center of the hurricane and Burrwood about 350 miles distant. By 8 a. m. of the 12th the storm tide was 1.7 feet at Burrwood and 0.7 of a foot at Galveston; and at 8 p. m. the height of the water in excess of the predicted tide was 1.9 feet at Burrwood and 1.6 feet at Galveston.

On the morning of the 13th the hurricane tide was 2.6 feet at Galveston, 300 miles in front of the center, and 2.4 feet at Burrwood, about 200 miles to the right of the line of advance of the center. No increase in the height of the water took place at Burrwood during the 13th, but at Galveston the storm tide at 8 p. m. was 3.6 feet, a gain of 1 foot in 12 hours; at this hour the water had commenced rising slowly at Aransas Pass, Tex. At 3 a. m. on the 14th the storm tide was 7.6 feet at Galveston, and 4 feet at Aransas Pass. At 8 a. m. of the 14th the height of the water had not changed at Galveston, but had risen 2 feet at Aransas Pass, during the preceding five hours and stood 6 feet. When the storm moved inland, about 3 p. m. on the 14th, there was a storm tide of 11.1 feet at Aransas Pass. The water, driven before the wind with the passage of the hurricane inland, banked up in places to depths of 12 to 16 feet.

This storm furnishes a good example for the study of the changes in the depth of the water along the coast in hurricanes which are moving coastwise. These heights are represented in figure 8. The rise of the storm tide in bays and estuaries to the right of the line of advance of the hurricane lags behind the rise on the coast. At Morgan City the highest water, 7 feet, occurred at 4 a. m. on the 14th, six hours after it had occurred on the near-by coast. At La Porte, Tex., near the upper end of Galveston Bay, the highest water, 8.5 feet, was at 1 p. m. on the 14th, about 12 hours after it had reached Galveston. At Carancahua, Tex., a tide of 10 feet occurred at 5 p. m., about 2 hours later than at Aransas Pass and at

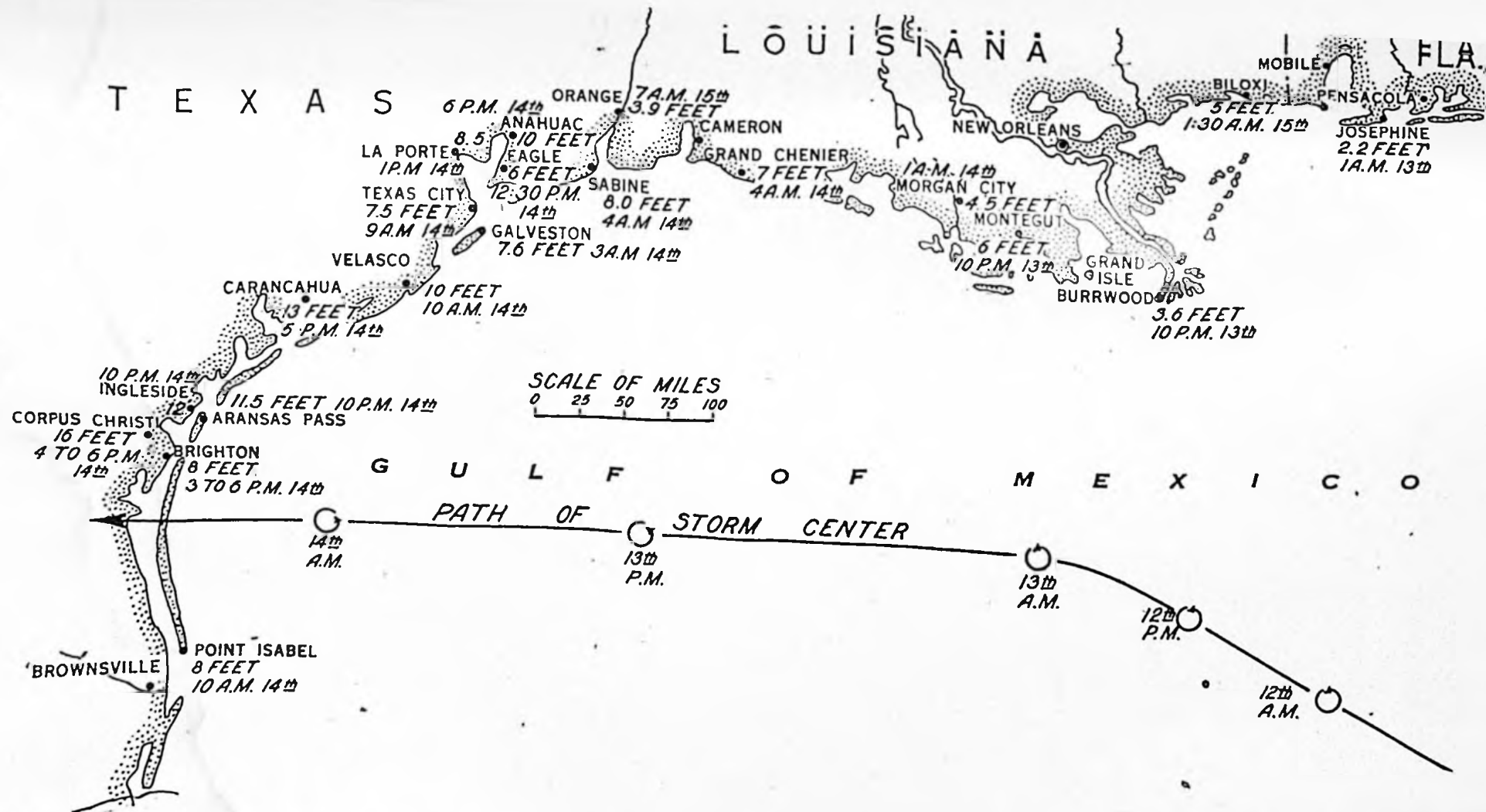


FIG. 8.—Height of storm tides along the Gulf coast above mean Gulf level and the time of their occurrence as related to the movement of the hurricane center through the Gulf of Mexico, September 11-14, 1919. This shows the storm tides in their relation to the path of a hurricane which moves in through the Florida Straits and thence across the Gulf to the Texas coast. The highest tide at stations, 30 to 50 miles inland, on bays and estuaries, occurred 8 to 12 hours later than at points on the coast line.—I. M. Cline.

NOTE.—The path of storm center shown here is subject to slight revision after all available reports have been carefully studied; e. g., the position on the 13th A. M. may have been farther west.—F. G. T.

Correction.—At Aransas Pass in the above diagram 10 P. M. should read 9 P. M., and at Biloxi the 15th should read the 13th.

Ingleside, 12 feet at 10 p. m. on the 14th, nearly 9 hours after Aransas Pass.

During the passage of this storm Trinity Shoals gas and whistling buoy (described under hurricane of Aug. 17, 1915), anchored in 42 feet of water, was carried $2\frac{1}{2}$ miles to the westward.

Galveston Bar gas and whistling buoy was carried $11\frac{1}{2}$ miles to the southwest.

Aransas Pass gas and whistling buoy anchored in 42 feet of water, latitude $27^{\circ} 50' N.$, longitude $92^{\circ} 02' W.$, was carried 5 miles nearly parallel to the coast and a little in toward the coast. This buoy weighs 8,000 pounds, the anchor 5,000 pounds, and 252 feet of chain weighing 3,528 pounds.

At Sabine Bank Lighthouse, 15 miles off Sabine Pass, cast-iron plates $\frac{7}{8}$ -inch thick, 27 feet above the surface of the water, were crushed in and bent up by the waves. This place was about 125 miles to the right of the line of advance of the center. This is cited as showing the power of the wave in that part of the hurricane.

The area along the Gulf coast, which has been flooded by storm tides, is shown by the heights of the water given on figures 1, 2, 5 and 8.

The damage caused by this hurricane amounted to \$20,272,000 and 284 lives were lost.

During the 20 years 1900 to 1919 hurricanes on the coast of the Gulf of Mexico have caused damage to property amounting to \$105,642,000, and 7,225 lives have been lost.

CONCRETE KNOWLEDGE OF WINDS IN HURRICANES.

Storm tides, in conjunction with hurricane winds, are such destructive agencies that it is of primary importance that we have definite information relative to their distribution of the winds in these disturbances. These winds are the physical agents that furnish the energy that develops and carries the storm waves and tides to shores far in advance of the arrival of the hurricanes and on the approach of the cyclonic area causes the inundation of our coasts and the destruction of property and lives over considerable areas. Concrete information regarding the winds in hurricanes that produce the swells and

tides is limited and, therefore, these are subjects that must be investigated in this connection. Definite knowledge of the action of these agents might be obtained if the wind directions and velocities in hurricanes could be charted simultaneously at a number of places in the different quadrants of the cyclonic area. However, the courses of hurricanes are mainly over water, and, therefore, it is not practicable to get simultaneous observations at a sufficient number of stations to give us definite knowledge of the actual winds in the different parts of the cyclonic area, and we must look for some other method by which we can obtain this information. We have the theoretical ideal conclusions and charts giving the direction and velocity of wind in hurricanes (3) (5), but these do not meet the requirements in the study of this subject, for here we have need for knowledge of conditions as they actually exist.

During the last 20 years two hurricanes have moved in at points on the middle Gulf coast, where sufficient records have been kept to enable a very complete study of the actual wind directions and velocities in different parts of the cyclonic areas over water. These hurricanes while moving into extra-tropical regions, retained in a marked degree their tropical characteristics.

BIHOURLY STUDIES OF WINDS IN HURRICANES.

The hurricanes of September 29, 1915, and July 5, 1916, moved inland with the center of the first near Grand Isle, La., and the center of the latter east of Gulfport, Miss., and we secured very complete automatic records at New Orleans (1), and Burrwood (2), La., Mobile (3), Ala., and Pensacola (4), Fla. The southeastern portion of Louisiana, and the Mississippi, Alabama and Florida coasts are low lying, near sea level, and sparsely timbered. The physical features of the area over which these hurricanes moved, much of it being water surface, give as nearly ideal conditions for the study of the winds in the different quadrants of the cyclonic area during its passage as we can expect to find. These were typical hurricanes and both of great intensity. The progressive velocities of the cyclonic areas were determined for 100 miles after passing the latitude of Burrwood, La. The hurricane of Septem-

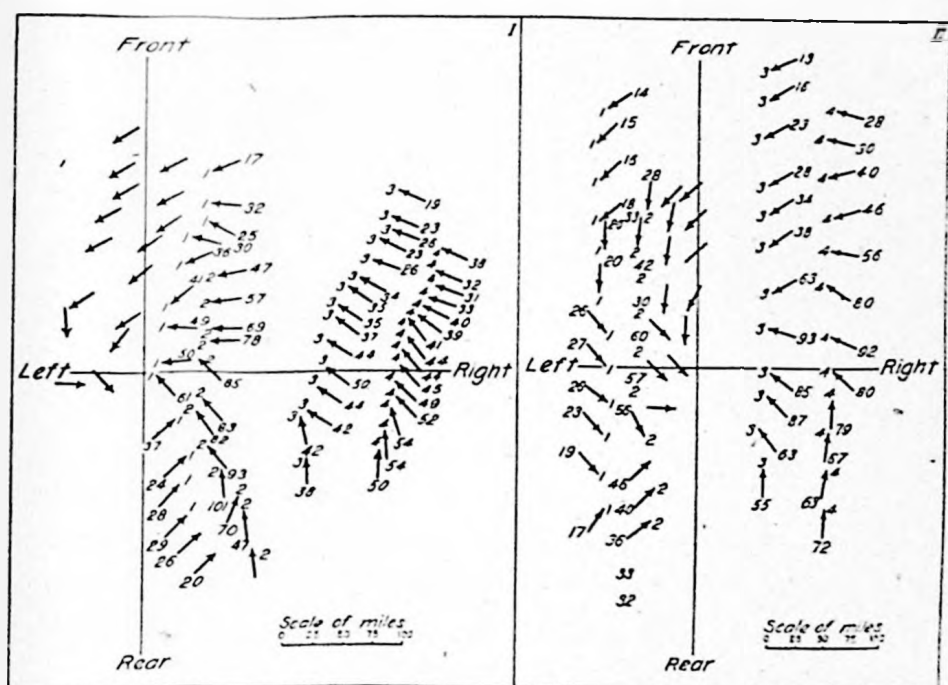
ber 29, 1915, advanced at the rate of about 12 miles per hour, and at this rate of progress the center was in the Gulf about 150 miles off the mouth of the Mississippi River at midnight of September 28. The hurricane of July 5, 1916, advanced with a velocity of 15 miles per hour, and it was centered in the Gulf about 275 miles off the Mississippi coast at midnight, July 4.

Based on a progressive movement of 12 miles per hour for the September 29, 1915, hurricane, and 15 miles per hour for the July 5, 1916, hurricane, maps were made every two hours during the passage of the hurricanes, using the automatic records at New Orleans (1), Burrwood (2), Mobile (3), and Pensacola (4), and observed pressure and wind directions from Morgan City and Lafourche, La., and Pass Christian and Gulfport, Miss. The sustained direction and velocity of the wind being of primary importance in producing waves, the prevailing direction for the preceding hour and the average velocity for the two hours preceding the time of each map have been used on these maps, instead of the direction and velocity at the hour. This gives us on the composite charts the sustained velocity of wind, not only for the two preceding hours, but during the entire passage of the hurricane. When the center of the hurricane of September 29, 1915, was 150, and that of July 5, 1916, was 275 miles distant from land, commencing at 2 a. m., at a time when the effects of the front of the storms were first being felt at Burrwood, La., and Pensacola, Fla., and at the end of each two hours following, the position of the center of the storm was carefully located geographically and charted from the automatic records mentioned above. A line was drawn on each map, through the center of the cyclonic area, the arrow pointing in the direction in which the storm was advancing at that time, dividing it into right and left segments; another line was drawn through the center at right angles to the first, dividing the storm into front and rear segments and also into quadrants.

COMPOSITE CHARTS SHOWING WIND DIRECTIONS AND VELOCITY.

From the maps we have prepared composite charts, showing the actual winds, both directions and velocity in different parts of the hurricane, viz., Charts I and II.

Chart I shows the distribution of wind direction and velocity in the hurricane of September 29, 1915, and Chart II shows the wind direction and velocity in the hurricane of



CHARTS I and II.—Composite wind charts. Prevailing wind direction for hour preceding and average wind velocity for two hours preceding time of observation in different parts of the hurricane. Chart I, September 29, 1915; Chart II, July 5, 1916.—I. M. Cline.

July 5, 1916. In these charts the long arrow points in the direction of the line of advance of the hurricane and the intersection of the cross lines represents the center of the cyclonic area. The figures 1, 2, 3, and 4, at the points of the short arrows show the positions of the stations they represent, on the charts, with reference to the cyclonic center at the times when the wind directions and velocities were recorded. The arrow flies with the wind and shows the prevailing direction for the preceding hour. The figures at the butts of the arrows are the average wind velocities for the preceding two hours.

The composite wind charts for September 29, 1915, and July 5, 1916, were prepared in the following manner: The intersection of the cross lines on Chart I was placed over the center of the cyclonic area as shown on the map at 2 a. m. September 29, 1915, the long arrow on this chart pointing in the direction toward which the cyclonic area was advancing at that time. The prevailing wind direction for the preceding hour and the average wind velocity for the preceding two hours as recorded on the map at 2 a. m. at New Orleans (1), Burrwood (2), Mobile (3), and Pensacola (4) were entered on Chart I, as shown by the first set of arrows and figures at the front of this chart. The positions of the numbers 1, 2, 3, and 4 at the points of the arrows bear the same relation to the intersection of the cross lines on this chart that the position of the stations they represent, occupied with reference to the center of the cyclonic area on the 2 a. m. map. Chart I was then placed over the 4 a. m. map in the same manner and the second set of figures from the front were entered on this chart, representing the wind directions and velocities as they appeared in that part of the cyclonic area on the 4 a. m. map. This was repeated for each map, the wind directions and velocities at the four stations being entered at their correct locations in respect to the center of the cyclonic area, on Chart I, at the end of each two hours as the cyclonic area advanced. The last set of entries in the rear of Chart I is for 6 a. m., September 30, 1915.

The same procedure was followed in preparing Chart II, composite wind chart for July 5, 1916, the first set of arrows and figures on this chart being 2 a. m., July 5, 1916, and the last set being for 12 midnight, July 5, 1916. Fifteen maps were made for the September 29, 1915, hurricane, covering 30 hours, and there are 15 entries of wind direction and velocity from the front to the rear of Chart I, for each station except Burrwood, the record for that station being missing for the last three entries. The hurricane of July 5, 1916, moved rapidly and diminished in intensity very soon after reaching land; therefore only 12 maps, covering 24 hours, were used in preparing the composite wind chart for that hurricane, and there are 12 entries of wind direction and velocity, from the

front to the rear of Chart II, for each station. There was very little change in the intensity of these hurricanes during the periods covered by the maps used in preparing the composite charts. Each entry of wind direction and velocity on Charts I and II has been made so that the figure at the point of each arrow is the same distance, in the same direction, from the intersection of the cross lines on these charts that the station which it represents, New Orleans (1), Burrwood (2), Mobile (3), and Pensacola (4), was from the center of the cyclonic area on the map at the hour when these directions and velocities were actually recorded.

The hurricane of September 29, 1915, recurved slowly during the 30 hours for which the maps were drawn. The greatest deviation from a straight line in the 360 miles traveled by the hurricane during this time was about 45 miles and occurred midway of the period. The hurricane of July 5, 1916, moved in nearly a straight line.

Chart III shows the pressure distribution and winds at 2 p. m., September 29, 1915, midway of the series of observations on which Chart I, composite wind chart, for that hurricane is based.

Charts I and II taken in connection with Charts III and IV show the relations of the winds to the isobars; both maps have been drawn from pressure reduced to sea level. These maps are considered preferable to composite, pressure charts for these hurricanes.

WINDS IN DIFFERENT PARTS OF CYCLONIC AREA.

Wind directions and velocities shown on Charts I and II approximate closely what would have been found to prevail if simultaneous observations could have been taken at the point of each arrow on the charts and the direction and velocity of the wind determined at the end of any hour during the progress of the hurricanes of September 29, 1915, and July 5, 1916, respectively.

In the hurricane of September 29, 1915, one that recurved slowly, the wind velocity for four stations in the right-hand front quadrant averaged 43, and in the right-hand rear quad-

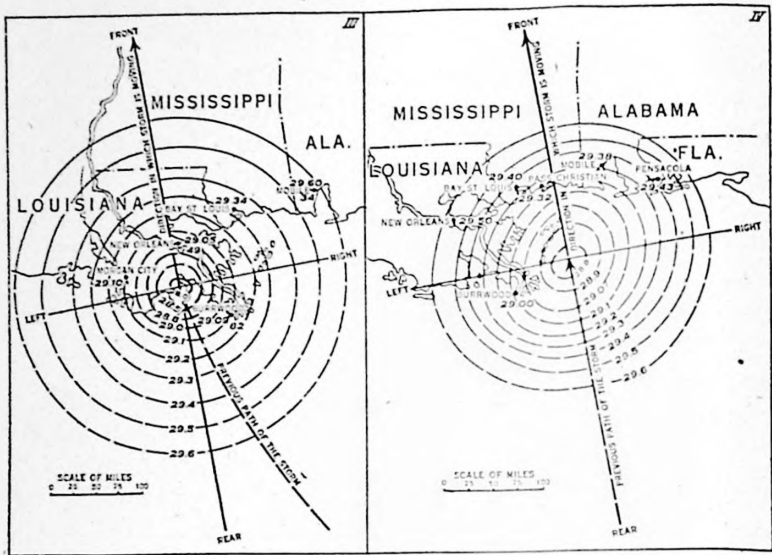


CHART III.—Hurricane, September 20, 1915. Pressure map at 2 p. m. midway of series used in preparing Chart I.

CHART IV.—Hurricane, July 5, 1916. Pressure map at 12 noon, midway of series used in preparing Chart II.—I. M. Cline.

rant 52 miles per hour. The winds in the right-hand front quadrant near the path of the center blow across the line of advance, and 150 to 200 miles to the right of the line of advance of the center of the storm they blow at an angle of about 45° across the line of advance in the direction in which the hurricane is traveling, while in the rear right-hand quadrant the winds are mainly in the same direction as the line of advance of the hurricane. Effects of the wind, in the western segment of the September 29, 1915, hurricane, indicate velocities considerably less than those recorded in the right-hand segment. The highest wind occurred at a distance of 50 to 75 miles to the right of the line of advance after the passage of the center of the storm. The destructive power of the winds 40 miles east of New Orleans showed a greater force than at New Orleans. If we had automatic wind records for the September 29, 1915, storm from a point 50 miles east of New Orleans, such reports would show an increase in the wind velocities in the right-hand rear quadrant over those actually averaged from Chart I.

Burrwood, La., located in the right-hand segment, 50 miles to the right of the line of advance of the center of the cyclonic area, September 29, 1915, furnishes an excellent example for the study of the wind in that part of a cyclonic area at an individual station. Commencing at the time the center of the storm passed near that place, we get sustained wind velocities, in the rear right-hand quadrant, blowing mainly in a direction in line with the advance of the hurricane, as follows:

Sixty miles per hour or above prevailed for a period of 13 hours.

Seventy miles per hour or above prevailed for a period of 12 hours.

Eighty miles per hour or above prevailed for a period of 11 hours.

Ninety miles per hour or above prevailed for a period of 3 hours.

One hundred and eight miles per hour prevailed for 2 hours.

One hundred and sixteen miles per hour prevailed for one-third of an hour.

There was a gust with 1 mile at the rate of 140 miles per hour.

The wind velocity at Burrwood from 10 p. m., September 29, 1915, to 8 a. m., September 30, 1915, was not recorded, but the direction up to 9 a. m., September 30, 1915, continued mainly in the same direction as the line of advance of the hurricane. The wind velocity at 9 a. m., September 30, 1915, was 23 miles and by interpolating for the 11 hours following the 13 hours with a sustained velocity of 60 miles per hour or above, we find that an average velocity of 35 miles per hour prevailed. The average velocity was 85 miles per hour during the first 13 hours and 35 miles per hour for the next 11 hours after the passage of the center of the hurricane, making a total period of 24 hours with the average wind velocity exceeding 60 miles per hour. During this time the wind was mainly in the same direction as the line of advance of the cyclonic area. Burrwood continued, during this 24 hours, in the rear right-hand quadrant of the cyclonic area.

In the hurricane of July 5, 1916, which progressed in nearly a straight line, the wind velocity averaged for all stations, 48

miles per hour in the right-hand front quadrant, 72 miles per hour in the right-hand rear quadrant, 29 miles per hour in the left-hand front quadrant, and 34 miles per hour in the left-hand rear quadrant. In this storm the stations in the left-hand and right-hand segments were nearly equi-distant from the path of the center of the hurricane.

Pensacola, Fla., located in the right-hand segment, 100 miles to the right of the center of the hurricane of July 5, 1916, furnishes a good example for the study of winds at an individual station in that part of the cyclonic area. Commencing at the time the center passed that station we get sustained wind velocities blowing mainly in a direction in line with the advance of the hurricane as follows:

Forty miles per hour or above prevailed for a period of 24 hours.

Fifty miles per hour or above prevailed for a period of 19 hours.

Sixty miles per hour or above prevailed for a period of 10 hours.

Seventy miles per hour or above prevailed for a period of 5 hours.

Eighty miles per hour or above prevailed for a period of 3 hours.

For a period of 24 hours after the passage of the center of the hurricane the average velocity was 59 miles per hour, with the wind blowing in a direction mainly in line with the advance of the hurricane. During this time Pensacola was in the rear right-hand quadrant of the cyclonic area.

The foregoing records from Burrwood and Pensacola, both on account of their location with respect to the centers of these storms and their positions on the coast, may safely be assumed to represent the winds which prevail in those parts of a hurricane in the open Gulf. The velocities may be greater or less, depending on the intensity of the hurricane.

The high winds which occur, as indicated in the above hurricanes, in the right-hand rear quadrant of the cyclonic area, are sustained velocities which persist in the same direction as the line of advance of the hurricane during the life

of the hurricane. Taking into account the diameter and progressive movement of the cyclonic area, we get a length of fetch of 300 to 400 miles in the rear right-hand quadrant of storms such as those represented in Charts I and II, with the wind 35 to 100 miles per hour for 24 hours, blowing mainly in the direction of the line of advance of the hurricane.

DEVELOPMENT OF WAVES AND TIDES BY THESE WINDS.

The wind velocities in the left-hand segment of a cyclonic area are never strong as compared with the winds in the right-hand segment (3) and are not long sustained in the same direction over the same area. Furthermore, the progressive movement of the cyclonic area causes the winds over the greater part of the left-hand segment to recede continually from the waves which these winds create; and thus their force for developing waves is diminished. Therefore there can be no great development of waves in this part of the hurricane.

In the right-hand front quadrant of the hurricane the winds near the center of the cyclonic area blow in a direction which carries the waves they develop across the line of advance of the hurricane; but at a distance of 100 to 150 miles to the right of the line drawn through the center of the cyclonic area in the direction in which it is advancing the winds coincide more nearly with the direction of advance of the cyclonic area. Furthermore, in the front right-hand quadrant the winds change direction as a result of the progressive movement of the cyclonic area so rapidly that one direction does not persist over a distance or fetch of 75 miles during a period of as much as four hours. This condition, even with the high wind velocities that occur in this quadrant, would not furnish sufficient energy for large wave development.

In the right-hand rear quadrant the winds are more inclined toward the center and blow, in the main, in the same direction as the line of advance of the hurricane at sustained velocities averaging 72 to 85 miles per hour for 13 hours and 55 to 60 miles per hour for 24 hours. It is in this part of the cyclonic area that the greatest length of fetch exists, for here the high winds persist mainly in the same direction as the line

of advance of the hurricane over a distance of 300 to 400 miles. The waves are under the influence of the wind from the same general direction not only over this entire distance but also for another 100 to 200 miles, for waves started in the rear do not pass out of the front of this area for many hours, during which time the fetch region has advanced a third to half a day's journey. For these waves, then, the actual length of the fetch is 400 to 600 miles in cyclones of the size and intensity similar to those illustrated in Charts I and II. When the size and speed of the cyclone and the velocity with which the waves are moving forward are known, the length of fetch for these waves may be computed, roughly, from the following equation by Dr. C. F. Brooks:

$$F_w = F + \frac{S}{W}F + \left[\frac{S}{W}\right]^2 F + \left[\frac{S}{W}\right]^3 F + \dots$$

in which F is the length of fetch at any moment, S the forward speed of the cyclone, and W the progressive motion of the waves.

This sustained direction and velocity of the wind in the right-hand rear quadrant, prevailing during the life of the hurricane, furnishes the energy that develops and carries forward the larger waves of long length which move on through the smaller and shorter waves, pass on beyond the limits of the storm, and are carried by their inertia, in the line of advance of the hurricane, to short long before even the front of the cyclonic area reaches there.

In this connection Eliot says (1): "The waves, when originally produced by the action of the moving air on the surface of the sea, move at a rate which is mainly dependent upon the velocity of the wind, and are hence called forced waves, because their rate of motion is determined by the body or action which produces them, viz., in this case the moving air. Waves when produced by such action do not cease when the action stops, or when they pass in their motion beyond the sphere of action of the producing winds. In such cases they pass onward in the same general direction as before, but gradually become smaller and smaller until at last they become imperceptible." He also in speaking of large waves, says:

"Whatever explanation be adopted of the production of these large waves, there is no doubt of the general principle that air moving over a water surface always produces waves, and that the magnitude of the waves is dependent upon the extent of the water area over which they blow and upon the force of the winds. It is evident that the strength of the swell

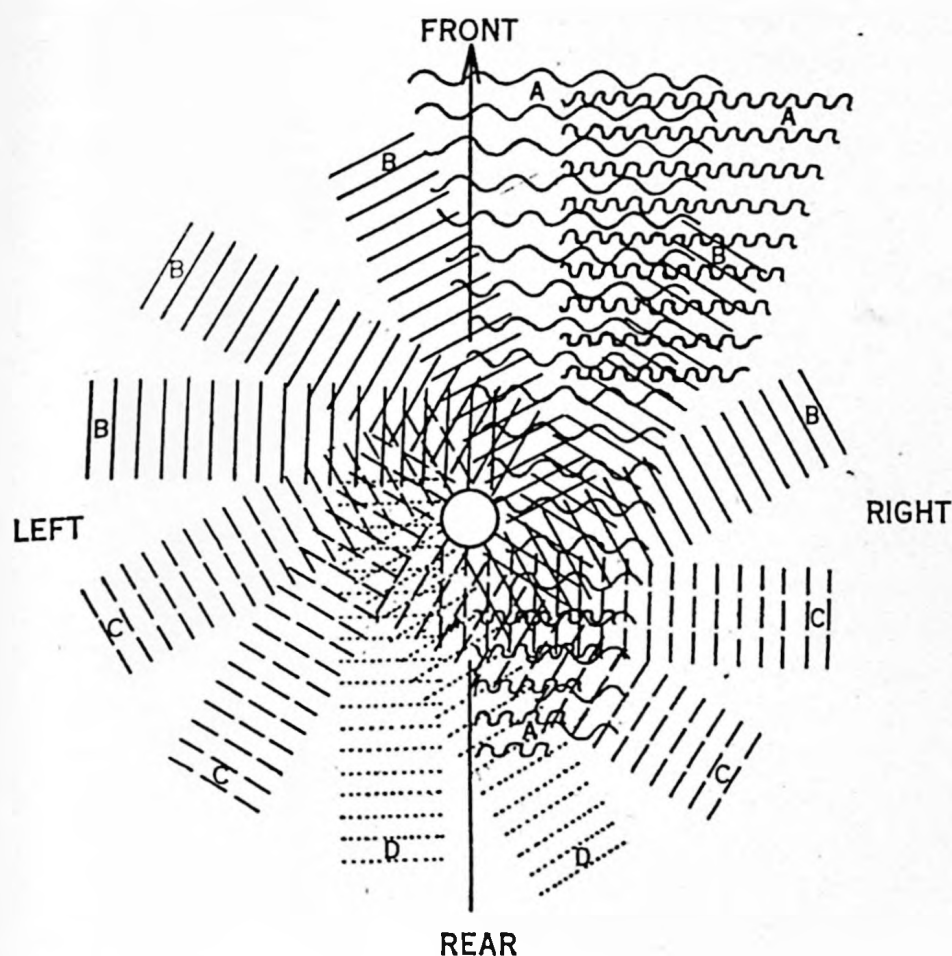


FIG 9.—A. Swells of greatest length and magnitude, traveling in the line of advance of the hurricane.

B. Swells and waves of moderate length and magnitude in the front segment of the hurricane moving outward to right and left of the line of advance.

C. Swells and waves of smaller length and lesser magnitude in the rear segment of the hurricane moving outward to right and left of the line of advance.

D. Swells and waves of least magnitude moving outward from the rear of the hurricane.—I. M. Cline.

or the distance at which it will be sensibly felt in the open sea, will depend partly upon the strength of the producing winds and partly upon the distance over which the producing winds act with no considerable change in direction. The rapid movement of air over the surface of the sea gives rise, by

some species of cumulative action to a continuous succession of large parallel waves so long as the winds are fairly steady in character. Waves that are produced in this manner travel steadily onward in the same general direction so long as they meet no obstruction, and if they pass beyond the area of strong winds, they decrease slowly in height and force." He also says, in speaking of the swell produced by cyclones in the Bay of Bengal: "It has been distinctly felt when the storm was at least 400 miles distant in space and 48 hours distant in time. In these extreme cases the storm was approaching the coast where the swell was observed."

It appears that no effort has been made to illustrate the differences in the relative sizes of the waves and swells produced by the winds which prevail in the different parts of the cyclonic area. Col. Reil, as early as 1849, gave us a diagram illustrating the power of the winds of a cyclonic storm to give rise to swells moving outward in all directions from the storm area, (1) but he did not differentiate between the size and persistency of the swells produced by the winds in the different parts of the storm. With the wind directions and velocities which prevail in the different parts of the cyclonic area, as shown in the foregoing discussion and on Charts I and II, we are able to illustrate the relative size and persistency of the swells which move out from the different parts of the cyclonic area and these are illustrated in figure 9, where the size of the swells going out from each part of the cyclonic area is shown to bear a certain and well-defined relation to the producing winds.

CONCLUSIONS.

1. The waves and swells of greatest size and length are developed in the rear right-hand quadrant of the cyclonic area and move through the smaller waves in the front of the storm and are carried by inertia to shore in the direction in which the cyclonic area was advancing at that time. The waves sent out in other directions, being smaller and shorter, do not persist long after leaving the cyclonic area and soon flatten out and disappear.

2. The transference of water with the long waves and swells causes rises in the water along the coast, which increase as the storm approaches. The rise in the water on the coast in front of the line of advance of the cyclonic area, beginning 12 to 24 hours after the hurricane enters the Gulf, indicates the rapid movement of the waves through the storm area and across the Gulf. From a study of the movements shown on the different charts and figures with this paper, the speed varies from 30 to 45 miles per hour. The rapidity with which the waves travel depends both upon the extent of the cyclonic area and the intensity of the winds that develop the waves and swells. The water rises at the shore in the front, and to the right, of the point toward which the center of the hurricane was moving at the time the waves started on their journey.

3. The rise at shore, of the water from the hurricane, shows long in advance of any change in the barometer. Take, for example, the hurricane of September 11-14, 1919. When the barometer at Burrwood, New Orleans, Galveston, and Corpus Christi was either stationary or falling only a few hundredths of an inch, the water, first at Burrwood, later at Galveston, and then at Aransas Pass was rising in feet, telling the story of the movement, and of the change in the course of the storm as plainly as could possibly be told.

4. In using the information conveyed by the tides in forecasting the movements of hurricanes, the tides as predicted by the Coast and Geodetic Survey should be plotted for each hour whenever a storm appears in the Gulf. The height of the tide above mean low tide should be telegraphed from coast stations with each observation and these should be plotted over the predicted tides. The place where the water exceeds the predicted tides and continues rising is in the line of advance of the hurricane at the time that water started on its journey.

5. The intensity and extent of the hurricane is indicated when the disturbance is at a considerable distance in space and time, by the rapidity of the rise in the water and the extent of the coast over which the rise is taking place.

6. The time between the commencement of the rise in the water at shore and the arrival of the hurricane will depend

upon the rapidity with which the cyclonic area is advancing and the intensity of the hurricane.

7. If the point of greatest rise shifts to the right or left, this indicates that the storm is changing its course in that direction toward which the increased rise is taking place.

8. When the crest of the storm tide is coincident with the crest of the regular tide the height of the water will be greater by more than one foot for hurricanes of equal intensity than when the crest of the storm tide is coincident with low tide, and in forecasting storm tides this must be borne in mind.

9. The regular tides are not obscured at any time by the storm tide, except at or near the point where the center of the storm moves inland, and then for only about twelve hours before the passage of the center of the hurricane.

10. The highest water occurs a few miles to the right, and about the time, of the passage of the center of the cyclonic area. At points on the coast some distance to the right of the line of advance of the center, the highest water occurs on a line drawn through the center of the cyclonic area at right angles to the line of advance of the hurricane, about the time of the passage of the center of the storm across that line.

11. The high water extends for only a short distance to the left of the point where the center of the storm moves inland. High water, however, is experienced to the right of the center for a distance of 100 to 200 miles.

12. The water commences rising at the shore toward which the cyclonic area is advancing in less than 24 hours after the center of the cyclonic area has entered the Gulf. The waves and swells which give this rise must have moved through and out of the rear right-hand quadrant of the cyclonic area within 12 to 15 hours after the center of the storm entered the Gulf of Mexico. This indicates that with a fetch of 150 to 200 miles in the rear right-hand quadrant of the cyclonic area the winds furnish sufficient energy to develop waves and swells of a size and length that travel 30 to 45 miles per hour, reaching the middle Gulf coast, 400 miles distant, in 10 to 15 hours, and the Texas coast, 800 miles distant, in 15 to 20 hours.

13. Strong currents are created in the right-hand segment of the cyclonic area which move in the main coastwise toward the line along which the cyclonic area is advancing. The fact that two gas and whistling buoys in August, 1915, and three in September, 1919, were carried 2 to 8 miles nearly parallel to the coast, shows the force of these currents. If these buoys had been moved by waves they would have been carried in toward the shore and not along the coast.

NEITHER A STORM NOR A TIDAL WAVE.

14. The high water attending the hurricane is frequently referred to as a "tidal wave," or "storm wave," but it is not a wave in any sense of that term. It is a cumulation of the water from successive "storm waves," reaching shore, covering a period of two or more days, with a gradual rise which increases as the center of the storm approaches. The "storm tide" results from the physical forces of the hurricane, driving the large waves forward and transferring the water in the same direction as the line of advance of the hurricane. In the open sea this storm tide is not so great, probably not exceeding, in the greatest storm, more than 5 feet. The obstruction formed by the coast line acts as a barrier and the water gradually banks up as it does against a dam across a stream. The rise in the water at shore is frequently against opposing off-shore winds as was the case at Galveston, Tex., in 1900 and in 1915, and at Corpus Christi, in 1919. In such cases the off-shore winds force the water back on the storm, retarding the rise; then when the winds shift and come in with the storm, the rise in water is much more rapid and consequently more destructive. The diminished pressure near the center of the hurricane will have some effect on the height of the water. The weight of 1 inch of mercury is equal to that of about 1 foot of water. The increase in the height of the water due to diminished pressure at Galveston, for example, in 1900, with the barometer 28.48 inches, could not have exceeded, under most favorable conditions, 1.5 feet, whereas the storm tide was 15 feet.

RECORDS OF WAVES AND SWELLS.

There are no records available for use in the study of the individual storm waves and storm swells and groups which reach the coast and cause the storm tides. A knowledge of the size and speed of these would aid in the study of the movements of water in hurricanes. A definite knowledge of these waves would aid in determining the location and intensity of hurricanes. Observations should be made along the coast, especially when hurricanes are approaching, of the speed and direction of waves and swells. The velocity of water waves and ripples is determined by the wave length. "Wave velocity = wave length $\times$ wave frequency."

Fleming says this relation may be stated in another manner: "We call the period of a wave the time taken in making one complete movement. The period in time, is, therefore, inversely proportional to the frequency. Hence, we can say that the wave length, divided by the periodic time, gives us the wave velocity. * * *"

"A formal and exact proof of the law connecting speed and wave length for deep-sea waves requires mathematical reasoning of an advanced character, but its results may be expressed in a very simple statement by saying that in the case of waves in deep water, the speed with which the waves travel, reckoned in miles per hour, is equal to the square root of $2\frac{1}{4}$ times the wave length measured in feet * * *."

"The above rule for the speed of deep-sea waves, viz, wave velocity = square root of $2\frac{1}{4}$ times the wave length combined with the general rule, wave velocity = wave length, multiplied by the frequency, provides us with a useful, practical method of finding the speed of deep-sea waves which are passing a fixed point * * *." Count the number of waves which pass the fixed point per minutes and divide the number into 198; the quotient is the speed of the waves in miles per hour. Thus, if ten waves per minute race past a fixed buoy, their velocity is nearly 20 (19.8)

miles per hour. If V is the velocity of the waves in feet per minute, and V' is the velocity in miles per hour, then

$V' \times \frac{5280}{60} = V$. But $V' = \sqrt{2\frac{1}{4}l}$ and $V = nl$, where " l " is the wave length in feet and " n " the frequency per minute; from which we have $V' = \frac{198}{n}$, or the rule given in the text.

ACKNOWLEDGMENTS.

Valuable suggestions and references have been received from the Chief of the United States Weather Bureau and other officials at the central office, Washington, D. C., and assistance has been given by officials at Gulf coast stations, and especially at New Orleans.

Automatic tide records for Port Eads and Burrwood, La., and Fort Morgan, Ala., have been furnished by the district engineers, United States Engineers Corps, New Orleans, La., and Mobile, Ala. Staff-gage tide records for 1909, 1915, and 1919, and other important matter for Galveston, Tex., have been furnished by the district engineer at Galveston, Tex.

Automatic tide records at Galveston for 1906, 1909, 1916, 1917, and 1919, and important references have been furnished by the Superintendent and other officials of the United States Coast and Geodetic Survey, Washington, D. C.

Reports from lighthouses in the Gulf, and the movement of buoys in storms have been furnished by the Inspector of the Light House District, New Orleans, La.

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DISCUSSION

The President: You have heard Dr. Cline's most interesting paper. Discussion of this paper is now in order, and I am sure Dr. Cline will be pleased to answer any questions that any member may desire to ask on this subject.

Mr. Theard: Dr. Cline, from the way you have explained the direction of the winds traveling around within the cyclonic area, in storms that come from the Yucatan Channel and that travel in a north or northeasterly direction, did you mean to dispel the rather generally accepted idea that the winds travel in a spiral from right to left?

Dr. Cline: They travel generally that way, but in the rear of nearly all storms where the whole body or area moves forward, the wind is in the same direction as the movement of the storm. I have looked into other storms, and that theory is not sound, about spirals.

I was up against that proposition when I began this piece of work. And I conceived the idea of looking into this from a comment by a professor of Harvard, who said that was not correct. I began working on this phase of the problem and found that the rear part moved in practically the same direction as the hurricane, instead of spirally. This is indicated by these charts which were made from actual observation.

Mr. Shaw: I have no particular question to ask Dr. Cline, but I do think that the engineers are beginning to appreciate the importance of the service of the weather bureau as applying strictly to engineering work, especially in this part of the country. One of the great engineering problems and one of the great works confronting us, not as spectacular, perhaps, as some others, but of considerable importance at present, however, is the reclamation of marsh lands and the protection of exposed areas and engineering works from storms along our coast. We can gather a great deal of information of real engineering value from such papers as we have listened to tonight.

I predict there will be some discussion among the scientists of the country when this theory of Dr. Cline's has been spread a little more broadcast, and there will probably be some

sharp criticism of it. It seems to me, from the way he has presented it, when it comes to meeting these criticisms, he will be in the position of the small boy who complained of trouble in the interior and whose mother, a Christian Scientist, said it was all imaginary, but he said he had "inside information."

I, for one, have been attempting to study the question of storm tides along the coast, and have spent considerable money for various reference books and have also prevailed upon the Library Committee to get others, and I find there are a great many theories concerning these storms. There will doubtless be a great deal of interesting discussion and comment upon Dr. Cline's theory in the technical press of the country, and I feel the Louisiana Engineering Society is most fortunate to have a paper like this presented before it. I move that we tender Dr. Cline a rising vote of thanks for his presentation of the matter.

Mr. Manley: I would like to ask Dr. Cline if steps have been taken to provide permanent tide gages, which will not go out of commission at a crucial time, and if provision has been made for communicating to the weather bureau here immediately any change of tides at various places?

Dr. Cline: Arrangement has been made to collect tide data, but not for tide gages that will stand in any storm. They are rather permanent now, except in the very big storms, and nothing will stand the severity of these. The big waves coming in in those storms will beat down anything of that character that may be put up. Engineers have erected buildings at Burrwood that have stood, but I think in every big storm the tide gages have gone. The same thing has happened to the gages at Galveston. Many of the charts shown here indicate where the records were broken off by reason of the destruction of the gages in practically every storm during the last twenty years.

Mr. Robert: In some of the charts a definite location of the center of the storm, at different times and on different dates, is shown at points out in the middle of the Gulf. Just how are those storm centers determined?

Dr. Cline: We get the data from ship reports. Every ship that sails keeps reports, though they may not be provided with

wireless outfits. From these reports we can chart the location of the storms.

A Member: I would like to ask where the tide gages are anchored.

Dr. Cline: The tide gage at Burrwood is situated about four miles from the Gulf, in the channel. I have not seen the gage, but it is in the channel in the Pass. At Port Eads I think it is three miles back. At Galveston it is at the foot of 20th street, in the bay. They are in accessible locations where they get the tide record, without being damaged by the wave action.

Mr. Klorer: Some questions have been asked concerning the construction of these tide gages. They are not very intricate machines. The gage consists simply of a float in the form of a box about 12 inches square arranged so that it can rise and fall with the tide between vertical guides. It is attached to a wharf usually and protected from drift and heavy waves by piling driving about it. As the float rises and falls it operates a fountain pen which draws a record on a specially prepared roll of paper operated by clock work.

There is one prominent feature about all these curves of the center of the storm which appear to me to present an interesting point. It seems to me they are parabolic curves, or similar to that, and if it is possible to trace the parabolic path of a comet by two observations, I think if we could get several observations of the center of the storm as it proceeds into the Gulf of Mexico, we might arrive at the equation of the curve. If we got the equation of the curve it would be a simple matter to complete the curve some three or four or five days in advance of the time the curve would hit the shore, and in that way we would gain something even on the tide prediction.

Dr. Cline: Our trouble would be on the sharp curves like those in 1917 and 1919, which recurved to the left. It was first curving to the Louisiana coast, and then went straight to the left. In 1917 it came close to Burrwood and curved to Pensacola. We have probably drawn most of the curves there more regular than they actually were; we might have had a sharper curve in 1917 than is shown on the chart.

Mr. Shaw: There is one point I neglected to mention which I think the engineers might bear in mind, and which was brought out in connection with the movement of the buoys. There seems to be a general impression, among those dealing with shore protection, that the damage results largely from frontal attack or waves, which the appearance of shores undergoing erosion along the Louisiana coast leads me to believe the greatest damage is from the littoral current. I am satisfied there have been certain works of considerable expense carried on in the Gulf coast country to resist the frontal attack of waves where the same amount of money might have been spent to better advantage by protecting against the littoral current. I think every shore should be made a point of special study, instead of building masonry walls to withstand frontal attack and not paying attention to littoral currents as illustrated by the movement of the buoys mentioned by Dr. Cline. We should give more attention to that particular feature of the protection of the Gulf coast country.

A Member: I would like to ask if there is any record as to the direction of these storms before they get into the Gulf of Mexico?

Dr. Cline: We have a certain amount of information on that line from ships in the Caribbean Sea and from stations on the islands. We have stations on Swan Island, on the Isle of Pines, and several other places. We are prepared for tracing these things. We have every ship that runs in there to report by wireless.

MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY.

Regular Meeting of the Board of Direction, September 13, 1920.

Meeting was called to order with President Riess in the chair and Messrs. Lawes, Barelli, Olsen, Moses, Manley and Robert present.

Ballots for new members were opened, there being 71 ballots cast, and as a result the following members were elected to the respective grades of membership in the Society:

Resident Member—Sexton Berg.

Associate Members—Joseph A. Brennan, Edward T. Malloy.

The following applications were ordered through the ballot subject to the approval of the Membership Committee—H. G. Martin, George R. Hammett, Lester C. Smith, John A. O'Brien, Harry D. Scott, John R. Dykers.

A letter from the Association of Commerce relative to the inspection of paving was read and tabled.

A letter from Loyola University asking for volunteers to teach in their Engineering Department was ordered read to the meeting. Upon motion duly seconded, it was decided to decline membership in the American Forestry Association.

Upon motion duly seconded, action upon delinquents was postponed until the next meeting.

Professor Gregory made a short report on the Federated Engineering Societies, and it was decided to have him give the same information to the regular meeting.

The report of the Secretary was read and approved.

There being no further business, the meeting adjourned.

JAMES M. ROBERT, Secretary.

Regular Meeting of the Society, September 13, 1920.

The meeting was called to order with President Riess in the chair and 44 members and guests present.

A letter from Loyola University asking for our assistance in securing instructors for their new school of Civil Engineering was read, and upon motion duly seconded, the Secretary was instructed to reply that we thoroughly approve the idea and that we will circularize our membership concerning this matter.

Professor Gregory gave a short report upon the meeting of the Federated Engineering Societies and brought up the question of our joining the same. Upon motion by Mr. Gregory, seconded by Mr. Seaver, a committee of five, three of whom are to be the original committee which took up the question of our joining the American Association of Engineers, were asked to look into the matter. This committee will report at the next meeting.

The technical exercises of the evening were then proceeded with and the membership was treated to a most delightful, interesting and instructive paper entitled, "Relation of Changes in Storm Tides on the Coast of the Gulf of Mexico to the Center and Movement of Hurricanes," by Dr. Isaac M. Cline. After quite a few questions and explanations, Dr. Cline was accorded a vote of thanks.

There being no further business to come before the meeting, same was adjourned to the usual collation.

JAMES M. ROBERT, Secretary.

Special Meeting of the Board of Direction, Sept. 30, 1920.

Meeting was called to order with President Riess in the chair and Messrs. Williamson, Moses, Olsen and Robert present.

A communication from the Association of Commerce, dated Sept. 18th, 1920, relative to the divorcement of the Atchafalaya and Red Rivers from the Mississippi, and asking for our opinion, was read and the Secretary directed to reply that in as much as the matter is one of considerable importance and on which there are several different opinions, that the same will be placed before a regular meeting of the Society.

A communication dated September 13th, 1920, also from the Association of Commerce, relative to a meeting in New Orleans of the Special Committee of the United States Senate on Reconstruction and Production, was read and the Secretary directed to reply that the Board heartily joins the Association of Commerce and other Civic, Commercial and Industrial bodies in an invitation to this Committee to meet in New Orleans.

A letter from Mr. E. H. Coleman, dated June 30th, 1920, relative to placing before the membership the question of whether or not an applicant be required to answer questions concerning military service or reasons for not performing same during the great war was read. This letter requested the matter to be placed before the membership and upon motion it was decided by the Board of Direction to refer the matter to the Society as a whole with the recommendation that the Board does not deem it wise to accept Mr. Coleman's suggestion.

There being no further business, the meeting adjourned.

JAMES M. ROBERT, Secretary.

PROCEEDINGS

OF THE

LOUISIANA ENGINEERING SOCIETY

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No. 6

CONTENTS

EDITORIAL NOTES AND COMMENT :	PAGE
Sewerage, Water and Drainage in New Orleans.....	259
The Red and Atchafalaya Divorce Case	261
Honor for Mr. Garsaud.....	262
The Individual Element.....	263
Additions to the Library.....	264
Prevention of Automobile Accidents	265
Westinghouse Turbine Makes a World's Record	271
PAPERS AND DISCUSSIONS:	
The Existing Status of the Sewerage, Water and Drainage Systems of New Orleans. <i>By George G. Earl</i>	274
The Proposed Separation of the Red and Atchafalaya Rivers from the Mississippi and the Probable Effect on Flood Heights. <i>By John Klorer</i>	300
MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY.....	327

EDITORIAL NOTES AND COMMENT

Sewerage, Water and Drainage in New Orleans. In a very able and comprehensive paper, read before the Society at its October meeting, Mr. George G. Earl, General Superintendent of the Sewerage and Water Board, presented certain facts and statistics with a very clear analysis of same, which will prove conclusively to the unprejudiced citizen that the existing status of these important public utilities is one requiring prompt and definite measures of financial adjustment, if New Orleans is to maintain and develop the proper conditions of sanitation, public health and fire protection, so necessary to any large and growing community.

Briefly stated, the present drainage system takes care of the rainfall over an area double the actually populated portion, while the Sewerage and Water system serves 600 miles of streets and 80,000 premises. The expenditure to date for the three services is approximately \$32,000,000, or \$400 for each of the premises served.

The only source of funds for the construction of extensions to the sewerage, water and drainage systems comes from the surplus of the two-mill tax and the half surplus of the 1% debt tax, after the 4% interest has been paid on the outstanding bonded indebtedness. Due to low assessments in past years, the amount of money available for these extensions and improvements has fallen far below the needs of the system, thus holding back those extensions which are rapidly becoming more and more urgent.

By law water rates in New Orleans are applicable only toward operation and maintenance, but maintenance involves replacements or reconstruction to meet changing conditions of municipal growth to such an extent that a considerable amount of annual extensions could be covered in this way from the water rates, provided these were adequate to the care of the extensions. It is interesting to note in this connection that in the cities of St. Louis, Pittsburgh, Cincinnati and Kansas City, all of which purify their water from some branch of the Mississippi River, the collection per capita for water is 2 to 2.7 times as much as in New Orleans. Water rates here are now limited to the values set in 1913 and are very low. In Mr. Earl's opinion this limit should be repealed by law, which would also define and limit the purposes to which the resulting funds could be applied. City property should also be assessed at such a valuation that the revenues so derived, together with those from the water rates, would be sufficient to take care of the urgently needed extensions and improvements.

Based upon the 1919 taxation and the average water bills, the per capita payments for the water, interest on debt, maintenance and operation and extensions, amounted to \$6.79.

With an increase of 50% in the water rates and the taxation for 1920, there would be available for the same purpose per capita the sum of \$10.25.

If the three systems are to be operated, maintained and extended as they should be, then each citizen of New Orleans must expect to contribute this amount of \$10.25 annually for the next sixteen years at least, probably longer.

Some of the more important items in the way of extension are:

A new 48" suction line from the river to the Main Water Works Pumping Station.

A 20" mud discharge from reservoirs to river with pump and motor.

Another main delivery line from pumping station to center of population.

An additional pumping engine at the Main Water Works Pumping Station.

Additional turbine and boiler capacity for power at Main Water Works Pumping Station.

Additional settling reservoirs.

Covering and lining of many open canals.

Installation of sub-surface drainage to replace open gutters in many portions of the city.

A careful perusal of Mr. Earl's paper, in which all these points are carefully brought out, will be of great interest and value to all the members of this Society, as well as to any citizens interested in the welfare and development of his city.

The Red and Atchafalaya Divorce Case. This celebrated case has quite recently come to the attention of the public again on account of the conference just held in this city among the parties most directly concerned in the economic results of the separation of the Red and Atchafalaya Rivers from the Mississippi. Mr. Klorer's paper, therefore, has a timely value, as it sets forth the views of an engineer of much experience in problems of the Mississippi River, and discusses the problems from the technical standpoint.

It goes without saying that the separation would result greatly to the economic advantage of the people living within the Atchafalaya Basin, but the corrolated question which must always come up is that of the disadvantage to the people living

along the Mississippi River below the mouth of the Red. This question is all the more important for the reason that it involves the economic interests of the largest city in the South and its immediately surrounding industrial territory.

Whether the separation of the rivers would have a harmful effect upon the lower Mississippi or otherwise is bound up with the technical problem of increased flood heights due to the closure of the present relief outlet at Old River. It is this problem which Mr. Klorer undertakes to discuss in his paper.

His conclusion is that the resulting higher flood waters will necessitate the raising and strengthening of the present levee system on the lower river to an extent that the cost of the same will be staggering in its proportions. The City of New Orleans would be required to spend millions of dollars upon the re-arrangement of its terminal facilities, its docks and its wharves.

In his discussion of Mr. Klorer's paper, Col. Dent brings out a very interesting point connected with the change in section of the Mississippi due to the necessity of taking care of the additional flood waters. His point, backed up by figures and experience with other streams, is that, while the cross section must necessarily be increased, this will result not in a deepening of the channel, as is generally assumed, but rather in a very great widening of the stream with a consequent decrease in depth of channel. This would necessitate the reconstruction of the levees along new lines as well as an increase in their height.

Honor for Mr. Garsaud. As the members of this Society have always taken an active interest in the furtherance of the good work of the Louisiana State Board of Engineering Examiners, it will be of interest to learn that during the month of November there was organized at a meeting held in Chicago a national body to be known as the Council of State Boards of Engineering Examiners, for the purpose of securing uniformity of action, co-operation and reciprocity among such boards in the different states. All of us who know and appreciate the very active interest Mr. Garsaud has always taken in their

work are gratified at the fact that he has been elected the first President of the New Council, and we extend our very hearty congratulations.

"The Individual Element." That very excellent little trade monthly, published by the Crane Co., of Chicago, always contains a good deal of matter well worth the reading, and here is a bit which strikes a particularly true note in these days of unsettled conditions and unsettled states of mind of individuals and masses. It has the title quoted above:

We most earnestly commend to the careful consideration of every reader of this magazine the thought involved in the following excerpt from the *Financial and Business Summary* of the Citizens' National Bank, of Los Angeles:

Nearly everything in the zone of business today hinges upon the sincerity of the interest that the individual takes in the performance of his duties. All occupations are suffering from the indifference of the bulk of their operatives. Both men and women workers do not seem to see that the losses their neglect and half-hearted work entail bulks to a terrific total which is projected directly against their own comfort. Many have more regret over the loss of a dollar than they have over a loss of the consciousness of duty. The real fact of the matter today is that this country is in far greater danger of a self-indulgence panic than it is of a money panic. Safety, prosperity and the ability to enjoy more fully the privileges of the present advancement of civilization are each wrapped in the desire to serve in the manner that the individual himself would be served. Such a belief *practised* makes one first worthy of prosperity, then presents him with it and protects him in it.

Once we can get a general acceptance of the fact—and it is a fact beyond dispute—that "safety, prosperity, and the ability to enjoy more fully the privileges of the present advancement of civilization are each wrapped in the desire to serve in the manner that the

individual himself would be served," we shall have advanced far toward a satisfactory solution of our economic problems. It is because of this fact that our appeal almost invariably is to the individual rather than to the mass.

Each one of must come to feel individual responsibility for existing conditions and to practice individual effort to bring about a change in these conditions. Progress lies along the way of individual consciousness and effort, not along the way of mass consciousness and effort. The "individual element" always has held, holds now and always will hold the secret of human advancement, morally, socially, and economically.

Additions to the Library. Mr. Muth, Chairman of the Library Committee, wishes to call attention to the list of pamphlets given below which have recently been added to the library. These pamphlets have to do with a variety of problems connected with the lumber industry and are issued by the Forests Product Laboratory at Madison, Wisconsin:

Timber Decay and Its Growing Importance—C. J. Humphrey.

Synthetic Culture Media for Wood-Destroying Fungi—Pieper, et al.

Sap Stain and Molds on Lumber—C. J. Humphrey.

The Toxicity to Fungi—Humphrey and Fleming.

Timber Storage Conditions—C. J. Humphrey.

Toxicity of Various Wood Preservatives—Humphrey and Fleming.

Chemical Composition of the Higher Fractions of Maplewood Creosote—Pieper, Acree and Humphrey.

Tests on the Durability of Greenheart—C. J. Humphrey.

Laboratory Tests on the Durability of American Woods—C. J. Humphrey.

Rot in Stored Lumber—C. J. Humphrey.

Prevention of Automobile Accidents. The National Safety Council sends out in its latest bulletin of information a statement of its activities and its plan of campaign for the purpose of trying to lessen and prevent accidents from automobiles. There are so many good points involved in the campaign that we are publishing herewith the statement in full, and wish to express our appreciation of their courtesy in sending us the information.

The eight thousand industrial organizations, trade associations, and governmental agencies comprising the National Safety Council have just undertaken the biggest job ever attempted by the Council during the eight years of its existence—to teach the fundamentals of safe driving and motor vehicle maintenance to every motor truck and passenger car driver employed in industry, whether or not his employer is a member of the Council.

The purpose of the undertaking is threefold:

First, to reduce so far as possible, the number of fatalities resulting from automobile accidents, which now approximate 15,000 a year—one person is killed by an automobile every thirty-five minutes.

Second, to save for industry and the public at large the millions of dollars lost each year through property damage resulting from automobile accidents; this loss amounting to \$500,000 a year in a city of little more than half a million population.

Third, to save for industry some of the many millions of dollars now paid out annually for compensation, medical attention, lost time, and damage for personal injuries resulting from automobile accidents.

The National Safety Council through its forty local councils has for several years carried on a campaign against jay-walking and other forms of carelessness on the part of pedestrians. But it has discovered in this campaign that while the pedestrian is responsible for a large percentage of accidents, at least an equal per-

centage of automobile accidents are due to ignorance of the safe methods of motor car driving or maintenance on the part of drivers of commercial vehicles.

The Council, with the aid of automobile manufacturers, automobile driving instructors, automobile traffic managers, repair men, and the representatives of practically every industry interested in any phase of the automobile accident problem, conducted a nine month study of the causes of accidents and means of eradicating those causes. This study has just been completed and the findings published by the Council in the form of a set of twelve Safety Bulletins and Lessons for Automobile Drivers.

With the view of getting a set of these lessons into the hands of every motor truck driver, every taxicab driver, every commercial passenger car driver, in the country, the Executive Committee for the first time has waived the rule which in the past has confined the distribution of National Safety Council research reports to the members of the Council.

The lessons, covering every phase of motor vehicle operation and maintenance which enters into the accident problem, will be distributed by the National Council through its local councils, through automobile schools, automobile clubs, automobile insurance companies, and through every other means which presents itself.

For the Council feels that if it succeeds in making a set of the lessons available to every chauffeur and truck driver in the country, it will mean annually a saving of thousands of lives, a saving of millions of dollars to industry, and the speeding up of automobile and motor truck traffic through the elimination of lost time due to accidents which now amounts to thousands of hours daily in every big industrial center.

"It is inconceivable," says C. W. Price, General Manager of the National Safety Council, "that any man into whose hands a set of these lessons is placed

should not get, at the very least, one idea which would at some time prevent one accident.

"Never in the history of the National Safety Council," Mr. Price said, "has there come such persistent demand from our members for help in solving any problem as that for help in controlling the automobile hazard.

"A few thousand automobiles in 1906—increasing to seven and one-half million in 1919—with a corresponding increase in deaths from 374 in 1906 to 10,000 in 1919, has suddenly thrust upon the people of the United States a problem more alarming and more far-reaching than any other in the history of accident prevention.

"Two striking facts reveal the seriousness of this hazard:

"First, one-half as many people were killed by this one machine alone in 1919 in the United States as in all the industries—railroads and mines combined.

"Second, probably not more than one-third of our people are exposed to industrial hazards, while practically every man, woman and child who walks out of his front door is exposed to this new and giant hazard which stalks down our streets and highways.

"Out of the serious study which the officers and staff of the Council have given this great problem has come the conviction that one of the first things which must be done toward a permanent solution is to develop standard instructions covering both the mechanical side of automobile safety and the safe operation of motor vehicles.

"If we are to train drivers of automobiles and trucks we must first furnish them with specific instructions covering the inspection, repair and operation of their machines. Thousands of accidents have happened because drivers did not know their machines. Years of experience are required before an engineer is allowed to run a locomotive, yet we allow

a boy of eighteen or twenty years, with only a few superficial instructions, to drive a monster truck down our streets, threatening many more lives than any locomotive which is confined to two steel rails."

As to the proportion of responsibility of the commercial truck in the annual slaughter caused by gasoline-propelled vehicles, no national figures are available, but in the two largest cities of the United States figures have been compiled which give a clew. The report of the Commissioner of Health of New York City shows that of a total of 638 automobile fatalities in the year 1918, trucks were responsible for 171, or more than one-fourth. The report of the Coroner of Cook county, Illinois, of which the City of Chicago constitutes practically the whole, shows that in 1918, of a total of 369 automobile fatalities, trucks were responsible for 144, and in 1919 of a total of 416 automobile fatalities, trucks were responsible for 133.

The lessons are printed on sheets 8½ by 11 inches. On the reverse side of each is a safety bulletin illustrating some specific automobile hazard. Nine of the lessons are devoted to motor vehicle maintenance, the rest to safe operation.

A resumé of the twelve Safety Lessons for Automobile Drivers will demonstrate how thoroughly the problem has been covered by the National Safety Council.

Lessons No. 1 deals with Brakes and Braking. This is one of the most important elements in the automobile accident problem. The lesson tells how to keep brakes in condition such that they will be reliable and certain of action.

Lesson No. 2 deals with Lubrication and Rules of the Road. Safety demands an engine that can be depended upon in an emergency. To keep an engine in such condition requires proper lubrication. Few drivers understand proper lubrication. This teaches the most approved lubrication methods. The im-

portance of complete knowledge of the rules of the road is too obvious to need emphasis here.

Lesson No. 3 discusses the necessity for and methods of keeping the Steering Mechanism in perfect condition. A car with an imperfect steering mechanism is destined for certain disaster. The psychology of the pedestrian is also treated in this lesson in such a way as to impress the driver with the necessity of having his car always in such control that he can avoid even an accident which would be considered the fault of the pedestrian.

Lessons No. 4 covers the engine. It shows the driver that when an engine "won't" it is not due to the perverse "temperament" often ascribed to gasoline engines by drivers, but to some improper adjustment or defect which generally can be discovered and remedied by a driver equipped with the necessary knowledge. The lesson gives this knowledge.

Lesson No. 5 treats of that delicate, and with those unskilled in its adjustment, troublesome mechanism, the carburetor. It teaches what it is necessary for a driver to know if his carburetor is to work efficiently and economically.

Lesson No. 6 takes up the problems of the ignition system. It teaches the driver that an ignition system is not made to work properly by mystic persuasions of cabalistic word combinations and tinkering, the formula which so many drivers experiment with, but by adjustments based upon scientific and definite mechanical principles, which are thoroughly explained in the lesson. How safely to cross railroad tracks is also treated. The need of impressing this upon drivers is shown by a report of the Interstate Commerce Commission on railroad crossing accidents, which states that in 1918, 2,270 such accidents occurred, in which 1,131 persons were killed and 3,109 injured. A railroad company which kept a close watch upon its crossings discovered that only 2 per cent

of automobile drivers look in both directions before crossing.

Lesson No. 7 explains the construction, operation and maintenance of the cooling system of the automobile engine, and what is necessary to be done in connection with it.

Lesson No. 8 is a thorough analysis of clutch, transmission and differential. Proper care and handling of these are necessary to safety. Garage accident hazards arising from careless handling of gasoline, oils, etc., are also discussed.

Lesson No. 9 is a discourse on the springs, frames, loading and tires of an automobile. Many accidents are due to these if they are not well understood and given proper attention. The lesson shows why and explains how to avoid dangers due to them. The other section of the lesson teaches the necessity of getting and reporting all the facts concerning any accident in which a driver may be involved, no matter how serious or how trivial it may be.

Lesson No. 10 treats of headlight laws and the hazards of blinding headlights. It gives the lighting standards for automobiles recommended by the Illuminating Engineering Society, the highest authority on this subject.

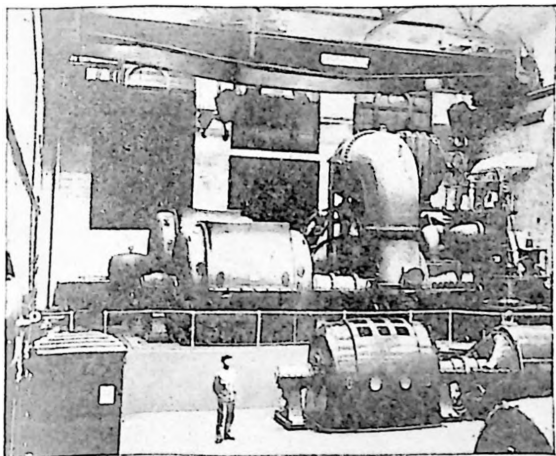
Lesson No. 11 deals with safe and efficient driving in general, and with the necessity of proper respect for the traffic laws and co-operation with the police.

Lesson No. 12 impresses on the driver the necessity of complete observance and understanding of all the foregoing by giving him the latest statistics showing the deaths due to automobiles, and emphasizing the way he can help in cutting down this staggering record by utmost care and vigilance in his own driving. It also gives the qualifications prescribed by the National Safety Council for a safe and competent driver. The Council is exerting every influence to have these qualifications made the basis of laws for

examination and licensing of drivers in every state in the union.

Aside from the saving of lives and the saving of property and claims for damages, the scope of these lessons must appeal to truck owners because the lessons, if observed by drivers, will prevent mechanical deterioration which is responsible for heavy lossess to truck operators. A report before the Ninth Annual Safety Congress of the National Safety Council recently brought out the fact that approximately 15 per cent of the average truck operator's machines are always in the repair show, as against 2 per cent of railroad rolling stock.

Westinghouse Turbine Makes a World's Record. At 5:20 p. m., March 8, 1920, there was finished what, from available data, is a world's record for the continuous operation of large steam turbines, in that the unit was stopped for the first time



"Westinghouse Turbine Generator Which Holds World's Record."

since the early morning of December 15, 1919. This continuous operation covered a period of 84 days, 11 hours and 36 minutes, and established a world's record for the operation of multiple

element steam turbines of the cross compound type. The machine was the 45,000 K. W. turbine manufactured by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., for Narragansett Electric Lighting Company.

During this run there were generated 51,104,000 K. W. H., or considerably more than the total yearly output of the Narragansett Company for any year prior to 1915. The average daily output was three or four times the maximum possible annual output of the first machines owned by the Narragansett Company. During this record run it turned out about 84.2 per cent of the total station output. Another interesting feature in connection with this record is the wide variation in load at various times, from a minimum of 6,000 K. W. to a minimum of 41,000 K. W.

To produce this output the machine used approximately 609,000,000 pounds of city water, which required over 71,000,000 pounds of coal to convert it into steam at 210 pounds pressure, and to condense this steam and maintain an average vacuum of better than 28 inches; approximately 32,000,000,000 pounds of water being taken in from and passed back to the Providence River. The twin-condenser pumps are driven by two 512 H. P. turbines and are capable of circulating 18,000,000 pounds of water per hour. Considering the fact that about 80 per cent of the total heat in the steam is absorbed by the condensing water, the city of Providence is enjoying among its many great advantages that of having a heating system continuously warming the waters of the Providence River, thereby keeping the upper reaches of the bay open to navigation all through the severe winter.

Some conception of the enormous amount of steam and air used by this machine may be had by some homely comparisons. During the present run sufficient steam was passed through the machine to equal about 540 times the entire weight of both electric and steam ends and the bedplates. Also to keep the generators cool over 18,000,000,000 cubic feet of air were passed through the generators, which equal 2,000 times the total weight of the generators and their bedplates. Sufficient air is pumped through the generators each hour to fill the turbine room seventeen times.

Not the least important feature by far, to promote continuous operation, is the self-contained lubricating system, which contains 800 gallons of oil. This oil is pumped through the cooler, which keeps down the temperature, to the bearings at the rate of 600 gallons per hour, and, in addition to lubricating the bearings and dissipating the heat due to friction, etc., is used to operate the main admission valves. Considerable importance is attached to the oiling system, since its failure for thirty seconds would wreck the bearings and possibly carry destruction to other parts of the machine. An auxiliary is also kept ready for immediate use, to prevent any such occurrence.

The spindle or revolving part of the high-pressure element with its generator rotor, together weighing nearly fifty tons, and turning at a speed of 1,800 revolutions per minute, made a total of 218,980,800 revolutions. Had it been possible for a fly, for example, to remain during this trip on the tip end of one of the blades, he would have made a journey of 1,300,000 miles, or approximately fifty-two times the circuit of the earth, or approximately five and one-half times the trip from the earth to the moon.

This run is the more remarkable in that the unit consists of two turbine generator sets, each of which has been operated independently of the other, so that in effect the result has been the mechanical equivalent of operating a single machine continuously for 169 days.

When the Westinghouse Company installed the machine early in December, there was no thought whatever of more than the ordinary weekly run, but abnormal weather conditions brought about such a demand for power that it was not considered economically advisable to shut it down until the date mentioned above.

"Since the turbine is always on the job and without complaint," says Assistant Chief Engineer F. M. Lucas, of the Narragansett Company, "it may truly be classified as 100 per cent American."

PAPERS AND DISCUSSIONS

THE EXISTING STATUS OF THE SEWERAGE, WATER AND DRAINAGE SYSTEMS OF NEW ORLEANS.

BY GEORGE G. EARL.

Read Before the Society, October 11, 1920.

The development of the Sewerage, Water and Drainage of New Orleans, correctly or otherwise, has been guided by the idea of making every available expenditure comply as nearly as possible with two conditions. First, that it shall form a logical part of ultimate essential systems, and, second, that it shall produce the greatest amount of service to the greatest number of people. It has been considered, when everybody was paying something toward the attainment, that justice demanded something of service as nearly as possible to everybody, most of the time, rather than iron-clad, puncture-proof service to a limited area or a limited number of people all of the time, no matter what the emergency.

Guided by these ideas the sewerage, water and drainage systems of the city have been gradually developed until today, speaking in round figures, the sewerage and water systems are serving 600 miles of streets and 80,000 premises with a service which from its inception has been almost perfect in every respect, and the main drainage system is not only removing the average annual maximum rainfall promptly from these streets and this area, but is also removing it from other surrounding areas, bringing them within opportunity for useful development and thereby creating new problems for the city and the Sewerage and Water Board to solve by the too rapid effort to utilize these newly-drained areas as city sub-divisions with widely-scattered buildings erected ahead of proper street or other improvements.

The construction expenditure for all three systems to date is approximately \$32,000,000, or \$400 for each of the 80,000 premises served by the sewerage and water systems.

The division of cost between the three systems is roughly as follows:

For the waterworks system, including connections to property line and meters, about \$130 per premises served.

For the sewerage system, including connections, \$110 per premises served.

For the main drainage system, including expenditures since 1892, by all agencies which have contributed to the present main drainage system, \$160 per premises served.

In the water and sewerage system the work executed to date covers only the fairly well-built portion of the city, with capacity only adequate for the needs of the population now served. In the main drainage system over twice the present populated area is drained, but with the gradual development of the present open areas, the open canals must be replaced by covered masonry canals and power and removal capacity must be gradually increased. It is not, therefore, far wide of the mark to say that with every additional mile of populated street beyond the 600 miles now served by sewerage and water, improvements in sewerage, water and main drainage systems, equivalent to those already made in the developed area, will eventually be required.

Figured for the 600 miles of streets served by the sewerage and water systems, and fairly well populated, there are 133 premises per mile of streets, and the systems, including the main drainage system, have cost about \$54,000 per mile of such populated streets. Present costs for improvements of this character are ranging roughly from 80% to 150% above their cost prior to 1915, and the problem of keeping these improvements safely apace with the needs of the city presents most serious difficulties.

The average citizen seems to think that it is a simple matter to build and finish water, sewerage and drainage systems adequate for all time to come, and just have it all over with. Unfortunately each of these average citizens wants service, and contributes only a limited amount toward its attainment.

and necessarily the aggregate of the contribution, is the measure of the character and amount of service which can be given.

The amount of water consumption per capita.

The population to be served.

The average density of that population, and the unit cost of labor and material are the factors which dictate the cost of a water and sewerage service.

The area to be drained.

The rate of rainfall per given unit of time.

The proportion of this rainfall which must be removed as fast as it falls.

The character of structures which can be utilized for such removal;

and, again, the unit cost of labor and material are the factors which dictate the cost of a drainage service.

Nearly all of these factors are changing.

Population is increasing say $1\frac{1}{2}\%$ per annum.

Total water consumption has been increasing about 11% per annum during the last five years.

The average density of population, due to widely-scattered building in new areas, is, if anything, decreasing.

The area drained by the city is constantly increased.

The rate of collection and run off toward, and the necessity for prompt removal from, the lower areas of the city, are both rapidly increasing with the natural development of the city.

The character of drainage structures acceptable in uninhabited sections become impossible as these sections are built up.

And, finally, we have an increased labor and material cost now of from 80% to 150% above 1914 and prior conditions.

The Sewerage and Water Board has only one source of construction fund for the extension of sewerage, water or drainage systems, viz., the surplus arising from the two-mill tax and the half surplus of the 1% debt tax, after there is paid there-

from the \$800,000 of interest on the \$20,000,000 of bonds outstanding against the three systems. This surplus depends upon the assessed value of the city and the portion thereof against which city taxes are levied.

The assessed values of New Orleans upon which city taxes were levied from 1880 to 1919 increased 40% per decade, and so far as I can judge have never averaged over 60% of the easy sales value of the property assessed. They have, however, not shown a steady growth, but have lagged very far behind the line of average growth for long periods, and then suddenly increased thereto. These lags in assessed value from 1908 to 1919 represent an aggregate of nearly \$3,000,000 of revenue which the Sewerage and Water Board did not receive, which, if it could have had from year to year, available for construction work, would have taken care of extensions and improvements which under present conditions will cost nearer \$5,000,000, and would have permitted the Board to extend the benefits of its system more rapidly to areas of scattered population as yet unserved by sewerage and water facilities, and to take care of a large part of the needs which are becoming rapidly more and more urgent.

In the latter part of 1919 the writer prepared a paper showing that, according to the Census-Statistics, the municipal per capita revenue of New Orleans was by far the lowest as compared with any other city in the United States of 300,000 or over of population. The average of such cities having had from 53% to 60% more per capita gross revenue; and, taking the 1918 statistics and deducting 4% on per capita indebtedness, New Orleans was shown as having only \$19 per capita revenue, available for all service, where the next lowest city had 27% more, the average of all cities of 300,000 or over of population had 73% more, and cities like Detroit, San Francisco, Boston, Los Angeles and Washington had from twice to two and four-tenths times as much.

Again taking the per capita collections from the waterworks systems (which are all municipally owned in cities of 300,000 or over population, except in San Francisco) it was shown that the average of these cities in 1918 collected 79%

more than New Orleans; that St. Louis, Pittsburgh, Cincinnati and Kansas City, each of which purify the water from a branch of the Mississippi River, collected from twice to two and seven-tenths times as much per capita as New Orleans.

From other sources of information it was shown that the existing San Francisco water rates as fixed for the private company which serves that city by the State Utility Commission, consisted of service charges, for various sized meters and connections, from three to over six times the New Orleans service charges, and that the rates per 1000 gallons for water were from three to four times the New Orleans rates so that the amount of service and water for which the Sewerage and Water Board received \$791,000.00 in 1919 would have yielded over \$3,000,000.00 at the San Francisco rates.

Theoretically water rates in New Orleans are not supposed to be a factor in the fund available for extension and improvements, since, by law, they can only be applied toward the maintenance and operation of the three systems. Maintenance, however, involves changes to meet ever changing conditions of municipal growth or renewals involving replacements or reconstruction, and there is, therefore, a wide margin of annual expenditures for these things which could be met out of water rates if the water rates were adequate to take care of them.

Water rates should be raised if for no other reason than to discourage excessive water consumption.

With consumption increasing 11% per annum during the last five years and with the cost of constructing, extending and enlarging and maintaining and operating to the water and sewerage systems moving with water consumption the necessity for this course is apparent. When we can have delivered in retail lots, in any amount, at any time, \$300 pounds of a liquid commodity at ten cents, it is little wonder that we get careless about its use or waste. The City has to purify and pump 100 gallons of water for every 65 that is paid for. Much of the unpaid for water goes through consumers' meters unrecorded since small leaks do not record on the meter, which accounts for the fact that people see leaks, neglect them, and for a time find no increase in their bills until as the leaks increase they get to a point where they begin to be recorded by the meter, when

the bill goes often to two, three or four times the average bill. It is quite likely that unrecorded water through the existing 55,000 pay consumers' meters aggregates over 3,000,000 gallons per day or a loss of revenue of over \$110,000.00 per annum at existing rates.

It would be entirely logical for the people to pay in water rates to cover the cost of maintenance and operation of both the water and sewerage systems including interest and depreciation since practically all of the water used has to be removed as sewage and water consumption more nearly than anything else represents participation in the sewerage service. If this were the basis of water rates they would have aggregated as follows for 1919:

Maintenance and Operation Waterworks System.....	\$621,000.00
Maintenance and Operation Sewerage System.....	133,000.00
Cost of Systems.....	\$18,900,000.00
Interest at 4% on \$18,000,000.00.....	720,000.00
Probable future minimum replacement value of systems	\$24,000,000.00
Depreciation at 1½%.....	360,000.00
Total	\$1,834,000.00

The above represents the actual cost for the two systems and if we paid that cost in water rates instead of in taxes we would see exactly what we are doing to ourselves when we waste or carelessly use water, reflected directly in our water bills.

The actual water collections for 1919 were \$791,000.00. This would mean probably about double the present water rates since present free consumers for public uses, including fire hydrants, would be paid for out of taxation, giving the City and each department a budget sufficient to pay its water bill and thereby an interest in reducing its water consumption. Obviously if water rates paid interest on water and sewerage, cost of systems and reasonable depreciation on the replacement cost of these systems, the replacement fund to be invested in extensions thereof, thus holding the value of these properties always well above the interest bearing debt against them, there would be just that much less to be raised from taxation and we

would approach more nearly the, to me, ideal condition, that every utility should earn its own way by charges for every item of service which it renders, covering the full average cost of said item of service and aggregating the total cost of the service. The Sewerage and Water Board law and plan absolutely precludes any basis of water rates in which interest on cost or any part thereof is payable out of water rates. At present the water rates are permitted by law to be expended for the operation and maintenance of the water, sewerage and drainage systems and the establishment of a sinking fund for their renewal, but they are limited to the rates established in 1913 which had at that date been reduced to a point which was believed to be the minimum to which they should go under the law as *then* existing which only permitted their utilization for the maintenance and operation and depreciation of the waterworks system alone.

In view of the legal status and of the difficulty of changing broad general plans upon which large bond issues are outstanding in a paper early in the present year I urged that any set limit on water rates be repealed, but that the law define the purposes to which they could be applied and limit them to these uses. I also urged that the assessed value of property be increased to more nearly its easy sales value and that the collection of city taxes be upon a sufficient percentage of this increased assessed value to give to every department of public service a reasonable opportunity to render and maintain reliably the best character of service for which the people can afford to pay, not a service built today to accomplish all of the unreasonable things which the average citizen expects, but rather a character of service which we can better offer to pay for than to do without because its omission will cost us more in other ways than it will cost to supply the service.

The assessed values as announced recently and the decision of the Commission Council to base taxation on 90% of said values indicates that the Sewerage and Water Board will have a surplus available for its construction fund for 1920 of \$1,700,000.00 instead of only from \$300,000.00 to \$450,000.00 as existed from 1911 to 1917. This begins to give a reasonable hope of gradually overtaking the growing needs of the sewerage, water and drainage systems depending upon the future

course of construction costs and of further logical increases in assessed values.

It is not likely that the people of New Orleans would want or care to pay for the kind of drainage system that would be able to take care of maximum downpours without, occasional local flooding to or above curb levels for short periods, during or immediately following their occurrence, if they consider that this would require probably double the run off capacity which now exists, and would entail an additional cost out of all proportion to the additional benefits which it would confer. The original drainage recommendations of the 1895 drainage report as to capacity to be provided were based, not upon the immediate and entire removal of the water from the heaviest storms, but rather from "rainfall recurring with sufficient frequency to make their entire and immediate removal necessary." New Orleans gets occasional rainfalls of extreme intensity, the maximum records for various periods of time range from rates of downpour for thirty minutes averaging $5\frac{1}{2}$ cubic feet per second per acre to rates of downpour for twelve hours averaging .75 cubic feet per second per acre. The maximum rainfalls of the average year will show about one-half of the above named rates and the ability to remove these without material inconvenience is about the limit to which it seems at present desirable or practicable to develop the run off capacity of the main drainage system. It is, however, important that all of the elements essential to guarantee approximately this capacity be thoroughly safeguarded.

The Sewerage and Water Board has available about 12,000 horse-power of generator capacity, 4,000 in small units at the old Central Power Station, and 8,000 in one big unit at the Waterworks Plant. It requires practically all of this power and all of the existing boiler capacity to carry through several times each year. If the 8,000 horse-power unit were out of service or should go wrong during a severe storm its need would be emphatically indicated by the retarded removal of the water from all sections of the city and especially from the lower areas which are now building up with a rapidly increasing population. More boiler capacity and another big power unit would give better service in extreme storms

than can at present be given regardless of any breakdown in any part of the existing system and in case of a breakdown in the existing turbine would be of almost vital necessity.

In connection with the drainage of the city it must be remembered that no amount of main canals and pumps can remove water any faster than it can get to the canals. The arrangement of street gutters or of local sub-surface drains to get the water to the main drains is, therefore, essential in each locality, if it is to receive its fair participation in drainage benefits. It is by no means certain that the original intention of the drainage system included local sub-surface drainage, but it is the desire of practically everyone to avoid open gutters and it seems to be entirely practicable and even more economical and desirable in every way, as streets are paved and improved, to include sub-surface drainage. This is purely a local benefit in every case and is properly paid for by the property benefited. Its execution, however, at the time of paving of streets and only as streets are being paved, presents many objectionable features. First, it makes it difficult to obtain the best results because only portions of certain local drainage systems are built and these have to receive drainage temporarily from areas which will eventually be otherwise provided for as other streets are improved. Temporary trouble in various localities is due to this factor. Again the construction of drains under streets just as they are about to be paved means settlement after the paving. It would be much better if the drains could be built two or three years ahead of paving, but there are many difficulties in reaching this result. Many seem to believe that the Sewerage and Water Board should build these local drains out of its construction funds. If they would remember that there are 600 miles of well populated streets already, which will require eventually nearly 1,200 miles of local drains, with only about 400 miles of such drains now built, and that there are another 600 miles of potential streets, over which population is beginning to scatter, which will call for another 1,200 miles of local drains, and that at present it is costing somewhere around \$3.50 to \$4.00 per foot of average sized drain it will be very obvious that the taxpayer would better *think* before he shoulders this

obligation. 2,400 miles of drains at \$4.00 per foot indicates an expenditure of \$50,000,000.00 or \$250.00 per premises when we have 200,000 premises or 1,000,000 of population on these 1,200 miles of streets, instead of about 80,000 premises, mostly in about 600 miles of them, as at present. If people will build and develop consecutively on continuous areas, with a fair density of population, they can well afford to pave their streets and to build effective local sub-surface drainage to serve their property, and incidentally they will be far more likely to get the benefit of every public service and to hold its cost within reasonable limits. The Sewerage and Water Board will go as far as its resources will permit in extending the sewerage and water systems and in the development of the main drainage system over the entire populated area of the city. It does this out of money raised by taxation, and the well built areas of the city, and especially the larger taxpayers, are contributing in taxes to this end. Counts of houses in the areas which are now showing the greatest growth and are most logical for water extensions show that in order to get water mains to every house it will cost from \$300.00 to over \$500.00 per house just for local water extensions and about as much for local sewer extensions, and the owners of these houses argue that the Board is losing a lot of valuable business by neglecting to make these extensions. The average house yields about \$8.00 a year of revenue in water rates. At present costs of labor and material it requires about 16 houses per square yielding \$8.00 each to pay 6% interest on the cost of local water extensions and meters and connections. Yet by the time two houses per city square are built it may require the construction of the full distribution system on every street to serve them. In other words, 15 houses per mile of water main may require the full construction of the water distribution system, where for the whole area now served there are 133 premises per mile of water main, and in many sections already served there is still a great deal of vacant property which should be utilized but which is too often being held for high prices and maintained in an unsightly if not an unsanitary condition, a detriment to the locality in which it exists. Such property should be so assessed as to force it to participate

fully in the costs of the developments which have created the value which it has obtained, especially in view of the fact that its existence, unused, is forcing similar developments in other localities.

So far as I know no large city other than New Orleans has thrown so great a share of the cost of its various services upon the taxpayer as New Orleans. Probably the results accomplished during the last twenty years could not have accomplished so well, if at all, in any other way. Usually a large portion of the local improvements are paid for by those directly benefited, for instance local sewers and water mains and all connections and meters and street paving and improvements, etc. It is, however, possible to consciously adjust assessed values so that they will reflect the amount of service which any given locality is receiving at the expense of the general taxpayer, and really essential that this be done to maintain equity. Undoubtedly every public service rendered free or at rates below the whole of its cost does add to the value of the property served. If these assessed values are held down where little service is given and increased with each added service rendered, two things are accomplished, the small amount of property receiving little service pays less taxes in proportion to the poor service which it receives, while that receiving full service pays more to assist in extending the same service to those as yet unserved, and those who are insisting upon extensions of service well know that with such extensions they will have to pay taxes on increased assessed values in order to do their share toward the still further extension of service to others.

The present Sewerage and Water Board law requires that sewerage and water connections, to the property line, be made at the cost of the construction fund. To date about \$2,700,000.00 has had to be expended for sewer and water connections and meters to connect existing mains to user's premises, while other would be users, who would be glad to pay the cost of their own connections if they could get the mains extended to them, have had to wait. It is true that proper city planning with continuous and contiguous development to a reasonable density of population would have resulted in service to everybody,

and that those who have had to wait are still for the most part those who have scattered so widely that even yet a service to them is really an unfair cost to put upon the general taxpayer, and a cost which with anything like present prices and present available resources the Sewerage and Water Board can only very gradually take care of.

The main problems for the Board to consider at present consist in the necessity to maintain all of its services up to their present standard of efficiency in the face of increasing demands.

The nominal capacity of the water purification systems (New Orleans and Algiers) is 42 M. G. D. These plants are now putting out an average of about 46 M. G. D. with days and hours of very much greater output. Early provision for a larger purification capacity must be made. The single 48" suction line to the river, at low water stage of the river, cannot yield probably over a 55 M. G. D. rate. It is often necessary to work it to the limit of its capacity for many hours at a time. An additional 48" suction line was something that was omitted when the plant was first built with the belief that the single line could be maintained constantly in operation and would serve to the limit of its capacity, and that we could by omitting a second line give just that much more service in other respects. This belief has been justified to date and a good many miles of small water mains and sewers exist today because the precaution of a duplication suction line was omitted in 1908, but the time has now come when the additional line is essential. The same is true of high lift-pumping capacity and of main line capacity to deliver water from the Waterworks Pumping Station to the center of distribution. Another large pump and another large main delivery line, from the inception, would have been as gratifying to the responsible heads of the Sewerage and Water Board Engineering Department as it would have been to the Engineers of the National Board of Underwriters who expressed their desire for these things at the start in no uncertain terms. We believed that we could maintain reasonable service up to the present demand without these things and we knew that we must omit them or else omit many more miles of small sewerage and water

mains and deprive a large number of people of a service which we believed we could maintain, and we took the chance, knowing it was a chance. It happens that there has been no serious consequence ensued. Water consumption, however, is increasing faster than had been expected and with it the hazard of longer deferring these safeguards cannot be justified. I had believed that with an all metered system water consumption in a city like New Orleans could be held down to something like 80 gallons per capita per day. Until 1918 there was nothing to change this belief. In 1918 total average water consumption went to 86 gallons per capita and in 1919 to 94 gallons per capita and seems to be heading toward 100 gallons per capita or more. At 80 gallons, roughly speaking, a 40 M. G. D. plant could serve up to 500,000 population. At 100 gallons it can only serve a 400,000 population. In other words the increased average per capita total consumption is making increases of capacity, etc., necessary ten years earlier than they would have been without it. About half of this increase in consumption is in flow recorded by meters and paid for and, therefore, reflected in revenue, while the other half is in unrecorded flow through meters or in uses of wastes through fire hydrants by public authorities or in leakage from mains. When you remember that a single fire hydrant wide open can discharge at a rate from 1 to 4 million gallons per day, and that many city department employees have access to fire hydrants for many uses, that there could go through existing meters in unrecordable leaks probably over 5 million gallons per day and that our soft ground permits of heavy vibration due to street traffic which is perpetually causing leaks which have to be repaired, it will be seen that the prevention of excessive total consumption presents many difficult angles.

In the development of the sewerage system it was assumed that an amount of under drainage equal to about $\frac{1}{3}$ of the annual rainfall would run off as a nearly constant dry weather flow through the sewers and that the rate of seepage through the soil to the sewers would prevent material fluctuations in the amount of under drainage flow entering them. The average dry weather flow is about as anticipated, but the assumption that greatly increased rates of flow would not follow when

the ground surface was flooded by heavy rains, was incorrect. The very facts of improved surface drainage and of under drainage, have changed the whole condition of the soil. Where it used to be saturated and dense close to the surface, it is now free of excess water and porous to very considerable depths and permits rapid filtration of water from the surface to the sewers. This appears to be a sanitary advantage in many ways, but it makes the problem of the entire separation of drainage and sewage flows at all times far more difficult than had been expected.

In the original sewerage plan a single 48" force main to the river and a main sewer adequate to carry the ultimate sewage flow of only a limited area were provided for immediate construction, with additional force mains, pumps and main delivery lines, for future construction, to meet future needs as they should develop.

The main trunk sewer, pumping capacity and outlet force main, can still take care of the dry-weather flow of the Sewerage system, but they are inadequate to take care of the flows during severe storms, when the sewers themselves act like storm drains and the big drainage lines are rivers, and the conclusion has been reached that it would be foolish to attempt to build main sewers and pumps and force mains to the river to take care of these exceptional flows when the same amount of money invested in drainage improvements would afford adequate relief for the sewage and at the same time more rapid development of the main drainage system. Another angle leading to the same conclusion is that the dry-weather flow collected in the big city drains is little if any less subject to septic action, and, therefore, little less objectionable than the sewage. In fact, in some cases we have found accumulated dry-weather drainage flows more objectionable than dry-weather sewage flows. If the sewage was collected in the big storm drainage-pipe system its condition therein would be intolerable. The collection, therefore, must be maintained separate, but, once collected, it is indicated that the carrying of these collected flows of either sewage or drainage in properly constructed, covered and lined masonry canals is altogether practicable, and that it is immaterial as to whether one or the

other or both are carried, except that the larger the flow the better the result. The one important thing is to keep the flow moving at good velocities in clean channels to an unobjectionable outlet. For the dry-weather flow of either the sewerage or drainage system, Lake Pontchartrain and the levied outfall canals leading thereto do not constitute proper outlets, and the necessity to perfect and maintain a cross-town dry-weather flow delivery to Jourdan avenue is clearly manifest. The drainage system had just reached the stage where practically all dry weather flow was being moved in this direction when the Industrial Canal cut off the Bayou Bienvenue outlet through Pumping Station No. 5 at Jourdan avenue. When the syphon under the navigation canal can be put into operation in connection with the present canal, it is intended to resume cross-town delivery of dry-weather flow, but there is a serious, and will be increasing need, for something more than the open and unlined canal from Station No. 3 at Broad and Marigny to Station No. 5 at Jourdan avenue, to give reasonably satisfactory service in this cross-town delivery of dry-weather flows. Eventually a masonry covered and lined canal of very large capacity must be constructed in this location. The best method of operation and disposal for this cross-town system of delivery can only be developed by experience, but New Orleans is fortunately situated in that it has the choice between concentration of all dry-weather flows at this point and their limitation and delivery, thence to the river, or their purification and delivery into Bayou Bienvenue, or, more cheaply than either, it may dilute such flow to any extent necessary by added water from Lake Pontchartrain at any available point or points en route and discharge it sufficiently diluted into Bayou Bienvenue to avoid objectionable conditions therein. Fortunately experience can dictate final development in all of these respects without any doubtful expenditures. Every step taken is a part of a safe ultimate plan and of an essential ultimate whole, and, taken step by step, each step will help determine the next logical step. The ultimate whole, to serve the present drained area of New Orleans fully with sewerage and drainage, will probably be less difficult and costly than the original intention of maintaining the

sewerage and drainage systems as entirely independent systems would have required, yet no single step will be taken which in any way precludes the possibility of going ahead with the full execution of this original intention, should funds become available, and the necessity so to do be demonstrated.

The sewerage and drainage systems of New Orleans as they exist today are operative and are operating as a whole and in every part to give the best possible service. They have no unnecessary or useless parts, but they are built with the idea of being able to render their maximum service under every conceivable contingency. Power enters nearly every pumping station from two directions and sources, so that it will require two accidents to power lines to cripple any single pumping station. At all intermediate lift pumping stations by-passes exist, and throughout both system available cross connections are provided all with the result that, so long as one single source of power and one single pumping station connected thereto, and delivering its output either to the Mississippi River or to the surrounding tidal waters, is operable, that pumping station can work to the limit of its capacity in the removal of either sewage or drainage from the whole city. The total capacity available for the removal of drainage water from the city prior to 1900 was 1,200 c.f. per second. The capacity of the final discharge pumps today is about 8,000 c.f. per second (with 5,000 c.f. per second intermediate lift capacity). Any one of the four final discharge stations on the east side of the Mississippi River has a larger capacity than the whole existing prior to 1900, ranging from over 40 to over 125% in excess of said 1,200 c.f. per second capacity.

It is interesting to note that the original Drainage Advisory Board report of 1895 indicated about 8,900 c.f. per second as the final discharge pumping capacity that would be wise to provide for "within say a period of 50 years," as compared with the 8,000 c.f. per second capacity now provided; and it is also illuminating to remember that 8,000 c.f. per second draining about 30,000 acres, provides for a run off of only about .27 c.f. per second per acre, where we have recorded average rates of downpour for a 12-hour period up to .73 c. f. per second per acre. Obviously such downpours must wait

somewhere until they can be removed. The storage capacity of canals and drains and absorptive capacity of soil have very small influence in holding the rate of potential run off below the rate of continuous average downpour in such cases.

Measured as a going concern, the Sewerage and Water Board enterprises, on the whole, may be said to be in a very prosperous condition. With \$20,000,000 outstanding 4% indebtedness, the city owns systems that have cost \$32,000,000, and could not be duplicated now for \$50,000,000, and which at no time in the future probably could be duplicated for \$40,000,000. The depreciation in these systems due to obsolescence is relatively small. The revenue from water rates plus city budget is inadequate to take care of their proper maintenance and operation, including renewals, replacements and changes, but the major portion of the revenue of the board is from taxation, and this is ample to pay interest on indebtedness and will provide for extensions and increases in capacity very much more rapidly than the accruing depreciation of the systems, but will *not provide for extensions* and improvements as rapidly as localities needing them would like to see them, and at the same time keep up with the increasing capacity demand. The trouble with this showing is that people generally do not regard payments through taxation as payments for service rendered. No matter how little the tax, or how great the service, the two are not connected in the taxpayer's mind, and especially not in a way to render the taxpayer the least interested in helping to hold down the cost of the service. If all participation in water, sewerage and drainage benefits came as an equivalent charge per 1,000 gallons of water used and per acre drained and were optional, with all of its average benefits, there would be no question in the mind of anyone as to the desirability of participating in the service.

Based upon the taxation of 1920 and water rates 50% in excess of those now prevailing, and city budget adequate to carry all drainage maintenance and operation costs, the average per capita payments to the Sewerage and Water Board would be about as follows:

Sewerage, Water and Drainage Systems of New Orleans 291

Water and sewerage maintenance and operation.....	\$3.00
Drainage maintenance and operation.....	1.00
Interest on debt.....	2.00
Extension three systems.....	4.25
Total	\$10.25

Based upon 1919 taxation and water rates the average per capita payment were about as follows:

Payment for water bills.....	\$2.08
Payments for drainage maintenance and operation out of city budget from tax.....	.46
Payments for interest out of Sewerage and Water Board revenue from tax.....	2.00
Payments toward extensions out of Sewerage and Water Board revenue from tax.....	2.25
Total	\$6.79

It was not until 1917 that the payments available for water, sewerage and drainage extensions reached \$1 per capita in excess of the interest charges on the \$20,000,000 of indebtedness.

Under the above assumed 1920 conditions the Sewerage and Water Board could begin again to gain ground, if the assumed increases in amounts available to cover maintenance and operation and depreciation in the three systems are approximately met, otherwise it will be left in a very awkward position—viz., that of having funds to build systems but not to operate and maintain them. This results from the effort to dictate by law a limit of some costs and to dictate that other costs shall be paid by the city, regardless of the ability of the city to meet these requirements. All of our muddles, railroad transportation, street railway, gas, and generally all public-service troubles, are due to the failure of everyone to recognize that every service and every item of service is entitled to earn its full average cost plus a reasonable margin, no more and no less. Said margin to be divided between profit to management and extension and improvement, without added capitalization, in privately owned plants, and to be all devoted to the last named objects in publicly-owned plants. Capitalization in all

cases should be limited to money from outside sources invested in the enterprise, and going value to any deficit below a fair return upon such money invested from outside sources.

Under the conditions shown for 1919 the Sewerage and Water Board was slipping backward in its ability to render the full service to the city which it will pay, everything considered, to render.

The gain made since 1900 has been the foundation upon which a reduction of total death rate equivalent to an increased expectancy of life of from less than 37 years to over 53 years has been built up, and upon which the city has overcome the old handicap of an unsavory sanitary reputation. To accomplish this we have contributed to date a per capita amount per annum starting at about \$1 in 1895 and gradually increasing as the services increased to less than \$7 in 1919. To maintain and further improve conditions and to give to others, at higher prevailing present costs, a chance to participate in equal benefits, we must now not only spend an average of say \$10.25 per capita per annum, but we must face the fact that we will, on the average, have this unpleasant duty facing us for 16 years longer than would have been required under the prevailing average age of all tax escapement prior to 1900. The slow way of defeating this necessity is to defeat necessary expenditures and allow these services to deteriorate, if you can persuade a majority of the people of the wisdom of this course. Probably, however, a majority will prefer to find their share of this \$10.25 per capita per annum and a few dollars extra for other improved services, even for the additional 16 years, or for a few years more, if by said general improvements a still better health showing can be made, as no doubt it can. To those who are convinced that purified water is certain and quick death, or that a sewerage connection leads rapidly to fatal results, and are really irreconcilable, there is the opportunity to prove their faith; either of these routes to complete tax escapement is always available. If they are wrong, they ought to be sports enough to reconcile themselves to living and paying. If they are right, they escape further payment promptly and have the joy of vindicating their views. The Sewerage and Water Board needs

their \$10.25 per annum, however, as long as possible, and I refrain, therefore, from suggesting many more certain means of avoiding payment. Moving to any other large city will not help, since it is more than probable that the United States Census Statistics for 1920 will still show New Orleans as collecting the lowest average per capita amount of any city of 300,000 or more of population.

Local conditions in New Orleans require more rather than less expenditures than other cities to obtain equivalent results in very many directions. The construction and maintenance and operation of sewerage, water and drainage systems certainly present unusual difficulties, and the same is true of all surface or underground structures under local soil conditions.

Street and sidewalk pavements and street railway tracks especially are subject to costs and difficulties of construction and maintenance due to the gradual shrinkage of the soil, which is inseparable from such drainage as is essential to sanitary conditions, and has been in evidence even before any drainage of any kind existed, witness two or more layers of stumps underlying existing recent growth now at tide level in areas which have never been drained, all of which have originally grown upon a surface about tidal level, which surface has gradually subsided. Settlements up to three or four feet are common after four or five years of cultivation in tidal level areas which have been leveed, and only surface drained, all through this locality, and more or less similar settlements, as irregular as the compositions of the various soils in the spots where they occur, are found in the more recently developed sections of New Orleans; the building of structures, some founded below the level of more rapid soil shrinkage and some closer to or at the surface, serves to bring into conspicuous evidence the effect and irregularity of such settlements, which were unnoticed formerly, and the effect of this shrinkage and settlement on the utility and life of structures is one of the most serious of the problems confronting the local engineering profession. People generally ignore this factor and accuse the works which suffer from this cause, of being themselves the cause of such settlements through improper construction or back-filling. The ramming of local clay back-filling beyond

a certain point is utterly futile, and the flooding of such clay back filling to compact it is worse than futile. The volume occupied by a given amount of local clay will vary with the amount of water which it contains, and puddling with water only increases the amount of subsequent shrinkage, as the added water gradually escapes. The roots and stumps and peaty matter in the soil in large quantities are subject to even greater shrinkage than the wet clay, as they decay and gradually revert from organic to inorganic matter with great shrinkage of volume and probably considerable disappearance of actual matters in gaseous form. With these unusual difficulties confronting us on every side, the best and most economical forms of development in many directions for most other cities are, for New Orleans most costly and disappointing in their results, and the ultimate price which we must pay to develop and maintain a great city on a soil which was not, by a few thousand years of natural development, ready for such use, will necessarily be large and increasing as we utilize more and more the tide level areas where the effect of soil shrinkage will be at its maximum.

Looking to the early future with the present status as to assessed values and percentage thereof upon which taxes are levied. Assuming natural and logical increases, it seems reasonable to hope that there will be available for construction expenditures during the next four years to July, 1924, something like \$7,600,000.

Out of this approximate amount available for expenditure a tentative schedule contemplates the following works or as much thereof as can be constructed at the prevailing costs for labor and material.

- 1st. The making of water and sewerage connections as required from the mains to the property line.
- 2nd. The construction of plumbing inspection and of the inspection of sub-surface drainage constructed by the city.
- 3rd. The completion of changes necessitated by the Industrial Canal or other similar changes or renewals.
- 4th. A new 48" suction line to the river from main water-works pumping station.

- 5th. A 20" main to discharge mud from reservoirs to river with pump and motor.
- 6th. About \$500,000 worth of minor water main extensions.
- 7th. An additional main delivery line from the pumping station to the center of population.
- 8th. About \$1,000,000 expenditure in minor sewer extensions, including sub-mains and two relifting sewage pumping stations.
- 9th. Additional power unit for Algiers water and sewage pumping station.
- 10th. Additional capacity for filtration at both plants.
- 11th. Additional pumping unit at Main Waterworks Pumping Station.
- 12th. Additional pump and outlet capacity Main Sewerage Pumping Station.
- 13th. Additional turbine and boilers for power at Waterworks Pumping Station.
- 14th. Additional settling reservoir capacity at Water Purification Station.
- 15th. The completion of the Alvar street lined and covered canal.
- 16th. The construction of a lined and covered canal on Lafayette avenue—St. Claude to Claiborne.
- 17th. The construction of intercepting canals on St. Claude from Lafayette avenue to the Industrial Canal.
- 18th. The sub-channel lining of the Florida Avenue Canal from Broad and Marigny (Station 3) to Jourdan avenue (Station 5).
- 19th. The construction of a covered and lined canal on Carrollton avenue—New Basin Canal to Orleans street.
- 20th. About \$200,000 expenditure in small drainage extensions.
- 21st. The lining and covering of the South Claiborne Canal from Nashville avenue to the Upper Protection Levee.

The above works based on approximate estimate made within the last few weeks would aggregate a cost of about

\$8,000,000, and could not be completed with the funds stated as available by July, 1924, unless a surplus from the maintenance and operating funds can take care of Items No. 2 and No. 3, and of some other items which could as fairly be charged to replacement as to new construction.

The tentative schedule of expenditures containing these items is being arranged with a view of maintaining service by doing those things which are most essential thereto first, or by withholding funds to do them as rapidly as conditions will permit. It is believed that the Board can maintain its service up to present standards and get a little ahead by working as above indicated, thus reaching a point after 1924 when it can devote more of its available construction resources to the more rapid extension or improvement of the local branches of its several services.

The fact that the Sewerage and Water Board has maintained the nucleus of the splendid organization which has been developed through the 25 years since the first work was undertaken on the original drainage plans, and that that organization has the accumulated experience of prior construction and of subsequent maintenance and operation work, is going to be a very potent factor in the further and more rapid development of the systems.

The drainage work was started under the Fitzpatrick administration. The Sewerage and Water Board was first organized under the Flower administration. The merging of the two boards occurred in 1902 under the Capdevielle administration.

In 1904 the first Behrman administration commenced and there have been four successive Behrman administrations.

The composition and membership of the Board has suffered changes due to merging and legal enactment and court decisions and other changes due to deaths, resignations, removals from district, to expiration of terms, and to shifting membership in the City Council, or later the Commission Council and in the Board of Liquidation. Through all of these changes there has not been a single case where an employee of any department of the service has lost his position or been jeopard-

dized therein or persecuted by reason of any political consideration.

Men from the original drainage forces and men taken on in the first organization of the Sewerage and Water Board forces under the Flower administration without exception have been retained and occupy many of the most responsible positions in every department of the service.

The writer cannot too highly praise the spirit of loyalty to the work, and co-operation that this organization has shown as a whole, often through most trying conditions, or the interest, integrity and ability of its members who are carrying the major responsibilities of its several departments.

The holding and development of this organization has been the result of the policy of the Sewerage and Water Board of retaining its employees, of making promotions from within the service in recognition of meritorious work, and of expecting and permitting its employees to exercise that character of initiative which gives to worth while men such interest in their work that they will sacrifice much of personal advantage rather than abandon it.

Discussion.

A. M. SHAW: In discussing the paper which has just been presented by Supt. Earl, I wish to share a little reflected honor in that, following a chance conversation with Mr. Earl earlier in the year, I conceived the idea that it would be a good plan if the Engineers of New Orleans could be brought to the realization of the existing conditions, especially with regard to the water supply of New Orleans. At the time of this conversation the situation was far more serious than at present, as action had not yet been taken by the authorities to provide funds necessary for even the most urgent requirements of the Sewerage and Water Board. Since that time I understand that these most urgent requirements have been taken care of, but I still feel that the original intention is well worth carrying out, as there is still the need of insuring that the funds be provided, and also insuring that the proper authorizations follow for the execution of the necessary work.

The motive which prompted me to secure this paper for the society could not be stated better than by quoting the discussion of Mr. Lockett and Col. Garsaud. The idea was to have the local engineers obtain intimate knowledge of conditions and then impress on them the necessity of carrying on a campaign of education among the various residents of the city.

It is the popular belief, and this belief is no doubt shared by many engineers who have not come in direct contact with the work of the Sewerage and Water Board, that New Orleans is supplied with an "unlimited quantity of the best water on earth." It is no doubt true that our supply of raw water may with safety be considered unlimited, but as shown by this paper we find that the manufactured product has its serious limitations.

Of the 21 items of construction work outlined for the Sewerage and Water Board, it would appear that 4 are of the most vital importance, and of a nature to justify the active and aggressive assistance of the members of this society in securing their early execution. These four are as follows: (1) The new 48-inch suction line from the river to the main waterworks plant. (2) Additional main delivery line from the main pumping station to the center of population. (3) Additional pumping unit at the main waterworks pumping station. (4) Additional capacity for filtration.

Without providing all of the above mentioned extensions New Orleans is not in a position to seek any reduction in its present rates of insurance, and apparently is in danger of having the present rates increased, to say nothing of the danger to the city regardless of the increase in insurance rates, of a disastrous fire. So far, this city has never been visited by a general conflagration such as has occurred in Chicago, Baltimore, Atlanta and San Francisco, but if a general fire should ever get under way, it is probable that the city would be at its mercy. We have just been shown that the present normal capacity of the plant is frequently exceeded by ordinary uses of water. With a large fire and its attending use of water by the entire fire-fighting equipment of the city, losses of water through broken connections in the burning buildings, etc., it is easy to imagine that even the maximum emergency capacity

of the present plant might be exhausted, resulting in a shortage of water at a most critical time.

The city has been fortunate in being practically 100% metered, but this very item which contributes to the economical use of water bars us from one of the means of emergency increase in available water supply which has occasionally been made use of by other cities at times of water shortage. A prompt installation of meters on a large portion of the service which has hitherto been on the flat rate system will result in an immediate increase in the amount of water available for other purposes.

There is an increasing and insistent demand among engineers that they receive more recognition by the public, and a willingness to assume their share in matters of general interest in order that this recognition may be justified. In my opinion there is no better opportunity now presenting itself to the members of this society to take an active part in the betterment of the conditions in New Orleans than to contribute their time and efforts toward the improvemens of the public works of the city, and especially towards the securing of an adequate supply of suitable water.

THE PROPOSED SEPARATION OF THE RED AND ATCHAFALAYA RIVERS FROM THE MISSISS- IPPI AND THE PROBABLE EFFECT ON FLOOD HEIGHTS.

By JOHN KLOSER.

Read Before the Society, November 8, 1920.

The closure of Old River, sometimes called the Separation of the Red and Atchafalaya Rivers from the Mississippi, and more often referred to by persons of poetic expression and temperament as the Divorce of the Red and Atchafalaya, is a subject which has occupied the attention of the River Engineers in this State for the past 25 or 30 years. But, as there are perhaps persons in this assembly not familiar with the problem involved, it may be well to rapidly sketch the situation as it exists, and state what is proposed.

The shaded area on the map (Fig. 1) indicates the extent of the flooded territory caused by the back water of the Mississippi River, and also the overflow section of the Atchafalaya Basin caused by the absence of levees on the lower Atchafalaya River. The letter "A" indicates Point Breeze, the end of the levee system of the Fifth Louisiana Levee District. The Mississippi River water enters this basin at bank-full stage and the overflow area extends as the river elevation increases. The tilt of the overflowed land from Vidalia is to the south, and corresponds generally with the high water slope of the river about $2\frac{1}{2}$ tenths to the mile. Extension of the levee, let us say, 4 miles beyond point "A," can be counted on to withdraw the upper margin of back water an equivalent distance. Under such conditions, the benefit derived per mile of levee extension at the lower end of the basin, is not very great. The same remark applies to the extension of the levee lines on both sides of the Atchafalaya beyond their present termini points "B" and "C." The maximum benefit to the whole area shaded on this map would be accomplished by extending the levee from Point Breeze across Old River and joining the Atchafalaya District Levee at or near Torras. This is what is being proposed by the interests situated in this section of the State

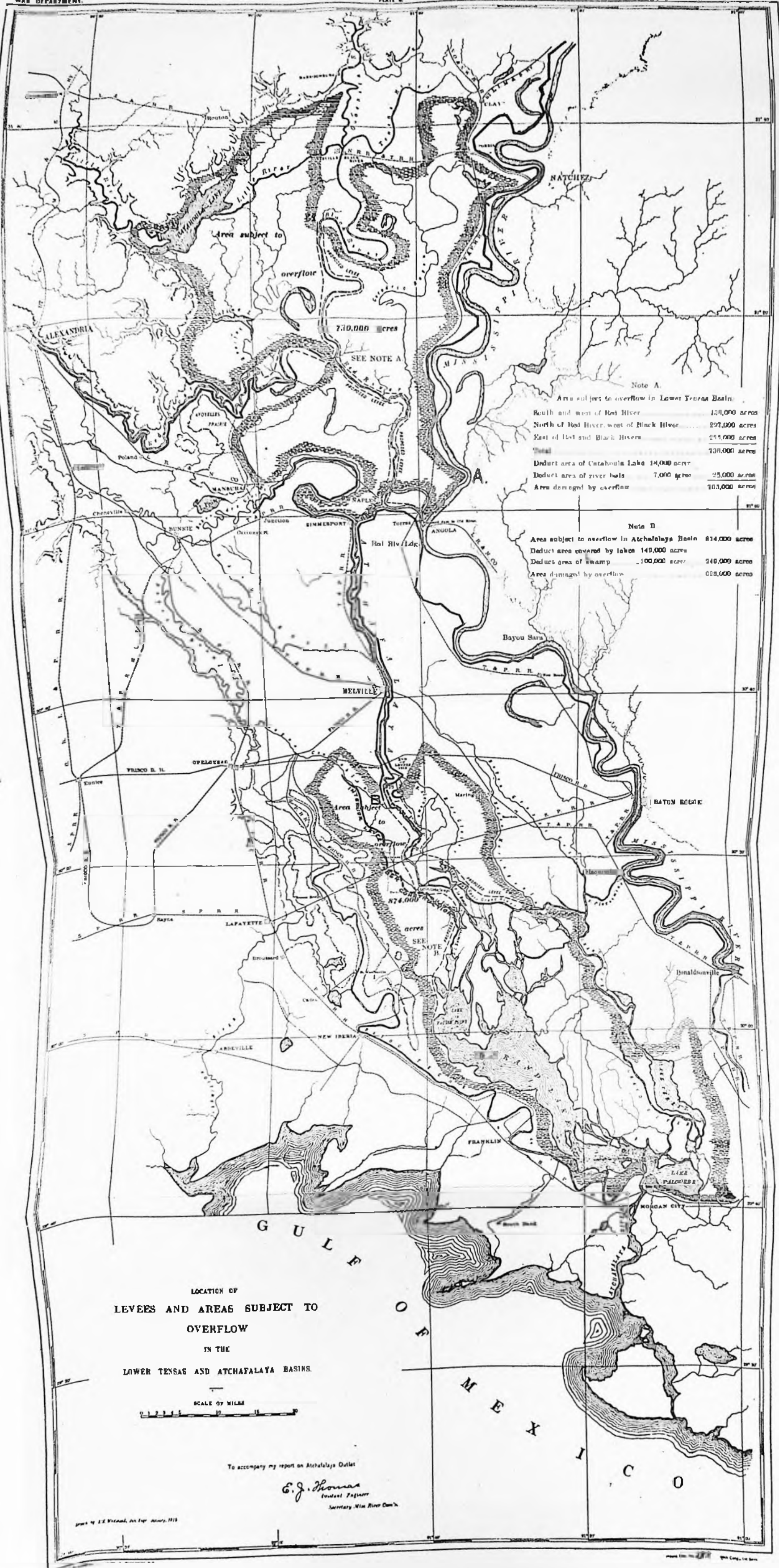


FIG. 1

This is what is being opposed by the interests situated on the Mississippi River below Red River Landing.

The people of the Lower Mississippi River say, if you close Old River, you are depriving the Mississippi River of a flood relief opening of considerable capacity, and force them to raise and enlarge their levees beyond grades and section now prescribed, and at an expense of many millions of dollars.

The people of the Lower Mississippi River also say, if protection from overflow is desired, let these people build a levee system to fence off the back water from their lands. But this suggestion is immediately discarded, because it will interfere with the natural drainage of their lands, and would make it necessary to resort to drainage by pumps in times of high water. It would also interfere with the ready removal of crevasse water should a break occur on the Fifth Louisiana Front. The above exceptions taken apply to that part of the overflowed area north of Old River. There are no drainage difficulties of consequence applying to that part of the overflowed area south of Old River.

In stating their objections to being leveed in, the people north of Old River lose sight of the fact that even though Old River be closed, in order to have protection from overflow from the Red River and tributaries, they will still need levees, though admittedly of lesser height and section. Likewise, the people on the lower Atchafalaya will still need levees, even though Old River be closed.

Those in favor of the separation of the River Systems argue that the fears of much increase in flood levels are unfounded, and quote engineers to that effect. They also lay stress on the statement that on account of the shorter distance from Red River Landing to the Gulf by way of the Atchafalaya, there is a possibility of the Mississippi changing its course to the sea, in which event New Orleans' future as a port would vanish. The above constitutes the salient points of this question.

In the discussion on the subject of the closure of Old River, it has been repeatedly stated that the Board of State Engineers was in favor of the proposition. This is only partly true. The Board of State Engineers has declared itself in favor of

the proposition, but always with the saving clause—that it be carried out only after provision was made to satisfy any new condition imposed by the separation. As a member of the Board of State Engineers, the writer subscribed to this statement in several reports of the past until observation of recent high waters and a study of the data obtained by the Mississippi River Commission, and published in their reports on the subject in recent years, convinced him that even this conditional endorsement should be withdrawn for the reason that some of the statements previously made by the advocates of the separation, and which statements were accepted unquestionably, because of the high authority from which they came, were not in accordance with the facts. Some of the theories advanced, and likewise accepted as authoritative, were not borne out by the actual performance of the river. Consequently there was engendered by these contradictions a feeling of distrust, and the more the subject was studied, the more convincing became the conclusion that the effect of the proposed closure on the lower river, insofar as additional flood levels were concerned, was greatly underestimated by those advocating the measure. As a matter of fact that most vital phase of this whole question was always referred to, in indefinite terms, as for example “the flood height at New Orleans will not be affected appreciably,” or, “the increase in flood heights on the Mississippi River below Red River Landing will be very slight.”

In 1914 there was published by the Mississippi River Commission the much-desired report on the Separation of the Red and Atchafalya Rivers from the Mississippi River.

As copies are difficult to obtain, and as great interest has been revived in the subject, it may be well to give the gist of this report, and of the report subsequently made. For this reason the extended abstracts following are justifiable:

“By Act of June 25, 1910, the Commission was directed to determine the necessity, urgency and practicability of permanently separating the two river systems. In this report the Commission stated that the observation of the 1913 flood afforded an opportunity of determining the height of the confined Mississippi River floods in the latitude of Red River

Landing that had not previously existed, and the Commission estimated the height of the flood of 1912, the levees holding, and the mouth of Old River open, at 54.5 on the Red River Landing gauge; that is, one (1) foot and three (3) tenths above the maximum 1912 reading at that point. It was estimated that with the two river systems separated, this height would have been increased four (4) feet, but the Commission added such increase would not be permanent.

The concluding paragraph of this report is as follows:

"In conclusion, the Commission reports that the project is practicable, but not urgent; that it is necessary to insure the reclamation of the Louisiana Delta; that it will reduce the expense of developing lands for agriculture in the interior of the basis, but by adding to the burden of those localities which are situated on the main river."

This report, addressed to the Chief of Engineers, U. S. Army, was, as is customary, referred by him to "The Board of Engineers for Rivers and Harbors," which is a reviewing body that must pass on every new project of importance, and in passing on this matter, the Board had this to say:

"This problem concerns mainly the citizens of the State of Louisiana. The proposed work would result in gains or benefits to those living or having property in the Atchafalaya Basin, due to a lowering of flood heights and a corresponding reduction in the cost of levees and development of lands, but, on the other hand, it would entail losses and disadvantages to those living or having property along the Mississippi River, because of increased flood heights and a corresponding increase in the cost of protecting lands that are already highly developed.

"While the Board concurs in general with the views of the Mississippi River Commission, it believes that the cost of the project discussed would be greater than estimated, on account of the probable necessity for revetment work to protect the banks when subjected to the action of the higher floods, and that the period in which the confined floods of the Mississippi would, if ever, cause a compensating increase in cross-section through erosion would extend over so many years as to have no practical bearing on the present problem. The Board must

differ with the Commission in its conclusion that the project is necessary for the reclamation of the Louisiana Delta. It would simplify and lessen the cost of such development, but those lands can be protected and developed without the separation of the river systems, although at greater cost, and, therefore, it cannot be held necessary. The Board concurs in the conclusion that the project is practicable, and also that it is not urgent."

I still quote from their report:

"The Board is required by law to express its opinion as to the advisability of the United States undertaking any improvement upon which it reports. In this case, it believes that the interests threatened by the proposed work, including the City of New Orleans, are of greater importance than those to be benefitted thereby, and it therefore reports that, in its opinion, it is not advisable for the United States to undertake a project for the permanent separation of the waters of the Red and Atchafalaya Rivers from those of the Mississippi at the present time."

The above report of the Board of Engineers was concurred in by the Chief Engineers, and it was thought the matter was ended. But the people in the Atchafalaya Basin were not content with the situation, and they were encouraged to think that a bill could be passed in Congress that would place the Levee Districts on the Atchafalaya River on the same footing as the Levee Districts on the Mississippi. They succeeded in having incorporated in the Rivers and Harbors Act of 1916, a provision for a survey and report to be made by the Mississippi River Commission on the improvement of the Atchafalaya, in accordance with the general plan of said Commission for the improvement of the Mississippi River. This survey ordered in July, 1916, had been just about completed when the subject of the separation of the rivers was brought up for a second time by a provision of the Flood Control Act, passed March 1, 1917, which called for "a survey of the Atchafalaya Outlet so far as may be necessary to determine the cost of protecting its basin from the flood waters of the Mississippi River, either by its divorcement from the Mississippi River, or by other means."

The second report submitted by the Commission, July, 1919, although comprising only thirty-four pages, contains very much more information and data than its previous report, and is a creditable and valuable document on the subject of the separation.

The Commission reported that the protection desired might be accomplished by closing the Atchafalaya and allowing the Red to flow into the Mississippi, but as this would add to the flood volume of the Mississippi, not only the full discharge of the Red, but also the present outflow through the Atchafalaya, it was not recommended. The Commission also reported that the protection desired might be accomplished by building levees along the Atchafalaya, and the Red, and the Black, and finally, as another way of protecting these basins, the Red and Atchafalaya could be separated from the Mississippi. But it was pointed out that the separation of the rivers was not necessary for the protection from flood waters of the Mississippi, and that this could be accomplished under the provisions of the Flood Control Act, in accordance with plans and estimates submitted by the Mississippi River Commission.

This report was concurred in by the Board of Engineers on Rivers and Harbors, and approved by the Chief of Engineers.

It would seem that after this second adverse action by the U. S. Engineer Department, the advocates of the separation of the rivers would be content to let the subject drop. But not so. The Honorable Riley J. Wilson, Congressman of the Fifth Congressional District, has introduced "A bill for the control of the Atchafalaya, Red and Black Rivers, La., and to protect their basins from the flood waters of the Mississippi River, and for other purposes." (This Act is to authorize the Secretary of War to carry on continuously by hired labor or otherwise the plans of the Mississippi River Commission heretofore or hereafter adopted, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate \$4,000,000. That not more than one million dollars shall be expended therefor during any one fiscal year, the local interests to contribute a sum which the Mississippi River Commission shall determine to be just.)

In the furtherance of the objects of this bill, Congressman Wilson is strongly urging the separation of the rivers again, as a means to that end. In this case, as in the previous one—namely, the protection of the Atchafalaya Basin—the advocates of the closure of Old River are set on doing what is apparently the obvious thing to do—the most expedient thing to do—from their point of view, but regardless of the consequences to the lower river.

I wonder if the magnitude of the undertaking is realized by the average person advocating it. Consider a moment; it is proposed to close a flood-relief opening that has a discharge capacity of over 300,000 cubic feet per second. In April, 1912, before the coming of the return crevasse water, it was discharging out of the Mississippi River 347,000 cubic feet per second, at a stage five (5) feet below the maximum reading on the Red River Landing gauge; and this year, with a gauge reading four (4) feet below the maximum, it was discharging 315,000 cubic feet per second. (See Figs. 4, 5, 6.) To the average person these expressions convey perhaps nothing more than the impression that they are large quantities. One can better visualize their magnitude by expressing them in comparative statements. I will, therefore, take the smaller of these, the discharge through the relief opening this year, and express it as follows:

It is equal to the maximum discharge of the St. Lawrence River.

It is equal to 90% of the maximum discharge of the Rhine River, 50 miles from its mouth.

It is equal to three-fourths of the greatest measured discharge of the Nile River at Cairo, Egypt.

It is equal to one-fourth of the greatest measured discharge of the Mississippi River at New Orleans in the record flood year of 1912.

These are astonishing statements to most persons, but the most amazing part of the proposition is that people will tell you that closing this opening "will not raise the flood levels on the lower river appreciably." The explanation given is that because the Mississippi River is an alluvial stream flowing through a bed of material deposited by itself, it will enlarge

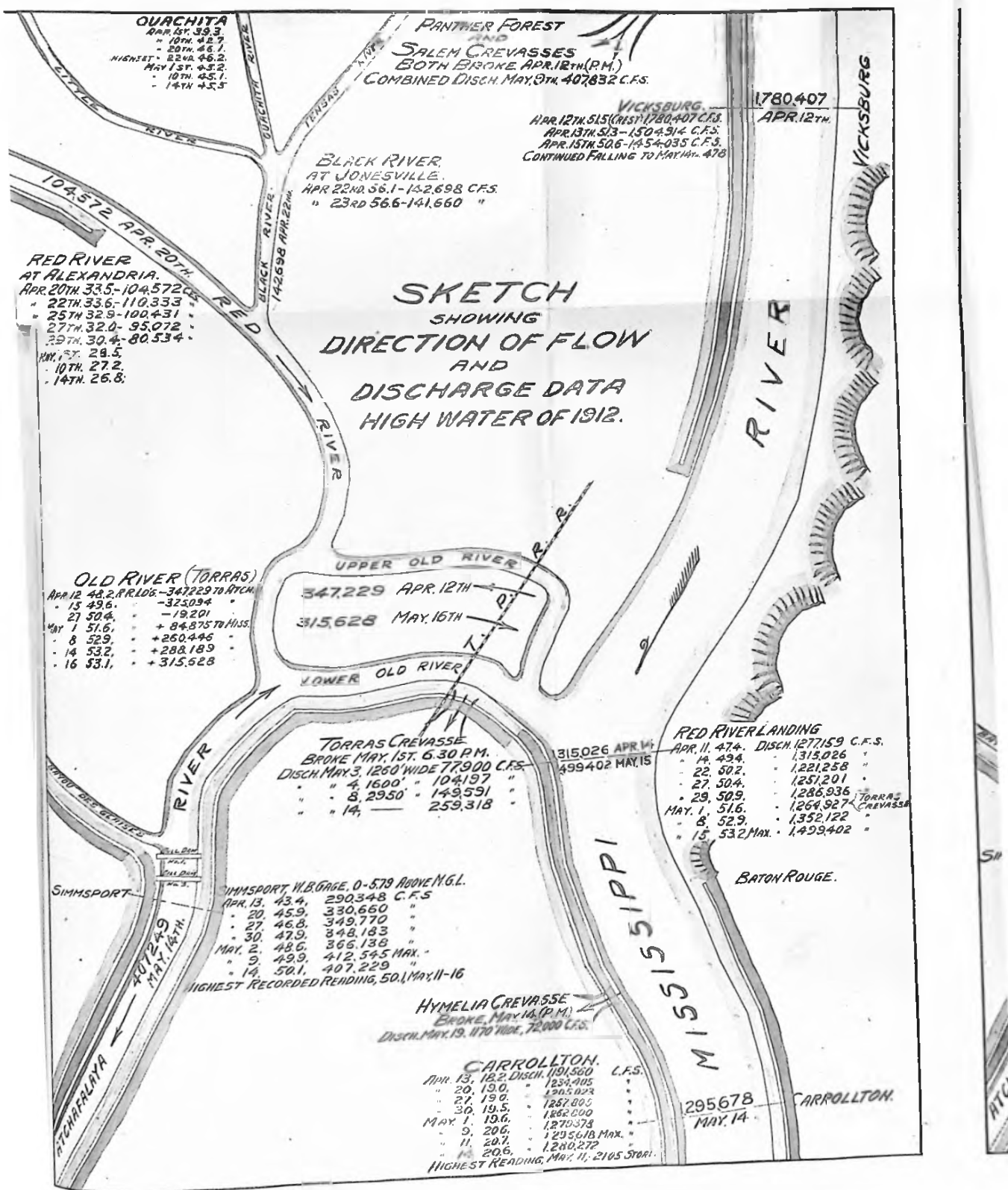
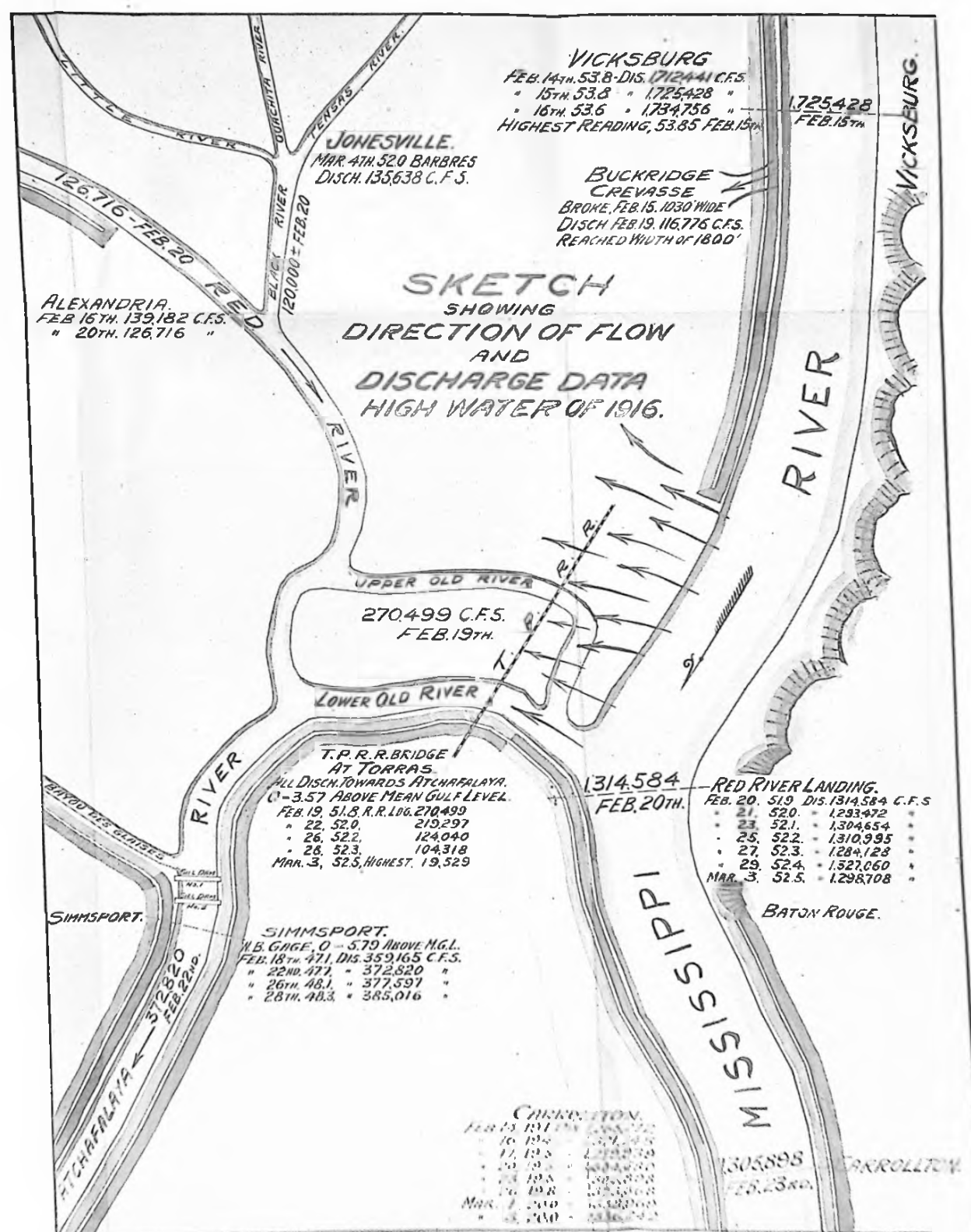


FIG. 4



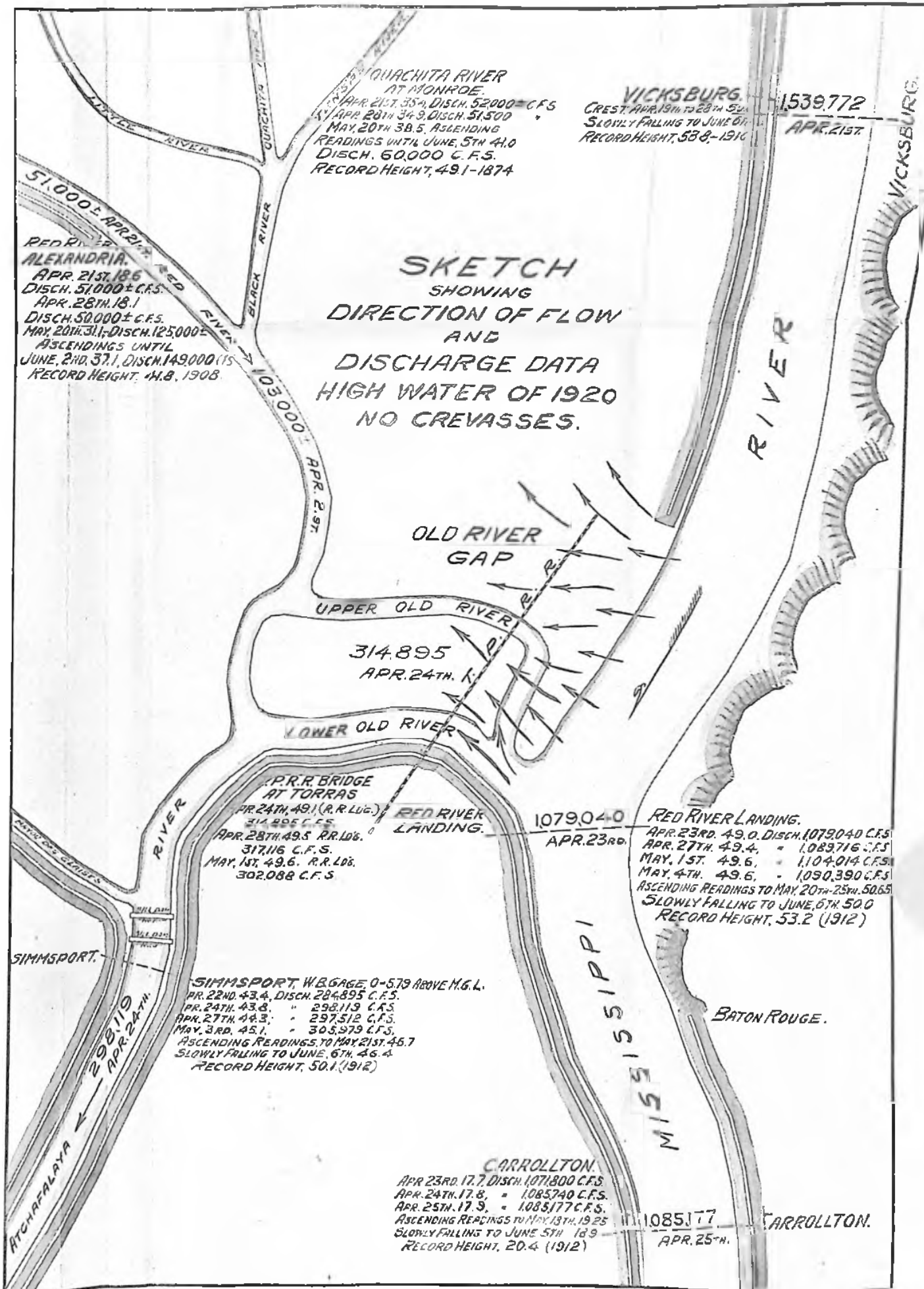


FIG. 6

its cross-section to accommodate the increased quantity of water. This is true, as a general proposition, but not universally true; and particularly not true insofar as the river in front of New Orleans is concerned. The Mississippi River at New Orleans is just effectively throttled between unyielding banks as it the Atchafalaya at the location of the sill dams. I find that with 16 feet on the gauge at Carrollton the discharge is between 1,000,000 and 1,100,000 cubic feet per second, just as it was with 16 feet on the gauge in 1898, or in 1904, or in 1912, or 1913. There has been no enlargement of its cross-section to accommodate the increased quantity of water, for if there had been, it would be reflected in greater discharge capacity for the same gauge reading, or the same discharge at a lesser gauge reading. The Mississippi River is not behaving true to theoretical form, and in a vital matter of this kind we must judge by past performances. There is too much at stake on this lower river to have it jeopardized in attempting to demonstrate a theory. Too many theories about the Mississippi River have not stood the test of actual performance. Not many years ago we were led to believe that we need not be unduly alarmed about the probability of any great increase in flood heights if Old River were closed. The reason given was that the escape of Mississippi River water through crevasses in the Fifth Louisiana Levee District, and returning to the Mississippi River at or near Red River Landing, had the effect of giving unduly high readings on the Red River Landing gauge, much higher readings than the same water would have given if it had remained in the river. It was explained in a plausible way. One of the most distinguished members of the Mississippi River Commission advanced the theory that the return crevasse water entering the river was like the placing of some obstruction in the path of the river. Not a solid obstruction to be sure, but what might be considered a liquid obstruction, that had to be surmounted by the water coming from above, and in climbing over this obstruction, or in the work of directing or starting this liquid obstruction on its way to the Gulf, there resulted higher gauge readings than otherwise would have been the case, not only at Red River Landing, but at stations below. They were called "abnormal"

gauge readings. There never was an opportunity of ascertaining to what degree these gauge readings were abnormally high, because in every high-water year we had the same condition—namely, crevasse water re-entering the Mississippi River at the lower end of the Fifth District Basin. But in 1916 we had a high water which, although not free of crevasses, gave us a good opportunity to see what this abnormality of gauge heights amounted to. A crevasse occurred at Buckridge; it was not much of a crevasse, however, and the discharge did not get to the lower end of this basin until after the crest of the flood had passed Red River Landing. Consequently, there was no liquid obstruction that might be held responsible for the highest reading on the Red River Landing gauge that year, and the surprising fact was that it was only seventy-five hundredths of a foot less than the so-called “abnormally high reading of 1912.” Thus expired another theory.

Some one has said “figures are recorded facts; diagrams are the graphical representation of facts.” I have some diagrams here which I wish to submit as evidence in the case and in contradiction to these various theories which have been so often cited to the effect that the increase in flood heights will be “inappreciable.” The burden of proof that there will be little or no increase in flood levels should rest with those who propose to turn this additional volume into the lower river, but I have not seen one statement expressed in quantitative terms showing upon what data this oft-expressed opinion is based.

Chart No. 2 is a gauge discharge relation at Carrollton, showing the various discharge measurements taken at Carrollton since 1889, and the stages at which these discharges were passed. The solid connected line is the 1912 curve; the dotted connected line is the 1916 curves. These two curves are the highest and the next highest floods of record at Carrollton, and their trace on the diagram should be indicative of what we might expect of future high waters. A zone such as is included between the dot and dash lines can be taken as representing the range in gauge heights for passing the same discharge. I assume that it is agreed that if Old River be closed, provision must be made for passing 300,000 cubic feet per

second more water at Carrollton than in the past. By reference to this diagram, which illustrates the past performances of the Mississippi River at this station, you will see that one cannot safely count on passing this increased discharge at a lesser reading than 25.2 on the Carrollton gauge, or 4.2 above the highest water of record. It will perhaps be stated that in projecting, or rather extending a discharge curve the tendency is for it to assume a convex shape with the higher gauge readings, but I submit that the observed results have not shown any such tendency for that part of the curve from 15 feet to 21 feet on the gauge.

In the lower right corner of Chart No. 2 are the plotted discharges of the Atchafalaya River at Simesport, from 1897 to 1920. It will be noted how constant these discharges have been for the same gauge readings for the last 23 years. Certainly nothing is going on there to justify the attempt to stampede the people of New Orleans to clamor for the separation, lest the Mississippi take the Atchafalaya route to the Gulf. For thirty years the sill dams placed by the U. S. Government to prevent the enlargement of the head of the Atchafalaya have successfully performed the service for which they were designed, and have done this with only two sill dams instead of with three, as originally contemplated.

Chart No. 3 is a plat giving the relation between Red River Landing gauge readings and the gauge readings at lower points on the river. The highest annual readings for the past twenty years at the respective places are plotted as ordinates against the Red River Landing gauge reading for the same year as abscissae. There is also given the height at the various stations that corresponds to the Mississippi River Commission's estimated height of 58.5 at Red River Landing, and which gives for Carrollton a reading of 24.0, or 3 feet above the highest waters. At Donaldsonville it is 39.3, or 4.2 feet above the highest of record; at Baton Rouge it is 48.5, or 4.7 feet above the highest of record. The effect of such increases in flood levels cannot be lightly considered. They represent one and one-half times the increase in flood heights that has taken place since 1897.

To cope with such flood heights will necessitate not only the completion of the levees in the districts affected to the existing grades and section, which is estimated to take 20,000,000 cubic yards of earthwork, but, in addition, will take between 40 million and 50 million cubic yards of earthwork to be built to the still higher grade required. The task is monumental; the cost staggering. The expenditures that would be required for the re-arrangement of terminal facilities, docks, wharves, at New Orleans alone, will run into millions, to say nothing of the extra high-water hazard to which the whole lower valley would be subjected to. No act of man should be permitted that will raise flood levels in this highly-developed section as much as one foot. I cannot understand how any one with a knowledge of the comparative values that are involved, unless he be governed by selfish motives, can approve the idea of separation.

River engineers in the past may have looked with favor on the project, through a mistaken idea as to how much additional water would have to be taken care of on the lower river, which was a difficult matter to determine, until recently, on account of the complication of return crevasse water; or how they have given too much weight to the so-called "abnormal gauge readings" theory; or they may have had a too hopeful belief in the theory that alluvial streams when confined will scour out their channels, overlooking the element of time in so doing. But now we have additional light before us; additional data, which contract some of the accepted assumptions, and under such conditions consistency of opinion is not a jewel.

Will it not surprise many of you to learn that in spite of that immense sand-bar in the Mississippi River at Red River Landing, to which reference is so often made, that the high-water cross-section of the Mississippi River at that point is far in excess of what it is at Carrollton? At the extreme stage of the 1912 high water the cross-sectional water area of the river at Red River Landing exceeded that at Carrollton by 65,000 square feet, or 35%; and, likewise, that in 1913, the excess area was 34%, and in 1916 the excess area was 36%; and in 1920 the excess area was 42%. And yet intelligent

people, some of them engineers, who do not know these facts, will tell you that one of the desirable objects to be accomplished by closing Old River, will be the washing out of this bar. For what purpose? Low water navigation may be improved thereby, but insofar as high-water conditions are concerned, there is nothing to be gained by increasing the already discrepant relations in sectional high-water area between Red River Landing and Carrollton.

It may be that those levee engineers who are favoring the separation of the streams are discounting the estimated increases in flood heights. If so, they should show their data; their deductions to support of their opinions. Or it may be that they are favoring this project because of their well-known antipathy to outlets, and cannot countenance this sole remaining breach in an otherwise continuous levee line from Arkansas to the Gulf. Permit me to say that I am a "levee man," as the term is understood. I believe in levees; but I believe in levees up to their limitations; and I believe we have reached the practical economical limitations of height and section to which any levee system should be built. I do not believe it is good business judgment to spend a Levee District's resources for a quarter of a century in building a levee system to a safe grade, and then, by one fell swoop, relegate that district twenty-five years insofar as levee protection against future floods is concerned. I do not believe it is a good engineering judgment to build and enlarge levees along banks that are now stable or slowly receding, and then, by one fell swoop, increase the flood discharge in the river 25% or 30% and accelerate the loss of half your levees by caving banks after having completed them to this new extra height.

I still retain my views as to the correctness of the theory of confinement of an alluvial stream to one channel, but I tolerate the Atchafalaya Outlet, because circumstances dictate that it must be tolerated. Millions have been spent, and are yet to be spent, at the mouth of the Mississippi River in the application of the theory of confinement, and yet Cubits Gap and Pass a L'Outre are tolerated. Few laws are without exceptions. A patient may be suffering from an incurable sore, on his own leg, and the doctor may be positive that the correct

medical procedure is to cut the leg off. But the patient has a weak heart and is unable to undergo a major operation. Is there any doubt but that the sore will be tolerated both by the patient and the doctor? So is it with this separation question; this outlet, this flood relief opening, must be tolerated because the greater interests, the greater values of the highly developed section of the lower river should not be subjected to an increased hazard of overflow to benefit a comparatively undeveloped section.

Gentlemen, Old River must remain open—the pipe at this end is too small.

Discussion.

COLONEL LEWIS: I do not know whether to call it fortunate or unfortunate that your President has called upon me to express my views on the able paper of Mr. John Klorer on The Divorcement of the Atchafalaya and the Mississippi Rivers. It is merely by accident that I am here this evening, as it had been my intention to leave for Arkansas City, where I have been engaged since 1917 as Resident Engineer for the Southeast Arkansas Levee District. As my departure, however, had to be postponed, I have taken advantage of the opportunity to hear Mr. Klorer.

I can give you in a somewhat sketchy manner some of my experiences and recollections and some of the traditions of this section of the Mississippi River.

In the year 1831 the Shreve Cut Off took place, giving rise to what is known as Turnbull Island. Previous to this time Red River and the drainage waters of the Tensas Basin discharged directly into the Mississippi River near what is now known as Upper Old River, north of Turnbull Island. About two and one-half miles below this, Bayou Atchafalaya, as it was then called, served during periods of high water as a small outlet to the waters of the Mississippi River. At low stages of the river this small bayou served as a drainage outlet for the upper end of the Atchafalaya Basin. This outlet was more or less silted up, filled with debris and timber rafts and was a very dangerous stream to navigate. In December, 1879, I had the uncomfortable experience of being wrecked some

twenty miles below Simsport, when the steamer C. H. Durfee struck a snag extending out from one of these old rafts.

Gradually through the diversions of the waters of the Red River into Old River and down the Atchafalaya, the upper Old River filled up with silt and became unnavigable in periods of low water, and later on was entirely abandoned for purposes of navigation.

The lower Old River also became silted up, and during the low water season of 1877, the State Board of Engineers of Louisiana made an endeavor to keep open a stretch of this river, to which the river pilots gave the name of the "Gut." I was detailed to superintend the work of cleaning out this gut. Two screw-propeller tugs lashed side by side plied up and down the stream stirring up the silt, but there was not sufficient current to carry off the silt and the experiment was a failure. Fortunately, water on the river rose and the six stranded stern-wheel packets were removed from a very unpleasant situation.

In 1879, by act of Congress, the Mississippi River Commission was created, and this problem of keeping open a navigable low-water channel was turned over to it. The Commission attempted to solve this problem by a section of jetties intended to divert the discharge of the Red River through the upper Old River, at the same time dredging both the upper Old River and the Gut through the lower Old River. Later on, low-water sills were placed in the Atchafalaya near Simsport for the purpose of lessening the discharge of that stream, as it was thought possible that the Mississippi River might take this route to the Gulf of Mexico. Meanwhile, the Atchafalaya Levee District has improved and extended its lines of levees some two miles below Bayou Alabama on the west bank of the Atchafalaya River. The Red River, Atchafalaya and Bayou Boeuf Levee District has done likewise with its levee lines fifteen miles below Melville, on the east bank of the river.

In periods of high water at the end of these levees the flood levels are higher than ever before, and lands are now inundated that in former years entirely escaped. About thirty miles below the levee the Atchafalaya River spreads out into numberless bayous and small lakes to the mouth of the Teche,

and then widens out and deepens its bed in the front of Morgan City and on to the Gulf. Red River discharges practically all of its water through the Atchafalaya. Upper Old River is filled with silt and the bar at the end of Turnbull Island has formed an obstruction at the mouth of the lower Old River. This bar is kept dredged through for the passage of the transfer boat of the Louisiana Railway and Navigation Company carrying passengers across the Mississippi River from Angola to its terminal on Red River.

The effect of the further divorcement of the Atchafalaya and Mississippi upon flood levels and below Red River can only be determined after the river has been subjected to perfect control. What nature has failed to do and what remains for man to do in order to fit the Mississippi River to his needs and uses may be summed up in one word—control. Controlled by means of protective banks is sufficient only so long as the river is within its banks. When it rises above their level the control becomes partially and necessarily inadequate. In years of heavy floods the surface of the water stands above the natural bank level for about two months at Cairo, and for about six months at New Orleans. Without artificial restraint nearly one-third of the entire discharge of the river at times of extreme floods takes place outside of its proper channel. It has been demonstrated that the fundamental principle upon which improvement is to be secured is the control of the water in the channel. To allow large quantities, sometimes as much as one-third of the whole, to escape, does violence to the very idea of the principle of control. The flow of water through the channel is the dominating factor of control, and when any of the water escapes a part of the potentiality of the system of control goes with it. The current is to be guided so as to do the desired work and to secure the greatest possible improvement in the channel, it is necessary that the greatest obtainable volume of water be made to flow through the same. That this condition is not realized if a large volume is escaping over the sides is self-evident. The necessary control of the current beyond that produced by the natural banks reinforced by protective works is effected by artificial embankments of sufficient heights to withstand the highest floods.

While the levees above and below the north of Old River have been very much improved, they are not yet up to the Mississippi River Commission section and grade, and not until they are completed should any drastic measures be taken to assist nature in this divorcement. Meantime, nature is simply doing its work and the low-water channel is improving. When the divorcement takes place the regimen of the river will have accommodated itself to its gradual discharge. While flood heights may attain higher levels for some miles above and below lower Old River, I do not believe that this will appreciably affect the gauge readings to the effect as figured out by the author of this paper, these readings being based upon gauge readings and calculations of the discharge of the river at this uncontrolled section.

COLONEL DENT (submitted): The proposed separation of the Atchafalaya River from the Mississippi River involves a material increase in the ~~good discharge of the latter below Red River Landing~~. Mr. Klorer gives this increase at about 25 per cent. It is generally recognized that this increase in discharge will result in an enlargement of the cross-section.

The increase in the discharge would be accompanied at first by an increase in flood heights requiring an increase in levee heights. There would also be an increase in velocity resulting in scour and an enlargement of the cross-section. The form of the new cross-section is as important as its area.

During certain stages the Mississippi River deposits suspended matter in its bed and on its battures. During other stages, it scours material from its bed and battures. In the course of time a bed is formed, such that the area and form of cross-section are accurately adjusted to the sediment in suspension and the velocity of the currents. When this has been accomplished, the bed becomes stable and prior to the construction of levees the bed of the Mississippi River from Baton Rouge to near the mouth, was relatively stable in cross-section and form.

The relation between velocity, slope, and form of bed is roughly expressed by the formula:

$$V = C \sqrt{RS}$$

in which

V = the mean velocity.

C = a variable found by Kutter's formula.

R = the mean hydraulic radius or in the case of a river approximately the mean depth.

S = the slope or the fall between two points divided by the distance.

For stability V can not be changed. A reduction in V will result in deposits and an increase in V will result in scour. Similarly, C is constant in a stabilized stream. To maintain stability, R and S must therefore vary inversely with each other. An increase in R must be accompanied by a corresponding decrease in S and vice versa.

The construction of levees has raised the level of the flood plane at Red River Landing and has slightly increased the slope from that point to the mouth of the river. The total fall from Red River Landing to the Gulf was about 56 feet in 1916. The distance to the Gulf is 307 miles. According to the formula, the past increase in slope should have been accompanied by a decrease in mean depth and any further increase in slope should be accompanied by a further decrease in mean depth.

Fig. 7 has been prepared to illustrate the popular idea of the result of an increase in volume of discharge and the more



FIG. 7. Let the solid line represent the cross-section of an alluvial river in its natural state. If the discharge be increased the cross-section will be increased and it is generally assumed that the increase will be as indicated by the dotted line. The fact is, however, that the change will ordinarily result in a decrease in mean depth with corresponding increase in width as indicated by the broken line.

scientific statement of the case. Confinement of the overflow water has already resulted in an increase in slope and the divorce of the Atchafalaya River from the Mississippi will result in a further increase in slope. The confinement of the overflow has already raised the level of the surface during floods and unless there has been a corresponding elevation of the bottom, there has been an increase in R.

If both S. and R. have been increased, the formula shows that V has been increased. If V has been increased, the stability of the bed has been destroyed and will not be restored until R has been reduced to its value in pre-levee days. Let us briefly examine the facts that may be available in this connection.

The following table is copied from p. 13 of the recent report on the Atchafalaya River, La., and Related Basins by the Mississippi River Commission, House Document No. 288, 66th Congress, 1st session:

TABLE NO. 1.

Averages of Cross-Sectional Elements by Reaches, Vicksburg to Donaldsonville. Bends and Crossings Combined
(272.1 Miles).

REACH	Average width.		Average areas.		Average mean depth.		Average maximum depth.	
	1882-1883	1895-1896	1882-1883	1895-1896	1882-1883	1895-1896	1882-1883	1895-1896
LOW WATER	1883	1896	1883	1896	1883	1896	1883	1896
Vicksburg to Natchez.....	1,963	2,025	49,312	50,406	26.7	26.5	45.1	46.0
Natchez to Red River.....	2,127	2,295	60,800	58,757	30.4	27.6	54.5	49.3
Red River to Scot Bluffs.	2,302	2,258	85,849	80,079	40.0	37.9	74.9	67.9
Scot Bluffs to Donaldsonville	2,427	2,506	114,256	107,953	49.4	45.9	90.4	83.8
MEDIUM STAGE								
Vicksburg to Natchez.....	4,000	4,239	142,484	146,076	37.6	36.9	.....	.....
Natchez to Red River.....	2,880	3,926	148,115	146,053	40.9	39.4	.....	.....
Red River to Scot Bluffs.	3,220	3,265	157,267	151,318	51.4	48.2	.....	.....
Scot Bluffs to Donaldsonville	2,687	2,877	158,146	154,756	61.8	54.7	.....	.....
BANK-FULL STAGE								
Vicksburg to Natchez.....	4,927	5,525	206,295	216,365	44.5	42.3	.....	.....
Natchez to Red River.....	4,501	4,951	212,866	217,541	50.4	46.4	.....	.....
Red River to Scot Bluffs.	2,561	3,598	199,868	194,573	58.7	55.8	.....	.....
Scot Bluffs to Donaldsonville	2,988	3,000	187,688	186,336	64.1	63.8	.....	.....

From the above table, the following has been prepared:

TABLE NO. 2.

Changes in Certain Reaches of the Mississippi River During the
13-Year Period 1882-3 and 1895-6.

CHANGE IN AVERAGE			
LOW WATER	Width	Area	Mean Depth
Vicksburg to Natchez.....	Increase 62	Increase 1,088	Decrease 0.2
Natchez to Red River.....	Increase 168	Decrease 2,043	Decrease 2.8
Red River to Scot Bluffs.....	Decrease 44	Decrease 5,770	Decrease 2.1
Scot Bluffs to Donaldsonville.....	Increase 79	Decrease 6,303	Decrease 3.5
MEDIUM STAGE			
Vicksburg to Natchez.....	Increase 230	Increase 3,592	Decrease 0.7
Natchez to Red River.....	Increase 46	Increase 2,062	Decrease 1.5
Red River to Scot Bluffs.....	Increase 45	Decrease 5,949	Decrease 3.2
Scot Bluffs to Donaldsonville.....	Increase 190	Decrease 3,390	Decrease 7.1
BANK-FULL STAGE			
Vicksburg to Natchez.....	Increase 598	Increase 10,070	Decrease 2.2
Natchez to Red River.....	Increase 450	Increase 4,675	Decrease 4.0
Red River to Scot Bluffs.....	Increase 37	Decrease 5,295	Decrease 2.9
Scot Bluffs to Donaldsonville.....	Increase 12	Decrease 1,352	Decrease 0.3

The above tables show that during the period under consideration, there was an increase in width of all reaches at all stages except for the reach from Red River to Scot Bluffs during the low water stage.

So far as change in area of cross-section is concerned, the increases and decreases are divided 5 to 7. Here is food for speculation, which the writer prefers not to attempt to digest at this time.

So far as mean depths are concerned, there has been a decrease in this factor in all reaches at all stages.

It is well known that the flood discharge of the Mississippi River, from Vicksburg to Red River, is greater than below that point. Table No. 1 shows that the mean depth is considerably less. The slope in 1916 was:

Vicksburg to Red River.....0.265 per mile.

Baton Rouge to New Orleans.....0.183 per mile.

The depth from Baton Rouge to New Orleans is sufficient for the largest ocean going ships, while the depth between Vicksburg and Red River is barely sufficient for shallow draft river steamers. Do not these facts indicate the correctness of the above theory in regard to the relation between slope, velocity, and depth?

It may be argued that diminished depth is the cause of increased slopes, and not the result of high velocity. The writer supervised the dredging of channels through certain bars and reaches in the Arkansas River in 1916. Where the slope was

excessive, it was found that an increase in R was promptly followed by a destructive velocity. The increased velocity started scour in the bed and the natural forces, instead of deepening the artificial channel and further increasing the velocities, worked in the opposite direction. Shortly after making one of these artificial cuts, the original depths were restored by nature.

An extended discussion of this subject is found in a paper "The Regulation of Rivers at Low Water," by H. Giraudon, VI International Congress of Navigation. (This paper is in the Howard Memorial Library). Mr. Giraudon concludes as a result of experience on the Rhone River, that there is a relation between depth and velocity that cannot be disturbed.

Illustrations may be multiplied indefinitely, but in general, it will be found that steep slopes and shallow depths go together, and that where the slope is steep, nature will restore the shallow depth if man attempts to disturb the natural relation.

The ultimate result of the divorce of the Mississippi River from the Atchafalaya River would probably involve a material widening of the Mississippi below Red River Landing, which would necessitate the reconstruction of the levees along new lines, as well as increasing their height. Bank protection to prevent the widening, is out of the question on account of its cost.

A. M. SHAW (submitted)—It appears as though the question of control of flood waters at the mouth of the Red River is gradually becoming, (if it has not already become), a matter of sectional controversy. By most of our best students of economic questions, it is agreed that our State, and the South in general, should diversify in more than one line of activities. For a number of years there has been a growing tendency toward diversification of crops and where this has been intelligently practiced, the results show the wisdom of the change. Within recent weeks, there has been an evidence of a hitherto unheard of condition in Louisiana, a diversification in politics. Many hold to the opinion that this also will rebound to the credit and benefit of the State.

While this shifting, whether it be the result of scientific study or the following of a momentary whim, will doubtless prove beneficial in matters agricultural and political, we must not be vacillating in our policies in dealing with the one greatest

engineering problem with which the State is confronted—the control of the flood waters of our rivers; and especially of the Mississippi River.

In the matter of the control of the Mississippi River, many plans have been advocated from time to time including the reservoir system, the multiple outlet plan, etc., but so far, control by levees seems to have been adhered to quite consistently by those in authority and while there have been occasional disasters, no plan has been proposed which, in the opinion of those charged with the control of the river, appears preferable to the levee plan. There has been a co-ordination of efforts of the Federal, State and Levee District authorities in the construction and maintenance of river levees, but there is still the one question about which those most interested do not appear to agree; the course to be followed in handling the flood waters of the Mississippi, the Red and other rivers at the mouth of the Red River.

My personal interests would tend to influence my opinion toward the closure of Red River rather than otherwise. In spite of all this I believe that such a closure *should not be considered for the present nor for any time in the near future*. To state my reasons for this belief would be to repeat the most excellent matter that has already been placed before you by Mr. Klorer, of the Board of State Engineers. Until it can be shown that the property values now suffering from back water overflow outweigh those which would be adversely affected or placed in extreme hazard by the proposal closure, *the opening at Old River should remain with substantially its present capacity, for the removal of flood water from the Mississippi River*. This statement is made with a full realization of the deplorable conditions that exist after every high water in the districts affected and after hearing many of the excellent arguments in favor of the closure of Old River. It is a case of choosing the lesser of two evils. It is true that the people of the Lower River have sat supinely by and watched the closure of Bayou Lafourche, Bayou Plaquemines, the St. Francis Basin in Arkansas, all of which formerly gave a certain measure of relief to high water conditions, but some of these projects were beyond our control and, accepting what appears to be the best information available,

not one of them assumed the importance of the present Atchafalaya.

Some maintain that the proposed closure would not have any material effect on the high water stage of the river, yet we have heard, on what appears to be excellent authority, that under maximum flood conditions, one-fourth of the water of the Mississippi River passes out through the Old River gap.

It will not require any hair splitting hydraulic formula to convince one living on the lower river that an addition of 33% to the extreme flood flow is not to be desired. There are many here present whose knowledge of the river is much more thorough and extends over a longer period than mine, but I can not refrain from recounting some of my own experience. I have either participated in, or been a close and interested spectator of several important river "fights," all of them fortunately resulting in success. The one that impressed me the most however, was a fight put up by one of the "grand old men" of the Lower Coast. Coupled with high water, the wind was blowing a gale directly up a long reach of the river. The waves, assisted by drifting logs, had battered down the timber revetment and were cutting into the levee section at a rapid rate. The plantation owner was there with only his ordinary labor forces, but he never lost his nerve and just as the river had cut through the front face and crown of the levee and the back slope had started to cave, a temporary timber revetment, with sack reinforcement, was completed and the day was saved. What would have been this planter's feelings if, at the critical moment, he had been told that "a 33% additional amount of water is being turned into the river just above you, but it won't affect you much?" Personally, I would hate to be the one to tell him, especially if he were to think that I had anything to do with putting that extra water into the river. Yet that is almost an exact parallel to the general situation at the present moment. Extensions of drainage systems in the upper valley, closure of overflow basins and of minor auxiliary outlets, clearing and cultivation of tributary farm lands, all have contributed to the general changing—always upward—of the high water mark. By strenuous effort and at tremendous cost, the levee system has *almost*—rarely quite—been able to keep ahead

of this increase. We are just reaching the point where we can say of a few sections of levee, "If the banks don't start cutting under, and if the river doesn't beat the 1912 mark, and if several other unknowable factors are in our favor, *that* levee is 100% safe." But of how much of the system can even this be said? Certainly not enough to justify a 33% increase in the amount of water to that which we now have. It may be that at some time in the far future, resources of the State in property, people and in engineering knowledge will be such as to justify this closure after sufficiently increasing the height and section of the levees, but in none of these items have we yet approached a point which would justify any such a radical step.

What, then, is to be done?

Any fair-minded person familiar with conditions will concede the following:

1. There are thousands of acres of timber and bottom lands in the Atchafalaya Basin now subject to overflow, the reclamation of which would be greatly simplified if all the waters of the Mississippi River were confined within the two levees.
2. There is another class of flooded lands, of smaller total area, but still of consequence. This includes plantations and small farms, the cultivation of which is precarious on account of back-water overflow. The amount of such land and also the extent of damage, is increasing with every increase in high water. This latter class includes at least the rear portions of many river front plantations.
3. Land drainage in the upper valley, closure of other outlets and the practical completion of the Mississippi levee system have combined to increase the flood conditions at Old River. Lands not previously flooded are now subject to overflow, and other lands, which were occasionally under water, are now covered more frequently, to greater depths and for longer periods.

While it is not conceded that the combined interests of the lands above specified are sufficient to justify any act which would place in jeopardy the infinitely greater interests of the lower valley, their need for relief is real, it is urgent and *it must be met*. Not only as a matter of justice but as a practical business proposition, the residents of the lower valley in general

and of New Orleans in particular, cannot afford to do other than to take an interest in the overflow conditions in the Atchafalaya and its tributary basins.

It is not proposed to suggest in detail how this relief might be given. The best method can be determined only after a careful and a most comprehensive study has been made of the entire situation by the best engineering talent that can be procured. A discussion of the relative merits of the several apparently possible plans would be of little value until we have at hand a much more complete knowledge of conditions. The cost of this survey, and especially of the regulating works to follow, should be borne by the parish, State and Federal governments, with emphasis on the "Federal." Here, again, must be confessed a shift in personal opinion. As shown by Mr. Klorer, the Special Board of Engineers of the Army Engineer Corps, in reviewing the report of the Mississippi River Commission, has gone on record as opposing any participation in this problem by the Federal government, on the grounds that it is a purely local or sectional problem. If it is purely local, the position is sound from the standpoint of political economy. But is this the case?

The reclamation of the Inlet Swamp in northern Illinois was purely local as regards the benefits derived, and the cost, amounting to an aggregate of over fifty dollars per acre, was properly borne by the owners of this 40,000 acre basin. The closure of Bayous Lafourche and Plaquemines were of local benefit, and, if I am not mistaken, the cost was carried by a tax on the lands benefitted. The control of the Yazoo and the St. Francis Basins was also local as to benefits, but these, and numberless similar works affecting the run off of the valley, have been local as regards the *benefits derived* only. Resulting damages frequently, if not usually, are found farther down the valley.

We cannot say that the entire nation has contributed to the present lack of drainage in the lower delta, but such a statement would be mighty close to the truth. Admitting that financial aid should not be furnished by the National Government to add to the value of private investments, it is maintained that private investment should be protected against loss resulting from acts of the country at large, such as those above enumerated, the

accumulative effect of which is to increase the flood heights of the river.

A number of years ago a poem by Douglas Malloch was printed in the *American Lumberman*, which stated this situation so aptly that it was cut out and pasted in my river scrap-book. As poetry it is not much, but as logic it is good. It reads as follows:

TO WHOM DOES THE RIVER BELONG ?

The river belongs to the Nation,
The levee, they say, to the State;
The Government runs navigation,
The Commonwealth, though, pays the freight.
Now here is the problem that's heavy,
Please which is the right or the wrong?
When the water runs over the levee,
To whom does the river belong?

It's the Government's river in summer
When the stage of the water is low,
But in spring, when it gets on the hummer
And starts o'er the levee to flow,
When the river gets suddenly dippy,
The State must dig down in its till
And push back the old Mississippi
Away from the farm and mill.

I know very little of lawing,
I've made little study of courts,
I've done little geeing and hawing
Through verdicts, opinions, reports;
Why need there be anything more said
When the river starts levees to climb?
If the Government owns the aforesaid,
It must own it all of the time.

If the bull you are leading should bellow
And jump over somebody's fence,
There isn't a doubt you're the fellow

Expected to bear the expense.
If it follows a Sunday school teacher
And chases the maid up a tree,
You're the owner the same of the creature,
Undoubtedly all will agree.

If some time should somebody's chickens
Get into your garden and dig
And pull up the plants like the dickens,
Or somebody's bull pup or pig
The owner thereof cannot blame it
On you or some party remote,
The owner thereof can't disclaim it,
The chicken, the pup or the shoat.

It it's your Mississippi in dry time,
It's yours, Uncle Sam, when it's wet,
If it's your Mississippi in fly time,
In flood time it's your river yet,
There's no other way you can make it,
And so when I give the alarm,
Come get your darned river and take it
Away from my timber and farm.

—*Douglas Malloch, in American Lumberman.*

MINUTES OF MEETINGS AND BUSINESS OF THE SOCIETY.

Regular Meeting of the Board of Direction, October 11, 1920.

The meeting was called to order with President Riess in the chair and Messrs. Barelli, Lawes, Manley, Moses, Williamson, and Robert present.

Ballots for new members were opened, there being 73 ballots cast, and as a result the following were elected to the respective grades of membership in the Society:

Resident Members—George R. Hammett, H. G. Martin, Lester C. Smith.

Transfer from Student to Resident—John A. O'Brien.

Non-Resident Member—Harry D. Scott.

Student Member—John Reginald Dykers.

A letter was read from the Engineering Council inviting us to send a delegate to their meeting on October 21st. No action was taken.

A letter from the Association of Commerce asking us to appoint two members to co-operate with them in their attempt to solve the local garbage problem, was read, and it was decided to refer the letter to the Society.

The following members were dropped as of January 1, 1920: Messrs. Robert Faget, Wendell Armour, C. S. Zimmer.

The matter of referring the letters of Mr. E. H. Coleman concerning military records on application blanks was laid over because of Mr. Coleman's absence.

A letter from the Association of Commerce with reference to a discussion of the divorcement of the Atchafalya and Red Rivers from the Mississippi was read and ordered referred to the Society, with the recommendation that it be made a title for discussion at the next meeting.

The term of Professor Derickson as member of the State Board of Engineering Examiners having expired in September, 1920, it was decided to recommend that the Governor reappoint Prof. Derickson, but that if this is not satisfactory to the Governor we shall be glad to offer further nominations for his consideration.

Prof. Williamson called our attention to the fact that the American Chemical Society will meet in this city on December 6th, and upon motion, it was decided that the attention be directed toward the fact that the American Chemical Society will meet here on that date and that the Society authorize the Board of Direction to take such steps as are necessary to co-operate to make this convention a success.

There being no further business, the meeting adjourned.

JAMES M. ROBERT, Secretary.

REGULAR MEETING OF THE SOCIETY, OCTOBER 11, 1920.

Meeting was called to order with President Riess in the chair and 47 members and guests present.

Letter from the Association of Commerce was read and it was the sense of the meeting that a special meeting be set for a discussion of divorcement of the Atchafalaya and Red Rivers from the Mississippi.

The attention of the Society was called to the fact that the American Association of Chemical Engineers will hold a meeting here the week of December 6th. Upon motion, duly seconded, the Board was authorized to co-operate with the local members of the Chemical Engineers in any way necessary to make the convention a success.

Upon motion, duly seconded, the President was authorized to appoint two members to co-operate with the Association of Commerce in their endeavor to solve the local garbage problem.

The technical exercises of the evening were then held and Mr. George E. Earl, of the Sewerage and Water Board, gave a most interesting talk on "Present Status of the Sewerage, Water and Drainage System of New Orleans." Upon motion, duly seconded, a rising vote of thanks was tendered Mr. Earl. The discussion following Mr. Earl's paper was very interesting and brought out the fact that if something is not done immediately the city will find itself in a bad way with reference to the water situation.

Upon motion, duly seconded, the President was authorized to appoint a committee of three to look into the question, and, with Mr. Earl as advisor, this committee is to study the whole problem and recommend action to the Society.

There being no further business the Society was adjourned to the usual collation.

JAMES M. ROBERT, Secretary.

Regular Meeting of the Board of Direction, November 8, 1920.

The meeting was called to order with Vice-President Manley in the chair and the following present: Messrs. Williamson, Lawes, Barelli and Robert. Messrs. Olsen, Moses and Riess came in later.

A letter from the Association of Commerce relative to an invitation to the Society of Naval Architects and Marine Engineers to meet here in convention next year was read, and upon motion, duly seconded, the Secretary was directed to wire this Society inviting them to meet in New Orleans next year.

Upon motion, duly seconded, the following resignations were accepted to become effective December 31, 1920: Messrs. George E. Durr, J. F. Fonville and R. C. Wilson.

The report of the Secretary was read and bills ordered paid.

Upon motion, duly seconded, it was decided to appropriate, if necessary, \$50 toward the meeting of the Society of the American Chemical Engineers to be held in New Orleans during December, 1920.

There being no further business, the meeting was adjourned.

JAMES M. ROBERT, Secretary.

Regular Meeting of the Society, November 8, 1920.

The meeting was called to order with President Riess in the chair and 71 members and guests present. The minutes of the previous meeting were read and approved.

A report of the Committee appointed to look into affiliation with the Federated American Engineering Societies was read and the following motion was duly seconded and carried:

That the Louisiana Engineering Society become a charter member of the Federated American Engineering Societies and that a delegate be sent to Washington to the organization meeting.

A progress report of the Committee on Garbage Disposal was made by Mr. Shaw. At this moment the crowd in the library became so great that the meeting was adjourned to the large room downstairs.

The technical exercises of the evening were then held and Mr. John Klorer read a very carefully prepared and interesting paper on "The Proposed Separation of the Red and Atchafalaya Rivers from the Mississippi, and Its Effect on Flood Heights." After quite a few remarks and considerable discussion, the following resolution was offered by Mr. Dusenbury:

Owing to the complexity of the problem involved, and the very extensive financial and agricultural interests that may be adversely affected, we view with much alarm any steps which may be taken looking towards the divorcement of the Red and Mississippi Rivers, but recommend that a thorough study by State and Federal Engineers be made of the Red, Black and Atchafalaya Rivers with the idea of protecting the territory against these streams from flood waters originating in this water shed, as well as high water caused by Mississippi floods.

After quite considerable discussion the resolution was tabled.

Mr. Ole K. Olsen, Chairman of the Membership Committee, made a few remarks relative to a membership drive.

There being no further business, the meeting was adjourned to the usual collation.

JAMES M. ROBERT, Secretary.