

# THE FLORIDA EAST COAST EXTENSION.

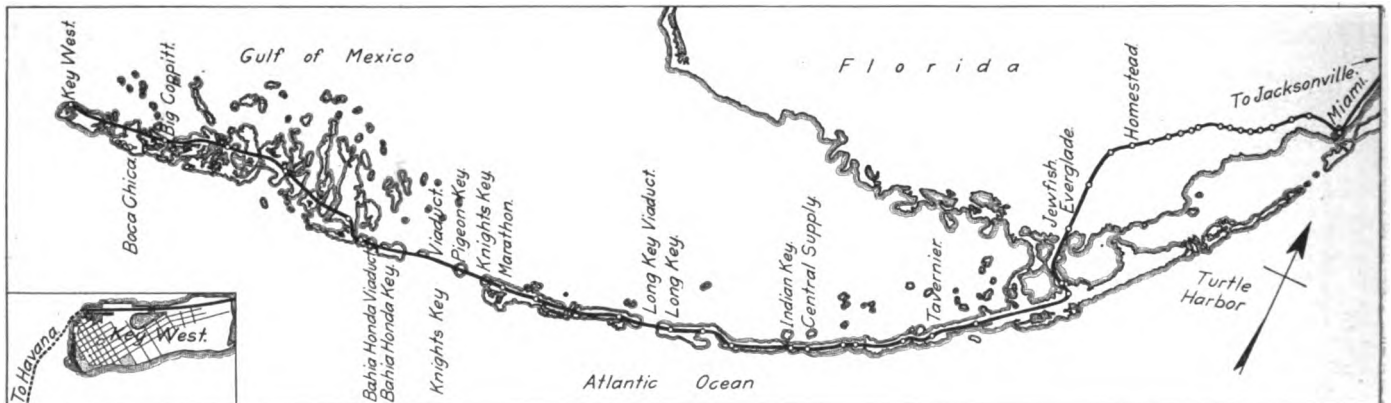
History of the Key West Project; Details of the Novel and Difficult Construction; Operating Prospects.

BY FRANK M. PATTERSON.

With the inauguration of traffic over the entire Florida East Coast Railway's Key West extension, on January 22 of the present year, came the realization of plans long nurtured by H. M. Flagler. Beginning his railway acquisitions in a modest way Mr. Flagler purchased in 1885 a small decrepit road extending from Jacksonville, Fla., to St. Augustine to improve the service to the latter place whither he had gone in 1883 for rest and recreation. He found St. Augustine a sleepy southern town with a delightful winter climate and became interested in its possibilities as a winter resort, as well as in the possibilities of the entire east coast, both as a winter play-ground, and as a fruit and vegetable growing section. To properly develop the country he purchased two additional railways south of St. Augustine giving him access to Palatka on the St. John's river and to Daytona on the coast, consolidated them with his original purchase

about 100 miles from Homestead. The route lay wholly in the Everglades and was rejected after a thorough investigation. The next survey was made to Turtle Harbor, but this plan was abandoned also, and it was decided in 1904 to build to Key West, a distance of 128 miles of which about 22 miles was on the mainland and the remainder across the string of keys or small islands that fringe the coast and extend beyond the mainland to deep water at Key West. Construction was started in 1905.

As far as Knight's Key the islands are admirably situated for the location of the railway, affording good alinement and necessitating comparatively little bridging, the longest stretch of water being at the lower end of Long Key where a concrete viaduct two miles in length was built. Immediately below Knight's Key is a stretch of water seven miles wide ranging in depth from 18 to 22 ft. A few miles further on Bahia Honda is encountered,



Key West Extension of the Florida East Coast Railway.

and pushed them southward until in 1896 the Florida East Coast Railway entered Miami, situated on Biscayne bay, 366 miles south of Jacksonville. Biscayne bay has practically all of the attributes of a first class harbor except water, the natural depth being only about 12 to 14 ft. Here construction stopped; steamer lines were established to Nassau, Key West and Havana, Cuba, and it seemed that Miami would remain the southern terminus.

However, the growing importance of our trade with Cuba, after the Spanish war and the certainty of the construction of the Panama canal led to the determination to extend the railway to some point where satisfactory harbor facilities could be obtained. The railway had been extended to Homestead, 28 miles south of Miami, in 1904, and from the latter point surveys were made to Cape Sable, the most southerly point on the mainland,

where a bridge 5,100 ft. long is required, in water whose greatest depth is 30 ft. The three structures just referred to, together with a concrete arch bridge, 2,573 ft. long at Boca Chica, a few miles north of Key West, were the principal bridges as originally planned, although later it was found necessary to provide additional arch structures to which reference will be made later.

Owing to the comparatively favorable conditions above Knight's Key and the large amount of bridging below that point it was determined to establish a temporary dock at Knight's Key. Traffic was opened to this point in February, 1908, and steamer connections made to Key West and Havana, displacing the service previously maintained between Miami and the latter points.

The construction on the extension resolved itself into three



Quarter Boat for Housing Men.



Temporary Dock and Approach at Knight's Key.

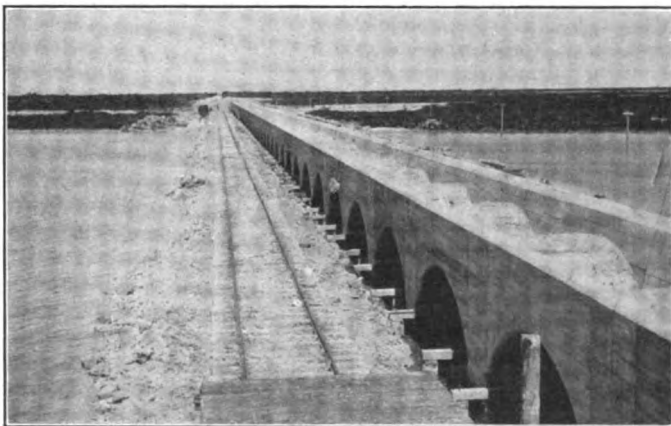
methods: grading across the Everglades and other submerged sections, grading across the keys and bridge work. On account of the conditions under which the construction had to be done and the desirability of having all labor under the undivided authority of the railway none of the work was let by contract, the company assembling equipment and perfecting an organization under the direct supervision of the constructing engineer.

From the nature of the work practically all of the outfit used on the original construction was floating equipment and this included a number of Mississippi river steamboats of the stern-wheel type, which proved most efficient for the transportation of material and supplies in the shallower waters, owing to their light draft. All material and supplies, including water for domestic and boiler use, had to be brought from the mainland.

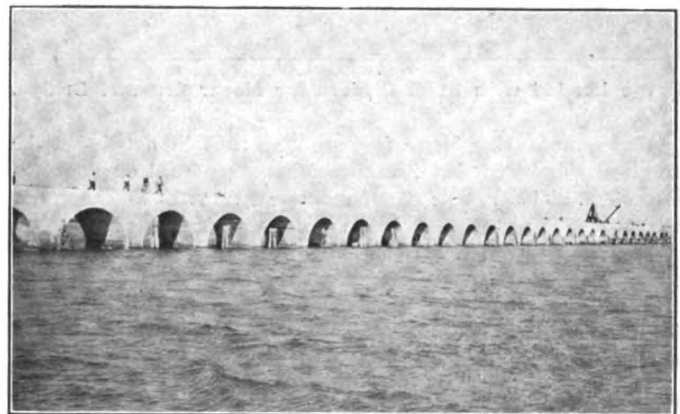
high to be built economically by hand labor the excavators were taken from their scows and placed on the embankment, moving forward on rollers as they completed the work ahead of them.

BRIDGE CONSTRUCTION.

Five permanent bridges were put in between the mainland and Knight's Key: a drawbridge at Jewfish Creek, single steel spans at Tavernier Creek, Snake Creek and Wilson's Key and the concrete arch bridge at Long Key. The drawbridge is deck girder swing span, 99 ft., 6 in. long and is operated by hand. The center used is somewhat unusual, being rimbearing with drum between flanges of main girders. In addition to these structures, several pile trestles were put in where the water was comparatively shallow, to be replaced later by concrete arches.



Temporary Trestle Alongside Permanent Line.



Boca Chica Arch Viaduct.

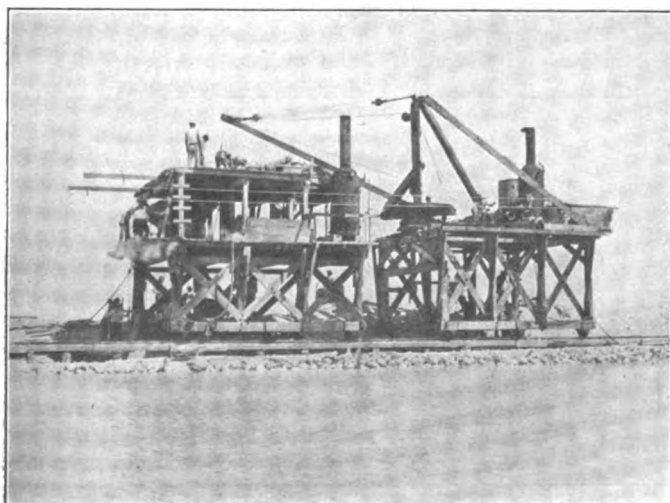
Material for concrete was shipped by steamer from northern points, trap rock being brought from the Hudson river, sand from Baltimore and American Portland cement from New York. German Portland cement was used in all concrete below high tide, being delivered by tramp steamers at the nearest available harbor.

From Homestead to Jewfish Creek, where the line leaves the mainland and crosses to Key Largo, the location lies entirely in the Everglades and the grading was done by means of floating excavators using a boom and orange peel bucket to excavate material from the sides and deposit it in the embankment. When open water was reached the dredges were towed to other places where their services might be needed.

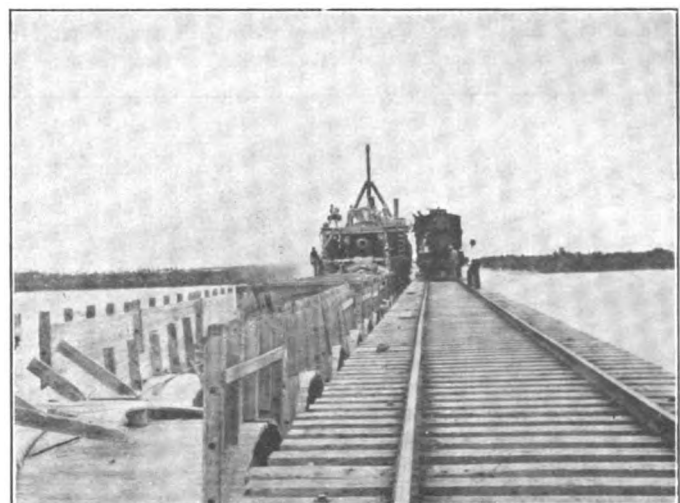
On the keys proper most of the grading was done by hand labor. The material is coralline rock with little or no overburden of dirt. This rock is light and easily worked and the quantities per mile averaged small. Where the embankments were too

The Long Key viaduct is the longest structure of the arch type on the line and is a notable piece of work, consisting of 180 semi-circular arches of 50 ft. span, the track being at an elevation of 30 ft. above high tide. The method of construction used here has been followed on all similar work and a description of it will serve for all.

The location of piers having been established the sand was removed from the rock bottom by dredging and a cofferdam floated into place and sunk. Piles were then driven into the rock to refusal, the average penetration being 12 to 14 ft. The purpose of the piling was three fold: first, to afford foundation should any erosion of the rock occur; second, to act as an anchor against any tendency to overturning or lateral displacement; and third, to act as an exploratory probe. It happened several times that cavities in the rock were encountered that had been missed by the sounding outfits. After the piles were driven a footing course of concrete from 3 to 5 ft. in depth was deposited by



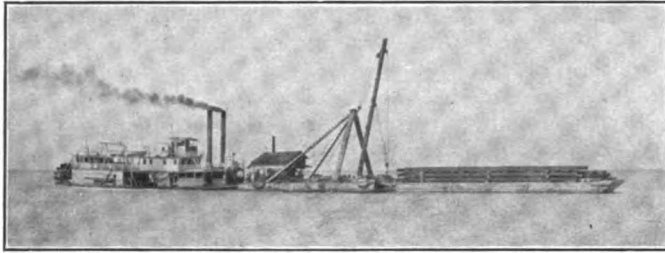
Side View of Traveling Concrete Mixer Outfit.



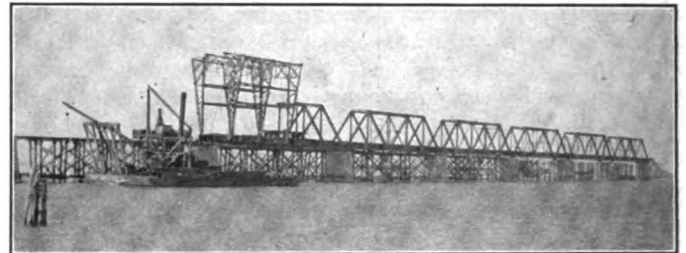
Building Concrete Arches with a Traveling Mixer.

tremie and allowed to set, forming a seal. The cofferdam was then unwatered, the piling cut off to a point well below low tide and forms erected for the piers. After the piers were completed to the springing line false work for the arch forms was driven and the forms put in place. To avoid expansion cracks the arches were put in alternately, the concreting being done by mixers and derricks on scows. A plan of these arches is shown

lying material and that it was necessary to punch holes through this crust before the piles could be driven. For this purpose a steel rod or bar was used, fitted with a driving head and cushion and was hung alongside the leads where it could be swung into place readily. This served admirably as a punch, but difficulty was found in withdrawing it on account of the side friction, which was obviated by fastening a collar 2 in. thick by 6 in. long



**Barge Loaded with Steel Girders for Moser Channel Bridge.**

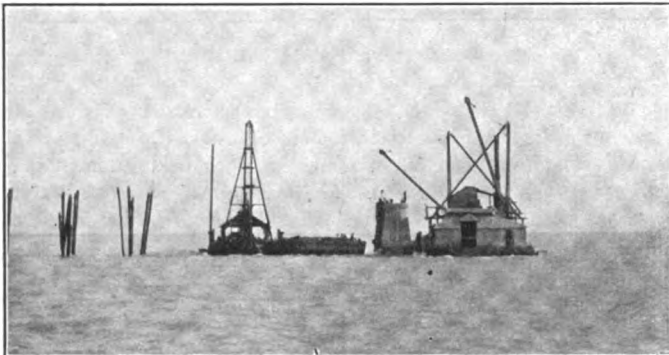


**Erection of Bahia Honda Bridge.**

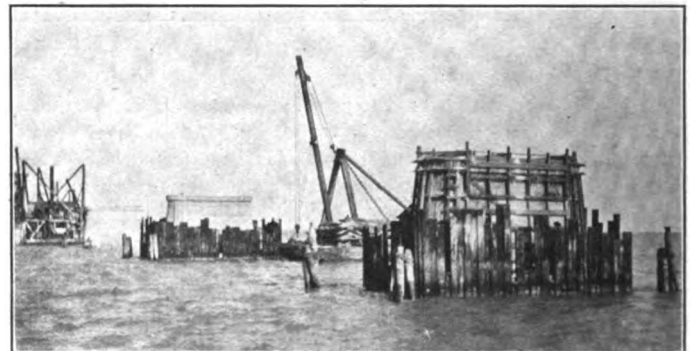
in the accompanying figure from which it will be noted that the arch is so designed that little dependence is placed on the reinforcement. This is true of all concrete structures on the entire line, as it was not thought wise to take any chances of corrosion of the reinforcement from the salt water, and weight was desired to withstand the action of the waves.

Below Knight's Key the rock changes from coralline to a highly fossiliferous sedimentary limestone, and it was found possible to use it for concrete, thereby effecting a saving in the cost of

around the lower end of the bar. This arrangement worked well with the floating drivers, but with the track drivers a further modification was necessary, as the force needed to withdraw the punch was enough to threaten overturning of the driver on any but a direct pull in line with the center of the track. A way out of the difficulty was found by using 2 in. x 2 in. bar iron bent to the form of a ring with a diameter slightly larger than the punch. This ring was then slipped over the lower end of the punch and fastened only enough so that it



**Driving Piles with Floating Driver.**



**Completed Piers, Bahia Honda Bridge.**

concrete of from \$3 to \$5 per cu. yd. The rock is blasted in shallow water and loaded by orange peel dredges. When blasted it breaks up into small sized pieces with enough fine stuff so that it can ordinarily be used as it comes from the dredge without the addition of sand, or any sorting other than the removal of occasional large chunks.

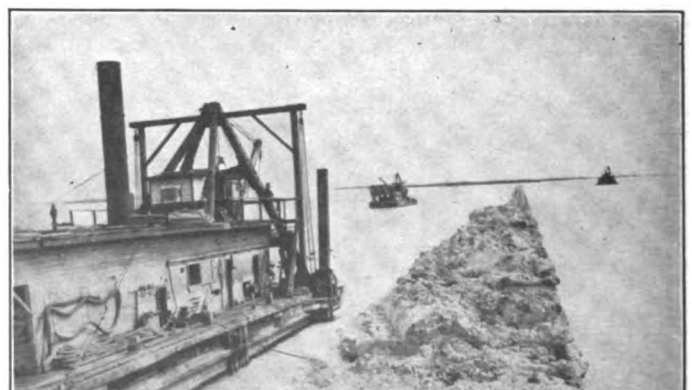
In driving piles through this limestone it was found that the top for a distance of from 3 to 5 ft. was harder than the under-

would not drop off until the punch was driven. The use of the punch and loose ring has shown a saving of about 50 per cent. over the cost of pile shoes besides being more efficient.

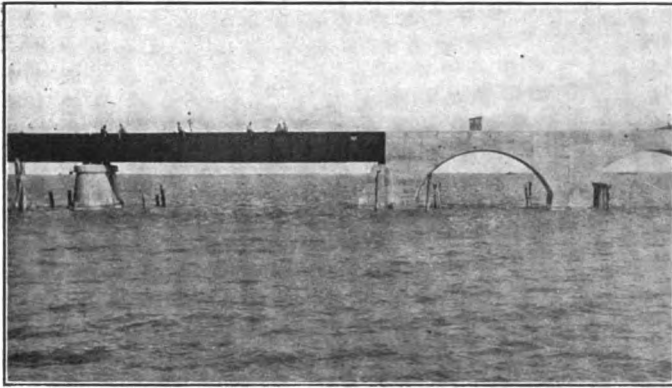
On account of the depth of water at Knight's Key the use of deck girders was decided on, and for the same reason through truss spans were used at Bahia Honda, the depths of water being as previously noted 18 to 22 ft. and 20 to 30 ft. respectively. The methods of pier construction were as previously described,



**Gasolene Excavator Removing Washed Out Embankment, Preparatory to Building Concrete Arches.**



**Clamshell Dredge Loading Marl on a Trestle; Florida East Coast Extension.**



Connection of Girder and Arch Structures, Knight's Key—  
Moser Channel Viaduct.

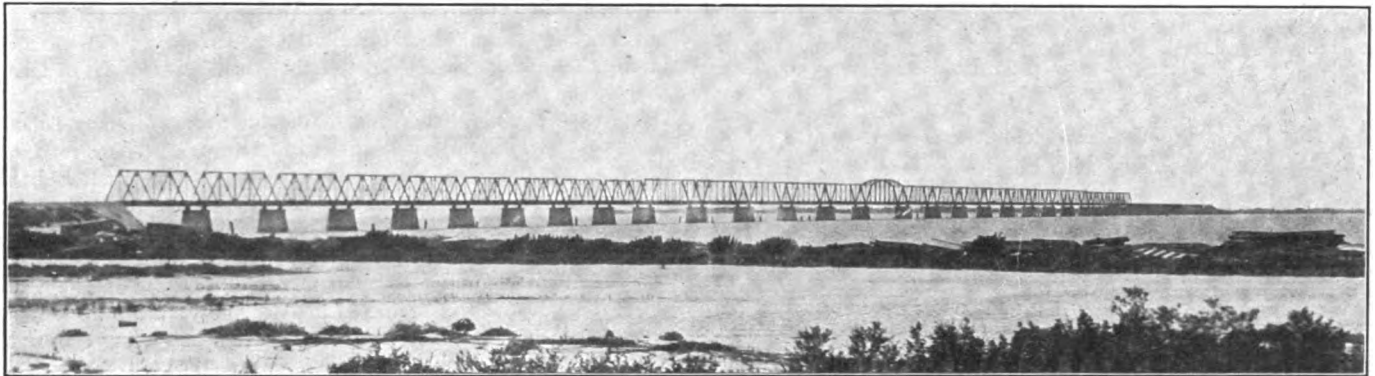
except that Friestedt and United States steel interlocking sheet piling was used for cofferdams at the Bahia Honda bridge. The sheet piles were driven several feet into the rock and the sealing course deposited over the entire area of the cofferdam. Little difficulty was met in pulling the piles, one or two blows of a pile driver being enough to loosen them from the concrete.

Knight's Key bridge consists of 316 80-ft. and 19 59-ft. 9 in. deck girders with 210 arches of 35 ft. span at the southerly end where shallower water is found, and a 253 ft. 6 in. through truss

it even has been necessary to paint the track rails with a coating prepared by the Cunningham formula, consisting of one part kerosene, four parts Portland cement and 16 parts refined coal tar, the cement and kerosene being first mixed and then stirred into the heated tar. The concrete arch bridge at Boca Chica, four miles north of Key West, is the last important bridge on the extension, having 83 arches of 25 ft. span.

At Key West all of the land needed for terminals was made by pumping material by hydraulic dredge, as no land was available on the island. The plans for the terminals are not fully decided upon, but work has been begun on a concrete pier 1,700 ft. long by 134 ft. wide, with a 24 ft. depth of water alongside. One of the accompanying drawings shows the traveller and concrete plant at work on this pier, and a part of the wooden pier now in use. It is also the intention to put in car ferry slips and to transport freight cars to and from Havana, 105 miles distant, to avoid breaking bulk on shipments between points in Cuba and points in this country. A small draw span was put in at Key West to afford access to the basin for small craft. The plans of this bridge reproduced herewith show the design which is somewhat unusual, being adopted to allow the use of some material on hand.

The effect of sea water on the concrete has been closely watched, both in the actual structures and on test cubes exposed for observation, and so far there is no reason to believe that any serious deterioration will take place. Shortly after being exposed to the water it is found that a scaling off occurs to a depth



Bahia Honda Bridge, Only Truss Bridge on Extension.

draw span over Moser channel operated by a gasoline engine.

The erection of the girders at Knight's Key was begun by contract, but was taken over by the railway after a comparatively small part had been erected, and the remainder was completed by the construction department. The erection was begun by derrick car, but after the company's forces assumed charge the work was done by means of floating derricks and much faster progress was made, at one time six spans being set in place in four hours, and at another one span being erected in 20 minutes.

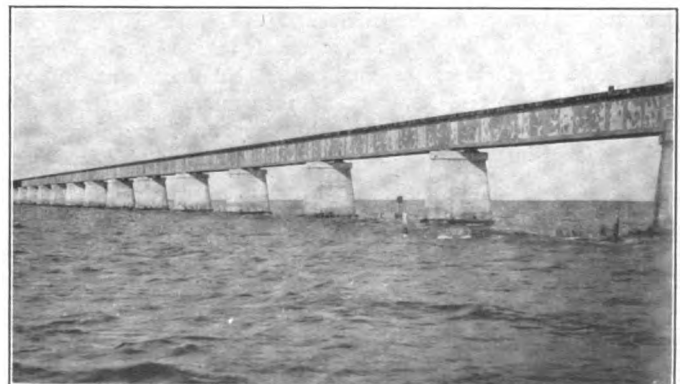
Bahia Honda bridge consists of 13 spans of 128 ft. 6 in., 13 spans of 186 ft., 1 span of 247 ft. 6 in., and 9 plate girders of 80 ft. span. The steel work was erected by the company's forces, using false work and overhead traveler, and it is interesting to note that not a life was lost in the erection of either the Knight's Key or the Bahia Honda bridge. The decks of the steel bridges are of the ordinary type fastened with hook bolts.

The protection of the steel spans from rust is one of the hardest problems facing the railway. In the warm, moist, salty air corrosion begins in an almost incredibly short time and no paint has been obtained that can be considered wholly satisfactory. Near the constructing engineer's office at Marathon a test rack is located in which are placed test plates coated with different paints, and so far none has been found that will afford protection for two years. The railway company's standard paint has proved about as efficient as any and on account of its bright yellow color corrosion is quickly detected. The ordinary galvanized telegraph wire rusts through in two years or less, and

of about 1/16 in. on the part of the concrete between the limits of high and low tide which amounts only to about 18 in. After the scaling off has taken place a marine growth forms on the parts exposed to the water and seems to protect the concrete from further damage.

#### EFFECT OF HURRICANES.

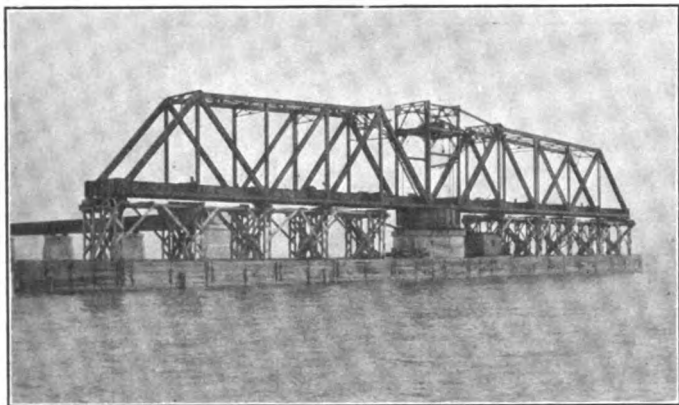
After surveys had been completed and plans made for the construction of the extension it was thought that the bridges already referred to would be all that would be necessary and



Knight's Key—Moser Channel Viaduct.



that solid embankments could be made from key to key in other places. It will be seen from the map that the keys are small and more numerous below Knight's Key than above that point, and it was found that the water between them below Bahia Honda was quite shallow, in some cases being only a few inches in depth. However, there was one factor that had not been considered and one that perhaps never had been encountered before in work of this kind. This is the impounding of the waters of the gulf by hurricanes in that pocket between the railway and the mainland known as the Bay of Florida. The hurricane of 1906, while very severe, came upon the work before those waterways had been closed, and it was not until the storms of 1909 and 1910 that their effects could be noted and studied in this connection. Under the stress of these storms continuing for several days from the south and west it was discovered that the water was banked up in the bay until it overtopped the embankments, and swept them away. It was also noted that the embankments across the water, even in the shallowest places, were the first to go, and that when they were gone the water rapidly subsided. This has led to the decision to build arches, varying from 16 to 25 ft. spans, across these stretches, the length required amounting to a total of between five and six miles. In the meantime pile trestles have been put in on a temporary location alongside the permanent line to carry traffic and also to act as construction track. In one of the accompanying photographs will be seen one of these temporary trestles with a gasoline dredge removing



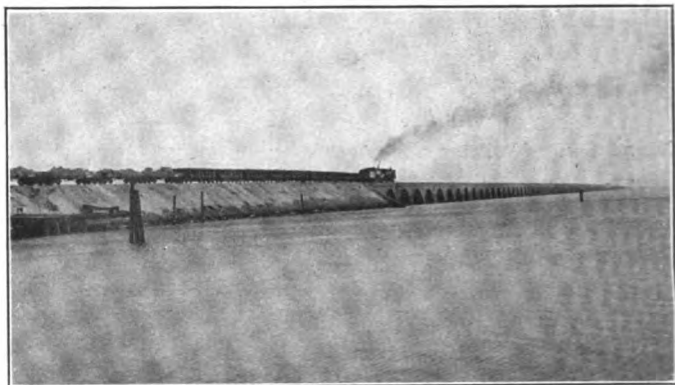
Moser Channel Drawbridge During Erection.

the remains of the old embankment; and another shows the construction of the arches. Especial attention is called to the traveling concrete outfit which is used on all the smaller arches and which has proved a highly efficient method. The embankments were made of rock and the material is loaded on cars and used for ballast or for concrete as required. It is interesting to note that while little trouble is experienced with the toredo, except at Key West where the waters are somewhat infected, the life of a timber trestle is only about three years, owing to rot.

In addition to providing more waterway it has been found necessary to protect the embankments from wave action in exposed places with some other material than riprap. Riprap from 3 to 5 ft. thick was originally used, but the suction of the receding waves carried it away and then attacked the embankments themselves. Deposits of calcareous marl are found at various places in the waters between the keys, and this is being unloaded along the banks where protection is needed. The marl is of such consistency that it takes a natural slope of about 5:1, corresponding very nearly to a beach slope and is dressed off to a smooth surface. After exposure to the air the marl hardens and affords complete protection from the waves. In one of the cuts is seen a clam shell dredge loading Goodwin cars on a trestle, while in the distance are two gasoline dredges throwing in marl to increase the deposit for the loading dredge. One of these trestles is in use at Central Supply where marl is being

loaded for use above Knight's Key, and the one shown in the illustration is at Big Coppitt about 10 miles northerly from Key West. Two other trestles for the same purpose are almost completed between Big Coppitt and Bahia Honda. North of Knight's Key the total requirements were about 3,000,000 cu. yds., of which approximately one-half has been placed. South of Knight's Key the requirements will be considerably larger.

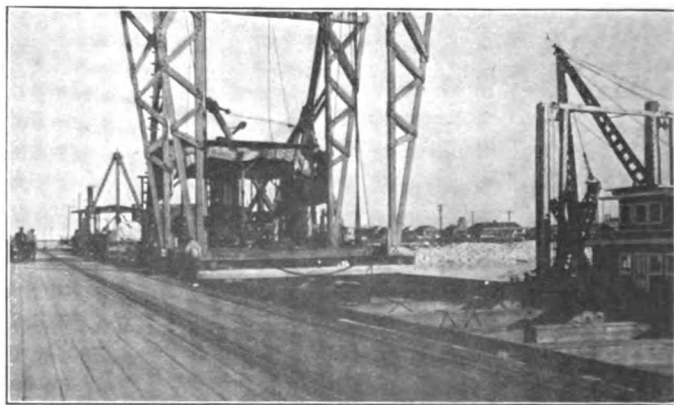
The railway is liable to face a charge of nature-faking while doing this work and if left to a jury of turkey buzzards the



South End of Long Key Viaduct.

charge would be sustained. There is a strong odor of sulphuretted hydrogen when the marl is freshly unloaded and wherever the work is in progress the banks are lined with the buzzards searching for the morsels that their sense of smell tells them should be there.

Reference having been made to the hurricanes, it may be of interest to review their connection with the work. These storms, arising in the West Indies and resembling the East Indian typhoons, may be looked for in August, September and October, but are most apt to occur in the latter month. The greatest loss of life and damage to equipment from this cause occurred in 1906, although that storm was not so severe as those of 1909 and 1910. A hurricane was predicted in 1905, the year the work was started, and strict orders were given by the constructing engineer to prepare for it. It is perhaps unfortunate that the predictions that year did not materialize into a moderately severe blow, for there were fewer men on the work then and a wholesome fear



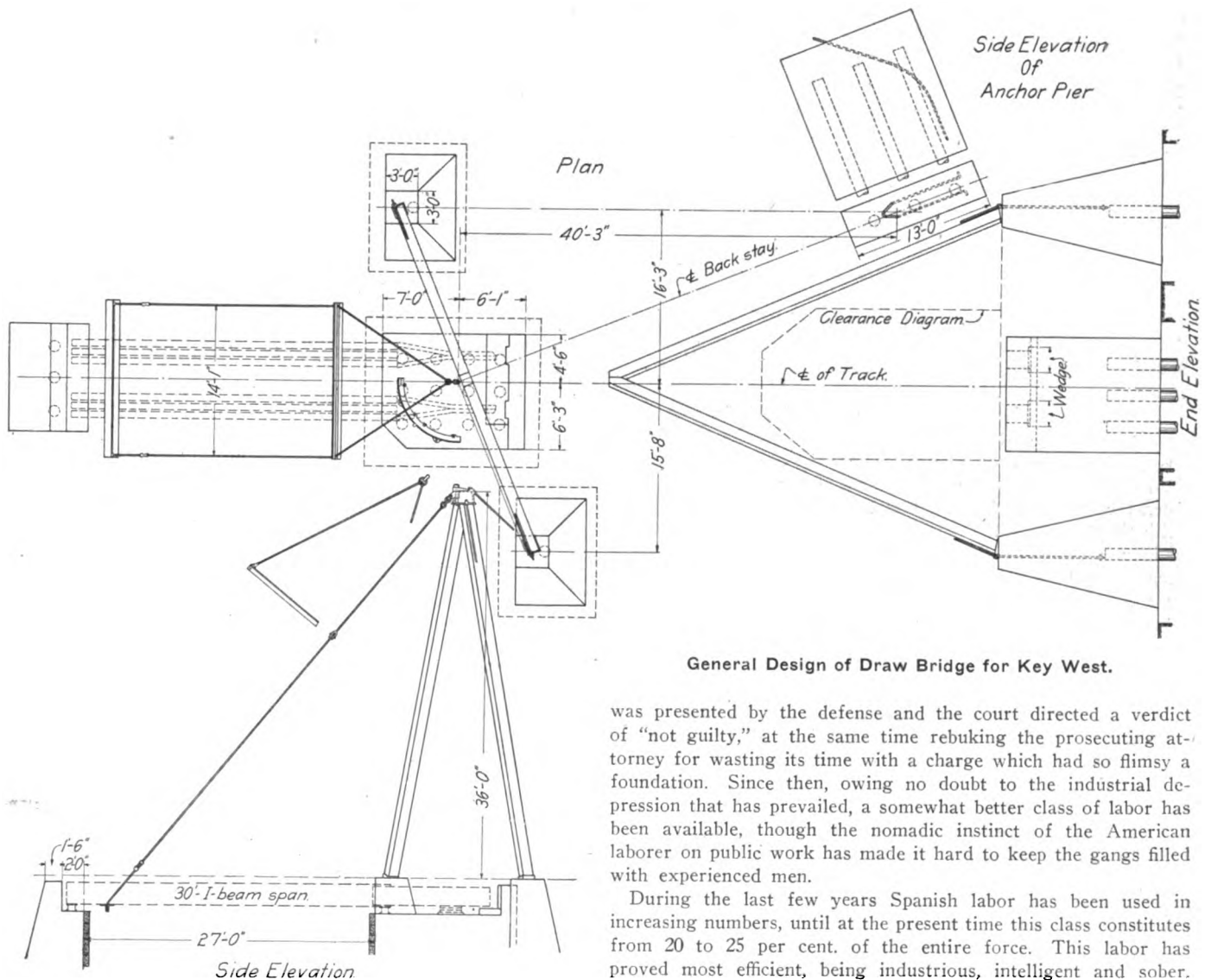
Traveler and Cement Mixer; Building the Concrete Pier at Key West; Florida East Coast.

would have been instilled in all. In 1906 when warnings were again issued they were not given much attention except where the constructing engineer and his principal assistant could see personally that they were observed. As a consequence when the storm broke it found the greater part of the men and equipment helpless, or worse than helpless, for most of the laborers were housed in quarterboats and had taken refuge in them. These boats were soon blown out to sea, over 70 men were lost and

many others were picked up by passing steamers after days of suffering. Since 1906 every precaution has been taken to protect lives and property when information of an impending hurricane is received. Each engineer's camp is provided with a barometer and the weather bureau at Washington has given valuable aid and sends warnings promptly whenever it gets reports of an approaching storm. At such times the land equipment is put in shape to stand the storm as best it may, the floating equipment is taken to sheltered places and sunk in shallow water and the men are assembled at such places as will afford the best protection. It is worthy of note that the storms of 1909 and 1910, the most severe known on the coast of Florida, caused little loss of life and equipment.

In 1909 the wind reached a velocity of 125 miles per hour and

of negroes recruited from Florida and neighboring states was considered, but the supply was found to be insufficient and inefficient on this class of work. Italian and Greek labor was tried and found wanting, and arrangements were made for securing common labor in New York through labor agencies established by the railway. In spite of the care taken to select only men fitted for the work, much trouble was experienced at first with incompetents and with those who recruited with no idea other than to secure a trip to Florida at the expense of the company. Out of this grew the peonage charges which resulted in federal indictment of the engineers in charge and their New York agent. These charges received highly sensational treatment in the press, but when, after hard fighting, the railway was able to bring the cases to trial, the result was a verdict of acquittal. No evidence



General Design of Draw Bridge for Key West.

the lowest barometric reading known in the United States was observed. While much embankment was washed away absolutely no damage was done to any of the concrete work in place. Five girders of the Knight's Key bridge were blown off the piers but this was due to the carelessness of the contractors who had failed to put in the anchor bolts as erection proceeded. Each girder is anchored to the pier with 16 bolts, four to each pedestal, and the contractors had put in only two to each girder at the time of the storm.

THE LABOR QUESTION.

The question of labor has been a serious one and was particularly troublesome in the early stages of the work. The use

was presented by the defense and the court directed a verdict of "not guilty," at the same time rebuking the prosecuting attorney for wasting its time with a charge which had so flimsy a foundation. Since then, owing no doubt to the industrial depression that has prevailed, a somewhat better class of labor has been available, though the nomadic instinct of the American laborer on public work has made it hard to keep the gangs filled with experienced men.

During the last few years Spanish labor has been used in increasing numbers, until at the present time this class constitutes from 20 to 25 per cent. of the entire force. This labor has proved most efficient, being industrious, intelligent and sober. The Spaniards are used principally as common laborers, though many have shown themselves capable of a higher class of work, and have been used as firemen, calkers and stationary engineers.

With the skilled labor little trouble has been experienced, the greatest difficulty having been to secure all around machinists capable of performing the diversified duties necessary on work using such a varied assortment of equipment and situated so remote from industrial centers. The machine shops are located at Boot Key Harbor but a short distance from Marathon where all the repairs to plant and equipment are made.

The men are furnished board and lodging by the railway and care is taken to see that they are comfortably housed and well fed. Sanitation is carefully looked after and hospitals are maintained at Miami and Key West for cases that cannot be cared

for in camp. That the care taken produces results is evidenced from the fact that the sick rate, including accidents, averages from 1 to 1½ per cent. of the force. One thing that contributes largely to the health of the men is the lack of local water supply with its likelihood of pollution.

Owing to the situation of the work comparatively little trouble has been experienced with drunkenness except in the camps easily accessible to Key West. "Bum boats" occasionally come among the keys with their contraband cargoes, but have to operate so stealthily that little trouble is caused.

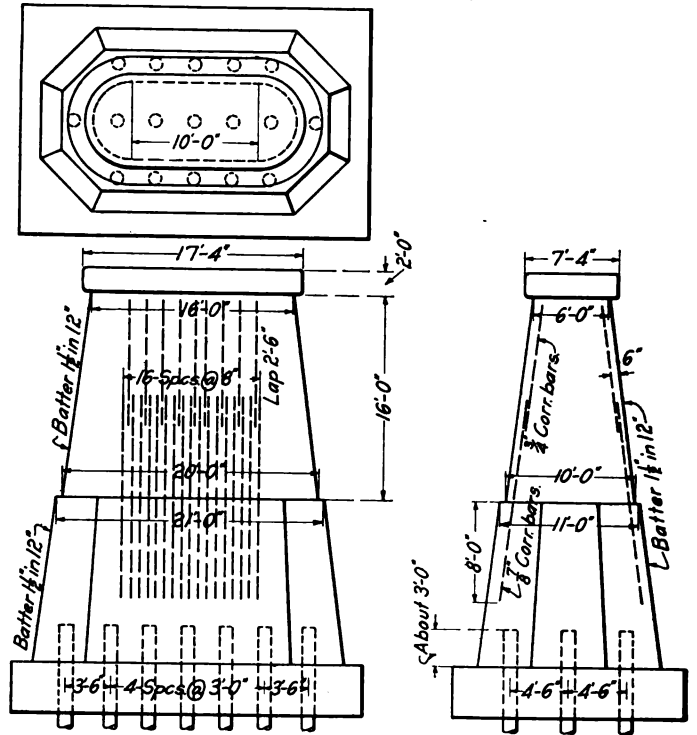
EQUIPMENT.

The equipment has been ample and well adapted for the work and comprises all that one would expect to find on construction of this character. One of the most efficient machines has been the gasoline excavator to which passing reference has been made. This device was evolved for this work and consists of a 30 h. p. Otto gasoline engine operating a boom and Hayward orange peel bucket of ¾ to 1¼ cu. yd. capacity. This has proved most economical, both in upkeep and in the saving effected in coal and water, both of which items are expensive owing to the cost of hauling and handling. Before the railway was completed to Key West the cost of water to the company at the latter place was ½ cent per gallon. The excavators are used either on land or water, being mounted on scows in such manner that they may be readily removed. Another efficient device is a steam drilling scow for putting in blast holes, the drills being driven in leads similar to a steam hammer pile driver. For driving piles from the track locomotive cranes, fitted with removable leads and Arnott steam hammers, have been used extensively, and for many classes of work are preferred to the regular track drivers.

From an operating standpoint the extension is in surprisingly good physical condition when one stops to consider that in February, 1911, orders were given to have the line ready for traffic into Key West in January, 1912, instead of a year later, as had been the intention. The track is laid with 70 lb. rail, well tied, with tie plates on all curves. The grade is practically level at a minimum elevation of about 10 ft. above sea level except at Long Key, Knight's Key and Bahia Honda bridges where it is at a 30 ft. elevation. At present the approach grades at these places are one per cent., but this will be reduced to 0.3 per cent. On the bridges referred to speed is restricted to 15 miles per hour, to minimize the danger of derailment. In addition to this

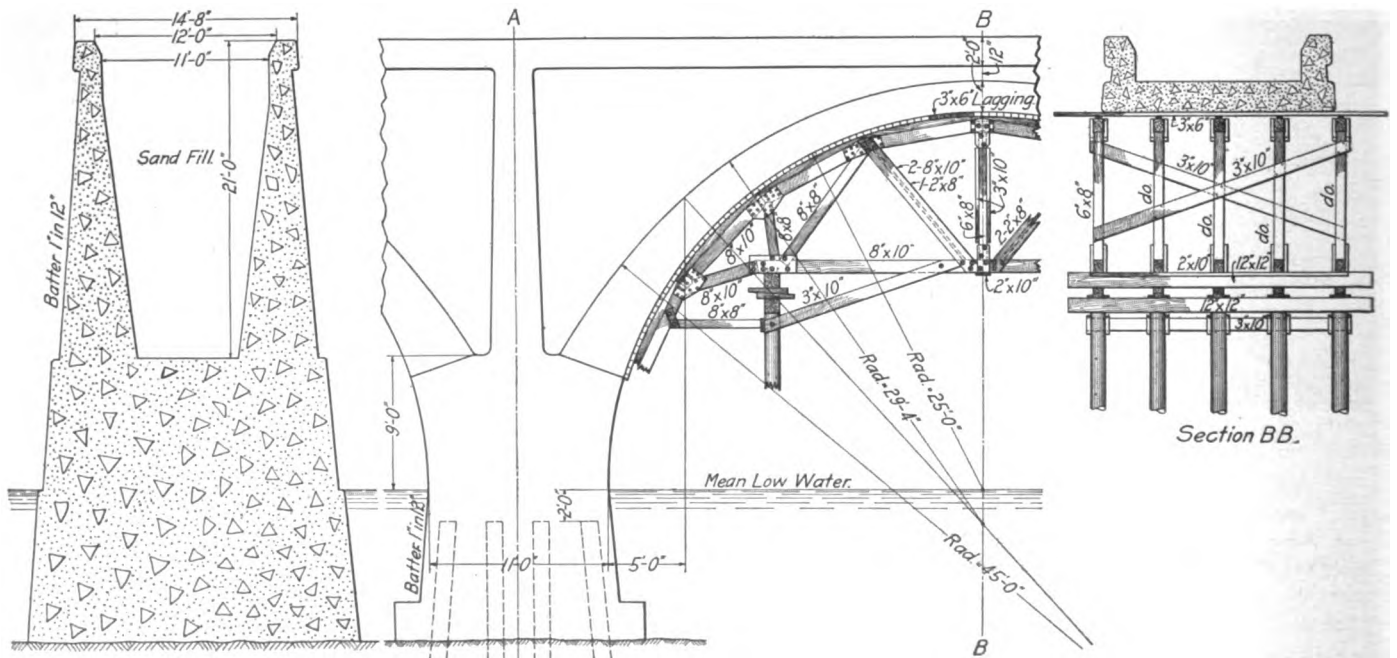
the despatcher's office is kept fully informed as to storm warnings and no train is allowed to proceed to exposed places when a hurricane is impending. Fortunately, severe storms are unusual except during the hurricane season.

Train service as scheduled provides two passenger trains and three freight trains each way daily except Sunday. One of the passenger trains is the "Oversea Limited," a solid Pullman train



Piers of Knight's Key Viaduct.

running between New York and Key West during the tourist season, and the other is a local from Jacksonville. The freight trains consist of one through freight, one way freight and one water train, the water for the entire extension being hauled from Everglade on the main land where a pumping plant and storage tanks are maintained. The water is hauled in cypress tanks of 3,000 gal. capacity erected on flat cars, each car holding



Section AA

A

Elevation

50-Ft. Concrete Arch, with Centers, on Long Key Viaduct; Florida East Coast.

two tanks. These cars are set out at water stations and construction camps as needed. The water is the surface water of the Everglades and is remarkably pure and soft, having but a small amount of lime.

"WILL IT PAY?"

The question has been asked, "Will it pay?" and the reply, whatever it may be is sure to start a discussion. Mr. Flagler thinks it will, backing his judgment with plenty of money, and his judgment in business matters in the past has shown itself to be sound. If there is any advantage in having a railway terminus insuring the shortest haul by vessel the Florida East Coast has that advantage, for business with the West Indies, Central America, the Panama canal and South America, and especially with Cuba, in the possibilities of through car shipments. Local traffic on the extension is small at present, but there are possibilities of increase, as the upper keys are well adapted for growing citrus fruits and afford excellent facilities during the winter months for yachting and fishing.

If in the foregoing Mr. Flagler and the railway company have been used synonymously it has not been through inadvertence nor for sentimental reasons. The railway has an authorized capital of \$5,000,000 of which Mr. Flagler is the sole owner of the \$3,000,000 outstanding stock and has agreed to purchase the remaining \$2,000,000 for the purpose of completing the road to Key West. There have been issued \$10,000,000 of 4½ per cent. first mortgage bonds, out of an authorized total of \$12,000,000, and \$20,000,000 of general mortgage income bonds, out of an authorized total of \$25,000,000. The latter bonds are entitled to interest up to 5 per cent. from earnings after operating expenses, taxes and interest on the first mortgage bonds have been deducted. In the year 1910 the interest paid on this issue was 3½ per cent.

Comparative statements of earnings and expenses for the fiscal years ending June 30, 1903, 1905 and 1910 follow, together with analysis of the statement for 1910:

BLOCK SIGNAL MILEAGE, JANUARY 1.

The Interstate Commerce Commission has issued its bulletin showing the mileage of railways in the United States worked by the block system on January 1, 1912. The principal table in this bulletin, table 1, is reproduced herewith; also table 2, showing the kinds of automatic block signals in use.

The total length of road operated under the block system on January 1, 1912, was 76,409.7 miles; 20,334.9 miles automatic and 56,074.8 miles manual. There was an increase of 2,623.4 miles automatic and 2,517.2 miles manual, a total increase in miles operated under the block system during the year of 5,140.6 miles.

The present bulletin includes the following roads which have not heretofore reported the use of the block system: Arizona & New Mexico; Carolina & Northwestern; Chicago, Terre Haute & Southeastern; Copper Range; Denver & Rio Grande; Lake Erie & Pittsburg (N. Y. C. freight railway); New York, Chicago & St. Louis, and New York, Philadelphia & Norfolk.

Five instances are noted where two companies operate their two single track lines jointly as a double track, and in the table these pieces of road are credited as double track to both companies.

From table 3, showing methods and apparatus used with the manual block system, it appears that the Seaboard Air Line, on 206 miles, now uses the telegraph in block signaling where, according to last year's report, the telephone was used. A number of roads have increased the use of the telephone for blocking, notably the Cleveland, Cincinnati, Chicago & St. Louis, which now reports 922 miles of road on which the blocking is done by telephone. The telegraph has been entirely abandoned for block signaling on that company's lines. The total length of road in the United States on which the telephone is used for blocking is now reported as 16,544 miles, as compared with 12,199 miles one year previous.

From information heretofore given in the *Railway Age*

COMPARATIVE STATEMENTS, FISCAL YEARS ENDING JUNE 30, 1903, 1905 AND 1910.

Year.	Capital Stock.	Bonded Debt.	Value of Road and Property.	Road Operated. Miles.	Gross Earnings.	Net Earnings.	Net Income.	Interest Charges.	Total Deductions.	Balance. + Surplus. — Deficit.
1903.....	\$1,000,000	\$13,259,000	\$13,656,737	484.95	\$2,018,207	\$666,614	\$666,614	\$523,777	\$594,899	+\$71,715
1905.....	1,000,000	13,259,000	14,552,134	500.84	2,328,864	720,334	722,674	669,200	743,605	—20,931
1910.....	3,000,000	30,000,000	31,176,122	583.47	3,687,434	1,481,621	1,490,213	1,150,000	1,376,288	+113,925

ANALYSIS OF EARNINGS AND EXPENSES, FISCAL YEAR ENDING JUNE 30, 1910.

Gross Earnings.		Operating Expenses.	
Passenger .....	\$1,276,051	Maintenance of way and structures.....	\$447,731
Freight .....	1,910,295	Maintenance of equipment .....	484,239
Mail .....	101,351	Transportation expenses .....	1,108,771
Express .....	260,107	Traffic expenses .....	64,995
Miscellaneous .....	139,630	General expenses .....	100,077
	\$3,687,434		\$2,205,813

With the opening of the Key West Extension the railway has 628 miles of main track in operation, as follows:

Jacksonville to Key West.....	522
Jacksonville to Mayport.....	26
East Palatka to Palatka.....	3
San Mateo Jct. to San Mateo.....	3
New Smyrna to Orange City.....	27
Titusville to Sanford.....	47
	<hr/> 628

In addition to the foregoing 160 miles is under construction from Maytown to Lake Okeechobee.

The work was begun under charge of J. C. Meredith as constructing engineer and W. J. Krome as principal assistant. In April, 1909, Mr. Meredith died from illness contracted on the work and was succeeded by Mr. Krome who has been in charge ever since. R. W. Carter is bridge engineer, and the division engineers are P. L. Wilson, C. S. Coe and Ernest Cotton. Edward Sheeran is general foreman in charge of equipment and the employment of labor. The writer is indebted to the railway company, and especially to Mr. Krome and Mr. Cotton, for information and for courtesies extended in making examinations of the work.

*Gazette*, it appears that in the case of two roads, the Chicago Great Western and the Northwestern Pacific, the apparent decrease shown below is explained by the fact that figures published one year ago were erroneous. The block system was never used on the sections of line referred to. The Grand Trunk now reappears in the tables. This road reported the manual block system as in use several years ago, but the report was sent in under a misapprehension of the meaning of the term block system. It appears that now the space interval is actually used, but only for passenger trains. The Louisville & Nashville has discontinued the use of the block system on certain sections.

The use of alternating currents in track circuits for automatic signals is now reported by a dozen roads, the aggregate length of track being 898 miles. Most of the track thus reported is on lines where electric motors are used.

Upper quadrant semaphores are now in use on over 2,000 miles of road, the most prominent roads reporting these being the Baltimore & Ohio, Chicago, Milwaukee & St. Paul, New York Central, Norfolk & Western and Northern Pacific. This list contains 25 companies altogether.

The bulletin includes the usual table, showing the length of



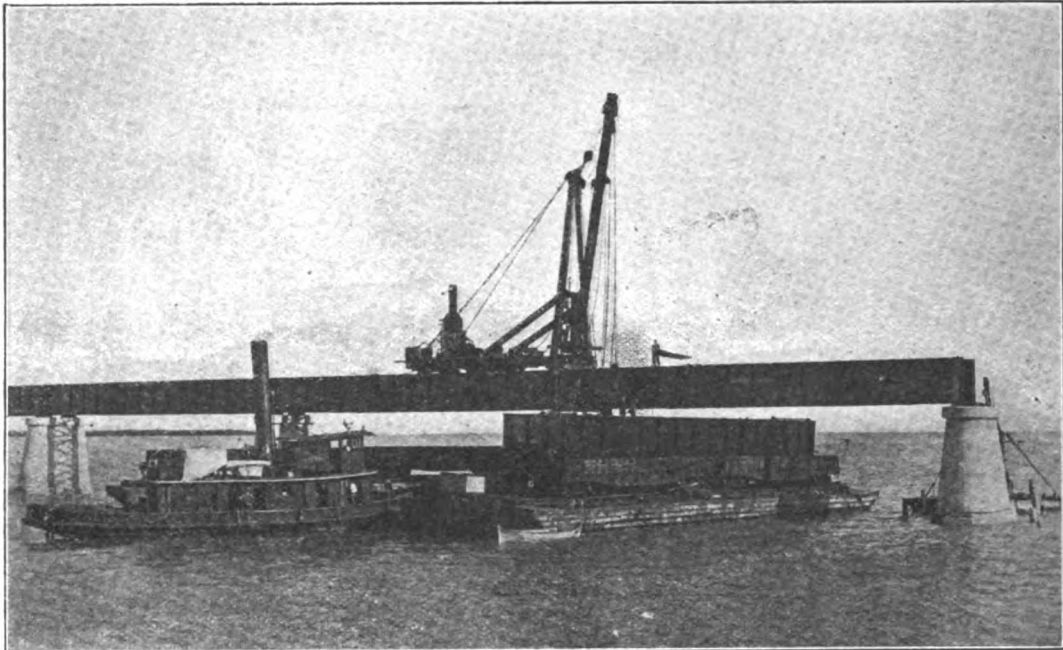
## ERECTION OF FLORIDA EAST COAST RAILWAY BRIDGES.

About 43 miles of the Florida East Coast Railway has a nearly north and south location on the mainland of the peninsula from Miami to Barnes' Sound, beyond which it runs southerly and westerly about 160 miles to Key West. This portion of the road follows a line of keys, most of which are small, long, narrow islands, close together, in almost continuous succession between the Bay of Florida on the north and the Atlantic Ocean on the south. The islands are elevated only a few feet above mean high tide, and the line is generally carried on them at a level grade at an elevation about 6 ft. above high tide. Between the islands it is carried sometimes on pile trestle filled-in embankments, forming a causeway, sometimes on concrete arches, and sometimes on steel viaducts and truss spans with concrete piers founded in water with a maximum depth of about 29 ft. In a distance of about 12 miles there are three single-track bridges over the Moser Channel, the Bahia Honda and Knights Key, which have an aggregate length of about  $3\frac{1}{2}$  miles of steel superstructure, with a total estimated weight of 10,950 tons.

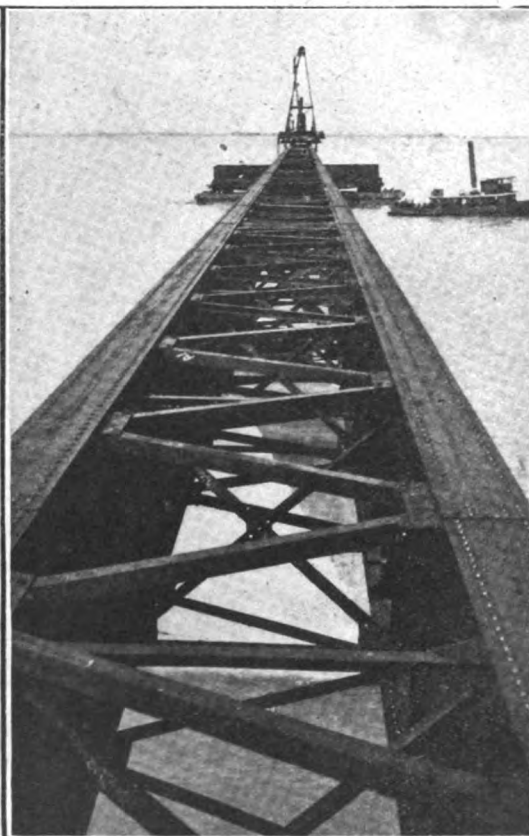
These bridges are very much exposed to north and south winds which are almost at right angles to their axes, and when strong enough, make dangerous waves, and considerably increase the average height of tide, which is about 15 in. As the keys in the vicinity of the bridges provide little or no suitable storage space and afford inadequate protection from severe storms, the work of erection presented some unusual difficulties and dangers. Supplies, equipment and labor could not be quickly secured on demand, and it was necessary to maintain them at the site sufficiently to provide for ordinary emergen-

The Knights Key and Moser Channel Bridges consist of 170 plate girder spans  $79\frac{1}{2}$  ft. long, which weigh about 40 tons each, and were fabricated at the Ambridge plant of the American Bridge Company. The long pieces were shipped entirely by rail; the rest of the steel was shipped by rail to Baltimore, thence by boat to Jacksonville, and thence by rail to the site where the girders, 8 ft. deep, and weighing about 18 tons each, were delivered braced together in pairs with their webs vertical, and each pair supported on two drop-end gondola cars.

The traveler had been previously used for the erection of the Manhattan Bridge, New York, and after the completion of that work was cut down from a transverse width of  $25\frac{1}{2}$  ft. to a width of 14 ft. which was as great as could be advantageously used on the narrow track here. It had an  $18 \times 41$ -ft. horizontal timber platform mounted on four single-flange wheels spaced 7 ft. 7 in. apart transversely, to roll on filler planks, lifting them clear of the rivets in the top flanges of the girders. A transverse vertical A-frame was pin-connected to the platform just in front of the forward wheels, and the top was guyed with wire cables to the rear of the platform. The shear legs were braced together about one-third



An Erection Scene on the Florida East Coast Railway Viaduct.



The Piers and Steel Spans of One of the Long Viaducts.

cies. The steel work was delivered as nearly as practicable in the sequence required for its erection; abundance of steel, timber, etc., were kept in stock, repair and construction shops were maintained, and the contractors were equipped with an unusually large plant and more duplicate items than are usually provided for work of this class and magnitude.

At Marathon, the temporary terminus of the track, the cars were transferred to floats and towed between the piers, where the girders were unloaded separately and erected by a traveler on the finished superstructure. The traveler had a single 52-ft. steel boom of 25 tons capacity, and was operated like a derrick car, sometimes erecting as many as three spans per day.

of the way from the bottom to the top by a horizontal transverse strut which received the upper ends of inclined longitudinal struts provided to receive any kicks from the booms.

The topping lift and hoisting tackle were attached to a vertical pin at the top of the shear legs, which permitted them to revolve as the boom was swung and thus avoided any twist in the fall lines, which were run through the Terry patent locked foot block secured to the forward sills and then passed over fixed sheaves to the drums of the hoisting engine located at the rear of the traveler platform, where it served as a partial counterweight.

When in service the traveler was wedged up to release the forward wheels and give solid bearing under the transverse bent, and vertical timber shores were firmly wedged on the pier under the feet of the inclined posts. The ends of the forward transverse sill were anchored by inclined tie rods and steamboat ratchets to hook plates engaging the bottom flanges of the main girders as close as possible to their bearings on the pier. The transverse sills at the rear of the traveler were anchored by screw rods with pairs of clamps engaging the top flanges of the main girders. These attachments provided ample stability for lifting the girders with the boom on the center line of the car, a position secured by delivering the girders between piers and thus obviating the necessity of swinging the heavily loaded boom. The accompanying illustration, prepared from the drawing of the traveler as designed for the Manhattan Bridge work, has been modified to correspond with the principal changes made, but does not show the diminished width, nor the correct position and details of forward clamps at AA.

The contractors employed a force of about 55 men who were quartered in an old Mississippi River stern-wheel boat, fitted up for the purpose

and moored to one of the keys near the bridge. The plant installed included two Mundy and two Lidgerwood double-drum hoisting engines with boilers, one Ingersoll-Rand air compressor, seven Chicago pneumatic hammers, six Thor pneumatic air reamers, and a car load of ropes and tackles, mostly steel, besides ordinary hand tools and supplies, aggregating in all about 200 tons. Repairs and simple steel construction were provided for by the railroad company's well-equipped floating machine shop, which the contractors were privileged to use, by paying for it.

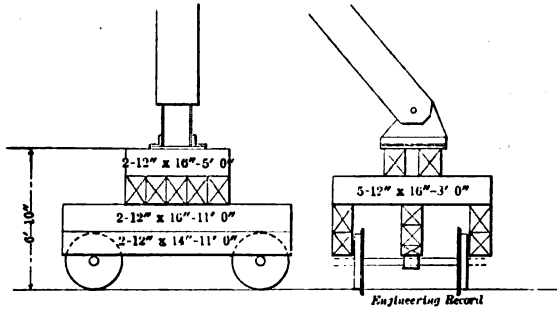
In order to avoid the delay, expense and danger of falsework for the truss spans it was at first proposed to erect them all successively at the same place and float them to position. Plans were

therefore made for a pile falsework platform about 200 ft. long, as shown in the accompanying drawing, located in water about 10 ft. deep adjacent to the railroad track.

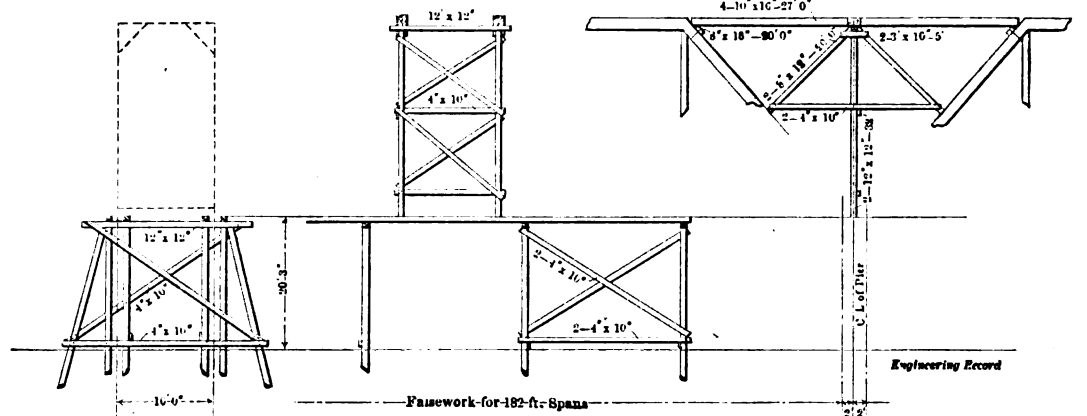
A 35x40-ft. falsework tower about 40 ft. high was to be built adjacent to the center point of the falsework and equipped with two stiffleg derricks, having booms by which the span could be completely erected on the falsework. After erection the span, weighing about 140 tons and seated on two 4-wheel trucks at each end, was to be moved transversely on pile falsework, extending

about 120 ft. at right angles to the main falsework from both ends of it towards the shore. While in the second position the field-riveting could be accomplished simultaneously with the erection of a second span in the first position and after the riveting was completed, the span could be transferred to barges floating under it, towed to position and deposited on the piers by pumping out the water ballast admitted to the barges to sink them under the span.

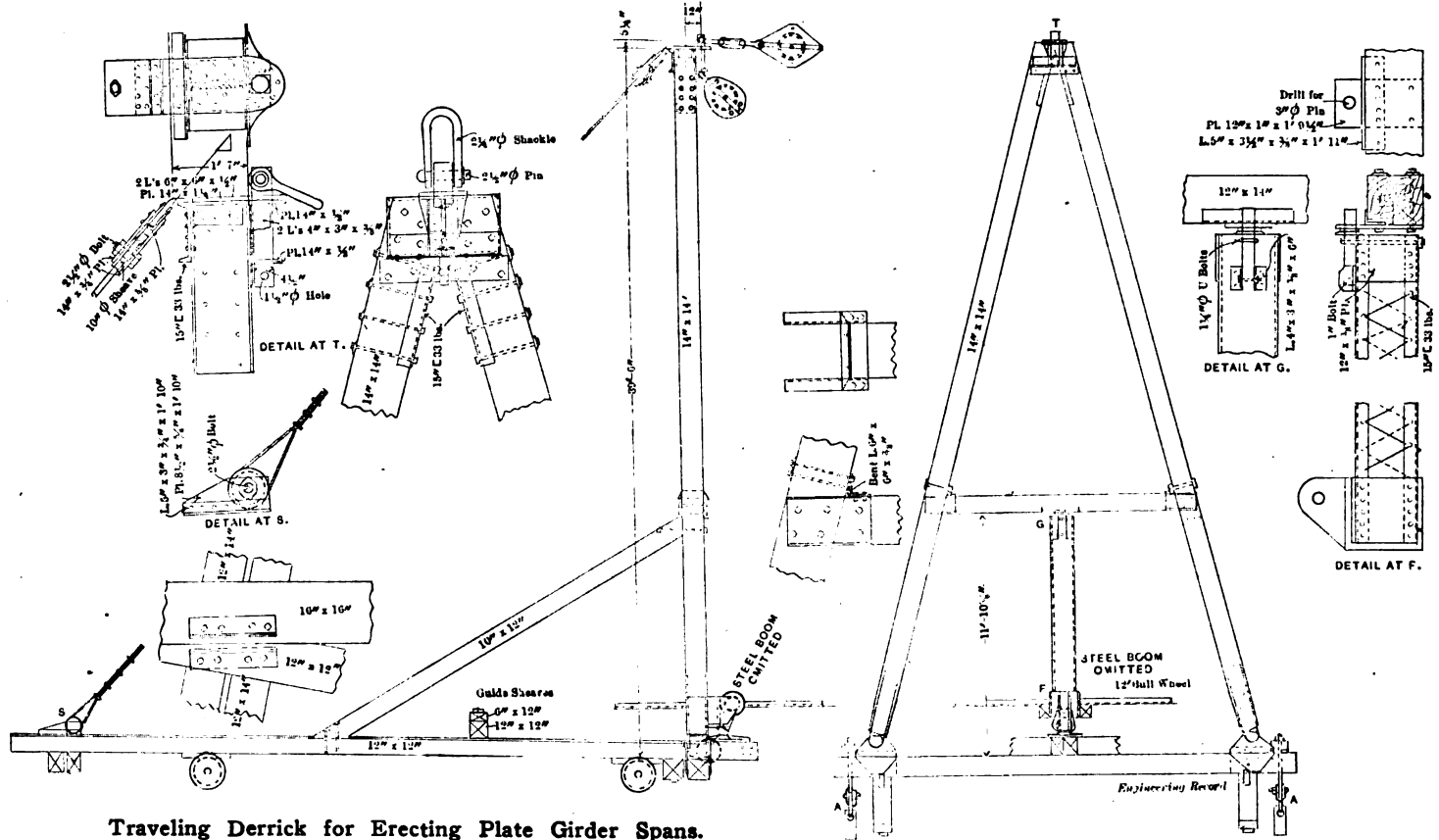
The trucks were of very simple design with a solid timber platform about 7 ft. above the base



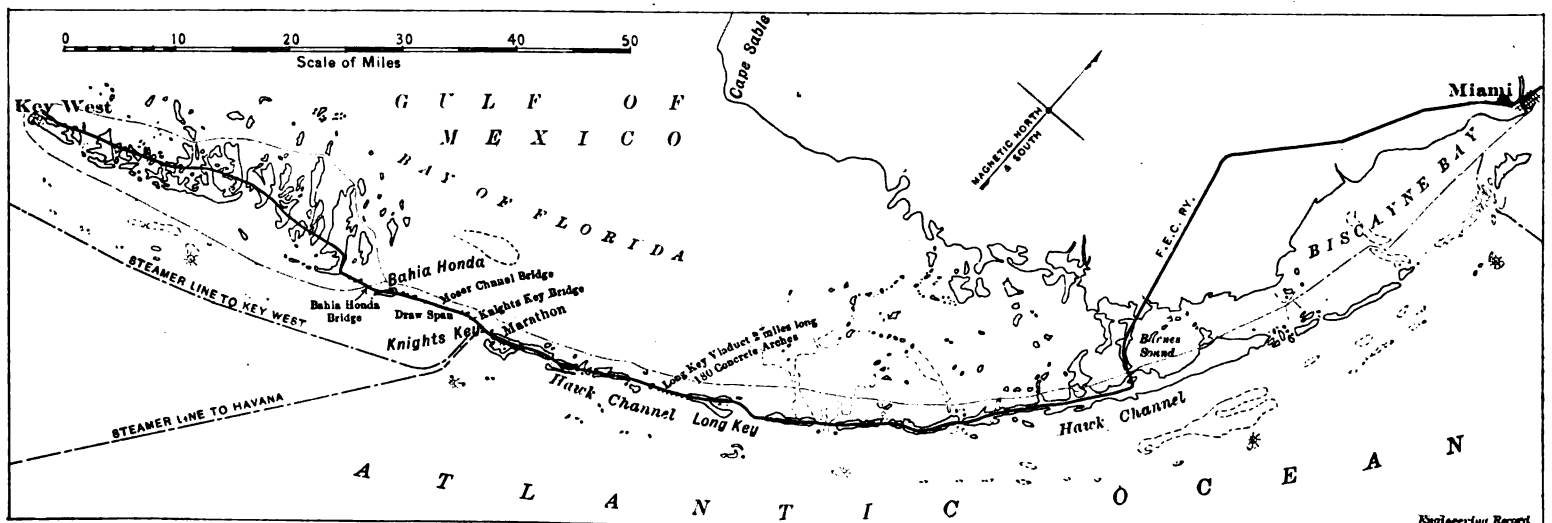
Truck for Moving Spans.



Falsework Used between Piers for Truss Spans.



Traveling Derrick for Erecting Plate Girder Spans.



General Plan of the Key West Extension of the Florida East Coast Railway.

of rail, supported on three longitudinal stringers taking bearing at the centers and ends of the axles.

The two 30 x 100-ft. barges about 6 ft. deep were each to be provided with a tower made with a pair of vertical bents 18 ft. high, seated on a 30 x 37-ft. distributing grillage on the deck of the barge. This plan was finally abandoned on account of possible danger apprehended from rough water.

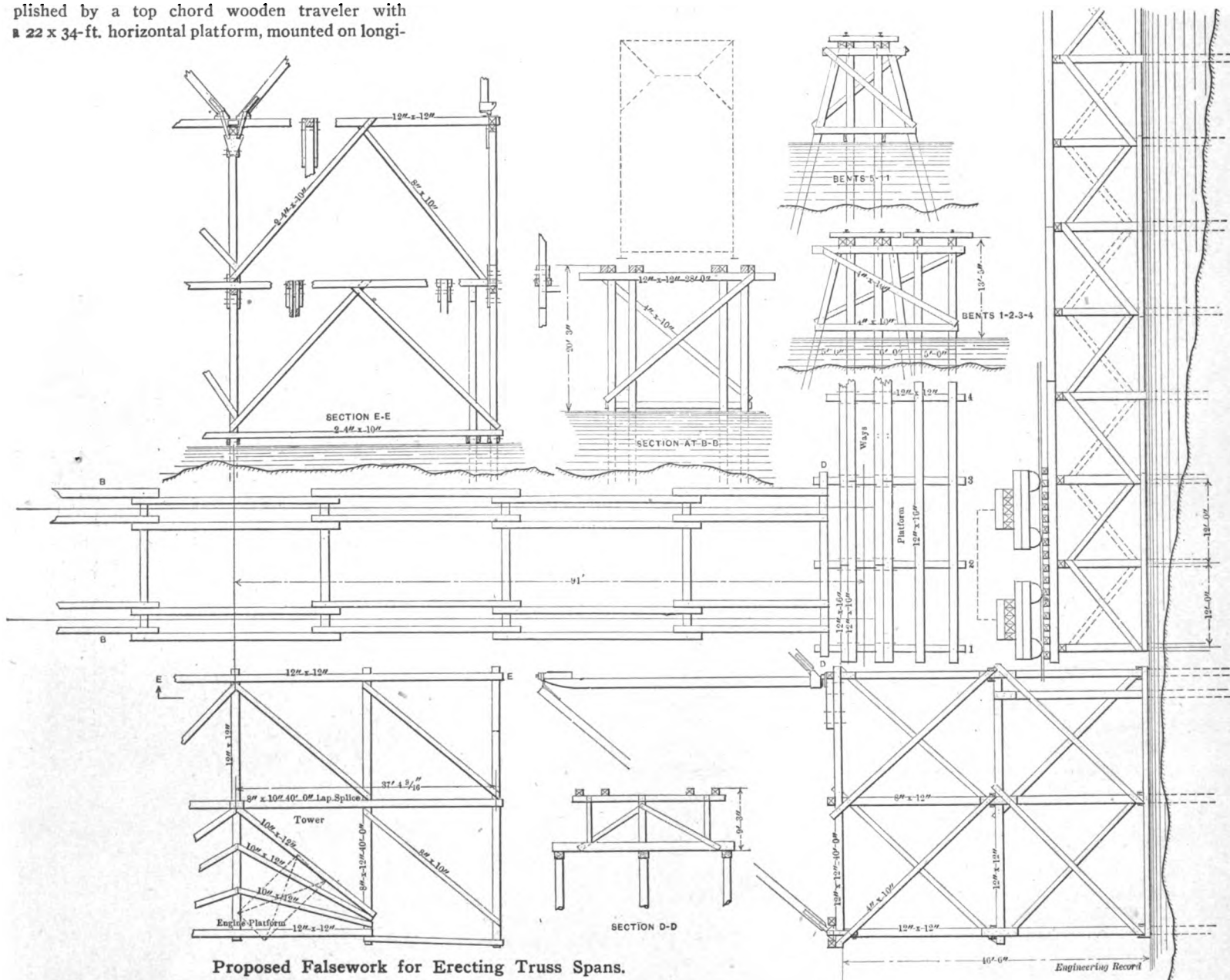
It was finally decided to erect the truss spans on ordinary pile falsework with four vertical and two battered piles in each transverse bent at panel points. The erection was to be accomplished by a top chord wooden traveler with a 22 x 34-ft. horizontal platform, mounted on longi-

drawn and ordinary wooden piles were driven in these holes in the usual manner.

After 68 plate girder spans had been erected great damage was done by a hurricane occurring Oct. 11, 1909, which subsided after a few hours, and almost immediately returned from a different direction, and continued several hours longer with increased fury attaining a velocity which was recorded at the nearest meteorological station at 120 miles per hour. The quarters boat was not destroyed, but the upper part of it was wrecked and it was first blown against the embankment and when the hurricane shifted was blown in the opposite direction so violently as to bend to

blown into the water. The surface of the water was raised about 7 ft. above normal, exclusive of the height of the waves, by the action of the wind, and had the wind continued two hours longer it would probably have raised the water so much higher as to drown all of the men on the work. As it was the water subsided without causing any fatalities. After the hurricane the erection contract was canceled and the work may be continued by the same or by different methods.

The bridges were designed and erected for the Florida East Coast Railroad, Mr. W. J. Krome, constructing engineer. The 205-ft. draw-span was fabricated by the American Bridge Com-



Proposed Falsework for Erecting Truss Spans.

tudinal skidding rails sliding between rivet heads on the top chords. At each of the forward corners of the platform there was to be installed a stiff-leg derrick with a 14 x 14-in. mast 29 ft. high and a 12 x 12-in. boom of 15 tons capacity, 50 ft. long. The gudgeons in the tops of the mast were to engage the overhanging ends of the cap of a transverse bent made with inclined posts clearing the booms so that the latter could swing more than 270 deg. horizontally. The bent was to be X-braced with adjustable sleeve nut rods and secured by inclined stifflegs pin-connected to the rears of the longitudinal sills. Standard fittings for the mast and boom were made with riveted and forged steel work arranged to be bolted to the timber without necessitating cutting the latter, and were shipped to the site but not assembled.

Steel spuds or pilots were driven a few feet with a pile driver to make holes through the soft, thin stratum of rock in the bottom of the bay which was underlaid by deep clay. Spuds were with-

U-shape the track rails to which it was moored.

A car float loaded with four cars and two girder spans was blown from its mooring in the refuge harbor and driven ashore. A similar float on the gulf side was blown on to a reef where it grounded. Five finished girder spans were blown completely off from their piers and into the water and six finished girder spans were blown from their bearing but were not blown from their piers. A barge containing the machinery for the draw span was blown adrift and beached. A 3000-gal. wooden tank filled with water was blown away and lost while a similar 1500-gal. empty tank nearby was not moved.

Part of the men took refuge behind a double line of drop-end gondola cars loaded with 18-ton girders, which were so heavy that they resisted the overturning effect of the wind. Other men, who were unable to make their way about 1,000 ft. from the quarters boat to these cars were obliged to lie flat on their faces for several hours holding to the track rails to prevent being

pany, at the Ambridge plant several years ago and has been at Miami ever since. The erection contract was awarded to the Terry & Tench Company, Inc., New York, Mr. W. L. Cline, superintendent in charge.

WOODEN CRIBS 4 ft. wide and 14 ft. long were used in laying a suction main for a small pumping plant at Hoosick Falls, N. Y. According to a note by Mr. A. W. Sherwood in the "Polytechnic," the cribs were so made that they could be put together readily in the water. The planks in the sides and ends were brought close together so that little water could leak through. The crib, having been put in place, was filled in around the outside with gravel and the water pumped out. Laborers would then begin digging, the pump being kept constantly at work. As the inside was dug out, the crib sank until grade was reached. The pipe was then put in, the joints calked, and the process repeated in laying the succeeding lengths.

more luxurious than first-class on the older boats.

In the trials of the *France* an average speed of 25 knots was maintained for twenty-four hours, which exceeded all expectations. With the exception of the *Mauretania* and *Lusi-*

*tania* of the Cunard line, the *France* is the fastest steamship in the world. At this speed the engines developed 47,000 horse-power, and yet the coal consumption was one-tenth less than the amount estimated previous to the trials.

## THE FLORIDA EAST COAST RAILWAY

DETAILS IN THE CONSTRUCTION OF THE OVER-SEA ROUTE TO KEY WEST

Frank M. Patterson—*Railway Age Gazette*

**T**HE inauguration of traffic over the entire extension of the Florida East Coast Railway to Key West on January 22nd of this year effected the realization of the plans long held by Mr. H. M. Flagler, the promoter of the road. With the purchase of a small railway extending from Jacksonville to St. Augustine, in 1885, Mr. Flagler became impressed with the opportunities for agricultural development in southern Florida, and eventually, by purchase and construction, extended his holdings until in 1896 the Florida East Coast Railway entered Miami, on Biscayne Bay, 366 miles south of Jacksonville.

The growing importance of trade with Cuba, after the Spanish war, and the certainty of the construction of the Panama canal led to the determination to extend the railway to some point where more satisfactory harbor facilities could be obtained. With this intent surveys were made through the Everglades to Cape Sable, the most southerly point on the mainland. After thorough investigation, however, this route was rejected, and it was decided in 1904 to build to Key West, a distance of 128 miles, of which about 22 miles was on the mainland and the remainder across the string of keys which

fringe the coast and extend to deep water at Key West.

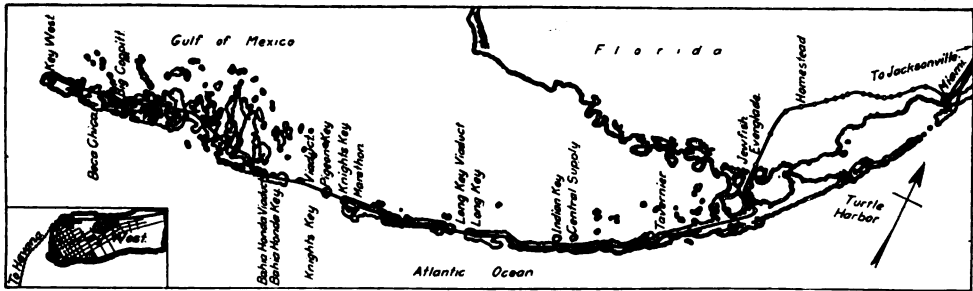
As far as Knight's Key the islands are admirably situated for the location of the railway, affording good alignment and necessitating comparatively little bridging, the longest stretch of water being at the lower end of Long Key where a concrete viaduct two miles in length was built. Immediately below Knight's Key is a stretch of water seven miles wide ranging in depth from 18 to 22 feet. A few miles further on Bahia Honda is encountered, where a bridge 5,100 feet long is required, in water whose greatest depth is 30 feet. The three structures just referred to, together with a concrete arch bridge, 2,573 feet long at Boca Chica, a few miles north of Key West, were the principal bridges as originally planned, although later it was found necessary to provide additional arch structures.

From the nature of the work practically all of the outfit used on the original construction was floating equipment and this included a number of Mississippi river steamboats of the stern-wheel type, which proved most efficient for the transportation of material and supplies in the shallower waters, owing to their light draft. All material and

supplies, including water for domestic and boiler use, had to be brought from the mainland. Material for concrete was shipped by steamer from northern points, trap rock being brought from the Hudson river, sand from Baltimore and American Portland cement from New York. German Portland cement was used in all concrete below high tide, being delivered by tramp steamers at the nearest available harbor.

On the keys proper most of the grading was done by hand labor. The material is coraline rock with little or no overburden of dirt. This rock is light and easily worked and

and sunk. Piles were then driven into the rock to refusal, the average penetration being 12 to 14 feet. The purpose of the piling was three fold: first, to afford foundation should any erosion of the rock occur; second, to act as an anchor against any tendency to overturning or lateral displacement; and third, to act as an exploratory probe. It happened several times that cavities in the rock were encountered that had been missed by the sounding outfits. After the piles were driven a footing course of concrete from 3 to 5 feet in depth was deposited by tremie and allowed to set, forming a seal. The cofferdam was then unwatered, the



KEY WEST EXTENSION OF THE FLORIDA EAST COAST RAILWAY

the quantities per mile averaged small. Where the embankments were too high to be built economically by hand labor the excavators were taken from their scows and placed on the embankment, moving forward on rollers as they completed the work ahead of them.

The Long Key viaduct is the longest structure of the arch type on the line and is a notable piece of work, consisting of 180 semi-circular arches of 50 feet span, the track being at an elevation of 30 feet above high tide. The method of construction used here has been followed on all similar work and a description of it will serve for all.

The location of piers having been established the sand was removed from the rock bottom by dredging and a cofferdam floated into place

piling cut off to a point well below low tide and forms erected for the piers. After the piers were completed to the springing line false work for the arch forms was driven and the forms put in place. To avoid expansion cracks the arches were put in alternately, the concreting being done by mixers and derricks on scows.

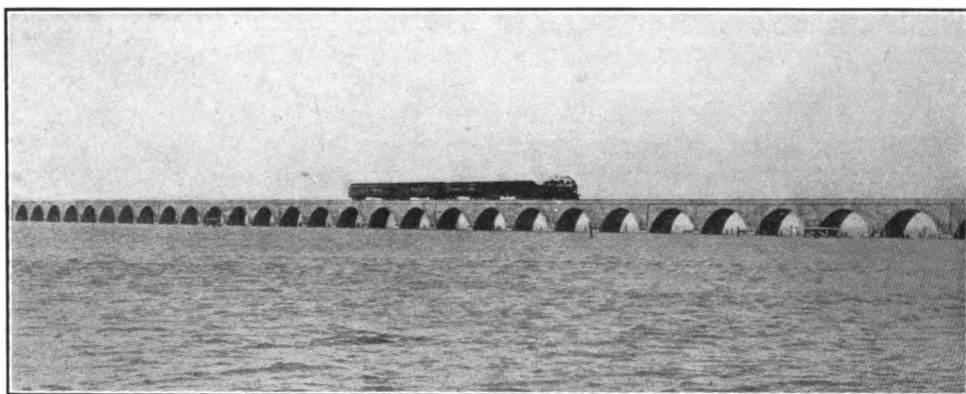
Below Knight's Key the rock changes from coraline to a highly fossiliferous sedimentary limestone, and it was found possible to use it for concrete, thereby effecting a saving in the cost of concrete of from \$3 to \$5 per cubic yard. The rock is blasted in shallow water and loaded by orange peel dredges. When blasted it breaks up into small sized pieces with enough fine stuff so that it can ordinarily be used as it comes



from the dredge without the addition of sand, or any sorting other than the removal of occasional large chunks.

Knight's Key bridge consists of 316 deck girders of 80-foot span and 19 deck girders of 59-foot 9-inch span, with 210 arches of 35-foot span at the southerly end where

bright yellow color corrosion is quickly detected. The ordinary galvanized telegraph wire rusts through in two years or less, and it even has been necessary to paint the track rails with a coating prepared by the Cunningham formula, consisting of one part kerosene, four parts Portland cement and 16 parts refined



LONG KEY VIADUCT OF CONCRETE—2.7 MILES LONG

shallower water is found, and a 253-foot 6-inch through-truss drawspan over Moser channel, the draw being operated by a gasoline engine.

Bahia Honda bridge consists of 13 spans of 128½ feet, 13 spans of 186 feet, 1 span of 247½ feet, and 9 80-foot plate girders. The decks of the steel bridges are of the ordinary type fastened with hook bolts.

The protection of the steel spans from rust is one of the hardest problems facing the railway. In the warm, moist, salty air corrosion begins in an almost incredibly short time, and no paint has been obtained that can be considered wholly satisfactory. Near the constructing engineer's office at Marathon a test rack is located in which are placed test plates coated with different paints, and so far none has been found that will afford protection for two years. The railway company's standard paint has proved about as efficient as any and on account of its

coal tar, the cement and kerosene being first mixed and then stirred into the heated tar. The concrete arch bridge at Boca Chica, four miles north of Key West, is the last important bridge on the extension, having 83 arches of 25-foot span.

The effect of sea water on the concrete has been closely watched, both in the actual structures and on test cubes exposed for observation, and so far there is no reason to believe that any serious deterioration will take place. Shortly after being exposed to the water it is found that a scaling off occurs to a depth of about one-sixteenth inch on the part of the concrete between the limits of high and low tide which amounts only to about 18 inches. After the scaling off has taken place a marine growth forms on the parts exposed to the water and seems to protect the concrete from further damage.

After surveys had been completed and plans made for the construction

of the extension it was thought that the bridges already referred to would be all that would be necessary and that solid embankments could be made from key to key in other places. However, there was one factor that had not been considered which has probably never been encountered in previous work of this kind. This is the impounding of the waters of the gulf by hurricanes in that pocket between the railway and the mainland known as the Bay of Florida. The hurricane of 1906, while very severe, came upon the work before those waterways had been closed, and it was not until the storms of 1909 and 1910 that their effects could be noted and studied in this connection. Under the stress of these storms continuing for several days from the south and west it was discovered that the water was banked up in the bay until it overtopped the embankments, and swept them away. It was also noted that the embankments across the water, even in the shallowest places, were the first to go, and that when they were gone the water rapidly subsided. This led to the decision to build arches, varying from 16 to 25 foot spans, across these stretches, the length required amounting to a total of between five and six miles.

From an operating standpoint the extension is in surprisingly good physical condition when one stops to

consider that in February, 1911, orders were given to have the line ready for traffic to Key West in January, 1912, instead of a year later, as had been the intention. The track is laid with 70-pound rail, well tied, with tie plates on all curves. The grade is practically level at a minimum elevation of about 10 feet above sea level except at Long Key, Knight's Key and Bahia Honda bridges where it is at a 30-foot elevation. On the bridges referred to speed is restricted to 15 miles per hour, to minimize the danger of derailment. For additional safety the despatcher's office is kept fully informed as to storm warnings and no train is allowed to proceed to exposed places when a hurricane is impending. Fortunately, severe storms are unusual except during the hurricane season.

Train service as scheduled provides two passenger trains and three freight trains each way daily except Sunday. One of the passenger trains is the "Oversea Limited," a solid Pullman train running between New York and Key West during the tourist season, and the other is a local from Jacksonville. The freight trains consist of one through freight one way freight and one water train, the water for the entire extension being hauled from Everglade on the main land where a pumping plant and storage tanks are maintained.

## "WIRED WIRELESS" FOR MILITARY PURPOSES

A COMBINATION OF WIRED AND WIRELESS TELEGRAPHY IN FIELD SERVICE

*Major George O. Squier—Journal Franklin Institute*

**P**URE radio-communication is ideal for rapidly moving troops, but has the inherent defect that interference is always possible, and the information may un-

der certain conditions be received by the enemy. Radio methods and field wire methods, however, have taken their places as permanent means of electrical communication in war, and

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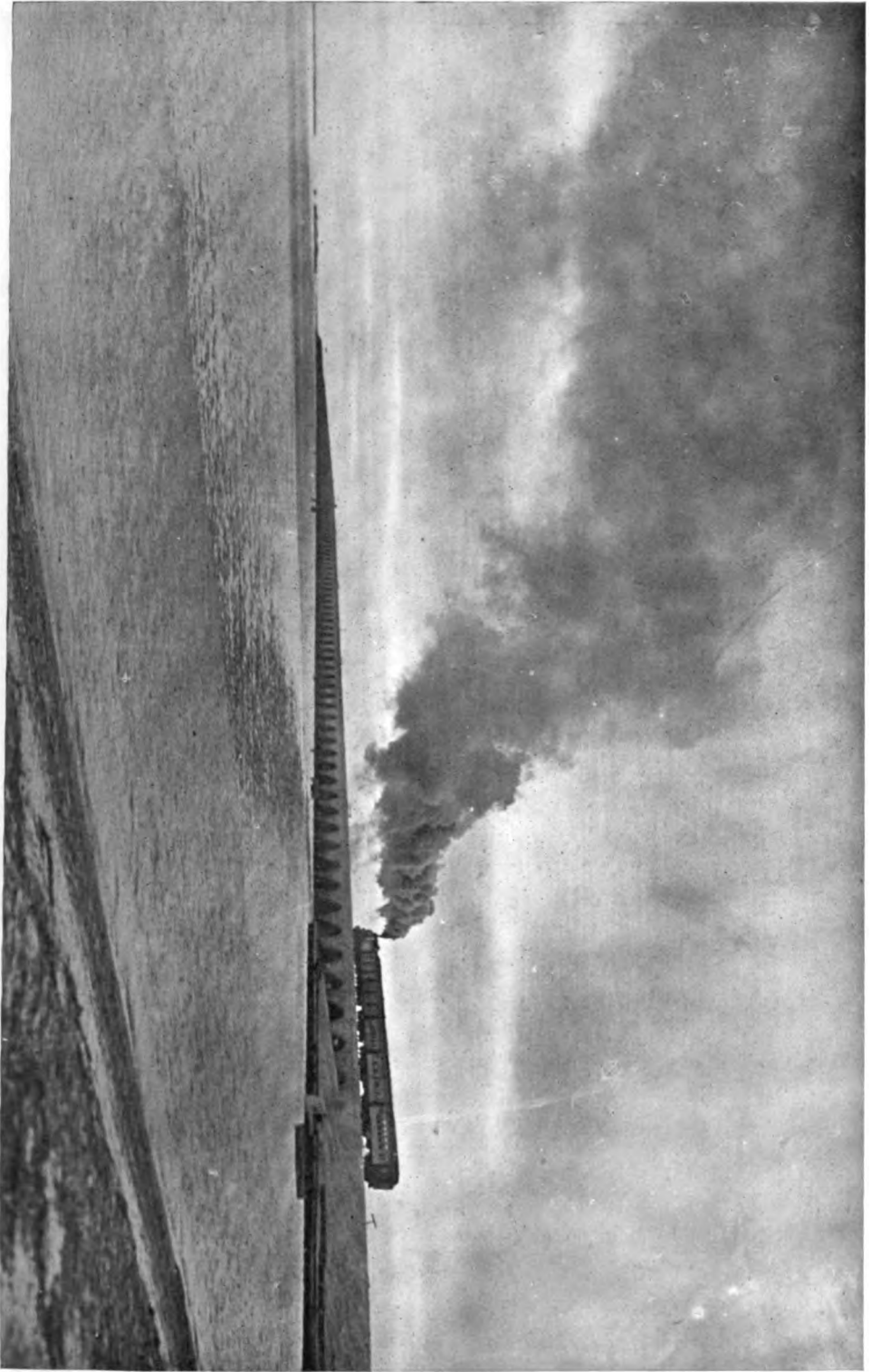
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LONG KEY VIADUCT ON THE SEA-GOING RAILROAD



## THE SEA-GOING RAILROAD

BY CHESTER C. POPE

Early in the morning of January twenty-second, nineteen hundred and twelve, a steady stream of people commenced to flow from all portions of the City of Key West out onto the dazzling white expanse of "Trumbo Island."

At first they went in small numbers, singly and in parties, but as the morning advanced the numbers increased and carriages holding anywhere from two to ten travelled out and returned empty to seek other loads.

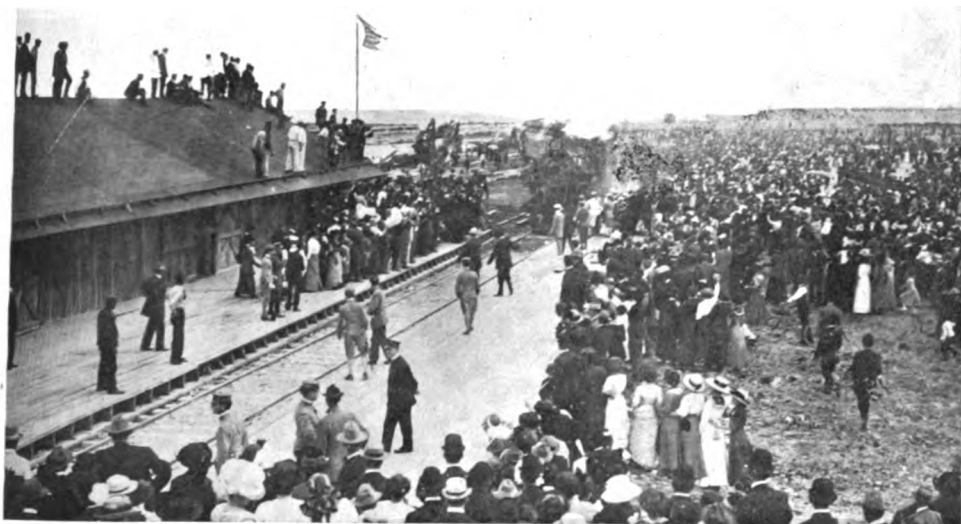
By ten o'clock the causeway leading from the city to the terminal yards was a black mass of people moving out toward the station. The station itself was not only surrounded by a compact mass of humanity but also carried a generous load on its roof, while pile drivers, freight cars and telegraph poles, anything that offered a foothold and afforded a view of the track, were loaded down to their capacity with citizens of the largest and last of the Florida Keys—Key West.

At ten forty-three A. M., amid a roar of fire works and the shouts and acclaims of fully fifteen thousand people, "Uncle Henry's Special," with its whistle rope tied down, rolled slowly down the lane formed by the massed population and came to a stop at the station of Key West, Fla., the new terminus of the Florida East Coast Railway.

On this train was Mr. Flagler, with Mrs. Flagler and some of the high officials of the road. As Mr. Flagler came out onto the platform of his car he was presented with a beautiful testimonial by the people of Key West, consisting of two solid silver medallions, eight inches in diameter, one of which bore an engraved likeness of Mr. Flagler, and the other a suitable inscription. Joining the two were gold filigree work and a gold medallion, on which was a map showing the relative position of Key West in reference to Cuba and the Panama Canal. These medallions were mounted in a mahogany frame.

A short informal reception was held at the train, during which there was singing by a chorus of five hundred school children, and also a short band concert by the military band of Cuba.





**ARRIVAL OF THE FIRST TRAIN AT KEY WEST**



**MR. FLAGLER, ON THE ARM OF MAYOR FOGARTY, BEING GREETED BY ADMIRAL YOUNG.  
FLAGLER TESTIMONIAL IN THE BACKGROUND**



About an hour after the Flagler Special arrived the "Congressional Special" pulled in, carrying the largest body of government officials and congressmen that ever left Washington at the same time to go to the same place. There were about seventy-five persons in the party, which included practically the entire membership of the House Committees on Rivers and Harbors, Military Affairs, and Naval Affairs, as well as members of other committees and Senators Fletcher and Chamberlain. On board this train were also General Oliver, Assistant Secretary of War, and Aide, Major Lassiter, the personal representatives of the President; Brig. Gen. Bixby; Rear Admirals Fletcher and Cone; and official representatives of various foreign countries.

This train was followed at close intervals by many others bringing Governor Gilchrist and his staff, members of the Chattanooga (Tenn.) board of trade, delegations from Jacksonville and Miami, and many besides. By nightfall the terminal fill, which such a short time before had been almost as barren as a desert, was converted into a veritable city of Pullman cars.

Accommodations had of course been prepared for the official guests, but some anxiety had been felt concerning the ability of the city to care for the other visitors who might arrive. It had been originally planned to have a "Tented City" to accommodate these people, but this plan proved unnecessary and was not put into effect. A systematic canvass of all rentable rooms in the city was made, and lists were compiled and placed in the Headquarters of the Celebration Committee, to assist in locating visitors in desirable quarters with the least possible inconvenience. The P. & O. S. S. Co. very considerably tendered the use of one of their large steamers, which when tied up at the dock afforded comfortable accommodations to a large number. Many people who came for a few days only made their home in their Pullman cars. And by one means or another all were taken care of and everybody seemed satisfied.

A number of carnival shows had set up their tents on an unoccupied portion of Trumbo Island and the great Pubillones Circus from Cuba was located further up town, so that there was amusement for all at all times of day.

The first day of the ten days' celebration was brought to a fitting close by a public reception at Mayor Fogarty's house, followed by a grand ball at the Naval Station, the attendance

at the latter being estimated at nearly a thousand. These two functions were the most brilliant of all during the celebration; they were attended by all the distinguished guests, as well as by the officers from the war vessels in the harbor. Two foreign ships, the Portuguese cruiser *Republica* and the Cuban gunboat *Hatuey*, and four American vessels were in the harbor during most of the celebration.

The second day of the celebration was opened by a civic and military parade. The marines and sailors from both foreign and American war vessels, the detachments of the regular army and navy stationed here, the two branches of Florida national guard, three troops of Boy Scouts, and innumerable representatives from patriotic and benevolent societies, with many decorative floats representing different industries, made the long parade a varied and interesting procession.

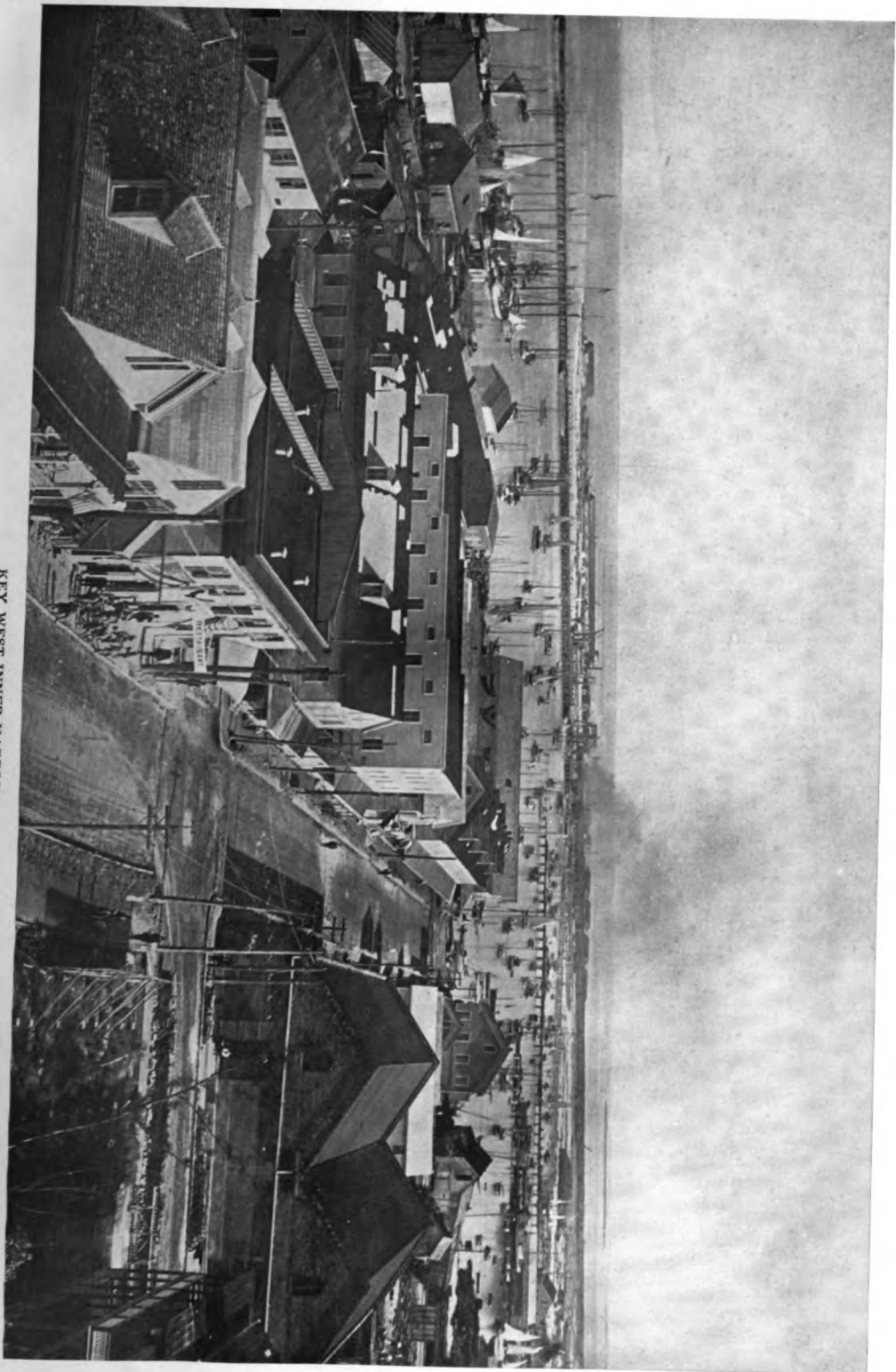
After the parade the official guests were driven about the city and afforded an opportunity to inspect the Government reservations and municipal improvements now in progress or proposed.

In the afternoon the members of the Rivers and Harbors Committee, and others, were taken on a cruise around the harbor, during which their attention was called to the needs of Key West in the way of government improvements. Upon their return they attended a reception given by Captain Percy Willis at the army post. During the afternoon there was also a reception to official guests at the quarters of Admiral Young in the Naval Station.

In the evening an elaborate banquet was tendered the visitors, in the equipment building of the U. S. Naval Station. This was in charge of the Celebration Committee, who imported from New York not only the waiters and chefs but all the dishes, silver and other paraphernalia necessary to such an undertaking. About 300 persons sat down to the dinner, which passed off in an astonishingly smooth manner.

The only untoward incident of the evening was a temporary failure of the electric lights, this being caused by a break-down of an engine in the Government's private plant. The line force of The Key West Electric Company was quickly summoned, however, and with their assistance things were straightened out again in short order.

During and after the banquet there were speeches. Two



KEY WEST INNER HARBOR





themes were uppermost: the great future of Key West; and the man who had made it possible. Mr. Flagler himself was called upon and, much to every one's surprise, responded. His reluctance to speak in public is well known; in fact, he told one of the Committee members in December that unless he should be freed from the obligation to speak, he would send Mr. Parrott as his representative and not be present at all. However, on this occasion he made an exception. The applause was deafening when he made the assertion that in ten years Key West would have a population of fifty thousand, and that he was going to try to live and see it.

The Congressional party and most of the official guests left the next morning, but many of the other visitors to the city stayed until the end of the celebration. Yacht races, baseball, dancing, band concerts and fireworks displays entertained the visiting thousands as well as the regular inhabitants of the city. Beckwith Havens, the noted aviator, made several flights in his hydro-aeroplane, demonstrating the adaptability of this style of machine to either air or water. These flights were given on February 4th and marked the close of the festivities.

The celebration was planned and carried through by a committee acting for the people of the city, in an endeavor to show their appreciation of the great undertaking which Henry M. Flagler has at last brought to a successful conclusion, after years of persistent effort, and after overcoming obstacles seemingly insurmountable. It was Mr. Flagler who first realized the possibilities that such a railroad would have, and it was Mr. Flagler who had the indomitable energy and pluck, not only to start the gigantic undertaking, but also to carry it through to a successful finish.

Starting in 1883 with the idea of making St. Augustine a winter resort for tourists, he bought and improved the railroad from Jacksonville. In 1892 he began the construction of new lines and the work was pushed rapidly southward. It was completed to Rockledge in January 1893, to West Palm Beach and Palm Beach in April 1894, and two years afterward to Miami. During these years Mr. Flagler's ideas expanded and he formulated the project of making his road a medium for the commerce and travel of the United States to and from Cuba and the West Indies and the countries of Central and South America. The first idea of going straight through Florida to Cape Sable

was abandoned as impracticable, and in 1904 the order was given to go by way of Turtle Harbor on Key Largo; it was decreed that the extension should be to Key West—the Island City, the city farthest south in the United States, the American port nearest the Panama Canal, and the logical point of entry from and departure to the West Indian and Carribean markets.

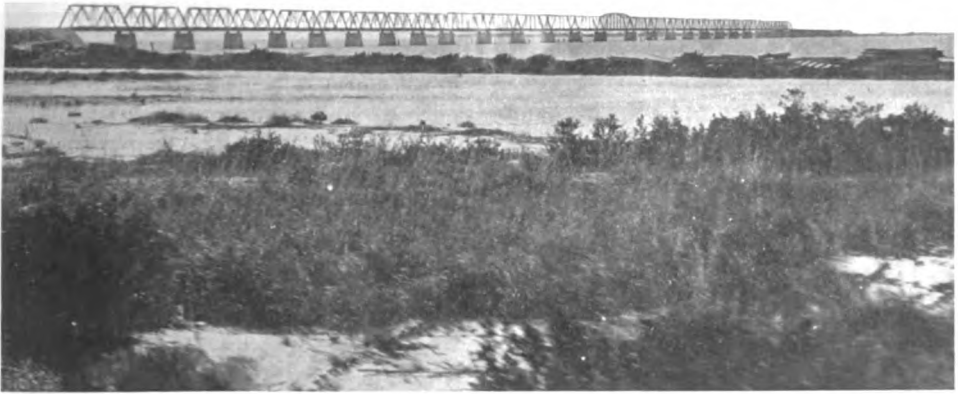
The work of construction south of Homestead was begun in April 1905, and the first train to enter Key West on a continuous line of rails over the entire main line of the road was that of Mr. Flagler on January 22, 1912.

The construction of the "Extension," as it has been called, may be divided into two classes: the grade work and the viaducts. The grade was constructed by means of dredges, which scooped the material from beside the right of way and deposited it on the road bed. Originally the road bed was constructed of marl, with the embankment rip-rapped with rock. But the hurricanes of 1906, 1909 and 1910 taught the engineers, among other things, that the damage to the grade by wave action was not done by the impact, but by the receding motion and undertow. Hence the construction was reversed and the road bed was formed of rock with marl filling and long sloping embankments of marl, which, while being soft when first dug, hardened in the sun and formed a surface over which the waves slid as if on glass.

The viaducts may be divided into two classes of construction: solid concrete arch work, concrete piers with steel girders, and concrete piers with steel trusses.

Long Key, two and one-quarter miles long, Boca Chica, one mile, and Pacet Channel, something over a mile long, are the principal viaducts of the first class, namely, concrete arch. These viaducts are not entirely solid as one would suppose from a casual glance, but are built in the form of a trough. This is filled with sand and marl up to the level of the top of the viaduct, and the ties and rails are laid on this bed.

Knights Key and Pigeon Key and Moser Channel are the two principal places where the second type of viaduct is used. In this type of construction concrete piers are snuk and massive steel girders laid on them. Knights Key, Pigeon Key and Moser Channel and Pacet Channel viaducts are all joined together and make one continuous stretch of viaduct work, seven miles without a break.



**BAHIA HONDA BRIDGE—THE SEA-GOING RAILROAD**



**KNIGHTS KEY VIADUCT—THE SEA-GOING RAILROAD**





The third type of construction is used in the Bahia Honda bridge, the only piece of regular bridge construction on the line. This bridge like the Knights Key viaduct has concrete piers for a foundation, but instead of girders Bahia Honda has great steel trusses placed on the piers.

At Key West, when Mr. Flagler was looking for land upon which to build his terminal, he was met by a sort of passive resistance and in the end he had to make his own ground by filling in a shallow part of the harbor with the everpresent marl. He has covered approximately 200 acres in this way, on which are the freight yards, station and all the offices and shops belonging to the "Extension." A mammoth temporary dock has been built, which will be replaced later by a permanent structure. The latter will be of reinforced concrete 2,000 feet long and 134 feet wide. At the inner end will be the terminal depot and at the outer end a freight shed and offices of the F. E. C. Ry., P. & O. S. S. Co. and U. S. custom house. Trains arriving from the North are run out to the end of the dock to meet the steamers for Cuba.

Other docks of large dimensions are already planned to take care of the increased freight and passenger traffic which is bound to come. It is expected that soon a car ferry service to Cuba will be inaugurated, so that the timid traveller may enter his sleeper in New York and not get out until he arrives in Havana, fifty-two hours later. This service will also save considerable handling of freight.

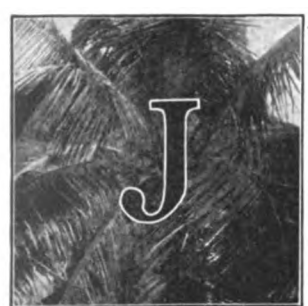
A person visiting Key West to-day would be struck by the change in the attitude of the citizens of this coral isle. Formerly affairs drifted along as best they could. A few "boosters" were crying down old, outgrown and antique customs and practices, but the majority would roll another cigarette and languidly murmur, "Mañana," in the soft language of the Caribbean. But to-day there is a distinct difference in the spirit of the people, and in place of the languid "Mañana" (to-morrow), we hear the energetic "Hoy" (to-day).

A wonderful transformation, this, and all as a result of the energy, courage and keen insight of one man—"Uncle Henry"—who first came to Florida in search of health.

# Opening the Over Sea

## The Remarkable Highway Which Now

By JOHN MA  
PHOTOGRAP



**J**ANUARY twenty-second will be a great day for Key West. President Taft will be there—at least, he has been invited—and the army and navy, and representatives of foreign powers, and they and all the people of Key West, and Henry M. Flagler, who made it possible, will open one of the most remarkable railways in the world.

By the opening of the Key West Extension of the Florida East Coast Railway, Key West, which is built on a little island far out at sea, will be joined to the Florida mainland. It will be joined to Cuba—ninety miles away—by the nearest thing to a bridge—ferries which will carry trains across so that you may get into a Pullman in New York and not get out until you alight at Havana or Santiago. Key West will be the nearest American city to the Panama Canal, and, it would seem, the natural gateway to it as far as passengers and mail are concerned. People will know it as a naval station, coast artillery post, and railroad terminus just as they know it now as a place where cigars come from. No wonder Key West is interested.

This curious little city is built on the last of the low reefs which curve round the lower end of Florida far out into the blue waters of

to finish," with those unique and picturesque difficulties which come when the water is salt water and the surrounding country the shifting sea.

The Key West Extension is the appropriate conclusion to Mr. Henry M. Flagler's long line of constructive investments on the east coast—a monument to the rich man who went to Florida after the work of his life seemed over, and there discovered a second youth. A quarter of a century has passed since Mr. Flagler began the development of the east coast, and he has spent between forty and fifty millions there. Twelve millions went into hotels, eighteen into old railroads, another million or so into steamships, and the rest into the Key West Extension.

### The Man Who Began Life Over Again

**M**R. FLAGLER was fifty-five years old when he first went to Florida. He had grown up in the hard, dry Rockefeller school, and, like his associate in the oil business, had more money than he knew what to do with. The son of a Presbyterian clergyman, a man who scarcely knew what pleasure for its own sake meant, he had given his whole life to business. He had never been to Europe nor even to California. He went down to that semitropical coast with its palms and red poinsettias, its white beaches and blue water, and, so to speak, began life all over again.

The Ponce de Leon and the other huge hotels which have made the "American Riviera" rose one after another down that shimmering, dreamy coast. Orange and grapefruit groves began to break the wilderness, people

would pay. He asked if it could be built. Parrott said it certainly could, and the work began. The first plan was to find a way across the Everglades to Cape Sable. Engineers spent several desperate months at this, but finally gave it up as impossible. The surveying parties turned then to the labyrinthine keys, and, after all sorts of difficulties—it would have saved weeks of time, they say now, if the aeroplane had been in its present stage of development—they finally selected forty-one across which to run the road.

### The Engineers

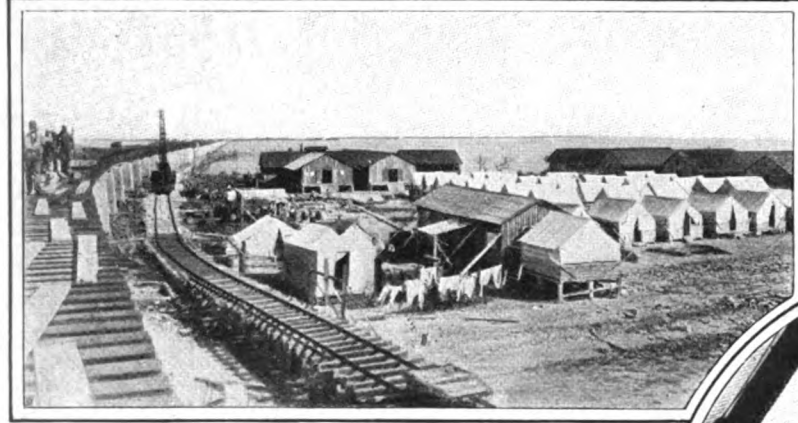
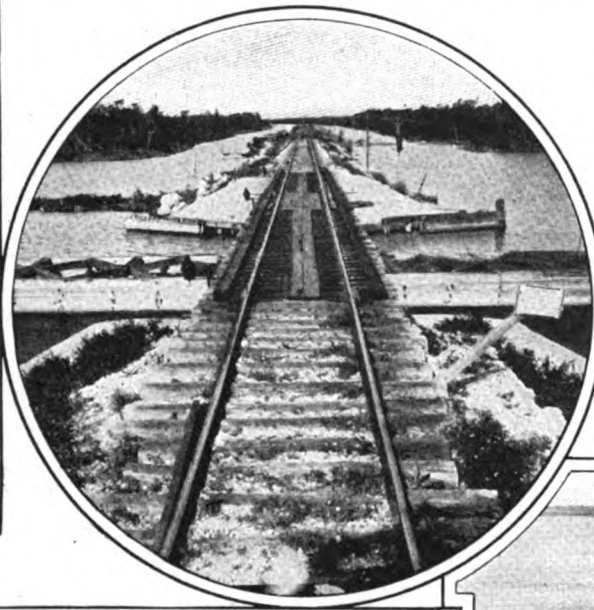
**T**HAT was in 1905. Mr. Flagler had already spent thirty millions in Florida and he was seventy-five years old. He is not a man who says much, nor one given to being conscious of his emotions—if he has any—but there is no doubt that he has been anxious to see this last impressive link in his chain completed and that this desire of his has spurred his faithful lieutenants on.

A constructing engineer, J. C. Meredith, was found over in Tampico, where he was building a pier for the Mexican Government. Meredith was a quiet little man who knew all about reënforced concrete. They expected him to ask a month to look over the ground—or, rather, water—and more time to make up his mind, but Meredith said that he was ready to begin that afternoon. Nevertheless, he did go home to Kansas City to say good-bye to his family and to pack up a few things, and then hurried back to his work—his last work as it turned out, for he died in service and was succeeded by William J. Krome.

It was not a simple job that he had tackled. Before even they got down to the keys and the ticklish business of figuring the effect of hurricane winds and waves, and building bridges and track to withstand them, there were the Everglades to cross. They put in dredges with enough water to float them, and made them eat their way toward the sea by throwing up the mud between them as they went. Meanwhile Parrott was assembling men and steamers and barges for the main attack on the keys. There were eighty tramp ships to carry crushed rock. There was another fleet for coal, and camps and a transportation system had to be arranged to care for five thousand men. It was hard to get men



Constructing Engineer W. J. Krome



A construction camp on Pigeon Key



Drillers preparing submerged key for blasting



Filling in the concrete arches with sand



A general view of

the Gulf. From Key West to Cape Sable, the nearest mainland, is sixty miles of open water. It is 150 miles to Miami on the east Florida coast at the other end of the keys.

### "A Web-Footed Proposition"

**T**HESSE keys are low reefs of coral or limestone, with the ocean between—sometimes so much of it that you cannot see across. White gulls wheel about in the sunshine above, the creepy gray shapes of sharks glide so close that you may sometimes see them from the shore. You are almost as much at sea as if you were on a raft, with the Bay of Florida and the Gulf stretching to the north and west, and to the south and east the Atlantic, and at night the flashing lights of Alligator Reef, Sombrero Key, and American Shoal. And it is out across these keys and the water between them, for 128 miles from land solid enough to be called mainland, that the Key West Extension has been built.

Seventy-five miles of it have been built over water, more than seventeen of which could properly be called the sea itself. Between the nearest key and the mainland was another seventeen miles, here of marsh, through which steam dredges had to wallow slowly, digging their own channel and piling up a railroad embankment as they went. Many of the keys were merely ledges of swamp just above the surface of the ocean, and over these dredges had to waddle, too—all in all, forty-nine miles were dredge work. The rest of the construction, if not unusual in itself, was made so by the character of its surroundings. Hurricanes had to be reckoned with and to be met. Four of them have swept the work, the famous one of 1906 costing the lives of 130 men. The laborers' camps have been floating camps; fresh water had all to be brought in tanks from the mainland; in short, it was "a web-footed proposition from start

Pacific through to the coast was enthusiastic about railroads in Cuba, and Mr. Flagler saw the importance of Key West as a link in such a scheme. It was not a case of making money, however—the idea appealed to him; it seemed the logical climax of his work in Florida, and he determined to put it through. He called in Mr. Parrott—Joseph R. Parrott, once a famous Yale oarsman and, since 1885, in charge of Flagler's Florida interests—his viceroy, so to speak, along the east coast. Parrott was a bronzed, square-jawed man who had had as many as fourteen thousand men on his payrolls at one time, and was used to big things. Flagler did not ask him of the extension

Heat, mosquitoes, and the company's rule that there should be no whisky in the laborers' quarters were not enticing. As Key West and Miami were too far away to be reached on foot, the bosses were able to enforce this rule, although "booze boats" skulked about the keys like the smugglers that have so often haunted them, and took their chance of being handled with as little ceremony as actual pirates if they were caught. Some Spaniards and men from the Cayman Islands have been used—and very steady workmen they have made—and now and then a Norwegian, although the latter generally wouldn't stay long unless they were made foremen, but the bulk of the men were



Temporary trestle



# Railway to Key West

From the Island to the Florida Mainland

By ROCKWELL  
and HES. H. HARE



Mr. Flagler

The work, however, stood, and as soon as the sea was calm the line began to crawl southwestward again. Some of the reefs were far enough out of water and solid enough that their coral and limestone could be blasted and piled up as in ordinary railroad construction. Some of the shallow open water stretches were bridged by suction dredges, and these ramparts, rippapped with rock. Between Lower and Upper Metacombe Keys there was four miles of open water. This was shallow, and a trestle was sufficient, to be filled in solid later on. At Long Key, about fifty miles out, there was a more difficult gap, and here a solid reinforced concrete viaduct had to be built. For more than two miles it stretches across the blue waters—180 massive arches, with no land in sight except the narrow keys.

One of the reasons for this cement construction was what has been alliteratively spoken of as Mr. Flagler's "passion for permanence." And, of course, there is this practical advantage that cement carries almost no charges for upkeep, while steel must be kept painted and replaced after fifteen or twenty years.

### Viaducts of Concrete

THE building of these concrete viaducts was, naturally, one of the most interest-

shipped down from New York and Philadelphia—derelicts and "hoboes," who got away as soon as they were paid and drank up their earnings. Although less than four thousand men was the average number employed on the work, twenty thousand were carried down to the keys in the first three years.

### The Great Hurricane

THEN, in October, 1906, came the great hurricane. Many of the laborers were living in huge barges with two-story superstructures, which were towed from key to key as the work advanced. One of these was torn from its moorings at Long Key, with 145 poor fellows aboard, driven out across the Hawk Channel, and smashed on Florida Reef. Eighty-seven of these men were picked up, clinging to bits of wreckage. The Italian steamer *Jenny* and the British steamer *Allen* picked up many others, and for days and weeks after, the news of other rescued castaways kept coming from distant ports, as far away, even, as London and Buenos Aires.

concrete. The longest section, that across Moser Channel, is 13,947 feet, well over two miles. There are ten other gaps after Knight's Key—one the Bahia Honda Bridge, nearly a mile long, and another, the Boca Chica Viaduct, half a mile long, but most of the remainder are shorter than this.

The peculiar difficulties of this web-footed construction developed new schemes of construction in several places. Previous to the 1909 hurricane, the roadbed north of Knight's Key was protected at exposed points by a heavy riprap of rock. This is the usual way of building an embankment, to put the comparatively soft material on the inside and then riprap it with rock. It was found, however, that the receding waves during storms sucked the comparatively steep riprap awry, and the usual plan was, therefore, reversed.

The rock was put in first and then protected by a heavy layer of marine marl dredged from deep deposits near by. This material, when first applied, was in the form of a very soft mud, and gave the embankment a long, flat slope. It hardened on exposure, into a solid homogeneous mass, which is very resistant to wave action.

Another novelty was a gasoline-engine dredge which Engineer Meredith evolved when he found it impossible to use ordinary dredges because of the difficulty of getting coal and fresh water. It was in the keys west of Bahia Honda—many of them so low as to be mere swamps covered with mangrove—that these dredges were first tried. They were set up on barges, and the latter waddled across the key when there was enough water to float them, and when there wasn't, they were hauled out, mounted on wheels, slid on to a steel track, and so continued their work.

The providing of Looking down upon the road

Key Bridge, Pigeon Key and Moser Channel Bridges, and Pacet Channel Viaduct. The first three are concrete piers with steel girdle spans laid on top to carry the track. The fourth is composed of arches of unreinforced

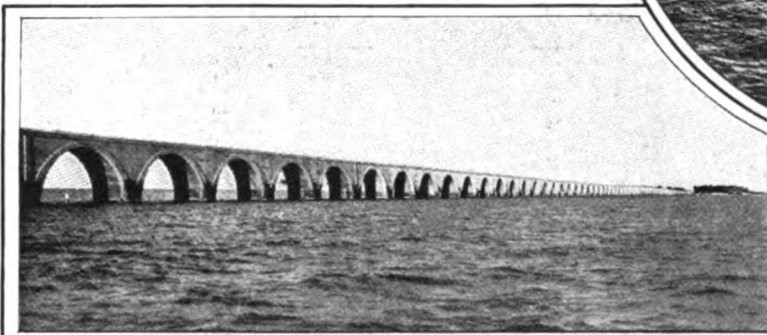
The plans for construction at Key West include one large dry-dock and ten wharves, each 800 feet long and 100 feet wide, with basins 200 feet wide between, in which the depth of water will be from 20 to 40 feet. The piers will afford berths for 40 vessels averaging 400 feet long.

It has often been said that the Flagler enterprises practically gave Florida 1,300 miles of new coast line. The value of the taxable property in the counties exclusively reached by the Flagler roads is said to have increased over fifty millions since he began, and only a small fraction of the land available for the cultivation of fruit and vegetables on the east coast is now under cultivation—25,000 acres, perhaps, out of 3,500,000.

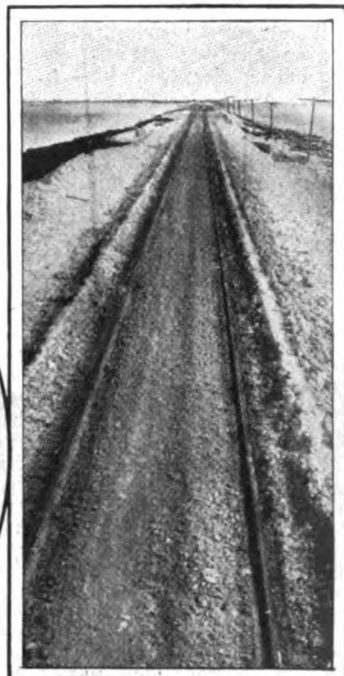
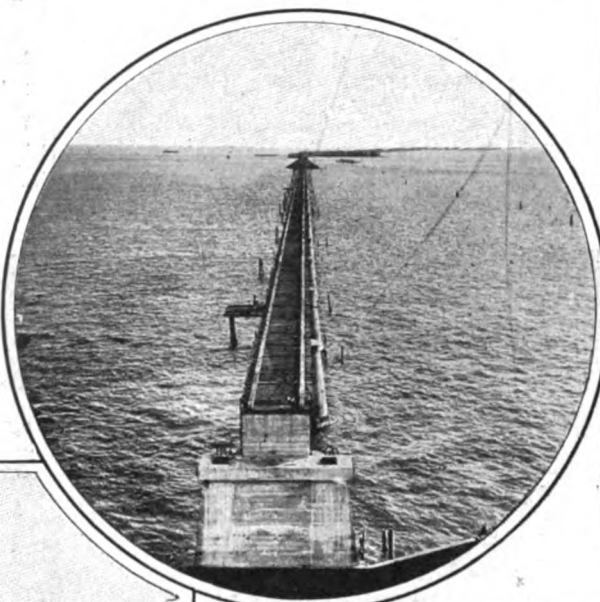
### The Industrial Side

IN 1897 the railroad moved 76,000 crates of vegetables; in 1909 about 1,500,000 crates of tomatoes alone; 150,000 barrels of Irish potatoes from one station alone; 700,000 crates of pineapples, besides other fruit and vegetables. The road earned, gross, \$819,000 in 1907 and over \$3,000,000 in 1908. Over 1,000,000 passengers were carried in 1908.

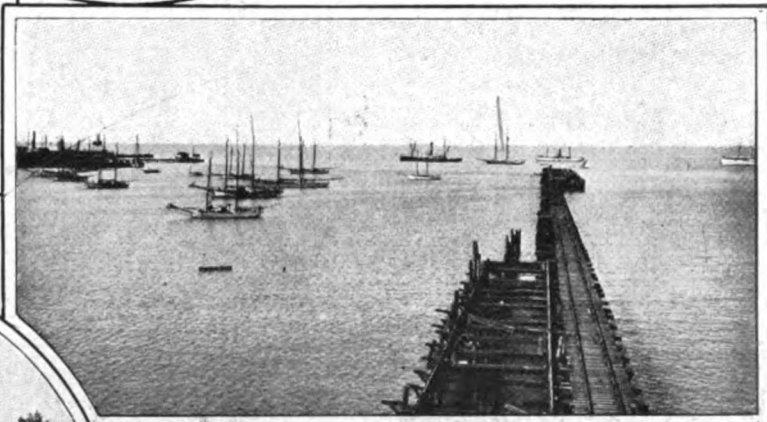
Steamship service was opened with Nassau in 1895 by the Florida East Coast Steamship Company, owned by Flagler. In 1896 the Key West line was opened and, in the winter of that year, operation was extended to the Havana line. There is now a daily service. In 1902 the Florida East Coast Steamship Company was consolidated with the Plant Steamship Company—Flagler owning one-half the stock. There is foundation for



Part of the new two-mile Long Key viaduct



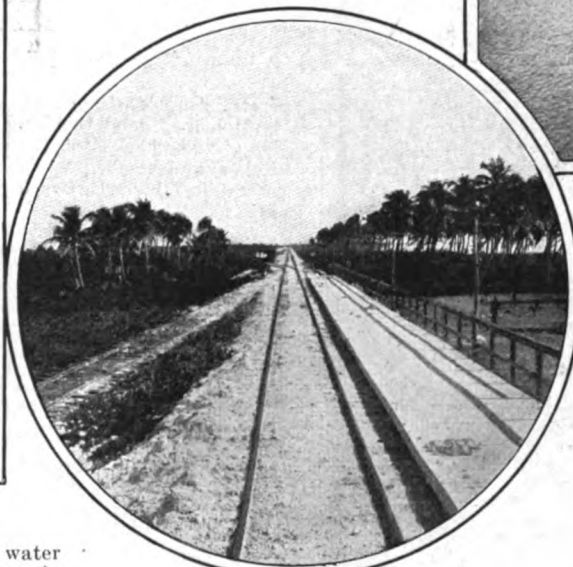
The roadbed across Jewfish Creek



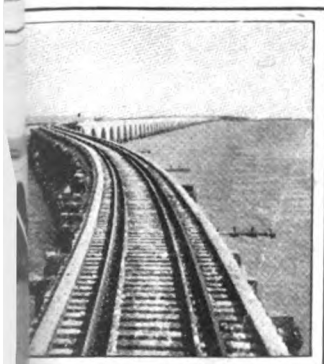
The end of the road at Key West



The city of Key West



On Long Key, approaching the viaduct



Until viaduct is finished

ing phases of the work. The water was from ten to thirty feet deep in most places and exposed to the full gales of the Atlantic, and at times the concrete had to be mixed in barges and placed in position by powerful boom derricks. In other places molds were formed by driving piling which held water-tight framework in place, or caissons were sunk or cofferdams built.

Between Knight's Key, whence steamers have been running to Havana for several years, and Bahia Honda there is seven miles of almost unbroken open water. Roughly speaking, it is one long bridge, 35,815 feet in length, although it is divided into four sections—the original Knight's

proper terminals at Key West was in itself a large piece of work. There was no place for deep-water terminals along the water front, so enough mud was dredged up from the shallows to cover 200 acres with it.

### The Key West Terminus

WHEN the Navy Department protested that maybe it might want some mud some day to fill in one of the nearby keys for a torpedo station, and that if the railroad dredges kept on they might sweep Key West Harbor clean, Mr. Parrott amiably replied that if the Government should find itself so embarrassed, he would put the mud back where it got it.

the jest that on the east coast "Fla." stands for Flagler. The extension, while it can scarcely be said to have continued this coast line, at least creates a new "farthest south" point for the United States, and brings into the bright, critical light of civilization a queer corner of our country which long has shifted peculiarly by itself.

It is along these keys that the Florida wreckers have hovered, to pounce like buzzards on a lost ship as soon as it was deserted by its crew—here, indeed, they have waited after arranging with some ship's master to run his vessel ashore. The keys have hidden all sorts of queer people from the inquisitive—smugglers and revolutionists, perhaps some strange renegade as anxious that the world should forget him as was he to forget the world.

And now their strange inhabitants, their white and shimmering silences broken only the cries of gulls and the long roll of blue waves breaking on the coral rock, are to know the shriek of the locomotive and the roar of passing trains.

Fruits fresh from the Cuban plantations—there must be some things in Cuba that Florida doesn't grow—will doubtless be hurried across the keys on their way to northern markets. Passengers southbound, to Havana, to Panama, to transact the business that some day we shall be doing with the west coast of South America, will, unless time is no object, come this way. Florida, known only for its climate and fruit and alligators and turtles, will then, perhaps, be shipping to Peru and Chile the products of its mills. The novelists will have to move over to the West Indian islands or across the Caribbean to find homes for their smugglers, absconding cashiers, and the lone lovely daughter of the irascible, civilization-hating hermit. The whistle of the locomotive will be heard in the land and another queer corner of the earth put on the civilized map.

more luxurious than first-class on the older boats.

In the trials of the *France* an average speed of 25 knots was maintained for twenty-four hours, which exceeded all expectations. With the exception of the *Mauretania* and *Lusi-*

*tania* of the Cunard line, the *France* is the fastest steamship in the world. At this speed the engines developed 47,000 horse-power, and yet the coal consumption was one-tenth less than the amount estimated previous to the trials.

## THE FLORIDA EAST COAST RAILWAY

DETAILS IN THE CONSTRUCTION OF THE OVER-SEA ROUTE TO KEY WEST

*Frank M. Patterson—Railway Age Gazette*

**T**HE inauguration of traffic over the entire extension of the Florida East Coast Railway to Key West on January 22nd of this year effected the realization of the plans long held by Mr. H. M. Flagler, the promoter of the road. With the purchase of a small railway extending from Jacksonville to St. Augustine, in 1885, Mr. Flagler became impressed with the opportunities for agricultural development in southern Florida, and eventually, by purchase and construction, extended his holdings until in 1896 the Florida East Coast Railway entered Miami, on Biscayne Bay, 366 miles south of Jacksonville.

The growing importance of trade with Cuba, after the Spanish war, and the certainty of the construction of the Panama canal led to the determination to extend the railway to some point where more satisfactory harbor facilities could be obtained. With this intent surveys were made through the Everglades to Cape Sable, the most southerly point on the mainland. After thorough investigation, however, this route was rejected, and it was decided in 1904 to build to Key West, a distance of 128 miles, of which about 22 miles was on the mainland and the remainder across the string of keys which

fringe the coast and extend to deep water at Key West.

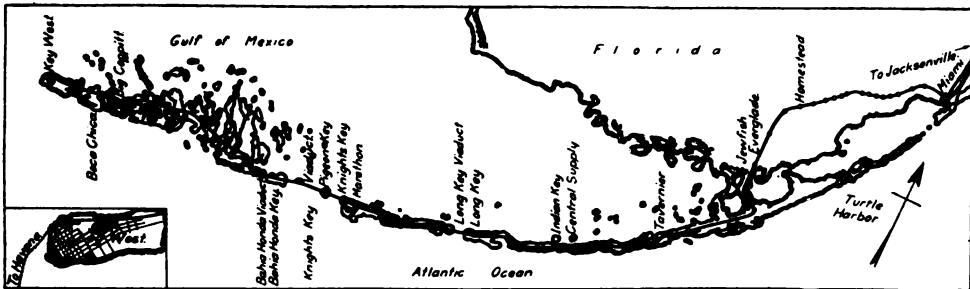
As far as Knight's Key the islands are admirably situated for the location of the railway, affording good alignment and necessitating comparatively little bridging, the longest stretch of water being at the lower end of Long Key where a concrete viaduct two miles in length was built. Immediately below Knight's Key is a stretch of water seven miles wide ranging in depth from 18 to 22 feet. A few miles further on Bahia Honda is encountered, where a bridge 5,100 feet long is required, in water whose greatest depth is 30 feet. The three structures just referred to, together with a concrete arch bridge, 2,573 feet long at Boca Chica, a few miles north of Key West, were the principal bridges as originally planned, although later it was found necessary to provide additional arch structures.

From the nature of the work practically all of the outfit used on the original construction was floating equipment and this included a number of Mississippi river steamboats of the stern-wheel type, which proved most efficient for the transportation of material and supplies in the shallower waters, owing to their light draft. All material and

supplies, including water for domestic and boiler use, had to be brought from the mainland. Material for concrete was shipped by steamer from northern points, trap rock being brought from the Hudson river, sand from Baltimore and American Portland cement from New York. German Portland cement was used in all concrete below high tide, being delivered by tramp steamers at the nearest available harbor.

On the keys proper most of the grading was done by hand labor. The material is coralline rock with little or no overburden of dirt. This rock is light and easily worked and

and sunk. Piles were then driven into the rock to refusal, the average penetration being 12 to 14 feet. The purpose of the piling was three fold: first, to afford foundation should any erosion of the rock occur; second, to act as an anchor against any tendency to overturning or lateral displacement; and third, to act as an exploratory probe. It happened several times that cavities in the rock were encountered that had been missed by the sounding outfits. After the piles were driven a footing course of concrete from 3 to 5 feet in depth was deposited by tremie and allowed to set, forming a seal. The cofferdam was then unwatered, the



KEY WEST EXTENSION OF THE FLORIDA EAST COAST RAILWAY

the quantities per mile averaged small. Where the embankments were too high to be built economically by hand labor the excavators were taken from their scows and placed on the embankment, moving forward on rollers as they completed the work ahead of them.

The Long Key viaduct is the longest structure of the arch type on the line and is a notable piece of work, consisting of 180 semi-circular arches of 50 feet span, the track being at an elevation of 30 feet above high tide. The method of construction used here has been followed on all similar work and a description of it will serve for all.

The location of piers having been established the sand was removed from the rock bottom by dredging and a cofferdam floated into place

piling cut off to a point well below low tide and forms erected for the piers. After the piers were completed to the springing line false work for the arch forms was driven and the forms put in place. To avoid expansion cracks the arches were put in alternately, the concreting being done by mixers and derricks on scows.

Below Knight's Key the rock changes from coralline to a highly fossiliferous sedimentary limestone, and it was found possible to use it for concrete, thereby effecting a saving in the cost of concrete of from \$3 to \$5 per cubic yard. The rock is blasted in shallow water and loaded by orange peel dredges. When blasted it breaks up into small sized pieces with enough fine stuff so that it can ordinarily be used as it comes

from the dredge without the addition of sand, or any sorting other than the removal of occasional large chunks.

Knight's Key bridge consists of 316 deck girders of 80-foot span and 19 deck girders of 59-foot 9-inch span, with 210 arches of 35-foot span at the southerly end where

bright yellow color corrosion is quickly detected. The ordinary galvanized telegraph wire rusts through in two years or less, and it even has been necessary to paint the track rails with a coating prepared by the Cunningham formula, consisting of one part kerosene, four parts Portland cement and 16 parts refined



LONG KEY VIADUCT OF CONCRETE—2.7 MILES LONG

shallower water is found, and a 253-foot 6-inch through-truss drawspan over Moser channel, the draw being operated by a gasoline engine.

Bahia Honda bridge consists of 13 spans of 128½ feet, 13 spans of 186 feet, 1 span of 247½ feet, and 9 80-foot plate girders. The decks of the steel bridges are of the ordinary type fastened with hook bolts.

The protection of the steel spans from rust is one of the hardest problems facing the railway. In the warm, moist, salty air corrosion begins in an almost incredibly short time, and no paint has been obtained that can be considered wholly satisfactory. Near the constructing engineer's office at Marathon a test rack is located in which are placed test plates coated with different paints, and so far none has been found that will afford protection for two years. The railway company's standard paint has proved about as efficient as any and on account of its

coal tar, the cement and kerosene being first mixed and then stirred into the heated tar. The concrete arch bridge at Boca Chica, four miles north of Key West, is the last important bridge on the extension, having 83 arches of 25-foot span.

The effect of sea water on the concrete has been closely watched, both in the actual structures and on test cubes exposed for observation, and so far there is no reason to believe that any serious deterioration will take place. Shortly after being exposed to the water it is found that a scaling off occurs to a depth of about one-sixteenth inch on the part of the concrete between the limits of high and low tide which amounts only to about 18 inches. After the scaling off has taken place a marine growth forms on the parts exposed to the water and seems to protect the concrete from further damage.

After surveys had been completed and plans made for the construction



of the extension it was thought that the bridges already referred to would be all that would be necessary and that solid embankments could be made from key to key in other places. However, there was one factor that had not been considered which has probably never been encountered in previous work of this kind. This is the impounding of the waters of the gulf by hurricanes in that pocket between the railway and the mainland known as the Bay of Florida. The hurricane of 1906, while very severe, came upon the work before those waterways had been closed, and it was not until the storms of 1909 and 1910 that their effects could be noted and studied in this connection. Under the stress of these storms continuing for several days from the south and west it was discovered that the water was banked up in the bay until it overtopped the embankments, and swept them away. It was also noted that the embankments across the water, even in the shallowest places, were the first to go, and that when they were gone the water rapidly subsided. This led to the decision to build arches, varying from 16 to 25 foot spans, across these stretches, the length required amounting to a total of between five and six miles.

From an operating standpoint the extension is in surprisingly good physical condition when one stops to

consider that in February, 1911, orders were given to have the line ready for traffic to Key West in January, 1912, instead of a year later, as had been the intention. The track is laid with 70-pound rail, well tied, with tie plates on all curves. The grade is practically level at a minimum elevation of about 10 feet above sea level except at Long Key, Knight's Key and Bahia Honda bridges where it is at a 30-foot elevation. On the bridges referred to speed is restricted to 15 miles per hour, to minimize the danger of derailment. For additional safety the despatcher's office is kept fully informed as to storm warnings and no train is allowed to proceed to exposed places when a hurricane is impending. Fortunately, severe storms are unusual except during the hurricane season.

Train service as scheduled provides two passenger trains and three freight trains each way daily except Sunday. One of the passenger trains is the "Oversea Limited," a solid Pullman train running between New York and Key West during the tourist season, and the other is a local from Jacksonville. The freight trains consist of one through freight one way freight and one water train, the water for the entire extension being hauled from Everglade on the main land where a pumping plant and storage tanks are maintained.

## "WIRED WIRELESS" FOR MILITARY PURPOSES

A COMBINATION OF WIRED AND WIRELESS TELEGRAPHY IN FIELD SERVICE

*Major George O. Squier—Journal Franklin Institute*

PURE radio-communication is ideal for rapidly moving troops, but has the inherent defect that interference is always possible, and the information may un-

der certain conditions be received by the enemy. Radio methods and field wire methods, however, have taken their places as permanent means of electrical communication in war, and



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## ENGINEERING ASSOCIATION OF THE SOUTH.

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### PAPERS.\*

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

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### KEY WEST EXTENSION OF THE FLORIDA EAST COAST RAILWAY.

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BY L. M. THACHER.  
MEMBER OF THE ASSOCIATION.

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Presented April 18, 1911.

The main line of the Florida East Coast Railway, at the time of the projection of the Key West Extension, extended from Jacksonville, on the north, to Miami, on the south—a distance of 364 miles. The whole property, including several branch lines and a large number of hotels on the east coast of Florida, is owned and controlled by Henry M. Flagler, sometimes called the “King of Florida,” a multimillionaire, connected with the Standard Oil interests. From Miami a line of steamboats is operated to Key West and Havana, Cuba. By boat the distance from Miami to Key West is 165 miles, and from Miami to Havana 240 miles, while from Key West to Havana is 90 miles. Recognizing the importance and volume of Cuban travel, as well as the future freight-carrying outlook in connection with the Panama Canal traf-

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\*Written discussion of papers is desired. Such discussion will be submitted to the Association at its next meeting, and will be published in the next quarterly and (with the paper) in the Transactions.—EDITOR.

fic, Mr. Flagler planned an extension of his railroad from Miami to some point where a deep, roomy harbor would accommodate ships drawing more water than could be accommodated at Miami. Since the Spanish-American War, Cuba has experienced a tremendous commercial development, as well as becoming a very popular winter resort. These facts probably decided Mr. Flagler in his extension from Miami to Key West.

**General Description.**

The extension follows the mainland of Florida for about 30 miles to Homestead. From this point it crosses Jew Fish Creek to Key Largo, the largest of the coral islands utilized. From Key Largo the extension runs in a southwesterly direction, crossing about thirty other keys in its course to Key West, as well as the water intervening between the keys. From Homestead to Key West by the located line it is 126 miles, and on only 65 miles of this distance is the roadbed on a natural foundation, so that nearly half of the distance is through water from 10 to 30 feet deep, subject to ocean currents and the effects of storms, etc.

Rock and earth embankments are built where the water is shallow; but where it is deeper and the openings more exposed to storms by breaks in the outer reefs, the concrete arch viaduct construction is used. In the embankments through the water there are a number of 25-foot openings to permit the passage of small craft, and at three important channels drawbridges are put in to pass larger vessels.

The construction of the concrete arch viaducts was the most difficult part of the work. There are four of these, aggregating 5.78 miles, as follows:

Long Key to Conch Key.....	10,500 feet
Across Knights Key Channel.....	7,300 feet
Across Moser Key Channel.....	7,800 feet
Across Bahia Honda Channel.....	4,950 feet
Total .....	30,550 feet

The entire work is second only to the Panama Canal in importance and the novel and difficult problems overcome.

### **The Location.**

The writer is not so familiar with the locating problem as with the construction, having been connected only with the latter. He is of the opinion that the greater part, if not the whole, of the preliminary surveys were made under the direction of Mr. William J. Krome, afterwards principal assistant engineer on construction, and at present constructing engineer. He became acquainted with a large number of engineers who were on the location work, and, judging from their description, the difficulties rivaled those encountered in the western portion of our country.

The Keys are really coral islands, rising, for the most part, but a few feet above the water level, Lower Matecombe Key, where the writer was located for a time, having its highest point 6.1 feet above mean low water. They are covered with a thick tropical growth of mangroves, gumbo, limbo, plum, cocconut, and a great variety of cacti and ferns. The inhabited Keys, like Largo and Upper Matecombe, grow oranges, grape fruit, bananas, pineapples, etc. In order to run a line on any of the Keys, it was necessary to do a large amount of cutting and clearing through the jungles so thick that a man could make his way through with great difficulty, if at all. Mosquitoes in swarms pestered the field parties, so that early in the morning or toward night it was simply impossible to work. Not the least interesting part of the locating work, at any rate to a landsman, was the obtaining of hydrographic data, soundings being taken over every foot of the line in the water intervals between the Keys, and to a considerable distance to the right and left. Stationing was carried from Key to Key by means of triangulation. The maximum curves are 2 degrees, and the maximum grades 0.2%. Subgrade on the Keys was at an elevation of 7.1 feet above

M. L. W.; at the drawbridges, 14.1 feet; and the tops of the arches in the viaduct work, 30 feet.

### **Construction.**

Before the work of construction was started, contractors were asked to submit bids, and some of the largest contractors in the country went over the work; but it was so entirely novel, the difficulties so great, that none were willing to submit bids, so it was determined to do the work by day labor.

### **Organization.**

The entire work of construction was under the direction of Mr. J. C. Meridith, with the title of constructing engineer, and headquarters at Miami. At headquarters were located the office engineer, bridge engineer, a corps of designers and draughtsmen, the storekeeper, the head steward, the paymaster, superintendent of docks and boats, and a large force of bookkeepers and clerks. In the field the principal assistant engineer directed the work, using a launch on which he lived, except when at headquarters. The general foreman took the place ordinarily filled by the contractor, and all head foremen, captains of dredges, excavators, pile drivers, etc., were directed by him. One division engineer handled from three to six residencies, and was allowed a launch to cover the work and get from Key to Key. The resident engineers had charge of from five to ten miles of work, usually on one Key, though sometimes two, or a stretch of waterwork between. His force consisted of an assistant resident, who acted as transitman, a levelman, two rodmen, head timekeeper with an assistant, and a steward, who looked after all subsistence. Each residency or camp had also a head foreman and as many gang foremen as necessary. Often a man above the ordinary in intelligence was taken from the gangs and made foreman. The head foreman had direction of the gang foremen and laborers, much as a contractor or his superintendent would, though he was under the direction of the resident engineer.

**Labor.**

As many camps as possible were opened with negro labor; but the supply was short, and recourse was had to white labor from the North and obtained mostly at New York and Philadelphia. Some 10,000 men were obtained in this way, though not more than 5,000 or 6,000 were at work at any one time. A great deal of care was taken in the selection of these men by the agents, but in spite of this a great many poor and worthless hands were obtained. Transportation was furnished each man, which was charged against him, and he was allowed to pay it back in small installments at his convenience. This labor was made up of all classes, from the clerk out of work to the worthless bum who did not intend to work, and even criminals. Those who came with the idea of escaping the cold weather North and living in a climate where the sunny skies would afford them all kinds of tropical fruits, without the trouble of working for them, were, of course, disappointed. These disgruntled men wrote to the Northern papers all sorts of harrowing tales regarding their hardships under cruel and remorseless taskmasters—how they were hounded by foremen with guns and driven to work under the lash. As a matter of fact, it is very doubtful if in the whole lot any one was ill treated, at least none within the writer's knowledge. Of course the men were more isolated and cut off from civilization than miners in the Black Hills of Dakota fifty years ago, as most of the Keys are out of sight of the mainland, with no way to reach it except by the boats of the company. The men had tents furnished them, and good, substantial food at a nominal cost, or they could board themselves from the commissary, as they chose. For any who really desired to make money and save it the situation was admirable, as there was absolutely no way to spend it, except by going to Miami or Key West.

### **Method of Handling the Work.**

In order to appreciate the extreme difficulty encountered in handling the work of construction, it is only necessary to know that every man, tool, machine, materials, provisions, and even water for cooking and drinking, had to be transported from Miami by boat. All of this traffic was handled by a fleet of Mississippi River steamboats, constructed to run on a heavy dew, as the jokers have it; and they needed to operate in very shallow water, for the route used was on the inside of the Keys. Leaving Miami, it crossed Biscayne Bay, Card Sound, Barnes Sound, Blackwater Bay, and the Bay of Florida until Bahia Honda was reached, where the route is outside the Keys, following what is known as "Hawk Channel" to Key West. To one taking this trip for the first time the views both above and below the water are indescribably beautiful, the water being almost as clear and transparent as the air.

The camps were selected in the most suitable places on the various Keys as regards boat landings and convenience for the work. Clearings were first made of the camp site and a rough dock or landing place constructed, at which the steamers could tie up and unload. Everything connected with this work carried one back to the primitive life, accompanied by the ideas connected with the opening up of a country entirely new.

At first houseboats were used to house and feed the engineers and foremen. Later portable buildings were used for the purpose, located on the Keys. As previously noted, tents were erected for the housing of the men, for cooking and serving food, etc. The commissary privileges were let to Miami parties, and each camp provided with a commissary building or tent and a commissary clerk to handle matters connected therewith. The engineers' and foremen's salaries included subsistence. The men were boarded at the company eating tent at a nominal cost, or they could provision themselves out of the commissary. The larger number chose the former, and most of those who complained about the qual-

ity of the food were the ones who seldom had a square meal when on their native heath.

At first the clearing and grading was done entirely by gangs at day wages. Later a part of this work was let by the station to some of the more enterprising of the men who desired to take a chance, and nearly all of them made several times as much as they would at day wages. The right of way was in most instances 100 feet wide, and the clearing was classified as follows: Extra heavy hammock, hammock, second-growth hammock, scrub, old field, black mangrove, red mangrove.

The grading on the land portion was largely in fill made from borrow pits on the right of way, though in a few places cuts were made. Nearly all of the Keys, however, lay below the established grade line. The larger portion of the borrow was in coral rock, though occasionally sand or shell was found, the sand being merely disintegrated coral rock. A peculiarity of this coral rock was that, though soft when first put in embankment, after a time it hardened like cement and afforded an excellent protection against wash. At one or two camps teams were used, but most of the material was handled with wheelbarrows.

Excavation was classified as follows:

First class .....	0 to 0.8	feet in depth
Second class .....	0.8 to 2.0	feet in depth
Third class .....	2.0 and over	feet in depth

Embankments:

First class .....	0 to 0.8	feet in depth
Second class .....	0.8 to 2.0	feet in depth
Third class .....	2.0 to 4.0	feet in depth
Fourth class .....	4.0 and over	feet in depth

At Camp No. 5, on Lower Matecombe Key, the average costs were as follows:



Grubbing, \$2.94 per station..	\$0.01	per cu. yd. of embankment
Drilling, 0.068 per foot.....	0.23	per cu. yd. of embankment
Blasting—		
Labor .....	0.030	per cu. yd. of embankment
Labor and materials.....	0.236	per cu. yd. of embankment
Dynamite, pounds .....	1.16	per cu. yd. of embankment
Grading .....	\$0.45	per cu. yd. of embankment
Total cost rock .....	0.936	per cu. yd. of embankment
Total cost sand .....	0.379	per cu. yd. of embankment

The above figures show average costs. It is to be noted that the costs were reduced slightly more than 50% as the work progressed and became more systematized. Camp No. 5, from which the above figures were taken, showed a larger reduction in costs than other camps on the entire work, as well as a lower total cost for the same class of work.

The embankments through low and swampy lands were made by clam or orange-peel dredges mounted on lighters, which floated in water in trenches they had dug, the lighter being hauled ahead and made fast with lines from the shore.

Between the Keys the water fills were made by suction dredges. Overlying the coral rock at the bottom or under the water is a layer of muck, marl, or shells from 1 to 10 feet in depth, except at the channels, where there was no such accumulation. This was the material pumped by the dredges and conducted by pipes to the desired location. No unusual difficulty was experienced in making these fills, apart from the channel portions, or until the fill approached the surface of the water, when a single storm would wash away the work of weeks and perhaps months.

Great difficulty was encountered at the channels or wherever the current was rapid. It is surprising what a swift movement of the water is created where the rise and fall of the tide is seldom over 2 feet and usually not exceeding 1¼ feet. The difficulty encountered in the wash was finally overcome by the use of sheet piling or similar devices. The slope

of these embankments was 2 to 1, riprapped to a depth of 36 inches on the seaward side and 12 inches on the bay side. Some of the stone for riprapping was moved to its place on lighters or barges, and some on a temporary track laid after the embankment was above water.

In addition to embankments put up by hand on the land work, some were handled in sand, by orange-peel excavators operated by gasoline engines, the whole outfit being moved on a temporary track on the fill which the excavator had made. With care these embankments made by excavator were kept to within a few inches of grade, so that very little dressing was required. Work was put up in this manner for from 6 to 8 cents per cubic yard.

Some fifteen camps were in operation at one time, each a unit by itself, and handling from 250 to 500 men each, so that the work was progressing on half the Keys at once. As fast as a camp completed its work at one Key it was moved to another.

On the grading work some eight steamers composed the fleet, besides any number of launches and small boats, with lighters and barges in great numbers. The steamers were kept busy moving men, transporting supplies for the subsistence of the camp and for the commissaries. To keep 5,000 or 6,000 men moving at the right time and well provisioned was in itself no small job, and the fleet was about the most important part of the work—at least we thought so who were isolated on the Keys—and the arrival of a boat with supplies and mail once or twice a week was an event greater by far than train time in a country village.

At the same time that the land grading was being carried on the same was true of the water work, or embankments between the Keys. An engineer, with a rodman or two, was assigned to each dredge, whose duty it was to look after grade, line, and reports.

All dredge work was under the direction of a superintend-

ent of dredges, and this part of the work was separate and distinct from the land work.

Speaking generally, this was the order of construction: Grading land work, grading water work, abutment and bridge work, docks, and, finally, concrete arch work.

### **Reports.**

The system of reports was most complete, and occupied a large part of the engineers' time. They were on the land work as follows:

1. Labor report, showing for each day of the week the total number of laborers in camp; days shown for day gang in weekly distribution; number of contractors and contractors' helpers; number of sick in camp; hours of rain; number of engineers, including instrument and rodmen; number of foremen; number on camp subsistence; and all other salaried employees.

2. Weekly cost report, showing the number of the report, the date, section, and camp; location of work by station; acres of clearing completed during week; class and cost; foremen or contractor; grubbing, cost; drilling, number of holes, total depth, and cost; blasting, pounds of dynamite, number of exploders, number of caps, feet of fuse and cost; grading, cubic yards of excavation, cubic yards of embankment, cost, foremen, and class.

3. Monthly cost report. This was a summary of the weekly reports under the same headings.

4. Cost of finished-work reports, showing number of report, date, section, and camp; station, clearing, acres in completed station, foremen or contractor; grubbing, cost per station; drilling, number of holes, total depth, and cost per lineal foot; blasting, pounds of dynamite, number of exploders, number of caps, feet of fuse, cost of labor, and cost per cubic yard of blasted material; grading, cubic yards of excavation, cubic yards of embankment, cost per cubic yard, foremen, and class.

These reports were called for by the principal assistant en-

gineer, who made the trip over the line from Miami to Key West each week.

#### **Medical Attention—Health.**

Each camp dredge or houseboat, as the case might be, was provided with a very complete supply of medicines, bandages, etc., to be used as a sort of first aid. The one or two men found most capable for the work did the doctoring for the camp. The company physician made the rounds of the camps once a month, or oftener if necessary. Any patients who could not be properly treated in camp were sent to the well-provided company hospital in Miami and cared for without charge. As a whole, there was very little sickness, and the health of all the men on the Keys was remarkable in that almost tropical climate. Bathing in the salt water could be indulged in every day of the year, so that there was no excuse for uncleanliness. No fresh water was allowed for bathing purposes, and a good fresh-water bath on reaching civilization was a luxury indeed.

#### **General Remarks.**

How little fresh water is absolutely required for cooking and drinking is shown by a record of water consumption kept by the writer at Camp No. 5. This record shows an average of 2.52 gallons per man per day, as compared with the average of American cities for domestic use alone of 20 gallons, and for total uses from 50 to 75 gallons per day. It makes a great difference, however, whether the water can be drawn from a faucet in kitchen or bathroom, or whether it has to be "toted" from 50 to 75 miles by boat.

The day in camp was begun with rising at 5 A.M.; breakfast, 5:30 A.M.; work, 6 to 11 A.M.; noon hour, 11 A.M. to 12 M.; work, 12 M. to 5 P.M. The food provided was at all times good and substantial, with turkey dinners on holidays for the engineers' mess. Occasionally the supply or the variety would run short through lack of arrival of the supply boat,

though this was almost always due to the steward not getting his requisition in on time. We had the greatest difficulty in making the ice last from one boat to another. This was remedied later by the use of refrigerators built on the barges, which the supply boats towed.

One of the greatest treats on the Keys was the supply of fresh fish, which greatly helped out the larder. These were bought in lots of from 300 to 500 pounds at 3 cents per pound live, and kept in crates submerged in the water. The fishing boats are all provided with a compartment in which the sea water has free access and in which the fish are placed as soon as caught.

The temperature on the Keys is not so oppressive as one would expect and there is a breeze most of the time, which helps out wonderfully. During the year the temperature rarely goes below 60 degrees F. in the winter or above 95 degrees F. in the summer in the shade. The writer found it very comfortable the year round. None of us were, however, burdened with any superfluous clothing, pajamas being a favorite costume for night and day.

Mosquitoes and booze boats were the greatest pest—the former night and morning, and the latter all the time. It was absolutely necessary to keep all liquor out of the camps, and, on the whole, we succeeded very well. Now and then some would be smuggled in, and the writer had several personal experiences in quieting disturbances arising from too much Cuban “arguident.”

The total estimated cost of the extension is \$12,000,000, or, in round numbers, \$95,000 per mile. Construction began in the fall of 1905, and it was expected that three years would complete the work. Many difficulties have been encountered, however; and it is now nearly twice that time, and the work is not fully completed, though trains have been operating for some time to Knights Key (25 miles from Key West), at which point a large dock has been constructed, from which steamers operate regularly to Havana.

Extensive docks and terminals are planned for Key West. This includes one large dry dock and ten wharves, each 800 feet long and 100 feet wide, with basins 200 feet wide between. Depth of water, from 20 to 40 feet. With these harbor facilities, Key West will rank with New Orleans, Mobile, and Galveston as a commercial port.

Engineers who have dealt with big problems in railroad building have said that the Key West Extension was one of the most difficult feats undertaken by any transportation system in recent years, and, with the exception of the Panama Canal, the greatest in this country.

The mere idea of riding for 100 miles almost in contact with the water, while but a short distance away the foaming combers from the Atlantic Ocean can be seen from the car windows, is in itself sufficiently unique to attract many people to the land of sunshine and flowers.

# **Cassier's Magazine**

**An Engineering Monthly**

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**Volume XLI**  
**January—June, 1912**



## TO SEA BY RAIL

By M. B. Claussen



R. J. PARROTT, PRESIDENT, FLORIDA EAST COAST RAILWAY

AS a boy, the writer remembers a lady, the wife of a wealthy man whose business took him to Europe yearly, who had such a horror of the sea that she always said to persons who asked why she never crossed with her husband, she was waiting until a bridge was built across the ocean. If the destination of that lady had been Cuba, a sea trip which she, no doubt, would have dreaded as much as an ocean crossing, it would be about time for her to pack her trunk, now that the Key West extension of the Florida East Coast Railway is completed, as she could board a train in New York and step out of her car in Havana, Cuba, forty-eight hours later, traveling all the way, except the last 90 miles, by rail, the last 90 miles being made by ferry, which took the train itself through to Cuba.

This extension is built by using the Florida Keys as stepping stones and constructing on them and across the stretches of open water between them mile after mile of steel and concrete viaduct, until Key West and the last bit of land formed by the low reefs which curve round the lower end of Florida far out into the blue waters of the Gulf is reached.

This road has 46 miles of construction over the water, the foundations of which are from a few feet to 36 feet below mean low tide level. This unique railway, 156 miles in length, was started in 1905 and formally opened on January 22, 1912.

This notable engineering achievement had its birth in the mind of Mr. Henry M. Flagler, who has had the idea constantly in mind ever since the Spanish-American war excitement, when he conceived the proposi-



H. M. FLAGLER

tion of making traffic communication between the United States and Cuba more practical. To him it seemed that such an extension was the logical climax of his work in Florida. He fully saw the importance of Key West as a link in his system, and it appealed to him, not as a money-making plan, but as such a climax to his Florida development work.

In 1905, when the blue prints called for by Mr. Flagler were submitted to him by engineers, he glanced at them, turned to Mr. R. J. Parrott, vice-president and manager of his extensive railway system and his right-hand man in all his Florida undertakings, and asked, not if the extension would pay, but said:

"All I want to know is whether the road can be built."

"It can!" promptly replied Mr. Parrott.

"Then go ahead and build it," was Mr. Flagler's direction.

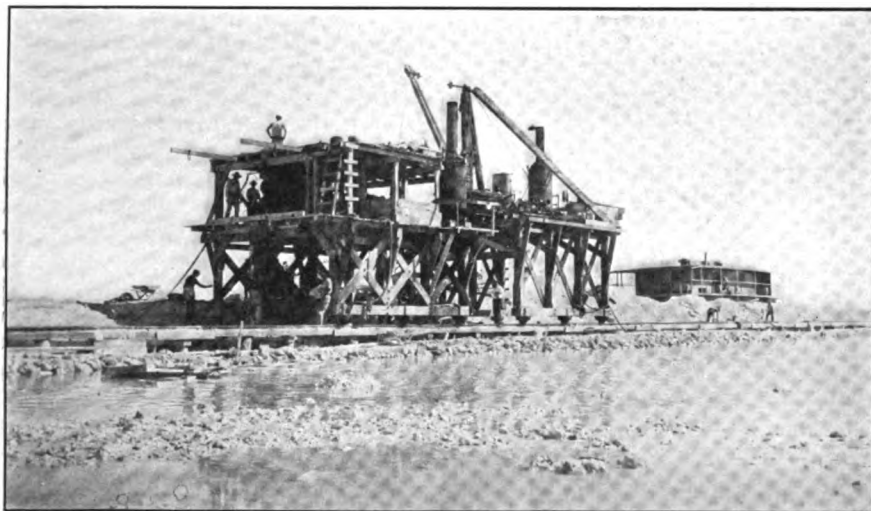
Mr. Parrott went ahead, and it has been his master hand that has guided this mammoth engineering work through all obstacles to its successful completion. Mr. Parrott was well fitted for such an undertaking. His boyhood was passed in the little town of Oxford, Me., and he was a born railroad man, though it was not until 1889 that circumstances proved him as such. Graduating from Yale, where he made a name for himself in the sports that require courage and endurance, and where he rowed in the crew from 1882 to 1885, he entered the profession of the law in Florida, and in 1888 he became counsel of the Jacksonville, Tampa & Key West Railroad. In 1889, when that road was merged with the Florida Southern, he was its general counsel, and in 1890, when the combined systems went into the hands of a receiver, Mr. Parrott was appointed receiver; and in the handling of the Florida Southern System Mr. Parrott gained his first experience as a practical railroad administrator. In June, 1892, he resigned his receivership and became vice-president and general counsel of the Flagler road. Since that date Mr. Parrott has been prominently identified with railroad extension and operation in Florida, and so well pleased was Mr. Flagler with the work of "that man Parrott" that he made him vice-president and general manager of all his vast Florida undertakings.

This was the man to whom was entrusted the organization of the construction forces for this railroad across the sea—no simple undertaking, and one which presented many unique features; for instance, the figuring of the effect of hurricane winds and waves on the bridges and tracks and the building of the latter to withstand them.

Mr. J. C. Meredith was selected for constructing engineer; and well he did his work, to which he showed such devotion that he died in service and was succeeded by William J. Krome.

Dredges were soon put to work, eating their way through the 17 miles of swamp between the mainland and the nearest Key and piling up a railroad embankment as they went. For 49 miles the dredge work continued, as many of the Keys were coral ledges just above the ocean's surface. The entire work, due to the charac-

Steadily the work progressed, however, now across reefs far enough above the water so that their coral and limestone could be blasted and piled up as in ordinary railroad construction, over shallow water bridged by suction dredges and their ramparts rip-rapped with rocks, through open water, a stretch of 4 miles by means of a trestle to be filled in later, by means of a solid reinforced cement viaduct of 186 massive arches stretching across the blue water for more than 2 miles, with no land save the many Keys in sight. These con-



TRAVELING CONCRETE MIXER FOR CONSTRUCTING VIADUCT ON THE FLORIDA EAST COAST RAILWAY

ter of its surroundings, was most unusual—in fact, it has been rightly called “A web-footed proposition from start to finish.”

Labour, too, was hard to get; men were not enticed by heat and mosquitoes and the company's rule, that there should be no whiskey in the labourers' quarters, which, owing to the distance of Key West and Miami, they were able to enforce. When it is said that though less than four thousand men was the average number employed in the work, twenty thousand were carried down to the Keys during the first three years, the difficulties of the labour problem will be understood.

crete viaducts are one of the most interesting portions of the work. They are built in water from 10 to 30 feet deep, which in most places is exposed to the full gales of the Atlantic. The concrete at times, after being mixed in barges, was placed in position by powerful boom derricks; again, molds were formed by driving piles to hold the water-tight framework in place. Sometimes caissons had to be sunk or cofferdams built, but steadily and permanently the line grew southward, practically jumping from Key to Key, as the longest stretch of track on any of the Keys is but 16 miles.

Seven miles of almost unbroken



LIGHTHOUSE ALONG THE KEYS

open water had to be crossed between Knight's Key and Bahia, Hunda. This was covered by bridges, divided into four sections, a total length of 35,815 feet. Three of these are concrete piers with steel girder spans, to carry the track, the fourth composed of arches of reinforced concrete. After this there were ten other gaps to be crossed, varying from a mile in length to shorter distances.

The viaduct at Long Key, nearly 7 miles long, used up 286,000 barrels

of cement, 177,000 yards of crumbled rock, 108,000 cubic yards of sand, 612,000 lineal feet of piling, 5,700 tons of reinforced rods and 2,600,000 feet of dressed lumber for arch forms.

The usual method of building a railroad embankment was reversed, the rocks being put in first and afterwards protected by a heavy layer of marine marl dredged from deep deposits nearby. The latter material is pulverized coral, a clayey substance, which was applied in the form of a very soft mud, but which when dry became a solid homogeneous mass, which proves very resistant to wave action, being, in fact, a sort of natural cement.

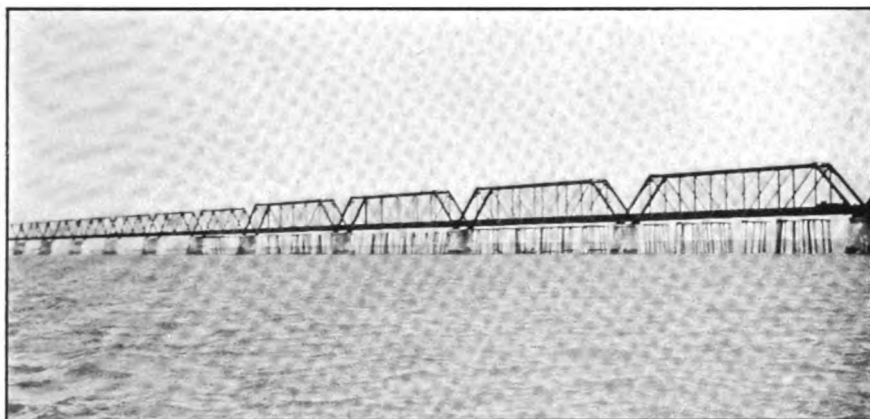
In all cases the track is placed far above high-water mark, so that there may be no fear of temporary inundation. Money had not been spared in any portion of the undertaking, cuts and fills are wide and substantial, and all work has been done in the most lasting manner.

This new road, which cost \$150,000 per mile—the record for single-track construction—makes Key West a part of the mainland for all practical purposes; and the harbour of Key West will become one of the most important in the United States after the opening of the Panama Canal, located, as it is, on the direct new artificial artery of commerce.

Cuba and its enormous wealth of tropical products are brought by it



MARL PIT TRESTLE AND DREDGES WHERE MATERIAL FOR PROTECTION OF SLOPES OF EXPOSED EMBANKMENTS IS OBTAINED. KEY WEST EXTENSION, FLORIDA EAST COAST RAILWAY



BAHIA HUNDA BRIDGE. ONE MILE IN LENGTH. WITH DEPTH OF WATER 30 FEET. KEY WEST EXTENSION, FLORIDA EAST COAST RAILWAY

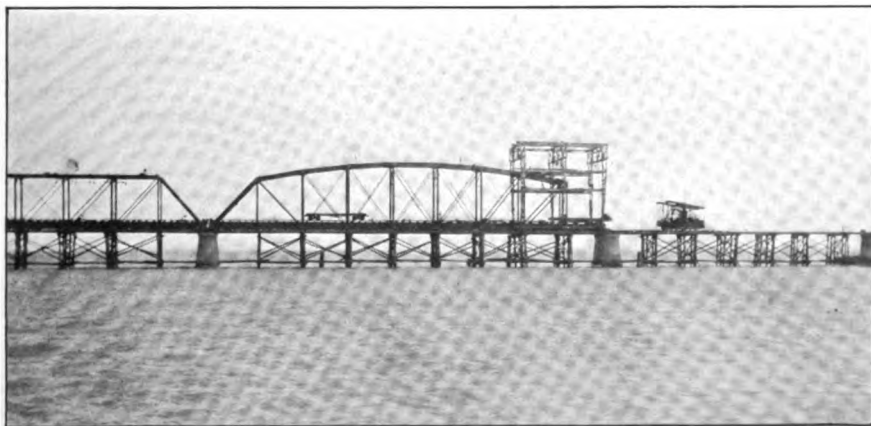
into direct railroad communication with the markets of the United States, and three years from now, when the Panama Canal is a reality, this rail route from the mainland of Florida to Key West, which will be the nearest railway terminal to Panama and the great cities of South America and their vast resources, will be a most important link in rapid communication with Western South America and beyond; and Key West will, without doubt, become not only an industrial centre, but also a military and naval base of the greatest strategic importance.

This extension forms the last link at the south of the great through-

railway service along the Atlantic Coast with South America and Central America, and it is one of the greatest feats of American engineering skill, of American enterprise and grit, and is in importance second only to Panama as an engineering feat.

At Key West, docks 1,900 feet long have been constructed. Eighty acres of fill are now completed and 75 acres will be added to this in the near future, making land for terminal purposes where only a few years ago the natives gathered sponges along the shores of Man-of-War harbour.

The total cost of this sea-going railway has been \$20,000,000, considerably more than the estimates of



BAHIA HUNDA BRIDGE SPAN OF 243 FEET UNDER ERECTION, KEY WEST EXTENSION, FLORIDA EAST COAST RAILWAY



BOCA CHICA VIADUCT ON THE KEY WEST EXTENSION, FLORIDA EAST COAST RAILWAY

eminent engineers when the work was first planned. Engineering problems hitherto unsolved were encountered. Fills were made in a day, only to disappear overnight, and unfinished work of months was swept away in one full hurricane. Many men would have given up the struggle against the unforeseen and the elements, but Mr. Flagler had faith in Mr. Parrott's ability and continued the work.

Engineering problems were not the only obstacles encountered in the construction of this railway. Among the thousands of labourers who were sent to the construction camps on the Keys were hundreds of hobos, ex-convicts and the riff-raff of Philadelphia, Boston and New York. This element accepted transportation to the camps with no idea of work. They expected to drop from the train along the way and spend the winter in a warm climate. The first few hundred succeeded in doing this, but soon the authorities of every State below Maryland had the trains policed, and Mr. Hobo found himself in a construction camp on one of the many Keys between Miami and Key West. Next morning he went out with one of the gang, and by shirking his part of the work was

soon spotted by the other labourers, who had to carry his share of the weight in moving heavy timber. They soon made life unpleasant for him, and, finding he could not remain in the construction camps without work, he took the boat back to Miami, with the idea of turning tramp for the rest of the winter and then beating his way back North. On arrival at Miami, after an enforced abstinence from beer, as it was not permitted on the Keys, he got good and drunk, made a disturbance, and was sent to the chain gang for thirty days, where he worked on the rock piles under armed guides. His time up, he wrote long letters to the newspapers in the North how he and other labourers were being held in slavery by Flagler. The press was full of it until they sent representatives to make investigations. Meanwhile, Mr. Flagler had been indicted for peonage. After the newspapers, through their special correspondents, learned the truth, they were profuse in their praise of the kind-hearted old man who was turning the east coast of Florida into a paradise. Some of the papers that had called him a slave-owner said he was the only man in the Standard Oil crowd that

deserved any credit for his life-work, and others stated that had he—Mr. Flagler—constructed the sea-going railway in any other country in the world the government would have subsidized it and given him a vote of thanks. When the case came to trial it was practically abandoned.

The extension of the Florida East Coast Railway will always remain a monument to the memory of H. M. Flagler, the man who had faith in the word of another man, and whom he rewarded by making J. R. Parrott president of his railway and all his Florida interests.

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## THE NEW BUSINESS CENTRE OF THE UNITED STATES

By A. E. Stilger

(Concluded.)

**I**N the previous articles of this series attention has been directed to the remarkable growth of the Thirty-fourth street section of New York City, as indicated by the extent to which the older buildings have been replaced by modern business structures of immense size devoted to all departments of industry; to the phenomenal rise in real estate values; to the establishment of financial institutions in the midst of the district, and to the selection of this portion of New York for the great terminal station of the Pennsylvania Railroad system.

The manner in which a commercial district is advancing may be better perceived while the changes are taking place than after all the old landmarks have been effaced by the demands of business. This fact has been emphasized by the illustrations which have been given, showing the portions about the new Pennsylvania station which are as yet unimproved and which, remaining in the condition in which the greater part of the section was a score of years ago, indicate most clearly the magnitude and nature of the immense change which has already taken place. The

parting of the ways is very clearly shown at the intersection of Madison avenue and Thirty-fourth street. Looking westward from this point the eye is held by the continuous stretch of business buildings, representing every conceivable line of effort, mercantile, manufacturing, professional, many of them imposing structures, and all filled to the limit of their capacity. Turning to the eastward, one is immediately impressed by the marked contrast, there being but few business places and a great preponderance of private residences.

Here, then, is the line for immediate development. Property on Thirty-fourth street, be it East or West, is far too valuable to be used for residential purposes. At the eastern end is the Long Island ferry, while at the western portion stands the Pennsylvania terminal, connecting with the cities and towns of Northern New Jersey. The obvious advantages of this line across New York, extending between the two vast home centres of the commercial metropolis and holding, at the same time, the central position between the crowded lower city and its rapidly growing upper