No. 37. JULY, 1880. Vol. IX.

Professional Papers

ON

INDIAN ENGINEERING.

SECOND SERIES.

EDITED BY

MAJOR A. M. BRANDRETH, R.E.,

PRINCIPAL, THOMASON CIVIL ENGINEERING COLLEGE, ROORKEE.

ROORKEE:

PRINTED AND PUBLISHED AT THE THOMASON COLLEGE PRESS.

1880.

PUBLISHED QUARTERLY.

LIST OF BOOKS PUBLISHED

AT THE

THOMASON CIVIL ENGINEERING COLLEGE PRESS, ROORKEE.

ROORKEE TREATISE ON CIVIL ENGINEERING IN INDIA.

In three Vols., containing over 1500 pages, Royal 8vo., with numerous Plates. Price, neatly bound in cloth, Rs. 37-8.

CONTENTS.

VOL. I. [*3rd edition, Reprint,* 1879.]

Section I.—BUILDING MATERIALS. Section II.—EARTHWORK. Section III.—

rice,

ADS.

AND

ERSE

Price.

4

4

		Rs.	As.
II.	Strength of Materials (5th edition),	1	0
III.	Examples of Applied Mechanics (by J. Eliot, Esq., B.A.),	3	0
IV.	Earthwork (4th edition),	1	0
VI.	Construction of Buildings (3rd edition),	1	4
	Do. do. (4th edition),	2	0
VII.	Surveying (by Lieut. Firebrace, R.E.), (3rd edition),	3	8
VIII.	Roads (2nd edition),	2	0
IX.	Bridges (2nd edition),	3	12
X.	Irrigation Works (2nd edition),	3	12
XI.	Carpentry (2nd edition),	1	4
XII.	Railways,	1	4
XIII.	Drawing (by Lieut. R. Pulford, R.E.),	11	0
XIIIA.	Drawing, First Principles of Geometrical (by Do.), (2nd edition),	1	4

		Price.	
XIV.	**Simple Explanations of some Engineering** Formulæ. By Major A. M. Brandreth, R.E., - -	1	12
XV.	**Examples of Estimating.** Comprising a progressive series of Estimates (with plans of Buildings and Bridges, worked in detail), (2nd edition). By (*the late*) P. Keay, Esq., Head Master, - - - -	3	8
XVI.	**Earthwork Estimating,** with Practical Tables and Diagrams. By Major A. M. Brandreth, R.E., -	1	0
XVII.	**Specimens of Printing,** used in the College Drawing Course and Entrance Examinations, - -	0	4
	Scantlings of Timber for Roofs. Tables and investigation of formulæ, for determining size of timbers for Flat Roofs from 8 to 22 feet span, and for Trussed Roofs from 16 to 50 feet span (2nd edition). By (*the late*) P. Keay, Esq., Head Master, -	1	8
	Useful Rules and Tables, relating to Measurement of Timber. Rules for Computing the cubic contents of Round Logs, as well as of Sawn Timbers, with Tables, *giving at sight* the above contents, for round Logs up to 240 inches girth, and 50 feet length, and Sawn Timbers of Scantlings from $\frac{1}{4}'' \times \frac{1}{4}''$ to $24'' \times 20'$; together with Tables of Cubic Contents of Round, Octagonal, and Hexagonal Posts, and Superficial Contents of Sawn Wood, in ordinary use. By Rai Kunhya Lal, -	2	8
	Cardboard Diagram for obtaining at sight the Scantlings of Timber Beams for all spans and loads. By Colonel W. H. Mackesy, - - - - - - - - - - -	4	0
	Rules for Calculating the Velocity and Discharge of Rivers and Open Canals. By Rai Kunhya Lal, - - -	0	12
	A Vocabulary of French and Italian Irrigation Terms, - - - - - - - - - - -	2	4
	Blasting under Water, (2nd edition,) - - - - -	0	12
	O'Callaghan's Earthwork Tables for India, in one large sheet, 8 annas; mounted on cloth, to fold up, - -	1	12
	Tables for Computing Earthwork in Distributaries and small open Channels, in use in Irrigation Department, N. W. Provinces, - - - - - - - - - -	1	4
	Examples of Brick Bond. By Sergt. G. Booley, - -	0	12
	Tables for Calculating Contents of Timber, - -	0	4

see p. 223
[Evans, Walton

PROFESSIONAL PAPERS

ON

INDIAN ENGINEERING.

[SECOND SERIES.]

EDITED BY
MAJOR A. M. BRANDRETH, R.E.,
PRINCIPAL, THOMASON C. E. COLLEGE, ROORKEE.

No. XXXVII.—JULY 1880.

ROORKEE:
PRINTED AND PUBLISHED AT THE THOMASON COLLEGE PRESS.
1880.

ROORKEE:
THOS. D. BONA, SUPERINTENDENT,
THOMASON COLLEGE PRESS.

As no Loose Copies of the Professional Papers are now kept in Stock, Subscribers wishing extra copies of any separate Articles in the present Number, should make early application to the SUPERINTENDENT OF THE PRESS, so as to reach him before the type is broken up. The price of Loose Copies is reduced to one anna per 8 pages, or part of 8 pages, and half an anna a Plate, up to a maximum of eight annas; but requisitions can only be complied with if received before the type is broken up. To facilitate this, the following list of Articles received for publication is issued. It will not, it should be remarked, bind the Editor to issue all Articles entered in case more interesting matter is received:—

1. Chambal Bridge, Indore.
2. Experiments on best form of Notch for Canal Falls.
3. Alluvion and Diluvion.
4. Alfred Nobel's Dynamite.

Subscribers wishing to be supplied with Covers for Volume No. VIII., are requested to send notice at once with price, i. e., Re. 1-0-0.

NOTE.—A Supplement to this Quarterly Number will be issued shortly to make it up to usual quantity.

A. M. B.

see p. 223

CONTENTS.

[Evans Walton W]

No. CCCXXVIII.

INTER-OCEANIC CANAL PROJECTS.

[*Vide* Plate.]

EDITOR'S NOTE.—In last quarterly number I published a paper about the Inter-Oceanic Canal by Mr. Menocal, imagining it was a plain statement of the advantages of the various routes. The discussions on the paper in the two following numbers of the Transactions of the American Society of Engineers show very decidedly that this view is not accepted generally by the members, no less than twelve gentlemen having "offered remarks" of considerable length. As these Transactions are not in general circulation, I reprint the first "discussion" by Mr. Walton W. Evans, as the most complete view of the through sea level advocates, and at all events it will be allowed to be amusing reading. Of the other members some are for one some for the other. The general opinion seems to be that Mr. Menocal's estimate is much too low for the Nicaraguan route, and one member, Mr. Edward P. North, states that none of the estimates give the total cost, he writes—"It is well known that in addition to the engineers' or absolute cost of any work, there are other expenses—some perfectly legitimate—which depend so largely on the honesty and discretion of the board of direction on the one hand, and on the confidence of the public in the scheme on the other, that it is almost impossible to correctly estimate them.

"An analysis of the cost of the Suez shows that the two items were in round numbers—

Absolute cost, ...	$48,000,000
Expenses of administration, ...	50,000,000
Total, ...	$98,000,000

"As in the present case there are rival projects in the field, and no route is now known that does not present complications, which though doubtless surmountable, will tend to alarm timid investors, and as the work is much further from the accumulated capital and low rate of interest of Europe, it may be assumed that even under Count de Lesseps experienced guidance, these administrative expenses will amount to at least 115 per cent. in place of the 104 per cent. of the Suez Canal.

"As a careful location has been made only on one route, and that is now generally admitted to require revision in the matter of curves, locks, &c., no estimate of the absolute cost can be advanced as more than a rough approximation, but the general impression seems to be that it will be in the neighbourhood of \$120,000,000; if to this \$138,000,000 (115 per cent.) be added for administrative expenses, we will have the cost at completion \$258,000,000.

"It can hardly be expected that on the completion of this canal the routes of commerce will immediately change, and even if that were probable, the investors must wait for an increase born of the facilities afforded by the canal before they can hope to receive a satisfactory income from their expenditure.

"As even a small railroad enterprise, shortly after completion, passes through the various phases of floating debts and ingeniously-named mortgages—if happily it escapes the hands of receivers, this canal, if ever built, must probably see its immense capital nearly if not quite doubled before its dividends can equal 15½ millions or 6 per cent. on the cost at completion."

The point noticed above that the surveys and data for any of the estimates are most incomplete is insisted on by most of the other members.

Mr. Julius W. Adams takes an entirely different view from all, and advocates a canal through the Isthmus of Tehuantepec, *vide Plate.* His argument is that the canal should be first for America, and should be entirely in the hands of America—"no European co-partnership." "The desire to make the Gulf of Mexico a closed American sea is as natural to us as a similar policy to other powers in regard to the Black Sea, the Caspian, the Zuyder Zee, and others." "There is no more reason why foreign nations should be allowed to guarantee the neutrality of an American thoroughfare than that the United States should be a party to defend the British Channel, the Straits of Gibraltar or the Isthmus of Suez." "A canal terminating in the Gulf of Mexico would be easily protected in time of war, and by making, in case of need, the Gulf a closed sea, our merchant marine would be safe from all attack, and our relations with the Pacific could be sustained without any interruption." But while starting on this basis as the most important point, he gives tables of routes, results of which are somewhat shown in the Plate, to show that independently of this, the upper is the better route. He states there is ample material and excellent climate on the upper route, but says there are no surveys on which to base an estimate. Comparing however by length and lift with Mr. Menocal's estimate for the Nicaraguan at the same rates, he runs out a rough estimate of 58 million dollars, against the Nicaraguan 66 millions. He allows that the transit will be 67 hours against Mr. Menocal's 38½, and he concludes as follows:—

"Whatever may be the advantage in point of time of a transit at Panama over that at Nicaragua, as we are dealing with the latter entirely in this comparison, we have to state that the passage of the Tehuantepec Canal will require one day more than the canal at Nicaragua, or, at the outside, two days. As regards the objections to locks—whatever route be adopted, even the through cut, so called, if it can be built, will require a tide-lock, at least, on the Pacific. In admitting that mean tide on either side would be at the same time the rise on one side of 20 odd feet, and on the other of 1½ feet, would require a tide-lock for adjustment of current. The fact that the Red Sea level was *traditionally* some 30 feet above the Mediterranean, and results demonstrated in a canal of 90 miles in length, connecting the two, that the difference was really inappreciable, has no bearing whatever upon this question.

"The route which, as we have seen, while giving all proper facility to European commerce through American water-ways, still from its geographical position gives a proper preponderance to our domestic commerce, requires the use of lift-locks. Shall 24 or 48 hours additional time for its passage, and the bugbear of the danger of such transit, which differs but in degree, and not in kind, from the most favorable route which European interests can point out, deter American enterprise from carrying out what the interests of her growing domestic commerce calls for, and leave her to gather such crumbs as older nations have determined shall be her share?

"Public opinion is beginning to express itself, in a manner not to be mistaken, adverse to any foreign occupancy among the small States of Central America, where a question of the infringement of the rights of such occupants by the local government could so easily be made the pretext for the interference of a foreign power, ostensibly for the protection of the rights of its own citizens, but virtually to deprive this Government of the control of her own domestic trade. This feeling has been aroused by the late movements of a French company at Panama. But, indeed, either at Panama or at Nicaragua, if a ship canal should be built under circumstances of control nominally favorable to this country, and in accord with the spirit of the Monroe doctrine, as we construe it, yet its location, although endorsed by high officials, would, as we have seen, be so much more favorable to foreign than to American commerce that the legitimate growth of the latter would be completely crippled; and to prevent such a consummation we must go still further, and refuse countenance or support, in any way, to the construction of a ship canal located at any point south of the Peninsula of Yucatan; or, in other words, south of the Isthmus of Tehuantepec. And the importance of enlightening our people as to the national bearing of this question of the location of a ship canal cannot be over-estimated. It is no longer *who* shall build it, nor *how*, but *where* it shall be built, that interests us as American citizens."

Discussion by WALTON W. EVANS.

I beg to offer a few remarks in discussion of Mr. Menocal's paper on the much-vexed project of the Inter-Oceanic Canal. I wish to give, first, my reasons for venturing an opinion:

1*st*. I have served for seven years as an engineer in the construction of canals.

2*nd*. I have had an experience in the construction of public works of over forty-two years.

3*rd*. I have crossed the Isthmus many times—partly by foot, by mule, by canal, and by rail.

4*th*. I have been detained on the Isthmus for weeks—by rains, revolutions, and want of transportation—before the railway was built.

5*th*. I have witnessed the heavens open their flood-gates, and seen the terrible washings the railway was subjected to.

6th. I have lived in earthquake countries for eleven years, and have witnessed the convulsions of Nature on the Isthmus as well as in Peru and Chile.

7th. I have, for over thirty years, made a study of this most interesting problem of cutting a canal for the largest ships through the narrow strip that divides North from South America.

8th. And I have read with care most of the public documents published in reference to it, and am clearly of the opinion that the "San Blas" route for a sea-level canal is far preferable to the Nicaragua route, with locks, or any other route ever reported on.

I beg to present some axioms in reference to this great problem :

1st. A canal thirty miles long is preferable to one a hundred and eighty-one and one-quarter miles long.

2nd. A canal without locks is preferable to one with locks.

3rd. A canal that has good harbours at its *termini* is preferable to one with no harbour at either end.

4th. A canal built in a healthy region is preferable to one it an unhealthly region.

5th. A canal that can be navigated in ten hours is better than one requiring one hundred hours.

6th. A canal that will call for very small repairs is preferable to one requiring immense repairs.

7th. A canal that has a small "water-shed," but a sure supply of water, is preferable to a canal having a great "water-shed."

8th. A canal that is not on a line of drainage is preferable to one on a line of drainage.

9th. A canal that can pass a ship of any length is preferable to one that limits the length to far below that of many existing ships.

10th. A canal that is virtually a straight line is preferable to one with many curves, some of them very objectionable.

I have read with care Mr. Menocal's clever paper, and beg to take issue with him on some points. He starts off with the assertion that the matter is narrowed down to two routes—the Panama and the Nicaragua. I should have been better satisfied if he had said the San Blas and the Nicaragua, for I look on the Panama route for a sea-level canal as simply ridiculous. I intimated the same, but with less forcible words, to Count Ferdinand de Lesseps, in Paris. After many years of study of this matter, and after for a time believing in the Nicaragua route as the proper one, I came to the conclusion that the San Blas route had many features in its favor that placed it far in advance of all others. I refer to the foregoing axioms for those features. I beg to say a word in defence of Count Lesseps. I have an impression that he is thoroughly honest, and find that is the opinion of all my friends in Paris who know him well. I think he was, in the conducting of the Congress, influenced by men who hoped to grow rich through the use of his name. He will soon see the error he has made when he reaches the Isthmus, and is made acquainted with the terrible destruction of the late floods. He said to me in Paris: "There is one point in this matter we must observe: wherever the canal is built *it must be a sea level canal.*" In this I fully agree with him; and I will add one more important engineering feature: it must not be built on any line of drainage, or across any line of drainage. What we require—what the world requires—is a perfectly reliable canal, that cannot by any accident run itself dry; that is perfectly secure against the accidents that can occur and do occur to all canals depending on dams and locks as working features, no matter how well and costly they may be built; if we cannot give the trade of the world such a canal we had better give it none.

I would not propose to run the San Blas canal into the Rio Bayano, but turn that river off into the Bay of Panama by a cut made expressly for it; this could not be done for the Chagres River, except at an expense of many millions. It it proposed to build the Nicaragua Canal in the Valley of the San Juan, and in close contact with the river for many miles. I would suggest to the advocates of that route, and to the capitalists who I am told stand ready and eager to put their money in it, to first visit the Valley of the Lehigh, in Pennsylvania, and view the ruins of what was, within my recollection, a canal that received the praise and admiration of everybody; it was built by skilled engineers; the money furnished by the most careful and long-headed Quakers of Philadelphia; it had locks of thirty feet lift, the greatest ever put on a canal; the water-shed of the Lehigh is very insignificant; all the owners slept, no doubt, quietly in the possession of what they supposed to be a very safe investment; but a storm came—a flood was the result; this little lamb-like river became a great, fierce tiger, bent on destruction; a weak point was found in the upper dam, the tiger poked his nose in it, a little leak was started, and away went the whole structure; with it went every dam and lock on the whole river, and hardly left a wreck behind; no one ever had the courage to rebuild that canal. There are many among us that recollect the destruction of the Croton River Dam; placed at the initial point of the Croton Aqueduct, it was built under the plans and direction of that Nestor in American engineering, John B. Jervis; he was an old and skilled canal engineer. Who have we at the present day who is his superior? That dam was built on rock, where the best of materials and skilled workmen were to be had in profusion; but it went—carrying havoc in its course—and destroyed every bridge, dam, mill, factory, and building it could reach down to the Hudson River. I well remember this river above the dam, and its lamb-like character in summer, for I built a railway on its banks, and have many times crossed it on stepping-stones without wetting my boots. The European news of the past two days tells us of floods in Hungary, and that many dams have been carried away on branches of the Danube. I for one would rather trust to a tunnel than a dam. I have had a good deal to do with dams, and I feel towards them as Robert Stephenson once told me he felt toward railways, that he was afraid of them.

There are other things that I would be afraid of in the construction of a canal with elevated reaches on the side of a valley where such rains occur as are frequent in the San Juan region, I mean the melting and running of the embankments. Once on arriving at Panama on my way home I was told I could not cross the Isthmus, as there was a wash-out a few miles from Panama. I took a hand-car, went to see it, and found Col. Totten there making an embankment of sleepers. This same embankment had been washed out three times before, and every time it had been, when rebuilt, reinforced by a row of piles, close together, on the down-hill side. Col. Totten said to me, "You see this embankment could not go out down hill this time, so it has gone *up hill*." It had actually squashed out on the up-hill side, and had run very much as molasses would run; a horse or man going into it would soon have gone out of sight. To know the Isthmus and its rains, and what rains can do in the way of making running mud out of embankments, it is necessary to go there and see it, for no one can imagine it from any pen sketch. I have an impression that all the arguments that can be urged against the Panama route will hold good against the Nicaragua, while the Panama route, adapted to have locks, has the advantage over the Nicaragua in the matter of length and harbours at the termini.

Mr. Menocal's estimate of cost appears to be made as many other estimates of cost of public works have been before his time, by dealing in too small figures, and making omissions. His estimate for drains (I suppose this covers aqueducts over side rivers, culverts over streams, changes of channels, waste-weirs, sluices, &c., &c.) is magnificently deficient, and I see no items for protection walls, inside and outside, puddle walls, lining to prevent leaks, gravel facings, &c., &c. Also draw bridges over the canal, light-houses, machine-shops, and whole villages of buildings for residences, &c., store-houses, &c., &c. I suppose these are all in the twenty-five per cent. for contingencies. I have found in practice that after estimating every item I could think of, the twenty-five per cent. for contingencies came in as a most comfortable assistant at the end. Captain Young, who built the Utica Railway, used to say that the only safe way to make an estimate, was to take the largest quantities you could get from the profiles, carry them out with the largest prices you ever heard of, add twenty per cent., and then double the whole. When the first estimate of the Hudson River Railway was made, there were many arguments offered to show that it could be built for about "half of nothing," the engineer gave the size and number of every arch and culvert required on the whole 145 miles, for each division. I, having a love of statistics, counted them, and found there were about sixteen or eighteen in all. Now, this same engineer had just before built the Croton Aqueduct over forty miles of the same route, and close to it, and had forgotten that he had built over three hundred culverts, arches, and bridges, on that forty miles. The protection walls for this railway, amounting to over 400,000 cubic yards, were estimated to cost fifty cents per cubic yard, and it was forgotten that the protection walls of the Croton Aqueduct (now nearly all, inside of forty years, replaced by better walls) cost $1·75 per cubic yard. I mention these things to show how errors creep into engineers' estimates, even among the most conscientious—their zeal, their desire, their anxiety to see their project go down the throats of somebody, overrides their judgment and stores away in oblivion for a time all their hard-earned experience, making true at this day the old Roman motto, "*Men try to believe what they wish to be true.*"

The Nicaragua route calls for the construction of artificial harbours at each *terminus*. This is a most unfortunate feature of this route. Such things have to be approached with fear and trembling, and a pocket full of money, and after they are built and handed over as something to be proud of, they, or their parts, very often go on excursions up and down the coast, through the alluring enticements of the wind and the sea. Some have their usefulness nipped in the bud by a failure to find funds for their completion, as was the case with the Dover Harbour, in England. I had occasion to examine those works in 1853, and then came to the conclusion that although "John Bull's" purse was long and large and full, that he had better leave that work alone, and since then he has left it severely alone. The one long wall which I saw in 1853, I was again on in June of this year, and found it had neither grown higher, longer, nor more complete, and its partner had never been attempted. In March of this year I walked, or rather clambered, out for a short distance on the concrete breakwater for the harbour of Port Said, at the northern *terminus* of the Suez Canal, found that it was far from finished, and unless finished would in a few years be knocked to pieces and rendered useless. In November of 1878 I had a chance to examine the concrete works of the harbour at Algiers, built by the French, evidently at great cost. The waters of the Mediterranean had quietly or unquietly, as the case may be, just knocked a considerable part of it into a "cocked hat," and the Algerines were, in their faith, no doubt, praying to "Allah" to knock the "cocked hat" into "pi."

Artificial harbours are contrivances to be avoided, if possible; they are apt to give engineers sleepless nights, to deplete plethoric pockets, and vanish when called on by the winds and the waves.

I have some experience in sleepless nights produced by things of this kind, for I built out into the Pacific Ocean the first pier ever built on the whole coast of South America, that a big ship could haul alongside of. The "Brave south-west winds" as Maury called them, were my friends for thirty days out of thirty-one, then "Æolus" sent "Boreas" down to make things lively with his "big guns," and at the same time make an engineer's heart sink into his boots. During construction I often saw the northers rolling in the waters, which went over my pier from 20 to 30 feet high, and bid fair at times to carry the whole structure, with its 80,000 tons of stone, on to the beach.

Mr. Menocal estimates the locks between gates to be 400 feet long; a lock of this length will pass a vessel of only 360 feet. Thirty years ago vessels of 360 feet long were scarce articles; we have now lots of vessels of 450 feet, and vessels of over 500 feet are being built. Who can say what will be the length of vessels in another thirty years? The locks of the Erie Canal of 1825 could not pass boats of half the size that are now locked through.

The locks of the Delaware and Raritan Canal had not been in use thirty years before they had to be doubled in length. I came through the Suez Canal in March in a Peninsular and Oriental Royal Mail steamer from Hong Kong and Bombay, that was over 400 feet long; other steamers of that line are over 450 feet long. I saw a number of steamers in the canal, and judge that most, if not all of them, were over 400 feet long; it would be a sorry mistake to build a canal with locks that cost over $300,000 each, and find that they could not pass these giant craft, for they are the cream of the business a canal company would seek.

The Suez Canal is virtually a straight line. When I arrived at Lake Timsah we found a huge steamer stuck in the mud in the lake, and a crowd of Arabs unloading her; the canal ahead was blocked; I took a steam pilot-boat, went ahead to see the difficulty, and found that a passing steamer had run into and sunk one of their large dredging machines; this once clear, the next day our Leviathan attempted the passage to Port Said, but we had hardly run in the canal a mile before our vessel run her bows into the right bank, her stern slewed around and went into the left bank; there we stuck for two hours, and in two hours more our craft was laid along side for the night, that being her second day in the canal; this steamer entered the canal at 4 P. M., March 22nd, and arrived at Port Said at 10 A.M., on the 24th, taking 42 hours to run just 100 miles in a sea-level canal, virtually one straight line. The very next mail steamer of the P. & O. line that came through after I did, ran into the bank, her stern swung into the opposite bank, and broke off two of the blades of her propeller. Accidents like this, of running into the banks, being apparently common on straight lines, it would be well to examine carefully into the manner of working these long steamers around the sharp curves of the proposed Nicaragua Canal.

We in America know that the English locomotives have a very unmannerly habit of jumping the track at sharp curves, which habit we in America have almost entirely eradicated from their vicious propensity by rendering them subservient to the ameliorating influences of a "Bogie," a mechanical persuader which accomplishes the object in a most satisfactory manner; if this admirable invention could be applied to a ship, we might overcome the difficulty; as yet I see no manner of making the application, but the Yankee brain is prolific, and some genius may work out the conditions of this important problem. Old canal men and sailors accustomed to handling these huge vessels will look with a smile on the estimate of $38\frac{1}{2}$ hours to pass through a canal $181\frac{1}{2}$ miles long, with many sharp curves and 22 locks; also the estimate of 20 minutes to a lock; to fill or empty a lock in 12 or 14 minutes would not be a difficulty, but that is only a small part of the time required to pass a lock; it must be recollected that a vessel has to be "slowed down" long before she reaches a lock, and in most cases come to a dead stop before she enters the lock, then to be hauled in slowly and with care, for if a large steamer, weighing with cargo 8,000 or 9,000 tons, enters or approaches a lock with any amount of headway on her, she will probably walk through the lock without asking permission, and in much less than 20 minutes. If any such trade as would certainly be offered to a sea-level canal were offered to a canal with locks, there would, most undoubtedly, be great detention at the locks, by one vessel finding another vessel in the lock, other vessels ahead of her, gates shut, lock empty, &c., &c. If any one thinks these large vessels can be started and stopped, and turned like children's toys, let him go down to the piers in New York and see one of these large steamers arrive and get berthed. I arrived in July in the Britannic, and we were full one hour from the time we touched the dock until the ship was hauled into her berth. Taking my trip on the Suez Canal as a base for calculation, I would make the time of passing the Nicaragua Canal as follows:—the speed was a mile in 25·2 minutes; 181·25 miles at 25·2 minutes per mile, 76 hours; 22 locks at $1\frac{1}{2}$ hours a lock, 33 hours; total 109 hours; or, say $4\frac{1}{2}$ days, and this may be put in opposition to one single day of ten hours in passing the clear, straight, unobstructed 30 miles of the San Blas route.

Mr. Menocal estimates the cost of the Nicaragua Canal at 66 millions dollars. Men with experience and analytical brains have criticised this estimate and found it deficient. I agree with them, and further believe that the dimensions estimated are not such as a world's Canal calls for and should have, particularly in available width and depth, and more particularly when carelessly handled ships are to be encountered. In going out of Marseilles harbour just one year ago in a straight channel of double the width of the canal proposed, our French captain had all his yards squared; he met an incoming brig, his vessel did not touch the brig by fifteen feet, but his main-yard struck the foremast of the brig and snapped in the middle, broke the fore-top mast of the brig, and down it came with all its spars close to the spot where I was standing with some ladies.

In pushing and preaching the merits of the Nicaragua route, there appears to be a fixed intention to ignore the San Blas route entirely, and "pooh-pooh" it out of sight; they may knock it down, but it will come up again; they may throw cold water on it, but it will come out of the fire brighter than ever; they may build the Nicaragua Canal, but the San Blas will be built too, and then it will require no very wise man to tell which will be the one used. In the papers and estimates made out to compare the different routes, I see nothing said of comparative cost of repairs and maintenance; leaving the Panama route out as an absurdity, the lengths of the San Blas and the Nicaragua are as 1 to 6, but when it is considered that one is a sea-level canal, with good harbours and without locks, cut for a large part of its length through solid rock, the southern half in an open "savanna" country, the whole easily made safe from the ravages of floods and drains; while the other route is on and parallel to a tremendous drain, where floods occur that may and probably would sweep the whole works to destruction in a few hours; where earthquakes may and probably would twist the locks so that the gates could be neither shut or opened; where side streams, with their floods, must cross the canal to get into the main drain; where the time of transit compared to the San Blas is as 5 to 1; where there are no good harbours at either *terminus*, and where one *terminus* is a notoriously unhealthy place. I think any careful and critical mind would put the ratio of conservation of the two routes not as 1 to 6, but as 1 to 20 or 30, or more.

A five-inch rain falling in twelve hours is a thing not unknown in the Nicaragua lake region; as the water-shed of the San Juan River is 12,500 square miles, a five-inch rain is represented by over 4,000 millions of tons of water, a greater part of which has to find its way to the sea by the San Juan river, and not take a great length of time either; it was undoubtedly after one of these great rainfalls that the San Juan River, rising above its banks, overflowed, and cut the Colorado River into the territory of Costa Rica. Those who are curious in the matter, might calculate the foot-pounds of energy or force developed by 4,000 millions of tons of water falling 107 feet, and its power for doing mischief.

Apparently the only objection to the San Blas route is its cost growing out of a long tunnel, and the inability to say what kind of material would be found in the tunnel. Let us examine this great bugbear, the tunnel, and compare it with other works.

The "Desaguadero" in Mexico, cut by the Spaniards, as a matter of precaution against floods, two hundred years ago, required about three times as many cubic yards of rock to be removed as would be required to cut a ship-tunnel 8 miles long, 180 feet high, and 80 feet wide. Now, if the Spaniards could do that two hundred years ago, should we, who have steam drills and wonderful explosive compounds, shrink in fright from a work of only one-third the size?

The St. Gothard Railway, now nearly completed in Switzerland, to connect the northern railway system of Europe with that of the South, is a work that involves immense difficulties. It has on its line forty-six tunnels, one of them at the summit being over nine and one-fourth miles long; one of them the engineer pointed out to me as being cut to secure the railway line from being buried by avalanches. Seven of these tunnels in complete circles of 1,000 metres diameter, are cut merely to get distance, and keep the gradient down to their fixed standard of 1 in 40 (132 feet per mile), and this tremendous work is being built for the very limited business of a railway. With this example staring us in the face, are we Americans, who boast ourselves of doing things with a bigger "auger" than our neighbours use, to turn tail and run away from a tunnel that would, if built, command the trade of the world, give us a grip on the trade of the whole Orient, allow us to manufacture all our own cotton and find a market for it in China, connect our Pacific possessions by a less expensive route than any railway can supply, consolidate our Union in stronger bonds, and lead in time to our becoming the most central and most powerful people in the world.

It has been objected to this tunnel, and reiterated by Mr. Menocal, that the rock found in it may be too soft, or of a character not fitted to support its sides and roof. This is all "moonshine." We know from mines and cuttings over all that country, and from surface rock that crops out everywhere, just what we may expect; there is but one material existing that we may be afraid of, and even that was successfully overcome in the Box-tunnel of the Great Western Railway of England—I mean quicksand, and that we know we will not find under the rocks of the Isthmus. Mr. Menocal thinks we have not the data by which we can calculate the cost of the San Blas Canal as fixed and clear as they have for the Nicaragua Canal. If they have not these data it is their fault; they should have got them; but I contend that we have all the data required, and more reliable than any data ever can be, on a line parallel to and close to a line of drainage, that Domine Sampson might call with truth, "prodigious:" we have the length of the whole route: we know what is tunnel and what open cutting; we know to a certainty that we can turn off all the streams and the one river, the Chepo or Bayano, and render them harmless to do evil. We know that we have good harbours on this route; we know that we have rock to contend with in fixed quantities, and by estimating it as granite, we know that the estimated cost cannot be far wrong. It has been intimated that earthquakes might make a tunnel unsafe and dangerous; in answer, I would say that we have sixty-two tunnels on the line of the Oroya Railway in Peru, that many of them are completed and have been run through for years, and to this day I have never heard of any injury done to a tunnel on that line from earthquakes, which are much more frequent there than on the San Blas route.

We need not be afraid of striking a great vein of gold or silver, for in a case of that kind, unless the tunnelers become demoralized, such a vein might be coaxed into paying all or a part of the expense of the tunnel. This is not a speculation, unprecedented in facts, for my old friend, Genl. O'Brien, when forced by San Martin, the Liberator, to accept the Salcedo mine, in Peru (the richest mine at that time that had ever been worked), for his services in the wars of independence in Buenos Ayres, Chile, and Peru, struck a rich vein of silver in cutting an adit level from Lake Titicaca that paid all the expenses of cutting the tunnel for a long time. If some of the Bonanza kings of California could be induced to suspect another Comstock Lode on the line of the San Blas tunnel, they would cut the tunnel for the fun of the thing, and thank you for the chance. But if we throw out the silver speculation and return to the "hard-pan" of a hard-hearted contractor's prices we may have the following estimate to stare in the face :—

14 millions of cubic yards of rock in the tunnel above the sea level (the tunnel being 8 miles long, 150 feet high above the sea, and 80 feet wide), at say, $3 per cubic yard, ...	$42,000,000
4 millions of cubic yards of work in tunnel below the level of the sea (this part being 80 feet wide and 30 feet deep), at say, $8 per cubic yard, ...	32,000,000
22 miles of open (earth and rock cutting) canal at the same price Mr. Menocal estimates his line from Del Medio to Brito, where it is all rock, at, say, one million per mile, ...	22,000,000
Diversion of the Rio Bayano, say six times as much as Mr. Menocal estimates for the diversion of the San Carlos, $283,578 × 6, ...	1,700,000
2,400 acres of grubbing and clearing, at $100 an acre, the same as Mr. Menocal estimates an acre at, this gives a width of 875 feet for 22 miles, say, ...	240,000
Diversion of other streams, all small ones, say, ...	1,000,000
Light-houses, piers, store-houses, buildings of all kinds, say, ...	1,000,000
Total, ..	$109,940,000
Say, ...	110,000,000
Add for contingencies 25 per cent., ..	27,500,000
Grand Total, ..	$137,500,000

The above estimate is considerably above the estimate of Mr. Menocal for the Nicaragua route, but I will here venture to predict that it is very much nearer the truth of what the Nicaragua Canal will cost, if ever built, than Mr. Menocal's estimate. We may as well stare the truth in the face now as at any other time; it is the most honest way.

The people of the United States have had too much to do at home to look with much enthusiasm on works in distant countries or study with care the vast interests wrapped up in foreign trade; but the day is fast coming when they will be forced to know and value this matter, and then they will cut a canal through the Ishmus on the shortest route that can be found, no matter if there is a Nicaragua Canal or not. I am glad to find that all of the old canal engineers that have ever visited the Isthmus, and made a study of this problem, join me in the opinion that the San Blas route is the best for a sea-level canal, and the proper one to construct. And Mr. Kelley, who has spent his life and a fortune in surveys and study of this matter, and who has as clear an understanding of the whole subject as any man living, also most enthusiastically gives his adherence and support to that route as the only one that can satisfy the coming demands of trade, which is doubling up on us much faster than any one but those who study statistics could imagine.

As I feel convinced that the indirect benefit to the nation to be reaped from this canal is far greater than any direct benefit to any company, I would propose that the canal be cut, not on the line that is found to be the cheapest in first cost, but on the line that can be worked the easiest and quickest, and in the most reliable manner as regards line, level, repairs, and freedom from accident, even if it cost double the amount of the cheap and unreliable line. And in view of this end, I would, if I were the Government, offer to any company that would undertake this great enterprise, to *give* them one-half of the entire cost, and let them enjoy the rights, immunities, and profits of the whole thing, free of interest, for one hundred years; but reserving to the Government the right to take the whole at the end of one hundred years by paying one-half the original cost. It may not be out of place in this discussion to bring to the notice of the people of this day the prophetic writings of some who have preceded our time. Gouverneur Morris, the statesman, in a long letter, written in January 1801, to John Parish, in Europe, says:

"As yet, my friend, we only crawl along the outer shell of our country. The interior excels the part we inhabit in soil, in climate, in everything. The proudest empire in Europe is but a bauble compared with what America will be, must be, in the course of two centuries, perhaps in one."

Robert Stephenson, the engineer, in writing to his brother-in-law (in London), when he was here in 1853, after speaking in the most enthusiastic terms of the progress and development of this country, says:

"Considering these circumstances, and looking at the boundless rich territories which are being opened and extended daily, I confess I am entirely at a loss to figure to myself the part which the United States are destined to play in the world's theatre; their influence must daily increase, and when her inhabitants reach the coast of the Pacific their power must become predominant as a commercial nation." * * * "Coal which has hitherto given England her commercial superiority, is possessed by the States in almost incredible quantities; it has as yet scarcely been touched, because other sources of profit have presented themselves; but the day must arrive when, like England, the Americans will become a powerful manufacturing nation. If this be anything like the truth, how strangely must the relations between the civilized nations of the earth be changed—and then arises the question, so full of interest to an Englishman: Will England still maintain a good position in the struggle of countries, or will she, like other empires that have dropped into the past, begin to decline, and in her infirmity, like an aged parent, be obliged to look to her trans-Atlantic children for aid and support?"

We are fast arriving at the point predicted by Mr. Stephenson. We must have outlets for our products. In what direction can we turn for a market for our manufactured goods but to the shores washed by the Pacific and the islands of that great ocean? China and Japan, Australia and New Zealand, invite us to a close intimacy. The Spanish republics of the South American West coast offer us many tempting chances for trade enjoyed at present almost solely by England. The Orient and Occident of our own country wish to shake hands over a cheaper route of transport than any railway can supply. Let us mingle the waters of the Atlantic with those of the Pacific on the best, shortest, and most reliable route that Nature has furnished, or let us leave it entirely undone, for others of greater courage to accomplish.

I find in some of the discussions on this important problem that the San Blas route is called impracticable, but in no case is an attempt made to demonstrate the impracticability. Surely it cannot be because it is so short, so straight, so free from floods, locks, dams, and aqueducts, or can it be that it is rejected on account of its having good harbours, and in a healthy region, free from swamps and lagoons. What can the claim of impracticability spring out of that blinds the Nicaragua promoters to the many points of merit of the San Blas route unsurpassed and unsurpassable by any other route; there is but one point on this route that the objectors can fix their harpoons into, with any shadow of a chance of bringing it home to the minds of men as a dead fish. It is the tunnel; that is the bugbear, the stumbling block, that narrow minds and unprofessional minds cannot climb over, creep under, or swallow whole. I am inclined to think that the tunnel is one of the best features of the whole route; it will cost, no doubt, a rousing big sum, but the amount will be a mere bagatelle to its value and importance, and when built it will be the surest and safest portion of the whole route; it will be through solid rock, and remain for ever intact, requiring little or no repairs. The heading, a very insignificant part of the whole, would cost as much per cubic yard as any railway tunnel, but the balance down to the sea-water level could, in that region, be done cheaper and quicker than an open cut of the same dimensions, where the average haul was the same, for the reasons that the men can work continuously without being driven off by the great rains that are so common on the Isthmus, and they can work, as in all tunnels, night and day. This tunnel can be cut cheaper per cubic yard than any railway tunnel could be in the same region, and for the reasons that the great width of the tunnel allows the men abundance of room to work in, and use all classes of labor-saving machinery; the force of the explosive compounds can be utilized to a greater extent, as there is more room for expansion. Any contractor can afford, and will afford, to take such an immense work at much less per cubic yard than he would think of asking for a small tunnel, such as are built for railways, for he can afford to procure and use the most perfect, extensive and efficient machinery ever used on any tunnel ever cut. I was shown at the St. Gothard Tunnel steam drills that by slow motion and high pressures would walk into granite as a knife would into cheese; there was nothing used on the Mount Cenis Tunnel to approach them in efficiency. I was shown air compressors that kept their great reservoirs night and day under pressures of 110 pounds to the square inch, and without difficulty; it was with difficulty and uncertainty that the air compressors of the Mount Cenis Tunnel could keep the pressure up to 60 pounds to the square inch. We are clearly a progressive race, and it would be a wise brain that could predict with certainty what advance may be made by some live Yankee in tunneling machinery when we come to cut a ship tunnel. I have copies of the entire maps and profiles of the St. Gothard Railway, and I have no hesitation in saying that they show the most complete and perfect surveys yet made for any public work ever attempted by man. There were 400 engineers and their assistants employed on these surveys, many of them highly educated and experienced men; their estimate of the cost of this great work, 109 miles long, was 187,000,000 of francs; that was the sum placed before the public at the time the International treaty (of Germany, Italy and Switzerland) was signed, and a company formed to build the works, but they were only started when it was discovered, that, as usual, the works had been under-estimated, and the cost was going to be swelled to 289,000,000 of francs, showing an error in the first estimate of 102,000,000 of francs. Where was this tremendous error made—in the great tunnel? No, for the estimate of that was 70,000,000 of francs. Monsieur Favre took the contract to build it at 50,000,000 francs, and if he had lived would have completed it in the coming year, without asking favors or assistance. There is an inference to be drawn from this statement of amounts, regarding estimates and costs of work in tunnels, and general work, which the intelligent reader will quickly see. Mr. Menocal estimates his great canal, 181¼ miles long, at $66,000,000; the St. Gothard Railway is to cost, for 109 miles, about $58,000,000; now, if the canal costs only as much per mile as this railway, it will cost about $97,000,000. The railway costs about $532,000 a mile, while Mr. Menocal estimates this great canal, with artificial harbours, great locks, but not large enough for great ships, great excavations of rock under water, great aqueducts and great dams, all liable to be swept out by the first great flood, and great embankments (sustaining a hydraulic head of 26 to 30 feet) perched upon side hills, all of which may be washed out through the never ending labors of rats and roots in boring holes, all complete and ready to accommodate the trade of the world, at $346,000 a mile.

It may be claimed that the rock excavation under sea-water level is the impracticable point. If so, are not the excavations under water on the Nicaragua route equally or more impracticable. Let us stare some of the facts of this matter in the face. Nearly all of the excavation of rock under sea level on the San Blas route will be in still water, not affected by currents or winds or tide, while the same class of excavations on the Nicaragua route, in the beds of the San Juan and Rio del Medio, and in the bed of the lake, will be severely affected by currents in the river and waves and winds in the lake. To excavate rock in a swift current, such as is to be seen in the San Juan, is a species of fun engineers do not much covet. General Newton preferred to burrow under rather than attack the current at Hell Gate. Then, as to the work to be done out in the lake, I have an impression that this feature has been very much under-estimated. Suppose we subject this to a few figures, from known data, at one point. It is to be regretted that there is no good hydrographic survey of this lake, so we must be content with such data as we can pick up. The history of this lake and river show that, some years ago, a certain Captain Sheppard took his schooner from the gulf up into the lake during a flood. He did this with great labor, by taking off his false keel and taking out his cargo, reducing the draft to about three feet. Once in the lake, he put on the keel, and, with the vessel loaded—drawing seven feet—he could not, in the dry season, get within two miles of San Carlos, at the upper end of the San Juan River. Now, taking this little piece of history to calculate by, and knowing the material to be rock, I make it that a canal only 100 feet wide (I call it 100 feet wide, not because that is enough, by three or four times, for the passage of a ship subject to the buffetings of winds and waves in a great lake and the canal out of sight, but because 100 feet is sufficient for the demonstration I wish to make), cut from the mouth of the river out into the lake, so as to have 28 feet of water all the way to deep water, will call for the excavation of about 1,100,000 cubic yards, which, at $8 a yard, will come to $8,800,000; but, for the sake of being generous and accommodating, suppose we call it the half of the above sum, and then it is six times as much as Mr. Menocal estimates as the cost of all the work to be done in the lake division, including mud and gravel, which, it is admitted, has to be dredged, and also the rock under water at the western end. Heaven only knows how much is required to be cut for a channel to get into the mouth of the Rio del Medio.

Let us return for a moment to the San Blas route, and take a fair, square look at the rock to be excavated there below the sea level. In the tunnel, where the great mass will be found, it may be dry, and it may not. Take it on the side of the "may not," and allow it to be as wet as ever was seen, is it supposable that any engineer in his senses, with but a smattering knowledge of hydrostatics, would attack it under water, when he can so easily build bulkheads, pump out the water, and work out the rock just as he did above the level of the sea. With this system of working kept fairly in view, I have a fancy that any intelligent man can see that this rock in the tunnel will come out more quickly and cheaply than will the rock in the bed of the lake, when the winds and the waves will be playing "hob" with the drilling machinery, and at times driving the men from their work. But suppose the work finished—who can estimate the distress of mind of a captain when he finds his ship in a great lake with a wave-swell of 8 to 10 feet and only 2 feet of water under his keel; and that, too, only in a canal out of sight.

In my estimate of cost I dealt in big figures, and estimated for a depth of 30 feet of water. To bring this to the 26 feet of Mr. Menocal's section, there should be deducted over $4,000,000. Then again the tunnel, on more accurate surveys being made, may be reduced to six miles instead of eight. This would reduce my estimate again by $15,000,000, and then the 25 per cent. for contingencies would come down some $5,000,000, making in all some $24,000,000 of reductions. But I prefer to let it stand as I had it, at $137,500,000, and time will show who comes nearest to the truth, for it is in my eyes a sure thing that a great world's canal will some day be cut on the San Blas route.

As the transit of any of these canals will have to be suspended during the night, and as the San Blas route is so short that it can be navigated from end to end in ten hours, or less, and as one passing place (at south end of tunnel) only is required, the whole of the rest of the canal can be made, and should be made, much narrower than would be allowable and required on the Nicaragua route, where passing places must be frequent and provided between all the locks.

As sailing vessels are destined to form a great feature in the traffic of this Isthmus Canal—a feature that the Suez Canal is entirely deprived of—I beg to refute the claim made by the Nicaragua projectors, that the Bay of Panama is difficult to get in or out of on account of calms. I have been at Panama for weeks—I have been a guest on board of a United States war vessel for two weeks in that bay—and I never saw a day when a vessel was detained there, or prevented from coming in by either calms or storms.

New Yorkers would feel very indignant if told that their port should be shunned on account of its being difficult to get in or out of, and yet, I suppose, they all know that sailing vessels have often been for days outside, afraid to come in, and for days, in the lower bay, afraid to go out, during times of storm and fog—two hygrometric and meteorological features never met with in Panama Bay. Let us place the "calm" claim alongside of the "impracticable" claim, and send them both to the safe keeping of croakers. Intelligent men of this age are not going to take much stock in those two articles of Nicaraguan faith.

It getting from our shores to China and Japan, the great objective points, we as a growing commercial nation should look with much respect and admiration on the pacific character of the Pacific Ocean. The Spaniards of old used to say that all a "skipper" had to do on leaving Panama for the Phillippine Islands was to set his course, tie his rudder fast, go to sleep, and not wake up until he reached the end of his voyage. Ships going from Panama to China can take a trade wind going and a trade wind returning. When the canal is cut, and we have a new highway to the East, this feature will play an important part in assisting us to the largest share of the trade and traffic of the Orientals—a trade which for centuries heaped wealth into the coffers of the Greeks the Jews, and the Armenians of the Mediterranean—a trade that England seized and grew her wealth and power out of, when Vasco de Gama showed her a new way to the East by the Cape of Good Hope, four hundred years ago—a trade that is destined to fall into our hands and give us wealth and power such as no nation ever held, as soon as we can muster courage enough to cut an Isthmus Canal on the shortest route that can be found, and throw it open for all the world to enjoy as best they may.

It may not be inopportune to mention in connection with this discussion that a late commanding officer of the United States Navy, now living in Washington—a gentleman well acquainted with Nicaragua, Panama, and the Pacific Ocean—once said to me: "I should be very loath to allow any ship I commanded to be run in a canal and locked up a hundred feet above the ocean. I should be afraid of never getting down again."

In connection with the risks run by placing a big body of water on the side-hill slopes of a river valley (in a region of great rains) in a prism made of cuts and embankments, crossing spurs of hills and ravines, and also to show the fallibilty of man's estimates, I beg to mention a little incident that occurred on the line of the Oroya Railway in Peru, in the Valley of the Rimac. The final location had been made, and for some time the construction of this railway had been going on in a region almost rainless. At a point in the valley where the line crossed the mouth of a ravine we had left an opening to be filled by a bridge of 100 feet span. At the head of this ravine some poor *peons* had been cultivating the soil on the top and side of the mountain by bringing the water of melted snow from other and higher mountains for irrigating the land, as water in many parts of Peru is valued like gold. The peons, with great labor, puddled and protected the edges of their "chacras" so as to prevent loss by waste. The water sunk into the soil, and permeated down deep through stratas of alluvium, gravel, clay, and loose rocks. This was close to and on the side hills leading down to the Valley of the Rimac. This gradual permeation of rock and gravel, clay and sand, with water had, no doubt, been going on for a long time. The water was trying to find its lowest level. The rocks and the earth were only waiting to be released from the bonds of cohesion that had held them on the mountain side for ages to show what attraction of gravitation could do. Day by day this insinuating element, water, was doing its work, in the dark and in the night. Ceaseless, unopposed, all powerful, it was cutting and severing the bonds of cohesion. The people in the valley in front of the ravine rested in quiet content. The peons of the mountain imagined no evil genius underlying their crops, but in a moment when no one suspected danger the whole mountain side started for a race to the valley. Five millions of cubic metres (about ten millions of tons) of rock and earth, gravel, mud, and water came rushing into the valley, crossed its whole width of 1,400 feet, surged up against the opposite side, rolled over and crushed out of sight all the houses in its annihilating course, and filled the valley with a dam 1,600 feet wide on the bottom and 108 feet deep. The average vertical fall of this vast body of earth was about 1,500 feet, and the horizontal movement over 5,000 feet. Surely water has power, and we are entitled to place it with its sister element, fire, as good servants but dreadful masters. Gouverneur Morris, the projector of the Erie Canal, proposed that it should be built without locks, and on a line that would give it a uniform descent per mile from Lake Erie to the Hudson River. What a magnificent idea. It was too magnificent for the time. A line of this kind would carry the canal to the south of Cayuga and Seneca Lakes. With fifteen millions of tons of surplus grain in the far West seeking a market on the Atlantic seaboard, it would soon make New York the imperial city of the world, if it could find its way by water lines, without one check or hindrance, from the great grain fields to the great city.

A canal built as Morris proposed would not have a greater descent per mile than is now existing in the Ganges Canal in India, which has a fall of fifteen inches to the mile, and is navigated in either direction with facility and certainty. I mention this canal and its gradient to show that even a guard-lock is not a necessity at the south end of the San Blas route to provide for the current that would be created in the canal at extremes of high and low tide of the Pacific, but a guard-lock there would be a convenience and an economy.

Since the above was set up, another number of the Transactions has come to hand, containing an account of the special meeting to welcome M. Ferdinand de Lesseps. M. Lesseps, it will be observed, states that he went out to examine the route selected at the Paris Conference, *i. e.*, the Panama, but he is equally strong in his condemnation of either lift locks as on the Nicaraguan or Tehuantepec routes, or tunnels as on the San Blas route. I think, however, I shall not err in printing the Proceedings *in extenso*, and it therefore follows here. I may remark also that M. Lesseps' estimate is 120 million dollars, but little under the figure predicted by Mr. Evans.

Introduction by O. Chanute.

Vice-President O. Chanute was in the chair, and after calling the meeting to order, said:

This is a special adjourned meeting of the American Society of Civil Engineers, held for the purpose of welcoming to the United States the distinguished Engineers who have just arrived from Central America, and of hearing what they wish to say concerning the American Inter-Oceanic Canal. We shall first be addressed by M. de Lesseps. As, much to his regret, he does not speak English, his communication will be made in French, and, at his request, a synopsis of each portion of it will be made in English by Mr. N. Appleton. M. de Lesseps will also answer any questions which may be asked. After he has terminated, we shall have an account of the works proposed, by Mr. J. Dirks, Chief Engineer of the canal from Amsterdam to the sea.

The American Society of Civil Engineers has heretofore endeavoured to contribute its share toward the understanding of the subject of the Inter-Oceanic Canal, by gathering information concerning the various routes, the plans proposed for the canal, their probable cost, and the commercial bearings of the project.

This it has done, not with a view to revising the plans of what is, after all, a private enterprise, nor to pass judgment upon them, for the Society commits itself, as a body, to no views, and neither for nor against any project, but rather to collect the data required, that its individual members might form an intelligent opinion concerning the merits and probable results of an important undertaking, in which the American public is to be invited to take a share.

Beginning in November last, with the reading of a paper upon "Inter-Oceanic Canal Projects," by Mr. Menocal, member of the Society, and one of the delegates to the Paris Congress, the discussion has been participated in by many prominent members of the Society, as well as by several gentlemen who promote particular routes, and we have been fully informed concerning the San Blas, the Nicaragua, and the Tehuantepec routes.

But little has yet been said in those discussions concerning the Panama route; it being generally felt, that pending the proposed revision of the location and of the plans for the canal, by the very able engineers who had the matter in charge, it was desirable, before any opinions were expressed, to await the announcement of the results.

We are now able to learn these results, as well as the facts and plans upon which they are based, in the most direct, certain, and satisfactory manner; for we have among us to-night, as a guest, the chief manager and promoter of the enterprise; a gentleman of world-wide fame, as the builder of the Suez Canal, who, having already accomplished labors which to other men would be the work of a lifetime, having connected in the face of the most strenuous difficulties, two great seas across the trackless sand of the desert, now proposes to perform the still greater feat of cleaving the American Isthmus asunder, to connect the two great oceans of the world. Gentlemen, I have the honor to introduce to you M. Ferdinand de Lesseps.

Discussion by M. Ferdinand de Lesseps.

Mr. President and Members of the American Society of Civil Engineers, Ladies and Gentlemen: I am very happy to be here this evening, not only because it gives me an opportunity to set forth my views on the great project which I have so much at heart, and which I think when completed will be so great a blessing to mankind, but also at finding myself immediately upon my arrival in America, the much honored guest of this Society of Civil Engineers, before which, above all others, I consider it proper that I should first address myself. I am not an engineer by education, having been for so many years in the profession of a diplomatist, yet I am happy to be received as an engineer, and I am happy on that account as well as for the personal honors which have been paid me and the many opportunities afforded me for seeing in the short time I have already spent on shore what were to me most interesting and instructive illustrations of American engineering, skill and science.

I desire to begin at the beginning. In 1870, soon after the completion of the Suez Canal, and after that work had begun to be put into regular use, I began to think seriously upon the question of an inter-oceanic canal across the narrow land separating the two oceans in the Western Hemisphere. The first difficulty was the supposed difference in the levels of the two seas. An impression that there was such a difference had gone out and in many quarters was seriously believed, though for what reason I could not find out. Upon a careful examination it was discovered that this difference of sea-level was a myth, and that the only basis of the myth was the ebb and flow of the tide, which differed on the two sides of the Isthmus, but which would make no difficulty in the construction of a sea-level canal—for that from the first was the sort of a canal on which I had set my heart, and which I will build or abandon the project. I will not take up the various steps through which we passed in the consideration of this problem, for I can assure you that there were much study and many investigations during the years intervening between my first determination on the subject and the present time.

I determined not to occupy myself with political opinions, but from the moment I began the enterprise to devote myself to the practical part of the undertaking. I looked at the subject from a commercial view.

I am convinced and persuaded that the enterprise will be not only for the great advantage of commerce, affording an easy route to the Asian continent or India or Japan, but will produce results which will develop the shipping interests of the United States to the place they occupied twenty-five years ago.

I had the honor of the acquaintance of Senator Sumner when he visited France, and he gave me many valuable figures on the state of

American shipping at that time. He stated that the tonnage of American commerce at that time was about 5,500,000 tons. England at the same period had about 5,000,000 tons. All the commerce of the earth could have been divided into three sections, America owning one, England another, and all other nations together having an amount about equal to that possessed by each of these. Since that time America has fallen away as regards maritime commerce, and especially since the opening of the Suez Canal. Its commerce is very low, much more so than it should be for a people so great and powerful as the Americans. But I reflected that this was not to remain so; it cannot remain so with the Panama Canal open to encourage American shipping, as it certainly will do.

The Suez Canal has had the effect of changing the commerce of the whole world, and improved its shipping to an extent altogether unanticipated. It has caused the building of large steam vessels, which have supplanted the sailing ships. You will see that a similar metamorphosis will follow the opening of a Panama Canal. American shipping has fallen off since the war, and the mercantile marine, I am informed, is now in a deplorable condition. The opening of such a canal would give a fresh impetus to the building of American shipping and assist you in regaining the position that you have lost. To-day I say to the American people, prepare yourselves in six or seven years to see your commerce extended from the North Pole to the South. When you shall have comprehended the importance of the canal, you will see that your commerce will be benefited according to your large population, and that no other country will have pre-eminence over you when the canal is opened. I work not for selfish motives, but for the interests of humanity. Should you not, therefore, concur in the project as other countries have done?

I will compare the Suez Canal with that proposed at Panama, and show, as I hope, that the one across the Isthmus would be an easier matter than that joining the Red Sea and the Mediterranean. In the first place, there was no precedent for the Suez Canal in modern times. The ground had been a battlefield of nations since the commencement of historic times. In the time of the Pharaohs, there were fresh water canals in Egypt, in the construction of which the natural watercourses were often utilized.

The first canal proposed for crossing the Isthmus of Suez was in the time of Phillip II. He at first acquiesced in the idea, but being a very jealous monarch, and afraid that other nations might profit by the canal, he afterwards insisted that the project should be abandoned. An edict was issued declaring all men impious who should propose such a canal. Even if they spoke about it they were to be put to death. This was his order, and as they knew he had the power to carry it out, the subject of the canal was quickly dropped. I hope the example of Philip II. will not be followed in America. It would be very inconvenient for some of us to have such an edict in force.

Since the time of Columbus there have not been wanting those who thought that the American Isthmus could be traversed. It was first thought feasible by using the natural ports, lakes and rivers. The regular study of the question of the inter-oceanic canal began in 1875. There was then at Paris a universal geographical congress, and there I talked with Professor Nourse, from your Government offices in Washington, and I discovered how much interest was felt in the canal in America. I was charged to preside over the inter-oceanic section, and I obtained from Washington all the plans of proposed routes. Of all countries the most concerned was America. Some said that America did not want the canal, but I replied, "You deceive yourselves. America wants to develop commerce in the entire world." To prove that America wanted the canal, perhaps I exaggerated a little, but I said that she had spent already about $1,000,000 in exploration and in the attempts to find out how to start right in this great work. I said at the Conference that America having built a line of railroad across the Isthmus, it was a good argument in favor of crossing it at that point. The American engineers chose this route thirty years ago, and built their railroad there.

A new congress was proposed, to which that special question of the canal was to be referred. I wrote a number of letters to leading engineers in Europe and America, inviting them to come to Paris to discuss the scheme. Every one came at his own expense, and the first engineers of Europe were there. Over one hundred persons were present, the èlite of the entire engineering world. We were divided up into sections, one on engineering, one on navigation, one on statistics, one on the movement of commerce, and one on finances. Each committee commenced its work without wasting any time. I said we should go to work *a l'Americaine.* "How is that?" they asked. "Quickly," I said. And after what I saw yesterday, I can say that I never before knew fully what it was to speak of anything being *a l'Americaine.* Now I know what it is when I see your bold street elevated road and your magnificent bridge and your other works of freedom in science.

At it we went for fifteen days, night and day. All our deliberations were afterward printed. I remember that in connection with the Congress something was said to the effect that the American delegation was not treated with due consideration. This was an erroneous idea. Admiral Ammen was made First Vice-President. I do not think any discussion was started that the Americans were not in courtesy first called upon to speak upon it, and when it came to the final vote, every man could vote as he pleased, and also give in writing his reasons for the vote. There was not only no disfavor shown the Americans, but I was even charged with showing partiality to them, and this charge will be found in the printed report of the proceedings. At the final vote, 78 voted for the Panama route and 8 against, 12 declining to vote. I did not expect until the last day to occupy the place I now do at the head of this gigantic work, but when I heard the exclamations of the Congress, and saw there before me, as I see it now, the face of my wife, I felt that I ought to put myself at the head of this work, and the completion of the circumnavigation of the globe.

I thought, moreover, I had not the right, after having gone so far, to refuse to see the work through. It would have been cowardice not to continue, so I advanced in spite of the opinion of Mme. de Lesseps. It has brought now the pleasure of a visit to America, and the enjoyment of the hospitalities which are now showering upon me, and which I should not otherwise have enjoyed.

The first thing after this was to get the concessions from the Compagnie Civile, which that body had secured from the State of Colombia. My plan was to offer the company $1,000,000 in cash when the subscription for our undertaking should be taken up, and $1,000,000 in the stock of the new company. This new company has not succeeded, partly on account of the opposition of the press, and the press is a great power and deserves to direct public opinion when it is managed by honest men. The subscription was not a success, and I paid back the money to all who had subscribed. Thereupon some of my friends came together, and placed $400,000 in my hands to enable me to verify the surveys, and to pay the deposit required by the Colombian Government. I could not have done this with my own means. I am not ashamed to say that I have no fortune. I have passed twenty years in diplomacy and thirty years in engineering, but I did not profit by any of the enterprises which I began. It is not my trade; I make it a principle not to gain anything from others. I have only the shares which I pay for myself. Those who invested their money in the enterprise have taken a great risk and have a fair right to the fruits of success. Now my work has commenced of executing the enterprise. It is a work of the entire world, not only for other nations, but especially for America.

Let us talk of the technical part. Determined to make a verification of former surveys upon which I had based my scheme, I repaired to Panama with a party of ten well-known engineers. The expedition to the country has been safely accomplished, notwithstanding the dangers forboded to us. Much has been said against the climate of Panama; but we did not suffer from it at all. The climate of Suez is infinitely worse. The heat at Panama is from 23° to 33° Centigrade; at Suez 30° to 35°. We all came back in safety. The country was not dangerous at all, and was much more favorable to such an undertaking than that surrounding the Suez Canal, which I will now tell you of. The most celebrated engineers of France and England did not expect such a great success. I was treated as a fool because I simply desired to cut away the earth, whereas they had expected I would make a canal with the assistance of the Nile. I took engineers there and we occupied the territory. There was no water near, no houses, and it was nothing but a great plain of sand, containing nothing that could be of use to us. We used camels, and our laborers were divided in companies, some going in search of water while the others worked. There are no rains at Suez; it never rains there. The difficulties were almost insurmountable. There were battles with workmen, water had to be carried sixty leagues, we had fierce storms to encounter, and for the first two or three years we scarcely got a foothold. The sand did not frighten me as it did the public. It did not take much trouble to remove it, of course, and most of it was done by hand, before we had machines. But the taking out of clay was a more serious undertaking; in some respects it was more difficult to deal with than stone, because it could not be blasted or removed in blocks. Suez was far worse than Panama can be. We remember how we were told most solemnly that Suez could not be built, but we went, I shall say again, *a l' Americaine,* and did it, and now we propose to do it again. I have shown you the difficulties at Suez; at Panama there are no such difficulties.

Now (referring to a model in relief, of the proposed line of the Panama Canal), I will briefly sketch the route for the canal: It begins on the Atlantic side, at Colon (Aspinwall), and joins the valley of the River Chagres, a little south of the bay of Limon. The River Chagres however, does not empty into the Bay of Limon, but into the sea at the old town of Chagres. The canal follows the valley of this river to a point near Matachin, where the river has a sharp turn towards the north-east, and runs between two mountains. Here the canal leaves this valley, and it is proposed to construct a dam between these two mountains to provide for the storage of the flood waters of the river. This dam will be forty metres in height, and will retain about one thousand millions cubic metres of water. There are at least three dams in the world, which are of equal magnitude with this, and which have stood for many years; one in Spain is higher, and has endured three centuries.

The canal, leaving the valley of the Chagres, cuts through the mountains at Culebra, where the extreme depth of cutting will be about 270 feet, almost exactly the same as that of the towers of your great Brooklyn bridge, which you have just kindly shown us. Thence the canal will follow the valley of the Rio Grande to the Pacific, which it enters near the City of Panama.

Another advantage possessed by the Isthmus of Panama over that of Suez is its fertility, being a perfect paradise; there is no botanical garden in the world which could surpass it in beauty. The stations on the American railroad are surrounded by villages, and there is plenty of game in the mountains. I leave to the engineers with me the explanation of the details of the proposed plan, who will report as to the country which they have passed through, and after they have finished I will be at the disposal of the public to respond to all questions which any one may choose to ask.

Now, I beg to present this model to the Society of Civil Engineers, and to thank them for this opportunity of addressing you.

Discussion by J. Dirks.*

In the first place I beg to call your attention to the fact that neither

* Chief Engineer of the Canal from Amsterdam to the Sea.

the English nor the French is my native language. For this reason I invoke your kindness in overlooking any mistake as regards pronunciation; also grammatical errors. M. de Lesseps, the great mind who pulled down the Suez barrier, and therefore deserved, as well as earned, the thanks of mankind in general—came to America with the object of removing a second barrier, in joining together both oceans by a great ship canal through the American Isthmus. Allow me, ladies and gentlemen, to explain, in a few words, why M. de Lesseps deemed it convenient to invite me to join, not alone the Paris Congress of May last, but the scientific and technical survey of the canal line between Colon (Aspinwall) and Panama, which took place during the last few weeks. I have the advantage of being the engineer of the ship canal going from Amsterdam to the sea, which canal is fully described by your esteemed countryman, General Barnard, and was visited as well by himself as by other engineers of this great country, among them Captain Eads, the renowned builder of the St. Louis Bridge and of the wonderful works at the mouth of the Mississippi. When the general plan of the Amsterdam Canal was proposed, about 1860, only very few engineers believed in its feasibility, and the majority of scientific men were of opinion that a sea harbour in the shifting sands of the broad and shallow beach at the North Sea, as well as the dredging of a canal in the very soft mud of the lake through which it ran, were to be considered as quite impossible. Belonging to the small minority who were convinced that the Amsterdam Canal could be made and would fully answer the purpose, I was charged with the execution of the whole, in conjunction with Sir John Hawkshaw, from London, who acted as consulting engineer.

It is a great satisfaction to me that the Amsterdam Canal has been constructed; that the dark forebodings of a large majority never were realized; that the canal, at a cost of about $16,000,000, is a complete success, and that the largest vessels, even to a draught of twenty-four feet, easily enter and leave the new North Sea Harbour and get to Amsterdam within four or five hours. If not for the results of this proportionally smaller, but nevertheless very important scheme, M. de Lesseps would very likely never have known even my name. I have to thank him here for his kind opinion regarding the little experience in canal matters that I may have got, and I beg to state at the same time, as recorded above, that I was not alone in my quality of acting chief engineer, but that the great mind of my friend, John Hawkshaw, was there also, in order to avoid or to put aside many difficulties of planning and construction. As regards the technical possibility of a level ship canal between both oceans at Panama, I am happy to say again what I told a few days ago to some very competent men, namely, that I would like to write down my very favorable opinion in very large characters and put at stake my reputation as an engineer that the difficulties of this enormous work will be not greater—perhaps even less important—than those of the Suez Canal and of so many other great works completed with full success in America and in Europe. I want to state that the making of a deep cutting is just as possible at Panama as in the United States; that the blowing up of rocks may be done there even with greater facility than at Hell Gate, near this city, and, finally, that the only serious technical question to be solved is that of the floods of the River Chagres, through the alluvial and present bed of which a great part of the ship canal will have to be led. But even that difficulty can be surmounted. The result of the studies of Colonel Totten and Mr. Dauzats, who went into the question with the utmost care, was set forth in the international report recently published, and known, as I presume, to the members of this scientific body. I may therefore confine myself to the renewed expression of my heartfelt thanks to the chairman and the members of the American Society of Civil Engineers, as well as to many other citizens of this great city. They show their regards and kind sympathy not only for the engineer but also for the Dutchman. They talk feelingly about the old ties between my country and the United States. The same old blood is running through the veins of many on both sides of the Atlantic, and what happened in past times may lead toward what may occur in the future, the relations between both peoples and the other nations will be progressing for ever, and each barrier pulled down on the broad way of commerce and industry will largely contribute toward such a blessed prospect.

O. Chanute.—M. de Lesseps is now prepared to answer questions, and I will begin by asking him, what are the estimates of the probable cost of the undertaking, and the probable returns?

M. de Lesseps.—One hundred and sixty-eight millions of dollars. Of this $20,000,000 are for the large dam to keep the waters of the River Chagres in. It would not be necessary to have the work entirely completed before vessels could be sent through. I am satisfied, too, that the final operations will show a considerable reduction. This is the reason that induces me to fix the capital at 600,000,000f. or $120,000,000. But should my hopes in this direction not be fulfilled, the difference necessary to make up the estimate can be supplied by bonds or otherwise.

According to the returns of the Congress at Paris, it was calculated by M. Levasseur, the Chairman of the Committee on Statistics, that 6,000,000 tons would pass through the canal in a year, and that within ten years they would rise to 7,250,000. At Suez the tariff was 10 francs or $2 per ton, but at Panama it could be raised to $3, which would give a gross yearly revenue of $18,000,000, which would be a very large return for a capital of $200,000,000, which is much more than the canal is estimated to cost, including the running expenses and the interest on the money. And as this tonnage is greater than that which was estimated to pass through the Suez Canal, the canal on this continent would be a better investment than the other, and the stock and bonds of the Suez Canal are very much above par.

O. Chanute.—What proportion of the necessary capital will be raised in Europe, and how much do you propose to raise in this country?

M. de Lesseps.—The original capital will be $120,000,000. One-quarter has to be paid up before a company can be formed under the French law. One-half of the capital stock will be allotted to the United States, and the other half to Europe. But in case it is not taken up by the United States I will try and have the sixty millions taken up in some other way. But I wish to have it understood that one-half the stock may be subscribed for in the United States, as the United States have an interest in the enterprise equal to all the rest of the world put together.

Horatio Allen.—Past President of the Society:—I would like to ask a question, so that we may have a little clearer conception of the subject. I understand that the length of the canal from ocean to ocean will be forty-five miles; that a certain portion of that canal will be a deep cut, and that a certain other portion will be ordinary canal work. I would like to ask how many miles are to be cut through, and how many will be a deep cut?

V. Dauzats.—The deep cutting extends for about six and a half or seven miles. The deepest excavation will be about ninety metres; and for this distance of seven miles the cutting may average about 180 feet. In other parts of the canal the cutting will not be of very great depth.

HORATIO ALLEN.—Is the deep cutting entirely in rock?

V. DAUZATS.—Not entirely in the rock. There is earth over the rock. Col. Totten thinks that the earth may be twenty feet in depth, but in order to be safe the estimate was based on a depth of earth of twelve feet and the remainder rock.

Q. A. GILLMORE.—Will you give some details as to the proposed dam for the Chagres River?

J. DIRKS.—The height will be 40 metres and the length 1,600 metres. It will form a reservoir capable of holding more water than the greatest flood known on the river. Before a second flood arrives the reservoir could be emptied by the main and the secondary canals. The dam can be sufficiently well built to make it perfectly safe.

ASHBEL WELCH.—Why go to the enormous expense of making a sea level canal across the Isthmus when a canal with two or three locks on each side of the deep cut could be made so much more cheaply?

M. DE LESSEPS.—If the Commission of Engineers which had gone down to Panama had reported in favor of a canal with locks I should have put on my hat and left the whole project and would have had nothing to do with it. That plan may do for small ships, but when we have vessels now afloat 500 feet long and others on the stocks 600 feet long, it is impossible to say for what you would have to build the locks. Single locks would be slow, and double locks though quicker would be very expensive and require constant repairs. At Nicaragua they intended the use of locks, and with the earthquakes which prevail there the repairs would be ruinously expensive, and even at Panama, where earthquakes do not exist, they would be fatal by reason of the loss of time. I would not have anything to do with a locked canal except for little ships. It is not the proper idea for a grand inter-oceanic canal.

C. BUTLER asked why the San Blas route has not been examined.

M. DE LESSEPS.—The object of the Commission was to examine the line accepted by the International Congress; but in reference to the route referred to by the gentleman, I would say, that although the port on the Atlantic side is very good, that on the Pacific side is not. This line would make necessary a tunnel of, say, seven miles in length, and as the Commission had already rejected a route in which there would be a tunnel of three or four miles, why adopt one having a tunnel so much greater in length?

Senator [illegible].—Is the deep cutting entirely in rock?

Mr. Davis.—Not entirely in the rock. There is earth over the rock. Col. Totten thinks that the earth must be twenty feet in depth, but in other places the estimate has been based on a depth of earth of twelve feet over the solid rock.

[illegible].—Will you give us a detail as to the proposed dam for the Chagres River?

Mr. Davis.—The height [illegible] and the length [illegible] [illegible] building more [illegible] flood [illegible] beyond flood [illegible] [illegible] secondary [illegible] be sufficient [illegible] perfectly safe.

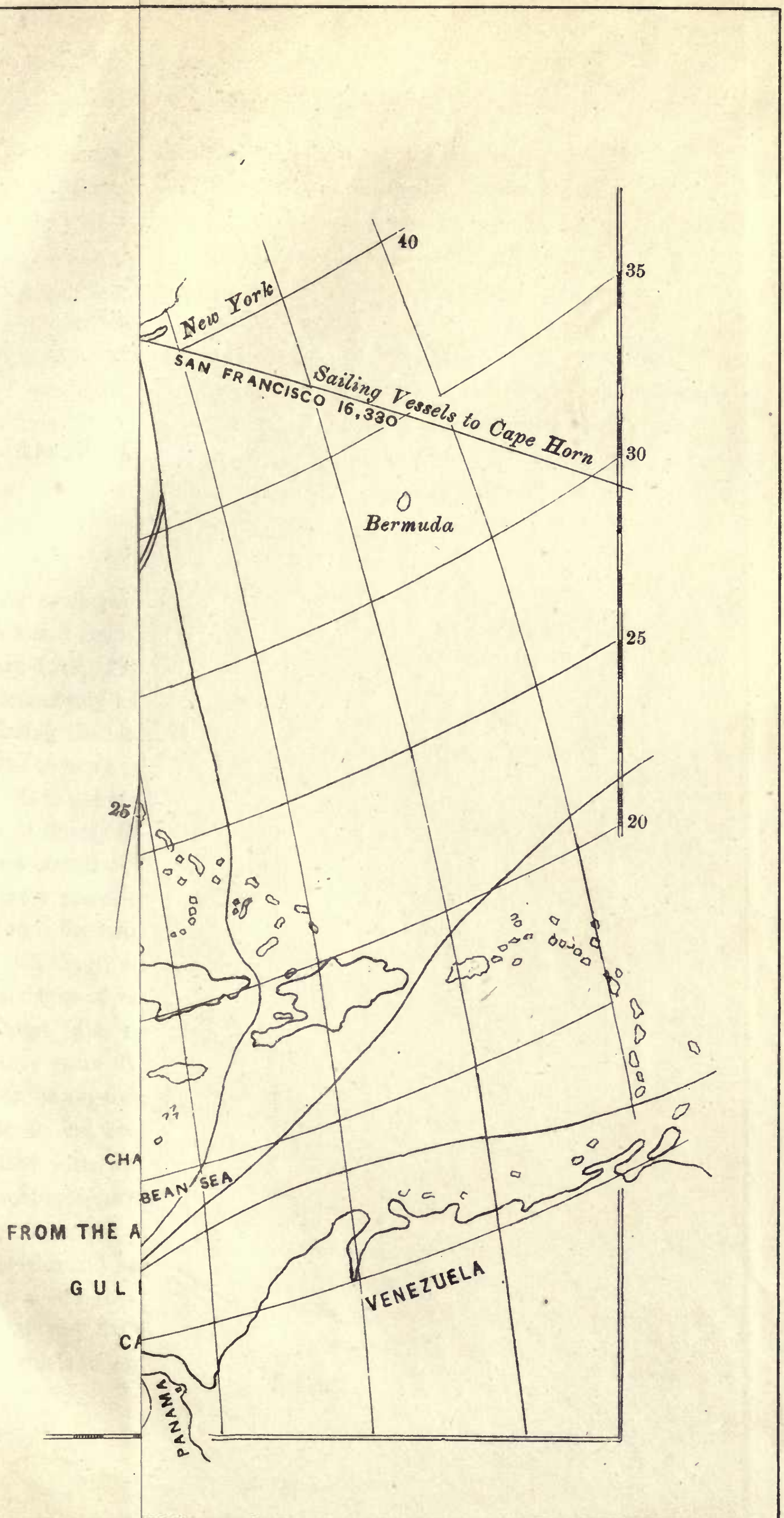
[illegible] to the enormous expense [illegible] lock canal [illegible] agree with [illegible] condition of the [illegible] which [illegible]

[illegible] the Commission of Engineers [illegible] had reported in favor of a canal [illegible] [illegible] [illegible] small ships [illegible] [illegible] we would have [illegible] Lake [illegible] would be [illegible] very [illegible] repairs, [illegible] the [illegible] earthquakes, which [illegible] even of Panama, [illegible] I would not [illegible] a lock canal [illegible] it [illegible]

[illegible] not been examined?

[illegible] the Commission [illegible] [illegible] [illegible] would [illegible] although the [illegible] side [illegible] the Pacific [illegible] The [illegible] miles in length, and as the [illegible] which there would be [illegible] of [illegible] a tunnel [illegible] in length.

[illegible]



40
35
30
25
20
New York
SAN FRANCISCO 16,330
Sailing Vessels to Cape Horn
Bermuda
25
CHA
BEAN SEA
FROM THE A
GUL
C
VENEZUELA
PANAMA

No. CCCXXIX.

JAMES CLEMINSON'S "FLEXIBLE WHEEL-BASE" OR RADIATING AXLES.

[*Vide* Plate].

As carriages are now being fitted on this principle on the Scinde, Punjab and Delhi Railway, the following extract from the *Engineer*, February 15th, 1878, may be interesting. The plan seems to have been extensively tried in England, America and the Continent of Europe, during the last three years, and to have met with very general approval, and to work practically perfectly up to curves of 70 feet radius.

It is not clear from the description or figures how "the central axle is at liberty to slide under the main frame" of the carriage, but this is a matter of detail. The main frame probably rests and slides on the corner plates shown on each minor axle frame, and the only other connection is the two swivel pins of the end frames.

"Though the desirability of using some arrangement of the under carriages of railway rolling stock, by which the axles would be free to depart from rigid parallelism when traversing curves, has been felt for many years, it is only recently that much has been done in this direction as regards passenger coaches in this country. Previously all the stock, and even now on most of our lines practically all was, and is, fitted with wheels whose axles are rigidly parallel, a condition which could not have been allowed to exist so long had it not been possible to obtain the requisite engine power and strength of the parts of the vehicles and permanent way which such a system of construction entails. On a straight line a vehicle with parallel axles may be considered to need very little guidance by the flanges or rails; the tendency of such a vehicle in motion is to pursue obstinately a straight course, and from it is only caused to depart by side pressure on flanges and rails. The intensity of that pressure may be imagined when the amount of skidding on any curve is remembered. For instance, a train passing round 90° of a curve of, say, 10 chains radius, is actually *skidded* through not less than 60 or 70 feet; the actual amount of skidding depending to some extent upon the length of the vehicles. The Americans first endeavoured in a practical manner to remove this defect by the application of the bogie, but even that very useful invention only partly removes it, as each bogie is in itself a vehicle with parallel axles, but with a short wheel-base. It is only recently, however, that even a bogie has been much used in this country, though it has for several years been known that long carriages run much more steadily than those of the ordinary length, and the proportion of dead weight, or non-paying load, may be made to decrease with increase of length. Carriages of increased length have been built, most of them running on six wheels with parallel axles, a certain amount of transverse play being allowed in the central axle. Even with this, however, the position of the wheels on a sharp curve is as illustrated in diagram, *Fig.* 4, from which the tendency of the wheels to mount the rails, and the increased power necessary on a curve as compared with a straight line, to pull such a carriage along, may be estimated. By the use of the bogie the strongest objections to long carriages have been overcome, but others have been imported by which the object of using long carriages has been partly defeated. The bogie car being supported only at or near the ends, its motion is little better than an ordinary short carriage, while the distance between the supports involves the use of very strong and heavy framing, and the bogies of themselves are of such weight that the paying proportion of the load, instead of increasing with the increased length, has in most instances decreased. The parallel axles of the bogies have, moreover, the objections which are attached to short carriages with such axles, so that, although it, as far as itself is concerned, permits the construction of long carriages, the grinding and waste of power on curves is as great as with ordinary short carriages, for the direction of pull of the long carriage on a curve causes a thrust on the inner rail at the foremost end and on the outer rail at the rear end.

"Our object here is to place before our readers a system of construction invented by Mr. James Cleminson, of Westminster, which overcomes these difficulties in a satisfactory manner, its chief recommendation being that while securing other advantages it provides the means of passing round the sharpest curves with the axles always normal and radial thereto, whatever its radius, as shown in *Fig.* 5.

"This result is achieved by so attaching the axles to the carriages and to each other as to permit them to adapt themselves automatically and with perfect truth to the varying conformations of a railroad. This is effected as follows :—The axles, with their axle-boxes, guards, and springs, are mounted in frames BCD, *Figs.* 1* and 2, separate from the main underframe E. The end frames B and D have central pivots H, around which they swivel freely, whilst the middle frame C is at liberty to slide transversely to the main underframe E through a range equal to the versed sine LM of an arc NLO, the chord of which equals the wheel-base NMO—*see Fig.* 6—and finally the frames are connected to each other by the articulated radiating gear IK. The action of the combination is simply thus—When a vehicle enters a curve, the middle axle and frame C move transversely through the versed sine of the wheel-base arc, and, in doing so, cause the end axles and frames B and D to swivel around their pivots H, so that all the axles assume positions of radii of the curve.

"There is, it will be noticed, nothing of a special nature, beyond the axle-frames, required in the application of the invention, either in building new carriages, or converting old stock, these frames entailing very little extra cost, for as the main underframe E is relieved of the strains ordinarily due to curves, it is said that it may be reduced in strength to such an extent as to compensate for the cost of the axle-frames. All standard fittings, such as axle-boxes, guards, and bearing springs, are retained without alteration.

"It will be seen that the system permits the construction of vehicles of any length, and secures the unattained objects of the bogie with the advantage of support throughout the length of the carriage. In very long carriages, say 80 feet, eight wheels would be employed, with a modification of the arrangement illustrated.

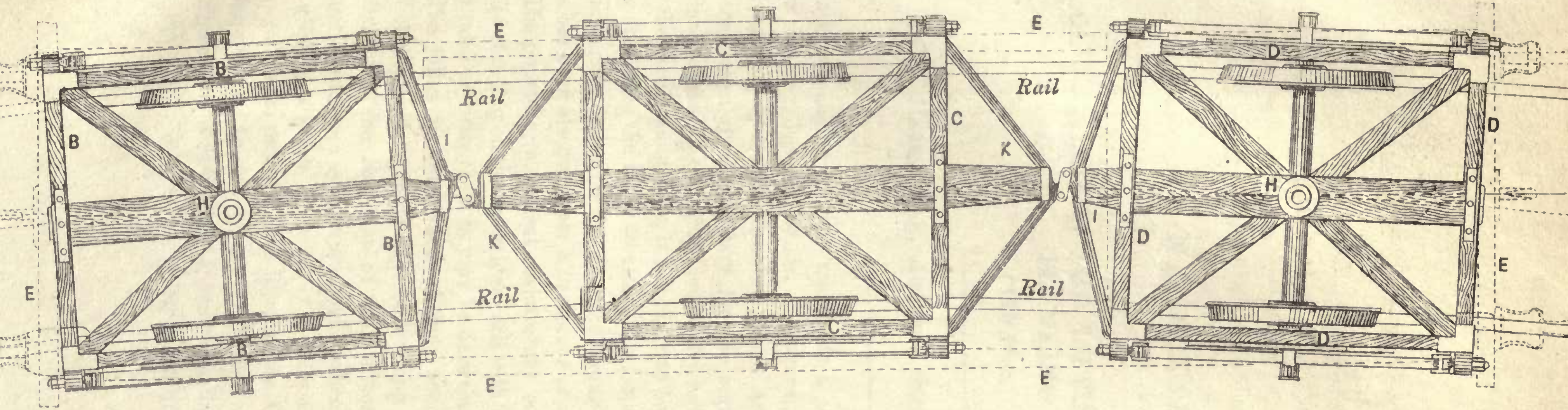
"The carriage illustrated by *Fig.* 1* is the new Royal Saloon carriage constructed by the South Western Railway Company, and was briefly described in the *Engineer* of the 30th of November last. Brief reference to the steadiness and ease with which the carriage passes round sharp

* Not reproduced.

curves was made on page 75 of the current volume. Carriages on the system described have been running for about a year on the London, Chatham, and Dover Railway, and any passenger travelling from Chatham to London will be able to make the journey in the old and new carriages, and prove for himself the great difference in the comfort of the two systems, especially when travelling by the boat express from Chatham to Herne-hill. The line is notoriously crooked, but it is on such lines that the new carriages show their great superiority in steadiness and smoothness in running.

"Besides being in use on the lines referred to, a number of pairs of short Metropolitan carriages are being converted into single long carriages on the new system by splicing, and a large quantity of stock is running on the Campanhia Paulista Railway of South America. Several English companies are making up whole trains, and a somewhat remarkable example of the application of the system is its use on the North Wales Narrow Gauge Railway. The gauge is 1 foot $11\frac{1}{2}$ inches, and an official trial of a whole new train was recently made at a speed of twenty miles per hour, which, on a line which may be almost considered as a continuous set of curves of two chains radius, would be attended with the greatest danger with any other stock. The stock has hitherto been of the bogie class, the carriages being 25 feet in length, carrying 30 passengers, and weighing $5\frac{1}{2}$ tons. The new carriages are 30 feet long, carry 42 passengers, and weigh $4\frac{1}{4}$ tons each. The latter have thus 33 per cent. more accommodation and weigh 20 per cent. less than the former. The bogie carriages rock very much in passing round the two chain curves, but this is not the case with the new carriages, which have a wheel base of 23 feet, or more than one-sixth the radius of the sharpest curve. The economy in weight in this instance is, it will be seen, very great, and is illustrative, for though on the stock of full size railways the gain is not so much, it is very large in all cases. In proof of the merits of the system, we may point out that it is being regarded with much favour by many locomotive and carriage superintendents, who are necessarily not the least easily satisfied. The facts that the carriage is so thoroughly supported throughout its breadth and length, and that the existing frames, springs, hornplates, &c., are all applicable, as well as the general simplicity of the arrangement, very strongly recommend it."

Fig. 2.



PLAN OF AXLE FRAMES ON A CURVE OF 100 FEET RADIUS

Fig. 6.

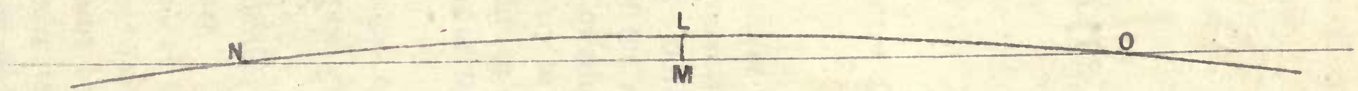


Fig. 4.

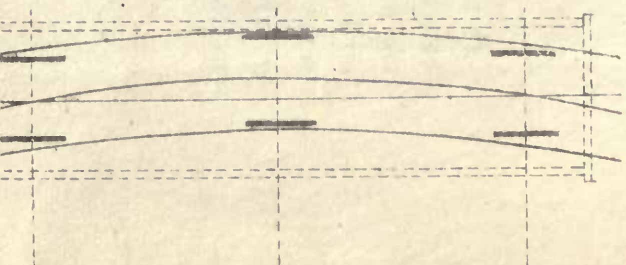
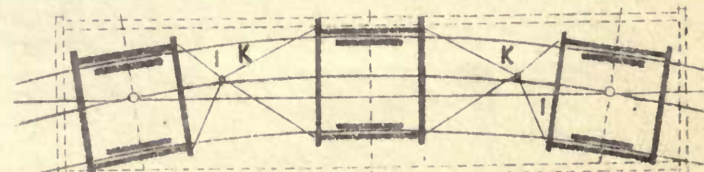


Fig. 5.



Thos. D. Bona, *Sup*

No. CCCXXX.

CLIP CALLIPER FOR LIFTING WASTE WEIR PLANKING.

[*Vide* Plate.]

By A. Hayes, Esq., *Assistant Engineer, Cossye Division.*

The accompanying drawing represents a clip calliper for lifting waste weir planking, designed by Mr. E. Raynean, Sub-Overseer, Cossye Division, formerly Dehree Training School Apprentice. During irrigation season, when it is necessary for the regulation of the supply to the various reaches to the pretty constantly raising and lowering the planks on the canal calingulahs, it has hitherto been necessary to send a khallasy down into the water to attach the loops of the lifting ropes to the wooden pins, driven for this purpose through each end of the planks, and this has been always rather a hazardous proceeding.

The present arrangement obviates any such necessity, for two khallasies standing on the one bridge each with a calliper, can grip the planks and raise or lower them as may be desirable.

The following description of their action, in addition to the plan, will clearly explain the method of working the calliper.

Raising.—The two jaws of the calliper weighted at the upper extremities with two cylindrical weights when opened out for the purpose of gripping a plank, are retained in position by a bent hook catch A. The calliper is provided with two sockets BB, in order to allow of its being attached to, and sliding on, a guide rod. When used in still water the guide rod is not required, and the calliper can be lowered fairly on to the plank, attached to a rope, but in an overfall of 2 to 4 feet or more, the use of the guide rod is indispensable. The guide rod is provided at its lower end with an elbow iron point, which, as the rod is carried down by the stream, catches on the face of the planking, and allows of the rod being brought to a vertical position in the current.

The rod being dropped well ahead of the planking and brought vertical (*Fig.* 1), the calliper with jaws open and set, and the upper catch inverted, is lowered by a line down the rod until the convex portion of the bent hook A, coming in contact with the planking the catch is freed, and the jaws close in an immoveable grip, the calliper assuming the position of the dotted lines. Both rod and calliper can now be hauled up with the plank or the rod detached, and the calliper and plank raised.

Lowering.—When it is desired to lower a plank, the plank is gripped as per *Fig.* 2, and the calliper lowered, the upper catch C being slipped up above its notch. On the plank reaching its place, the lowering rope is slackened, and the upper extremities of the jaws opening the upper catch C falls down into its notch, retaining the jaws open and the plank is freed, the calliper assuming the position of the dotted lines. It is generally found in a current that an additional blow or two with a rammer from above is necessary to overcome the friction of the plank against the grooves and drive it fairly down.

The main dimension and weight of a calliper is as follows :—

	Weight.
Jaws, flat iron (over all) 1′ 6″ × $1\frac{1}{2}$″ × $\frac{1}{4}$″	
Sockets, pins and other parts, ...	8 lbs.
2 Leaden weights, ...	7 „
Total weight of calliper,	15 „

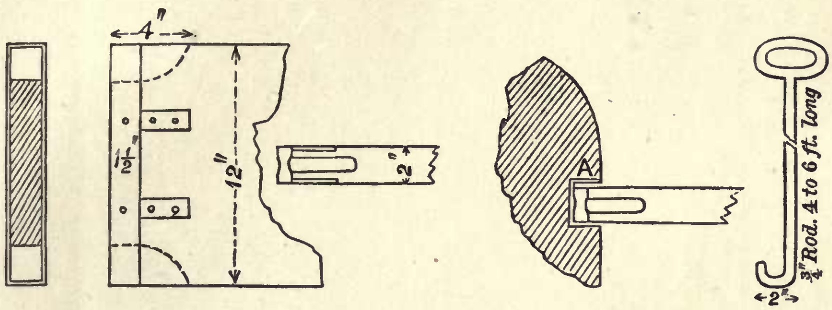
Rod 15′ × $1\frac{1}{2}$″ × $1\frac{1}{2}$″.

The dimensions of the calingulah planks are 5′ × 1′ × $2\frac{1}{2}$″. The head lock stop planks to prevent silt getting into the lock in flood time, dimensions 20′ × 6″ × 4″ are also lifted with a pair of callipers. The planking should be slightly notched to enable calliper jaws to obtain a securer hold.

A. H.

Editor's Note.—Practice with a simpler tool, see *Fig.* A, produces a fair result. The Dadupur dam, West Jamna Canal, over the branch of the Jamna, has 60 openings of 10 feet breadth, 4 to $6\frac{1}{2}$ feet deep, closed by about 290 planks. On approach of flood, about 230 of these are taken out and carried to banks by 45 men in two hours. The carrying is of course the heavy work requiring the number. Only 8 men are employed in lifting planks. The lower planks are of course lifted under 4 to 6 feet head and rush of water. Two hours is the night time, one and a half is sufficient in day light. This is rather smart practice, and I enter

Detail of end of plank at A.

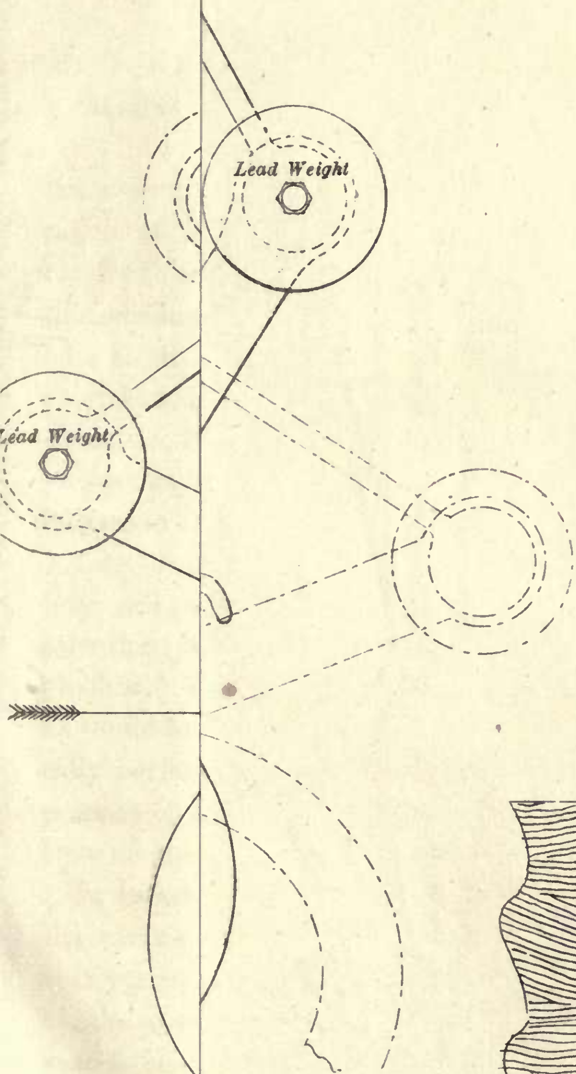


it here more as a bit of information as to what can be done, than to detract from the invention alongside. This is useful in cases of very deep water where a rod would be long and unwieldy, but the fact that the catch on the plank is *in* the groove in the pier makes it easy to find.

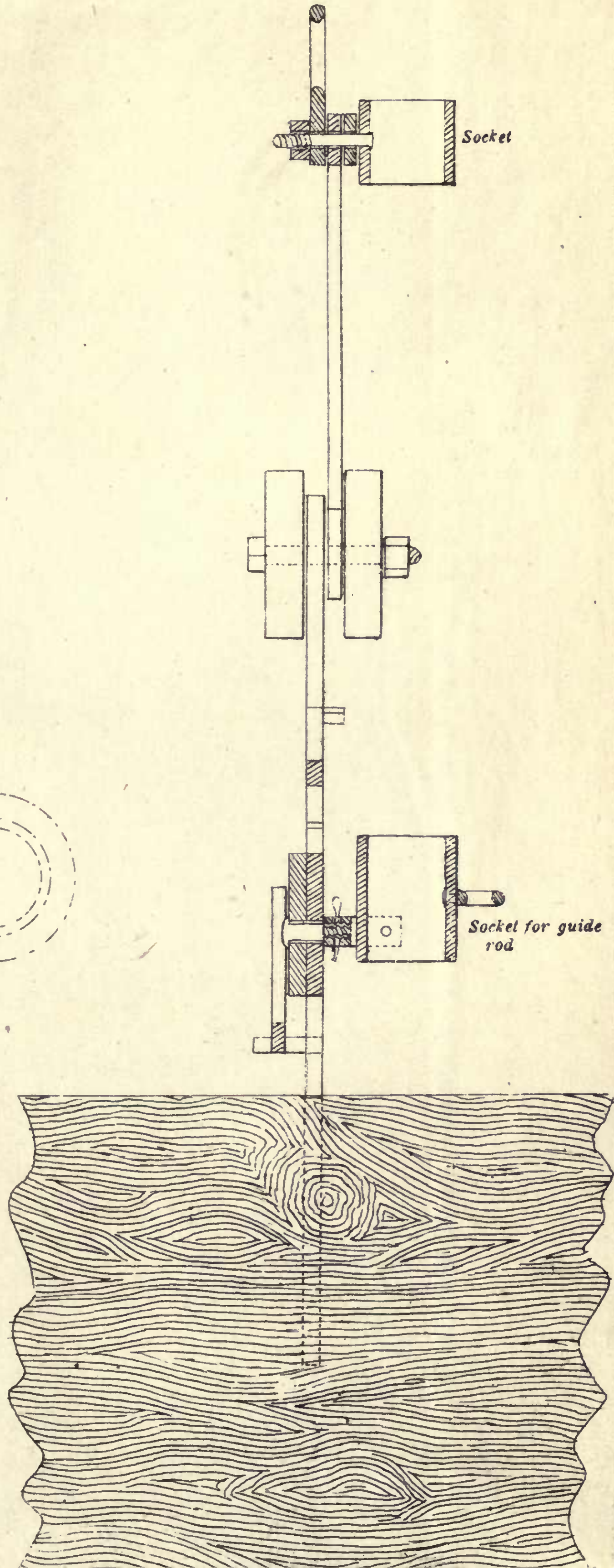
Fig.

POSITION IN

dotted lines thus ---
ition of the Callipers
ng released by the wei
plank the claws take the



SECTION THROUGH A B.



No. CCCXXXI.

ELECTRICAL INTER-COMMUNICATION IN TRAINS.

[*Vide* Plate].

By G. K. Winter, Esq., F.R.A.S., M.S.T.E., *Telegraph Engineer, Madras Railway.*

Amongst the numerous applications of Electricity, the rapid communication of intelligence from one place to another is that which has received the greatest development, and it is certainly the use to which this wonderful agent appears to be most specially adapted. In the early days of its employment for this purpose it was thought uncertain and capricious, but as time went on, difficulties one after another disappeared; its action, before uncertain, became more and more under control, and its very caprices have been found subject to law, and have been converted into some of the most useful of its attributes.

Inter-communication in trains, or the communication of intelligence from one part of a train to another, has received a large amount of attention, and much ingenuity has been devoted to the solution of the problem. The fact, however, that no system has been universally adopted would tend to show that no system hitherto brought forward is practically perfect. Captain Tyler has said that electricity offers the best promise of success, and in this view most men acquainted with the present state of electrical science would probably concur.

In looking carefully into the question of the merits and demerits of the various existing electrical methods, with a view of discovering the best system for adoption on the Madras Railway, I found that the use of the wheels and rails as an "earth" or return circuit, and the use of special electrical couplings, were nearly universal. A few experiments were sufficient to convince me that in India, at least, we could not make this use of the wheels and rails, for even supposing the electrical contact between the framework and the axles to be perfect, that between rail and rail could not be relied on, especially in dry weather; and with regard to the special electrical coupling, a little consideration was sufficient to show that any system which involved any extra labor or attention in forming or shunting trains, was unsuitable to our mixed and ever-changing traffic. There seems also to be little doubt that any difficulties which have been found to attend the application of the electrical systems hitherto proposed have been due to negligence or forgetfulness in forming the extra coupling, or to the imperfect earth formed by the wheels and rails; a coating of snow for instance over the rail would destroy communication even in England. The motion and consequent vibration of a train, on the contrary, presents no difficulty which cannot be easily overcome.

My endeavours have therefore been directed to the adaptation of the existing couplings to the purposes of communication, and to doing away with the necessity of using the wheels and rails as an earth. The result is a system which has been well tried on the Madras Railway, and has, I believe, given satisfaction to all who have seen it. It is impossible for any mistake to be made by the porters in forming or shunting a train, for they have only to do the work they have been always accustomed to, and it is impossible for any quantity of dust, tar, dirt, or grease on the surfaces of the hooks to damage in the slightest degree the integrity of the circuit, for the hooks are self-cleansing, and the weight of the chains is sufficient to insure the perfection of the contact.

Having abandoned the use of the wheels and rails as an earth, we require two conductors, insulated from each other, running from one end of the train to the other. This is simple enough as far as the carriages themselves are concerned, but the most difficult as well as the most important point is the mode of connecting electrically the conductors of one carriage, with the corresponding conductors of the next. This connection I accomplish by means of the side or safety chains in the following way :—

A strong and flexible cable is passed through the links of the chain; the conductors of this cable form a continuation of one of the insulated conductors of the carriage, and are fastened electrically to the hook at the end of the chain.

The cables are made by winding galvanized iron binding wire, weighing about 100 lbs. to the mile, helically round $1\frac{1}{2}$ inch tarred hemp rope, in the grooves between the strands. The end of this cable, which is to be attached to the hook at the end of the chain, is close bound with the same binding wire for a length of about 3 inches, and the ends of the wires projecting beyond the hemp rope are twisted together into a wire rope.

Two holes are drilled through the shank of the hook about $1\frac{1}{2}$ inches apart, and into these holes tinned iron eye bolts are soldered. The ring of the eye bolt nearest the end of hook is only large enough to admit the wire rope projecting beyond the cable, while the other is large enough to admit the cable together with the extra binding. The bound end of the cable is passed through the large eye bolt and carried as far as the small one, through which the wire rope is passed, and to which it is firmly soldered; the rope is then unwound and spread radially over the ring of the bolt, and again firmly soldered on to its surface, the ends of the wire being cut off if too long. The lower end of the cable being thus firmly fastened to the shank of the hook, the cable is passed through the links of the chain in the most convenient manner, and finally passed through a hole in the buffer plank of the carriage, the wires of the cable are then soldered to the end of one of the wires running underneath the vehicle. The chain and cable are well coated with tar, except on the inner surface of the hook.

The next point to be considered is the best mode of securing good electrical contact between the hook of one chain and that of the next carriage, when they are coupled. On the electrical condition of this contact depends the success or failure of the system, I have therefore spared no pains to ensure its perfection. The shape of the hook is first altered from the ordinary form shown in *Fig.* 1 to that shown in *Fig.* 2. To secure uniformity and correctness of figure, a steel or iron die is made of the shape shown in *Fig.* 3. The hooks are made red-hot, and are easily altered into the required shape by first driving the die between the jaws of the hook, and then completing the alteration by means of the hammer, keeping the die in its place during the operation. The bearing surface of the hook is then coated with a piece of sheet copper which is brazed on, and finally a small rib of gun-metal of semicircular section is soldered on to the inside of the outer jaw of the hook. *Fig.* 4 is a drawing of a complete chain with cable, &c., and *Fig.* 5 is an enlarged drawing of the hook with its copper lining, and gun-metal rib.

It has been found that with hooks prepared as above, neither grease, tar, nor dust, are able to impare the contact of hook with hook, and the small stones, which are occasionally thrown upon the chains from the ballast, are unable to insinuate themselves between the acting surfaces.

The method of working adopted on the Madras Railway is very simple, and might be still further simplified could a battery be conveniently placed on the engine.

A battery is placed in each brake van, and all batteries are so connected that they always tend to send a current in the same direction. The circuit is always open except when closed by pressing a plunger in the act of signalling. The disposition of the apparatus in a train will be understood from *Fig.* 6.

All that is necessary is to have a brake van between the passenger carriages and the engine, and even this rule would be rendered unnecessary, if we could place the battery on the engine, instead of in the vans. This system has been working exceedingly well on the Madras Railway, since the 1st January 1879, the daily train mileage worked being about 1,776 miles. The fitting of the whole stock of the Railway is being rapidly proceeded with, and at an early date the whole of the trains running on the Railway will be provided with an efficient means of communication between the Guards and Passengers and the Driver. The arrangements are tested on leaving or passing through each station, by the Guard in the rear van giving an all right signal to the Driver, and any failure or irregularity in the working of the apparatus is entered in the Guard's and Driver's Journals, and is reported to the Heads of their respective Departments, so that the letters that have been given me by the Traffic Manager and Locomotive Superintendent are written with full knowledge of the manner in which the system has worked.

It has not been thought necessary hitherto to apply a break-away signal to the system on the Madras Railway, and the author does not recommend its adoption, owing to the complication necessarily involved: it can however be applied in several ways, of which the following arrangement is probably the cheapest, simplest, and most easily applied.

The closed circuit is used, and signals are made by breaking or opening the circuit, so that if a train parts a signal is given automatically in consequence of the break in the circuit, caused by the parting of the train. The difficulty which has hitherto prevented this system from being adopted is that during shunting, or when the engine is separated from the train, the engine bell would be continually ringing, unless some act were performed to stop the ringing; and, in this case, there is always the danger of the apparatus not being re-adjusted for ringing, when the train is made up again. This difficulty I propose to overcome in the following simple manner.

A relay is used on the engine to complete the circuit of a local battery through the bell. This relay has two contacts, the armature making contact with the one when the train circuit is complete (that is when the constant current is flowing through the coils of the relay), and with the other when the train circuit is broken (that is when no current is flowing through the relay coils). A switch attached to the apparatus is arranged to join one contact with the battery and bell, when the switch handle is in one position, and the other contact with the battery and bell, when the handle is in its other position. Thus, suppose when the train is joined up, and the train circuit closed, the bell is silent when the switch handle is at A, and that it rings when the handle is at B; then, when the train is divided, and the train circuit broken, the bell will be silent when the handle is at B, and it will ring when the handle is at A. Thus on arriving at a station at which shunting is to be performed, directly the train is divided the bell will ring, and will continue to ring until the Driver turns the handle to B. Again, when the shunting is completed, and the train joined up again, the bell will ring until the Driver turns the handle back to A. So that, whether the train is being formed or broken, the Driver is reminded of the change to be made in the position of his switch handle, by the ringing of the bell, and there is consequently no chance of the proper adjustment being forgotten. The arrangement is shown in *Fig.* 7.

It will be seen that signals may be given to the Driver by simply dividing the circuit in any part of the train, and keys arranged to do this may be fixed in any or all of the vehicles. Also should any part of the train become separated, the act of separation will break the train circuit, and cause the bell to ring.

No. C $\frac{780\frac{1}{2}}{\text{A. \& M.}}$

From—H. E. CHURCH, ESQ., *Traffic Manager, Madras Railway Company.*

To—G. K. WINTER, ESQ., *Arconum.*

Madras, 9th October, 1879.

In reply to your enquiry as to our experience of the practical working of your electrical communication in trains, I have much pleasure in informing you that since its introduction, on the 1st January last, in the mail trains, it has worked most satisfactorily, and the comparatively few interruptions we have experienced have been found on enquiry to be due to carelessness on the part of the Train or Station staff, and not to any defect in the system.

The communication has been made use of by the public on more than one occasion, when a spark from the engine had set fire to clothes, or bedding, and there can be no doubt that it is much appreciated by the Train staff.

* * * * * * * *

No. $\frac{3224}{4626}$

From—F. H. TREVITHICK, ESQ., *Locomotive Superintendent, Madras Railway.*

To—G. K. WINTER, ESQ., *Telegraph Engineer, Arconum.*

Perambore Works, 27th November, 1879.

In compliance with your request that I should express an opinion upon the working of your electric inter-communication apparatus, I have much pleasure in testifying to the success with which it has been worked during the last 11 months on this Railway.

The apparatus is now fitted to nearly all the engines on this line; it has done good service to passengers on the occasions when it has been needed by them, and as far as I know, has not once failed from any defect in the apparatus.

The bell on the engine always rings, and so clear and strong in answer to the Guard's touch on the key in his van, that it has often occurred to me that the use of the apparatus ought to be extended by the adoption of some simple Code, so as to enable the Guards to communicate much more than an order to stop, or a signal that all is right behind. It would be most useful as a starting signal, especially for long goods trains on dark and stormy nights.

As there is no machinery to get out of order; as it requires no special couplings between the vehicles, and admits of easy application to foreign stock mixed up in the trains, and as, above all, it has now stood quite successfully the practical test of a year's working, I have no hesitation in asserting it to be the best inter-communication scheme yet brought out.

Extract from a letter from the Agent and Manager, to the Secretary, Madras Railway Company, No. 1388, *dated the* 18*th of October*, 1879.

From the 1st of January last the mail trains have been provided with electrical inter-communication between Guards and Passengers and the Drivers, and since the 1st of February the 7 A.M. and 6-15 A.M. passenger trains have also been similarly provided, the working of which in all cases has been satisfactory.

G. K. W.

ELECTRICAL INTER-COMMUNICATION IN TRAINS.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

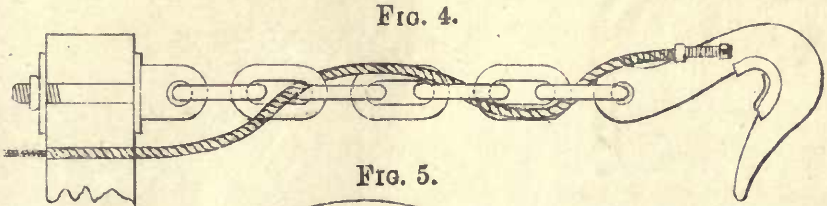


Fig. 5.

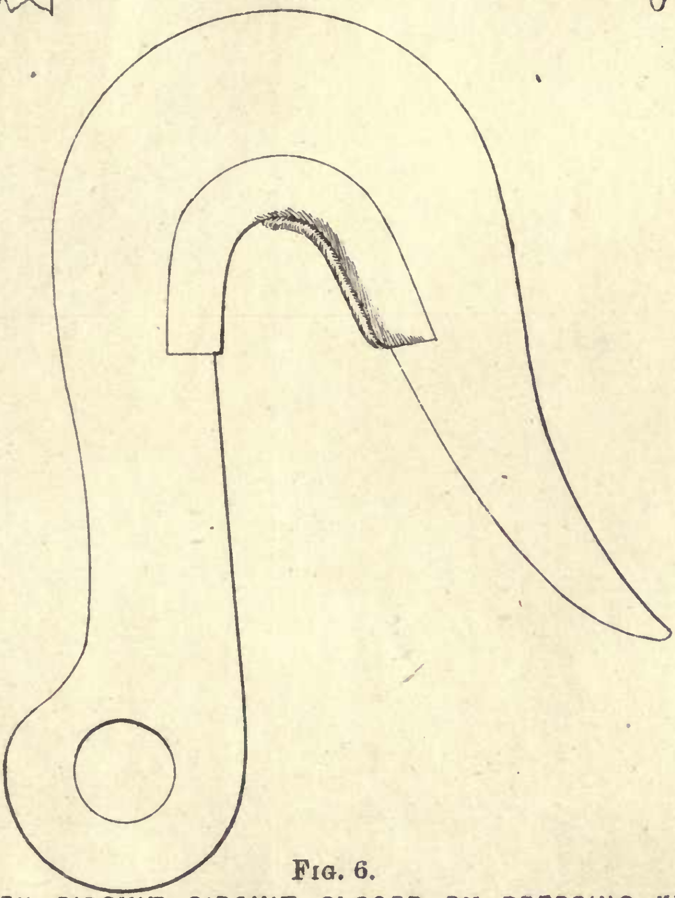
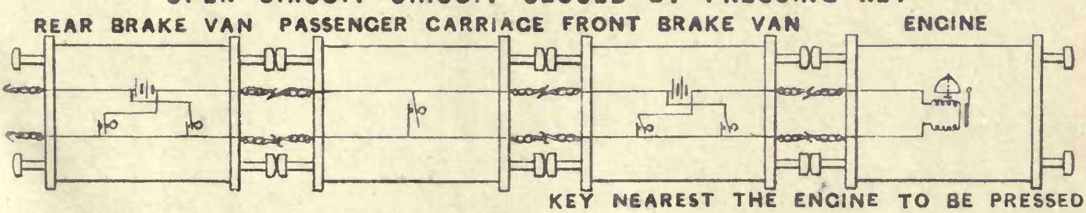


Fig. 6.

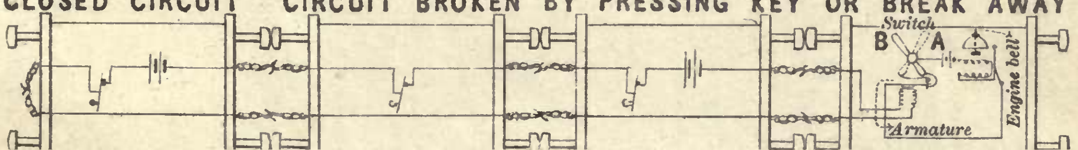
OPEN CIRCUIT CIRCUIT CLOSED BY PRESSING KEY



KEY NEAREST THE ENGINE TO BE PRESSED

Fig. 7.

CLOSED CIRCUIT CIRCUIT BROKEN BY PRESSING KEY OR BREAK AWAY



	Price.	
Wooden Bridges and Designs. By Rai Kunhya Lal Bahadur, - - - - - - - - - - -	4	0
Practical Astronomy for Surveyors (containing concise directions for determining the True Meridian, Latitude, Time and Longitude), - - - - - - - - - - - -	0	8
Waugh's Instructions for Topographical Surveying, - - - - - - - - - - - - - -	1	4
Slope Tables, - - - - - - - - - - - -	0	4
Boileau's Tables of Wages and Rent, &c., (4th ed.,)	2	0
„ **Tables of Log $\sin^2 \frac{1}{2}$ P** (for computing time,) -	0	8
Cape's Logarithms, with Tables of Squares, Cubes, &c.,	1	4
„ **Geometry,** - - - - - - - - - -	1	8
„ **Mechanics,** - - - - - - - - - -	2	4
Elements of Hindustani Grammar, - - - -	0	4
Technical Dialogues—English and Urdu, - -	1	4
A Vocabulary of Common and Technical Words in English-Urdu, - - - - - - - - - - - -	1	4
English and Urdu Words, ...	0	8
Note Books, Blank, Large, - - - - - - - -	1	4
Surveying Field Books (ruled), - - - - - - -	1	0
Levelling Field Books (English Pattern and Canal Pattern), each, - - - - - - - - - - - - - - -	1	8
D. P. W. Note Book, - - - - - - - - -	1	4
„ **Measurement Book,** - - - - - -	1	4
Molesworth's Pocket Book, - - - - - - - -	3	8
College Calendar for 1872-73, ...	3	0
„ „ „ **1877,**	3	8
„ „ „ **1878,**	4	12
„ „ „ **1880,**	4	12
Examination Papers, Engineer Class, Entrance, Monthly and Final, - - - - - - - - - - - - -	1	0
Do. do. Upper Subordinate Class, Entrance, Monthly and Final, - - - - - - - - -	1	0

	Price.	
Thomason College Library Catalogue,	4	4
Supplement to ditto, corrected to 1st April, 1869,	1	0
Ditto. ditto. 31st August 1871,	1	0
Description of Venemous Snakes (extract from the "Thanatophidia of India"),	1	0
Tyndall's Handbook of Specifications, &c.,	10	0

Lithographed Plans of the Cantonments and Regimental Lines in the different Military Stations of India. Drawn to a uniform scale, lately prepared for the Government of India, P. W. Department. (Useful for Executive Engineers and Superintending Engineers' Offices).

Detailed Catalogues of English and Vernacular Works, may be had, free, on application to the CURATOR, Thomason College Book Depot.

THOMASON COLLEGE PRESS.

Orders for Printing Professional and Scientific Publications and Miscellaneous Works, also for Lithography, Bookbinding and Wood Engraving, will be received by the SUPERINTENDENT of the Press, of whom estimates may be had on application.

COLLEGE LIBRARY.

Professional Works may be borrowed by Government Engineers on application to the Librarian, and by other Members of the Profession, on proper security being given against loss or damage.

COLLEGE REGISTER.

A Register is open at the College for the names of Passed Students and others belonging to the Profession, who may be in want of situations, and persons desirous of engaging their Services should apply to the Undersigned. Full particulars should in both cases be furnished.

A. M. BRANDRETH, MAJOR, R.E.,
Principal.

CONTENTS OF No. 37.

☞ THE "PROFESSIONAL PAPERS ON INDIAN ENGINEERING," are published as nearly as possible on the 15th of January, April, July, and October.