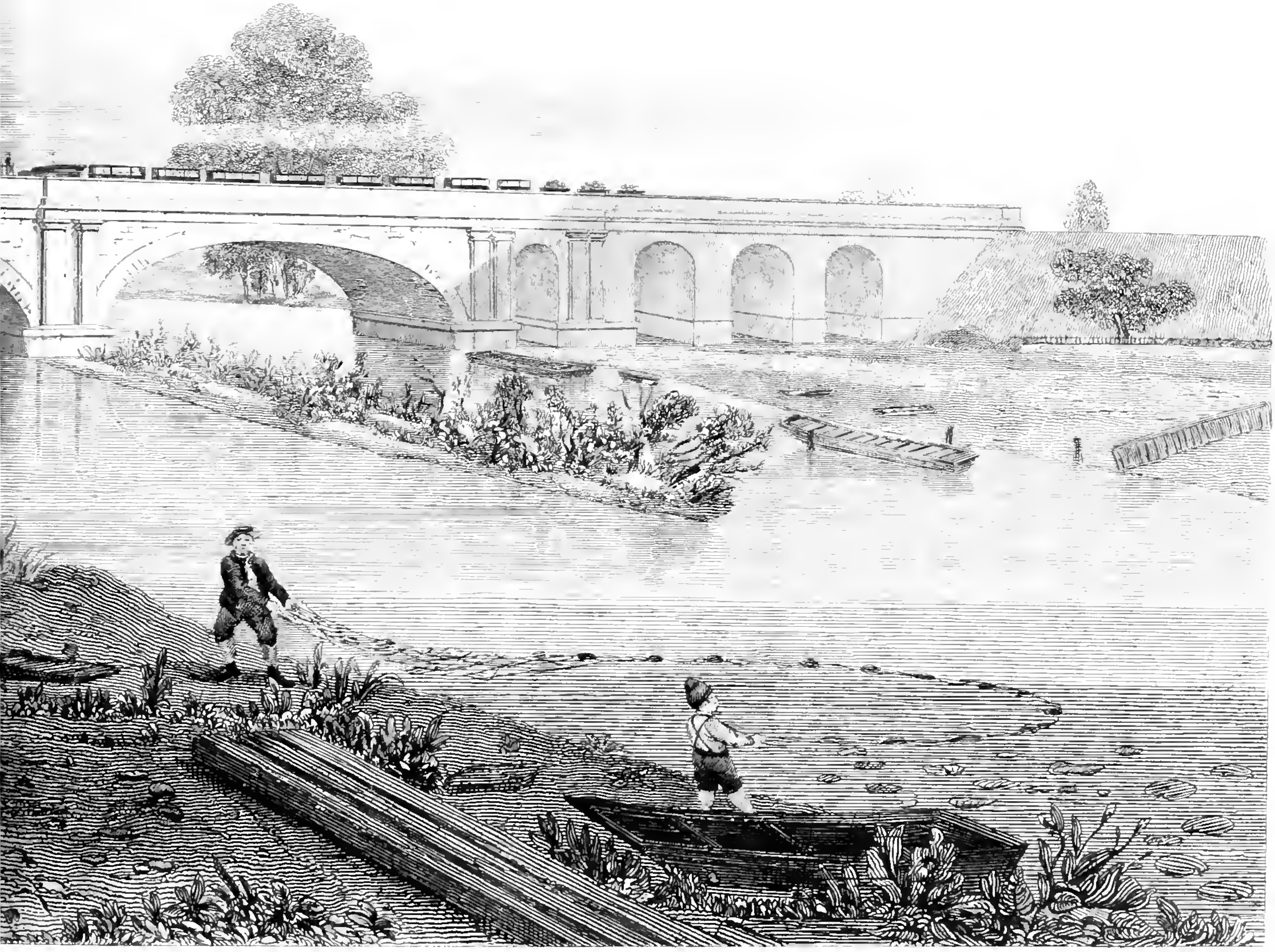
PRACTICE



SECOND SERIES
OF
RAILWAY PRACTICE:
A COLLECTION
OF
WORKING PLANS AND PRACTICAL DETAILS OF CONSTRUCTION
IN THE
PUBLIC WORKS
OF THE MOST
CELEBRATED ENGINEERS:

COMPRISING

ROADS, TRAMROADS, AND RAILROADS;
BRIDGES, AQUEDUCTS, VIADUCTS, WHARFS, WAREHOUSES, ROOFS, AND SHEDS;
CANALS, LOCKS, SLUICES, AND THE VARIOUS WORKS ON RIVERS, STREAMS, &c., &c.;
HARBORS, DOCKS, PIERS AND JETTIES, TUNNELS, CUTTINGS AND EMBANKMENTS;
THE SEVERAL WORKS CONNECTED WITH THE DRAINAGE OF MARSHES, MARINE SANDS,
AND THE IRRIGATION OF LAND;
WATER-WORKS, GAS-WORKS, WATER-WHEELS, MILLS, ENGINES, &c., &c.

BY S. C. BREES, C. E., &c.

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PREFACE.

The First Series of "Railway Practice" having been very favourably received by the profession, the publisher felt warranted in commencing a Second, but owing to untoward circumstances at the time was prevented proceeding with it; the Editor has, therefore, been induced to produce the work at his own cost, rather than that it should have been left unfinished.

In presenting the present volume to the notice of the profession the Editor begs to remark, that it consists simply of a collection of "Useful Examples in Civil Engineering," the works of eminent men; and all he has attempted has been to do justice to the various subjects, and to economise the time of the reader by making the illustrations as clear and explicit as possible; throwing forward the most essential points in the details, and keeping all subordinate parts at a due distance; and he considered it better to insert the specifications in their original form, than to give the matter in another shape, notwithstanding the appearance of conciseness which might be attained by the latter plan.

Since the object of the work is merely to ILLUSTRATE an important branch of the profession, and one little before pourtrayed, at least in a practical point of view, if he has succeeded in accomplishing this, and has moreover produced an useful book of reference for the student, he trusts it will not be found unacceptable.

To the numerous gentlemen who have so kindly assisted and cooperated with the Editor, comprising the engineers of the works represented—to each of those gentlemen individually he begs most respectfully to acknowledge his obligations, and to return his most grateful thanks.

12, South Square, Gray's-Inn,
May 1st, 1840.

INTRODUCTION.

The science of Civil Engineering is one of those which have arisen from the increased demands of the community, in consequence of the advance of civilization in modern times. and from the quiet workings of the wealth of nations in times of peace; hence those countries most secure from the presence of war are generally in better condition, as respects internal improvements, than others which are subject to be overrun by it.

Engineering, although of such paramount importance to the prosperity of a country, was but little understood or practised formerly, more especially for purposes of a civil nature, its application being almost exclusively confined to the service of warfare and military erections, such as fortifications, and their accompanying works; yet, it must be admitted that civil engineering has existed during all ages, and in most countries, in one shape or other.

The subject of roads was well understood by the Romans; in fact, they may be said to have excelled the moderns in this department, although it should not be forgotten, that the weight to which ancient roads were subjected was light compared to that of modern carriages, the traffic upon them was also much less, and their cost was extremely great, no expense whatever having been spared upon them. Canals were also constructed by the Romans, but not to the same extent as roads: they were used by the Egyptians also, and by the Chinese, from a very early period, as generally supposed; but they were not adopted by the moderns until the sixteenth century. The erection of bridges was probably among the earliest instances of civil engineering, roads only excepted: the aqueducts and bridges of the Romans are among their most celebrated works; yet, notwithstanding the costliness of these and other works of the ancients, all are comparatively inefficient, compared with many modern engineering works of a similar nature; but the materials employed by them were, from some cause, superior to those now used, and the excellence of their cement may be instanced, in corroboration of this remark. Our forefathers in the middle ages were also well acquainted with the properties of building materials.

From what has been stated, it follows that the profession of civil engineering is one of modern times, originating from the necessities of the art: the profession of architecture was anterior to it, although far from assuming a decided character in all ages, and the date of its practice in this country is not considerably in advance of that of engineering, the latter being formerly included in the architectural department; but it was then very limited, comprising merely the drainage of fens, which is of early origin, the navigation of certain rivers, the erection of bridges, and the formation of the New River, by Sir Hugh Myddleton, for the supply of the city of London with water, almost completes the list, up to the period of the introduction of canals by the celebrated Brindley, in the year 1758, when engineering received a grand stimulus. The subject of machinery was also making rapid progress about the same period, for the steam-engine being then very generally employed, afforded extended means in mining, and such like operations, which had previously existed in a very contracted state. The necessity of exclusive attention to the subject of civil engineering then became apparent, and which led ultimately to its severance from architecture: from henceforward it became a separate profession, partaking with the latter in some general principles, but comprehending a more extended range; and this dissolution may be easily accounted for, when the increased practice and importance of both professions at the time is considered.

In the early stage of the profession its followers may be styled self-taught, or men possessing great natural abilities for the subject, among whom may be mentioned Brindley and Smeaton; also, Jessop, Rennie, and Telford. To enumerate the many celebrated works of these great men, would be to form a list of almost all our public works since the period of their commencement; suffice it to say, that by the talents of these men civil engineering received a wonderful impulse: and it is further gratifying to its professors, to know that its influence is becoming yet more extended, as the many new applications of means for the accomplishment of various purposes, and the improvements effected by it every day, embracing the subject of roads, canals, harbours, docks, drainage of fens and marine sands, water-works, gas-works, mines, bridges, and railways, with the several collateral branches connected with each fully prove: and all scientific men agree, that far greater advantages will yet result from the practice of it. There is scarcely any department of engineering that can be described as perfect; improvement follows improvement, and the work last executed is always superior to the preceding.

It is therefore highly necessary that the student in civil engineering should be acquainted with the latest mode of construction employed, for although much may be derived from theory in all speculative sciences, yet, where great capital is at stake, it behoves those who have the direction of the works to be careful not to trust too much to new theories, but to be guided more by practice and experience; and upon referring to most great discoveries connected with engineering, it will be found that they have generally resulted from practice moving, as it were, step by step; hence the great desire of mathematicians to make the theory agree with the practice; yet we must, in justice, admit the value of correct theories on scientific subjects.

The practice of civil engineering, at the present time, comprises the construction of roads, tramroads, and railroads; the erection of bridges, aqueducts, and viaducts, also wharfs, warehouses, roofs, and sheds; the preservation of the navigation of rivers, streams, &c.; the execution of canals, locks, sluices, &c., also tunnels, cuttings, and embankments; the formation of harbours, docks, piers, and jetties; the drainage of marshes and marine sands, and the irrigation of land; the execution of water-works, gas-works, water-wheels, mills, engines, &c.; the working of mines, &c.; together with the general direction of all engines, machines, and contrivances, contingent or connected with any of the above-stated departments, although the absolute construction and manufacture of the latter are conducted by another class, who may be styled "Mechanical Engineers;" and there are instances of the same individuals practising in both departments.

Having enumerated the several branches in the practice of civil engineering, we have now only to remark, that it is the intention of the present work to illustrate them, which we have endeavoured to effect, by a series of suitable examples in each.

GREAT WESTERN RAILWAY.

I. K. BRUNEL, Esq., Engineer.

The Frontispiece represents the Bridge over the Thames, at Maidenhead, on the line of the Great Western Railway.

The two river arches are each 128 feet span, with a rise of 24 feet 3 inches, and there is a towing-path arch on each side 21 feet span, and three land arches each of 28 feet span. The whole structure is built of brickwork, except the cornice and coping, which are of stone; the two principal arches are the largest yet constructed of brickwork, and are turned in cement and in half-brick rings; the thickness of the arch at the springing being 7 feet 1½ inches, and each of them are gradually diminished towards the crown, where they are made 5 feet 3 inches.

This bridge has created a great sensation in the scientific world, and many have been the predictions respecting it; a portion of the eastern river arch was taken down, and rebuilt: after the period of its first erection, certain defects of workmanship having appeared in the crown, where some of the rings had partially separated from each other, extending for a distance of two or three yards on each side of it, and the cracks were about half an inch wide, but the whole is now executed thoroughly strong, and to the true form required; it is, therefore, likely to remain a lasting monument of the skill of its engineers and builders.

In constructing arches of great span in brickwork, it becomes a point of immense importance to secure good materials and workmanship; this bridge may be said to have been wholly accomplished by the great care bestowed upon it in this respect; had the cement or bricks proved to have been inferior, the whole must have come down, it may, therefore, be described as an extremely hazardous undertaking, and one which few men would have risked.

LONDON AND CROYDON RAILWAY.

JOSEPH GIBBS, Esq., Engineer.

This railway forms a junction with the Greenwich railway, at about a mile from the terminus at London Bridge: the Act was obtained in the year 1835, and the works were shortly afterwards commenced.

The mode of constructing the line and contingent works differs from the usual plan of execution, but the alterations are of such a nature that the engineer could safely make, and are within the bounds of prudence, although nothing is more injudicious than the premature adoption of new systems, more especially when employed upon an extensive scale; as improvements in engineering have hitherto proceeded step by step, the safest way, most undoubtedly, must be to continue in the same course, and to perfect those systems which have already been in use, as in the present case, in preference to commencing altogether *de novo* upon a different plan: in the former, the full benefit of experience is taken advantage of.

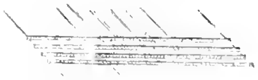
The rails are laid bodily upon beams, as shown in the plates, and thus have a continuous bearing throughout; the system of securing them is very simple, and has been found to answer exceedingly well, it may be called the most perfect plan of simple continuous bearings up to the present period; some of the bridges are also in a new style of construction. There is an oblique bridge formed by separate walls, thus,  and stone landings are laid across the paces between them at the top, upon which the road is laid, instead of the usual expensive process of forming the arch and abutments aslant.

TABLE OF GRADIENTS.

Miles.	Chains.	Links.	
1	60	0	*(Greenwich railway).*
0	41	15	falling 1 in 4.744
0	57	63	,, 1 ,, 1.311
2	50	36	rising 1 ,, 100
0	34	40	level ,, ,, ,,
0	34	55	falling 1 ,, 2.591
1	4	70	rising 1 ,, 660
0	46	39	level ,, ,, ,,
1	29	13	falling 1 ,, 660
0	41	50	rising 1 ,, 823
0	40	97	level ,, ,, ,,

The earth employed in forming the embankments was sorted; and the upper stratum, or yellow plastic clay, was taken to spoil, the blue arenacious clay only being used; the extra expense accompanying this has been amply repaid, a slip not having occurred on any of the embankments, although they are formed throughout the line with side slopes of 2 horizontal to 1 vertical. The cuttings in clay are, for the most part, at slopes of 2 to 1, except in places where the depth is less than 10 feet, where they are made 1½ to 1, and in the diluvial deposits of gravel, near Croydon, they stand well at ¾ to 1, and at 1 to 1.

RADII OF CURVES ON MAIN LINE.

1	curve of	142	chains radius.
1	,,	140	,,
1	,,	112	,,
2	,,	90	,,
6	,,	80	,,
4	,,	60	,,
1	,,	20	,,

The curve of twenty chains radius is situated near the Croydon terminus, and is never traversed at a speed exceeding 15 miles per hour.

The curves in the stations practicable for the working of six-wheeled engines, vary from 1.050 to 250 feet radius; an engine will readily traverse a curve of the latter radius, if the outer rails be lifted 1½ inches higher than the inner ones.

PERFORMANCES OF ENGINES.

The Surrey engine, with one carriage attached, traversed the distance, between London and Croydon, 10½ miles, on the 2nd of June, 1839, in sixteen minutes, including starting, easing off at the junction with the Greenwich railway, ascending the inclined plane (without an assistant engine), and stopping, which gives an average of 39.37 miles per hour throughout.

The highest measured velocity attained by an engine attached to a train of carriages on this line, was 50 miles per hour, in which case there were six carriages, containing 120 passengers in the whole. The highest measured velocity attained by the above-mentioned train in descending the inclined plane of 1 in 100, was 47 miles per hour, which was from the force of gravity only; but the average of several journeys seldom exceeds 25⅓rd miles per hour.

The average velocities of several trials in ascending the inclined plane with the above train, were as follows:—

Time in Minutes.	Distance in Miles.
0	*(Foot of plane.)*
1	¼
¾	½
½	¾
½	1
½	1¼
½	1½
½	1¾
½	2
½	2¼
½	2½
½	2¾
6¼ minutes.	2¾ miles.

which gives an average velocity of 26.40 miles per hour.

The train had not the help of an assistant engine; and it started from a state of rest in each instance, without any lead whatever.

The average time employed in performing the journey of 10½ miles, both up and down, is 30½ minutes, including starting, stopping at five intermediate stations, and easing off at the junction with the Greenwich railway. The average time occupied in stopping at the whole of the stations is 2½ minutes, or half a minute at each, during which period the engine is completely idle.

There is an inclined plane rising 1 in 50, and 330 yards in length, communicating with the main line from the Surrey canal wharf, on which there are three curves—one of twenty chains radius, and two of 600 feet radius—and a six-wheeled engine, weighing thirteen tons, drew itself and tender up this incline with a load of 11.33 tons, at a velocity of 7½ miles per hour, having a lead of 125 yards to the foot of the plane; the same engine, starting on the plane without any lead, took up 10.83 tons, at a velocity of 6.18 miles an hour, the diameter of the cylinder of the engine being 13 inches, with an 18 inch stroke, and the diameter of the driving wheels 3 feet 6 inches.

PLATE 2.—Represents the method of forming the Permanent way; the transverse sleepers are of oak, and the longitudinal beams are of Memel fir, and each of them are subjected to the process denominated "Kyanizing;" the longitudinal sleepers are secured to the transverse beams by spring bolts, and to the rails by wood screws, as they are termed, or screws in which the bodies taper, but not the worms, which continue straight, a layer of patent felt being placed between the sleeper and the flanges.

PLATE 3.—Bridge for Occupation Road on Deptford Common. There are several bridges built after this plan upon the line, and they have a very elegant appearance.

DETAILS OF THE

LOCOMOTIVE ENGINE NAMED THE "CROYDON,"

For assisting the Trains up the Inclined Plane, of 1 in 100, on the Croydon Railway.

GEORGE AND JOHN RENNIE, Esqs., Engineers.

Plate 4.—Side Elevation of engine.

Plate 5.—Plan of ditto.

Plate 6.—Transverse Sections of ditto, taken through the boiler and through the cylinders and smoke box.

Diameter of cylinder		0 ft.	13 in.
Length of stroke of piston		0	18
Diameter of driving wheels		5	6
Ditto smaller wheels		3	6
Ditto of tubes	No. 117	0	1$\frac{7}{8}$
	No. 4	0	1$\frac{5}{8}$
Length of ditto		8	5
Fire box	Length	3	0
	Breadth	3	7
	Depth	4	0
Boiler, (cylindrical part)	Length	8	0
	Diameter	3	3$\frac{5}{8}$
Chimney	Height	5	6
	Diameter	1	2
Steam passage		0	1$\frac{3}{8}$ × 8$\frac{5}{8}$
Diameter of blast pipe		0	3
Weight of engine		13 tons.	
Ditto with water		14 „	5 cwt.

The "Croydon" locomotive was constructed in the month of September 1838, and was worked for four months with scarcely any repairs, being employed twelve hours per day, viz., from 6 o'clock in the morning until 6 in the evening, performing about 170 miles daily; and it accomplished a speed of 28 miles an hour up the inclined plane, with 12 ballast waggons attached to it, the weight of which was 43 tons.

The cylinders are situated on the outside of the wheels, as shown on the plates, the piston rods working in slides, and the connecting rods are fixed to the naves of the driving wheels, the latter being coupled to the foremost wheels, whereby the power of adhesion of the engine is increased.

Messrs. Rennie also constructed another locomotive engine for this railway, of precisely similar form and dimensions to the Croydon, which was named the "Archimedes."

BIRMINGHAM AND GLOUCESTER RAILWAY.

CAPTAIN W. S. MOORSOM. ENGINEER.

PLATE 7.—Plans, Elevations and Sections of bridge. Nos. 5 and 6. at Cheltenham, *(see Specification of same.)*

PLATE 8.—Ditto. ditto. Details of iron girders and framing, *(see Specification.)*

PLATE 9.—Plans, Elevations and Sections of bridge. No. 35. Bredon Contract.

PLATE 10.—Elevations and Sections of Tewkesbury Depôt. Contract 15 G. *(See Specification, &c. of same.)*

PLATE 11.—Ditto, ditto. Plans of ground and one-pair floors.

BIRMINGHAM AND GLOUCESTER RAILWAY.

CONTRACT, No. 12, G.

Lansdown Extension. Bridges 5, 6, *and* 27, *Cheltenham. Masonry.*

SPECIFICATION of the several works to be performed in making and completing the masonry in the girder bridges to be built for carrying the Gloucester turnpike road and tramway, Nos. 5 and 6 on the plan, and the Arle road, No. 27 on the plan, over the railway in the parish of Cheltenham, in the county of Gloucester.

CONDITIONS ON WHICH CONTRACTS ARE TO BE MADE.

1. The contractor is to furnish all materials (with exception of stone), implements, and tackle that may be required during the execution of the works.

2. The contractor is to execute the whole of the works, as described in the specification, according to the working plans, sections, and drawings, to the satisfaction of the company's principal engineer and resident assistant engineer, who shall have power to reject materials which are not of the best quality, and to take down imperfect workmanship. The principal engineer is to decide disputes, if any arise; and the works are to be executed within the periods limited, either in whole or in successive portions, as stated in the specification

3. The contractor to receive fortnightly 90 per cent. of the amount due for works performed. The balance to be retained by the company until after completion of his contract, under certificate of the engineer-in-chief, and to be then paid to him.

4. The work to be measured by the engineer. and the payment to be made by the company, through their secretary or pay-clerk, upon the certificates of amount due, signed by the engineer-in-chief.

5. Copies of the specification, &c., and of the tender annexed, to be deposited with the resident assistant engineer. Contractor to have access to them.

6. In case of workmen employed or materials provided by contractor not being sufficient for completion of the works within the period named, contractor shall, upon notice from the company, provide such additional workmen or materials as the principal engineer shall deem necessary; and, in default, company shall employ such additional workmen or materials at the cost of the contractor, and may also deduct their wages and cost out of monies due to the contractor, so far as the same may be sufficient for that purpose.

7. The company to have power to remove any persons in employ of contractor on the line, after notice thereof being given to the contractor.

8. The contractor is to deliver, at the office of the resident assistant engineer, an account, every fortnight, of the number of artificers and other workmen employed the preceding fortnight, according to a form to be furnished, or to pay £2. on default; also to deliver, at the same time and place, an acknowledgment, under the hand of the sub-contractors, or foremen, or overlookers, or head-workmen, that every person engaged by or under the contractor, has received the whole amount of his demand upon the contractor up to the date of such acknowledgment, or in case of any exception, to state the reason for such exception.

9. The contractor not to use adjoining lands without consent, in writing, of the engineer-in-chief.

10. The contractor to dispose of spoil as directed by the principal engineer.

11. The contractor not to make bricks, &c., without consent of the engineer, in writing; nor to use the land for any purpose, nor upon any spots to which prohibitions attach in the Act.

12. If temporary roads be necessary, engineer to set them out; contractor not to deviate therefrom.

13. The contractor to make satisfaction and compensation, as required by the Act, to all owners and occupiers, for damages by trespass of himself or his men.

14. The contractor not to make sub-contract without the consent of the company, except as to labour only.

15. Alterations or additions to works not to be executed without written authority, signed by the engineer-in-chief or resident engineer. Works omitted by the same authority to be deducted for, according to the scale established in the "Schedule of Prices."

16. The contractor, if required by the company, is to pay the sub-contractors and workmen their full wages (vouched as stated in clause 8) on the day to be appointed by the company, and in presence of the company's agent, in such places as the company may appoint, and no other. The same rule to apply to all payments made by sub-contractors, and company to have the power of dismissal in case of non-compliance.

17. The contractor to employ no men on Sundays, except on such works as are certified in writing by the engineer-in-chief, or resident engineer, to be absolutely necessary. The company to have power to dismiss any man found so employed on Sundays, except under this certificate.

18. The contractor not to retail, either directly or indirectly, (without permission of directors) any article of consumption to the workmen.

EXTENT OF CONTRACT.

This contract comprises the formation and completion of the wing walls and abutments up to the level of the timber bearing plate to be placed on the latter, and may be extended at the option of the company's chief engineer; to be included, on the same terms and conditions, the entire completion of the masonry of these bridges, including coping, string courses, and moulded imposts, caps, &c.

It will comprehend the following works, viz.:—

1. Excavating for foundations to such depth as in the judgment of the engineer shall be found requisite, and as shall be set out by him; or by such person as he shall appoint.
2. Building with clure-hill oolite stone, laid in mortar, the foundations and upper walls of the abutments and counterforts, piers and wing walls, up to the level of the springing plate.
3. Filling into the walls as they are carried up, and backing to them with gravel or other dry material from the neighbourhood, and approved by the engineer

Also the following extra works, if required to be executed, viz. :—

1. Completing the parapets to the wing walls, and carrying up the latter to the height shown in the drawings; as also the parapet walls over the arched girders.
2. Dressing and setting the coping, and caps, and moulded imposts.
3. Turning 9 inch coombs* in brick between the girders, and carrying up side walls on the flanges, to keep their springing line at its proper level.
4. Spreading a course of concrete over the whole surface of the bridge to a thickness of not less than 3 inches over the crown of the coombs.

DRAWINGS AND SPECIFICATIONS.

The preceding enumerated works, and mode of execution, are described in the specification of each particular work, and their forms and dimensions are represented on the accompanying drawings, which are referred to in this specification; but should any discrepancy exist between the scale attached and the written dimensions, or between the drawings and specifications, or any ambiguity in them, the same are to be referred to the engineer-in-chief, whose decision shall be conclusive.

Also anything contained either in the drawings or specifications shall be equally binding upon the contractor, as if it were contained in both.

The written dimensions upon the drawings are to be taken in all cases in preference to the scale attached.

The drawings attached to this contract contain a plan and elevation of the bridges when finished, and sections of the wings and abutments, and of the parapet wall over the arched girder, showing the method of fitting the stones to the flanges of the upper and lower ribs of the principal girders; also enlarged sections of the cap stones, coping and mouldings to the pilasters, and a section showing the brick coombs,* and concrete laid over them.

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* Forest of Dean landings were substituted for brick coombs in the bridges Nos. 5 and 6.

FOUNDATIONS.

The contractor is to excavate for the foundations of all the walls; and, in cases of the foundation requiring, in the opinion of the engineer, to be carried lower than is represented in the drawings, the contractor shall execute the same, where so directed, and shall be allowed for the additional work, according to the prices set forth in the "Schedule, No. 1.;" and he shall be allowed in like manner for concrete placed under the foundations, or in other situations, by the direction of the engineer, in cases where the same has not been specified or shown on the drawings.

When the excavation is complete, the ground is to be well rammed before laying any masonry, if required by the engineer.

MASONRY.

1. The footing courses are to consist of large flat stones, with fair beds and joints squared so as to lie close, they are to be laid full in mortar, and properly bonded vertically and horizontally, and of the heights and onsets figured on the drawings.

2. The foundations of the wing walls will rise along the slopes of the railway in successive level steps, as shown on the drawings.

3. The upper walls shall be carried up in level courses on each side of the railway, and each side is to be built if so required at the same time. They shall consist of sound rubble masonry, without regard to courses, and to be faced with ashlar, axed on the face in the best manner.

4. The ashlar must be dressed in courses, not less than 8 inches in height; width of top bed not less than 16 inches, and length not less than 2 feet; the beds to be full and square for their whole depths, and the joints for a distance of not less than 8 inches from the face.

5. The faces are to be fine axed or chopped, at least equal to the best portion of a sample to be seen on application to the sub-engineer in charge of the works at Cheltenham.

6. The face work shall be laid with a header to every three stretchers, on a fair and even bed of mortar, the joints pointed, and the whole grouted full in.

7. No joint of mortar on the face shall exceed $\frac{1}{8}$th of an inch thick; and if the outer arrises of a stone are imperfect it must be removed and redressed, and on packing or pinning will be allowed.

8. The vertical bond shall be such, that the headers shall lie in the interior

(and as near its centre as may be), between the headers in the course below and the lengths of the stretchers so regulated under the limits already assigned, that the vertical bond of the joints shall not be less than half the height of the course below.

9. The quoins, cheeks, and internal angles must be carefully cut, and the stones composing them bonded with the strictest attention.

10. The backing of uncoursed rubble work shall be carried up at the same time, as the face of the stones shall be laid in a thick bed of mortar, and shall be properly selected as to size.

11. Thorough stones shall extend from the face to the back of the walls at intervals in the abutments, not exceeding two spaces of headers and stretchers horizontally, nor the height of three courses vertically, and in the wing walls not exceeding three spaces of headers and stretchers horizontally, nor the height of four courses vertically, and these thorough stones must be properly arranged for bond.

12. The counterforts must be built up with the walls, and well bonded in with them.

13. In carrying up the abutment walls cast iron plates, 18 inches square and 1½ inch thick (which will be furnished by the Railway Company), shall be built in, so as to have their lower surfaces 7 feet 2 inches from the top of the wall, when finished, to the under side of the springing plate; the hole which perforates these plates shall be 15 inches from the face of the wall; wooden trunks, for the holding down bolts, 2 inches square in the clear, shall be built in the thickness of the wall, standing plumb over the holes in the plates. Holes, 9 inches square on the face and 2 feet deep, shall be left under the cast iron plates; and these holes shall have stones neatly dressed and fitted to them, but which may be removed when it may be necessary to have access to the ends of the holding down bolts.

14. When up to their proper height the abutments shall be levelled out, and the timber bearing plates shall be well bedded by the mason.

15. The abutments and wing walls shall be filled into and backed with clean dry gravel or other material approved by the engineer, and procurable in the neighbourhood; as they are carried up the filling and backing shall be well rammed with punning malls, in courses not exceeding 18 inches thick.

16. The parapets are to be built solid in header and stretcher without above. One header to every two stretchers on the face, and dressed on both faces above the intended level of roadway; they are not to be built until the concrete is laid over the bridge.

17. Nine inch brick coombs,* laid in roman cement, are to be turned between

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* Forest of Dean landings were substituted for brick coombs in the bridges Nos. 5 and 6.

the girders, in such manner that the crown at the back shall be level with the upper flange of the middle girder at its middle point; and, in order to keep the springing courses level through, side walls are to be built upon the flanges of the girders of bricks on their flat sides, the lower courses being properly cut or rubbed to fit the curve of the girder as it falls.

18. The open spaces at the ends are to be filled up with 13 inch brick walls. in english bond, laid in cement.

19. A course of concrete, not less than 3 inches thick over the crown of the coombs, shall be spread uniformly over the whole surface of the brickwork, and rammed hard.

20. The contractor will be required to take every necessary precaution for the security of the temporary tramway bridge during the progress of the work, as well as for the security of the public, by keeping up the fencing, and watching and lighting, if requisite.

COPING

Shall be of the form and dimensions shewn upon the drawings; each stone shall not be less than 3 feet in length, unless directed otherwise by the engineer; and each stone must be dowelled and leaded to the adjoining one, and well throated. The string courses, parapet walls, and coping, shall not be put on until after the centres are struck, which shall not be done in any case without the permission of the engineer. Caps to the piers to be of one stone only.

The mouldings to the pilasters must be neatly worked with the chisel or tool. and there shall not be more than two stones in each impost in length, and the bottom beds when set must have a solid bearing on the wall of at least 18 inches.

MORTAR.

The mortar shall consist of fresh burnt lime of the best quality (to be approved by the engineer), and clean sharp river sand, mixed in the proportion of three measures of sand to one of lime, or in other proportions if deemed necessary by the engineer; they must be mixed in a dry state, and well tempered, by passing through a pug-mill, with a proper quantity of water.

CONCRETE.

The concrete shall consist of good coarse gravel or broken oolite stone not larger than a hen's egg, mixed with unslacked lime in the proportions of 5 measures of gravel or stone to 1 of lime, and beat up with a proper quantity of water.

The lime must be thoroughly ground to powder before being mixed up with the gravel. And it shall not be mixed up till wanted for use.

ROMAN CEMENT.

The roman cement shall be of the best quality, and shall be mixed with an equal quantity of clean sharp river sand; it shall be mixed immediately before being used, and none of it shall be employed which has become hard or set.

GENERAL STIPULATIONS.

The general regulations for the observance of the contractor are set forth in the printed form of " Conditions" at the commencement of this specification, and to them the contractor is referred.

Should it become necessary in the opinion of the engineer at any time during the progress of the works to increase, diminish, or alter the form or dimensions of any part of the work, the contractor shall comply with any order he may receive to that effect in writing from the engineer; the addition, diminution, or alteration to be allowed for according to the rates stated in the " Schedule of Prices" for the particular work annexed to the tender, and the general contract not being vitiated thereby.

The contractor is to provide all the necessary machinery and materials for thoroughly draining the works during their progress, whether by drifting, pumping, or other means. Also all planks, waggons, barrows, tools, and materials whatsoever for temporary ways that may be required in the execution of his contract; all of which are to be of a quality and construction approved by the engineer.

Any materials which the engineer shall deem insufficient or improper to be used shall be removed from the ground by the contractor within three days after notice has been given him in writing to that effect; and in case of his failing to remove such materials in the time above specified, the engineer shall have the power to cause them to be removed by the most convenient means, and at the contractor's expense.

The contractor will be held liable by the company for all damage to adjoining lands done by trespass of the people in his employ.

The whole of the work executed under the contractor is to be of the soundest description, done in a substantial and perfect manner.

The contractor will be at liberty to use the quantities of the several descriptions of work from which the engineer's estimates have been made, without the engineer being any further pledged for their accuracy.

In case of foreclosure of the contract, the contractor shall forfeit all claim to the balance of monies, if any then due to him from the company, upon this contract.

PROGRESS OF THE WORKS.

The work shall be commenced immediately, and shall proceed at such rate as to insure the completing the abutments and wings up to the level of the timber springing plate, within nine weeks from the date of contract; and if this rate of progress is not complied with, it shall be at the option of the engineer to close this contract at any period during the same, upon giving a week's notice in writing to the contractor to that effect.

TENDER.

WE, Masons, of do hereby propose to execute the masonry of bridges, Nos. 5, 6, and 27, Cheltenham, according to the plans and specifications exhibited to us; and to maintain the same until delivered over to the engineer on completion of the contract; and provide all the requisite materials within the periods, and upon the terms and conditions mentioned and contained in the draft also exhibited to us, for the sum of *four hundred and eleven pounds eighteen shillings* (the springing course or impost is not included in this tender, as per instruction), allowance more or less being made at the above rate when the work actually performed is measured.

And we have in the "First Schedule," hereto annexed, set forth the prices of the different descriptions of work at which this tender is computed.

And we further propose to execute the several works in the said specification, denominated "Extra Works," at the prices affixed to each description of work in the "Second Schedule" hereto annexed.

And in case this tender shall be accepted, we hereby undertake to execute the agreement following to perform the works as above proposed, and under the conditions above referred to.

And lastly, we do hereby undertake and agree that in case the said agreement shall not be executed by us within one week from the date hereof, the said company shall not (unless they think fit) be bound by this tender, but the same shall be absolutely void, in case the company shall so think fit; nor shall they in that case be liable to any claim by us in respect of work then already done by us upon the said railway.

Witness our hands this day of 1838.

To the Directors of the
Birmingham and Gloucester Railway.

FIRST SCHEDULE REFERRED TO,

Containing a list of the prices of the several descriptions of works at which the accompanying tender is computed. the whole of the work being executed and completed according to the foregoing specification:—

1. The price of masonry set in mortar in foundations, abutments, counterforts, wing walls, and piers, &c., per cubic yard of masonry. . . . . . .
2. The price of excavating for foundations, at per cubic yard .
3. The price of concrete laid and set in place, at per cubic yard .
4. The price of mouldings to imposts, pilasters, &c., if not paid for as work under extension of contract for 2nd schedule below, at per foot run . . . . .
5. The price of backing and filling into walls punned, at per cubic yard. . . . . . .

SECOND SCHEDULE REFERRED TO,

Containing a list of the prices of the extra works:—

1. The price of masonry set in mortar in the parapets to wings, and also in parapets over arched girders, at per cubic yard.
2. The price of coping with cramps and dowelled joints run with lead weathered and throated, at per foot superficial .
3. The price of mouldings to imposts, pilasters, &c., at per foot run. . . . .
4. The price of concrete laid over the surface of the bridges, at per cubic yard . . . . .
5. The price of brickwork in coombs and wide walls to ditto, laid in cement, at per cubic yard. . . .

AGREEMENT.

WE, Masons of do hereby agree and undertake to execute, according to the specifications hereunto annexed, and subject to the conditions prescribed, the works on the Birmingham and Glouscester Railway, comprised in the permanent bridges, 5, 6, and 27, Cheltenham, amounting by computation to *four hundred and eleven pounds eighteen shillings*, more or less, at the average price of per cubic yard of masonry, and of other particulars to be paid to us according to the "Schedule of Prices" for each particular work hereunto annexed.

Dated this day of 1838.

For selves and partners ______________________

(Signed) JAMES P. RENNIE.
JOHN LOUGAN.

BIRMINGHAM AND GLOUCESTER RAILWAY.

CONTRACT FOR IRON-WORK IN BRIDGES.

SPECIFICATION of the several works to be performed in making and completing the iron-work in the bridges hereinafter enumerated on the line of the Birmingham and Gloucester Railway.

CONDITIONS ON WHICH CONTRACTS ARE TO BE MADE.

1. The contractor is to furnish all materials, implements, and tackle, that may be required during the execution of the works.

2. The contractor is to execute the whole of the works, as described in the specification, according to the working plans, sections and drawings, to the satisfaction of the company's principal engineer and resident assistant engineer, who shall have power to reject materials which are not of the best quality, and to take down imperfect workmanship. The principal engineer is to decide disputes, if any arise; and the works are to be executed within the periods limited, either in whole or in successive portions, as stated in the specification.

3. The contractor to receive fortnightly 90 per cent. of the amount due for works performed less by the instalment due to the company on account of materials. The balance to be retained by the company until after completion of his contract, under certificate of the engineer-in-chief, and to be then paid to him.

4. The work to be measured by the engineer, and the payment to be made by the company, through their secretary or pay-clerk, upon the certificates of amount due, signed by the engineer-in-chief.

5. Copies of the specification, &c., and of the tender to be annexed, to be deposited with the resident assistant engineer and contractor.

6. In case of workmen employed or materials provided by contractor not being sufficient for completion of the works within the period named, contractor shall, upon notice from the company, provide such additional workmen or materials as the principal engineer shall deem necessary; and, in default, company shall employ such additional workmen or materials, at the cost of the contractor, and may also deduct their wages and cost out of monies due to the contractor, so far as the same may be sufficient for that purpose.

7. The company to have power to remove any persons in employ of contractor on the line, after notice thereof being given to the contractor.

8. The contractor not to make sub-contract without the consent of the company. except as to labour only.

9. Alterations or additions to works not to be executed without written authority, signed by the engineer-in-chief or resident engineer. Works omitted by the same authority to be deducted for, according to the scale established in the "Schedule of Prices."

10. The contractor to employ no men on Sundays, except on such works as are certified in writing by the engineer-in-chief, or resident engineer, to be absolutely necessary. The company to have power to dismiss any man found so employed on Sundays, except under this certificate.

11. The contractor not to retail, either directly or indirectly, (without permission of director) any article of consumption to the workmen.

EXTENT OF CONTRACT.

This contract comprises the formation and completion of the cast and wrought iron-work, in the several particulars hereinafter enumerated, for the whole of the bridges enumerated in the list accompanying this specification; the accurate fitting and proving the same; the delivery of the whole in a complete state, at such places as are herein specified; and fitting and fixing the same in place.

It will comprehend the following works, viz.:—

1. Providing the materials and casting the interior and exterior girders and beams of the forms and dimensions shown on the drawings, Nos.

1 and 2, to which more particular reference is hereinafter made, when the several bridges are enumerated to which each drawing is intended to apply.

2. Bearing plates to lay upon the timber plates and to receive the upper ends of the holding down bolts, as also bottom plates to be fitted on the lower ends of the same as shown in the drawing, No. 3.
3. Manufacturing and completing in wrought iron the tie bolts with couplings, cotters and washers complete, the holding down bolts, the king bolts for the principal girders, and the connecting bolts for the flange plates, with requisite nuts, washers and cotters.
4. The manufacturing, completing and fitting in wrought iron the segmental bars in the straight girders designed for bridges under the railway. with the requisite bolts and fastenings.
5. Also all other bolts and fastenings which may be thought requisite by the engineer for securing the timber or iron-work in any or the whole of the bridges hereinafter enumerated.
6. Fitting and fixing in place the whole of the iron-work, after being delivered, to be considered as "Extra Work," and to be paid for separately.

The preceding enumerated works, and the mode of execution, are described in the specification of each particular work, and their forms and dimensions are represented on the accompanying drawings, which are referred to in this specification; but should any discrepancy exist between the scale attached and the written dimensions, or between the drawings and specifications, or any ambiguity in them, the same are to be referred to the engineer-in-chief, whose decision shall be conclusive.

Also anything contained either in the drawings or specifications shall be equally binding upon the contractor, as if it were contained in both.

The written dimensions upon the drawings are to be taken in all cases in preference to the scale attached.

DRAWINGS.

The drawings are three in number, and are arranged for a general design; they show plans, elevations and sections of the several girders and beams, and of their principal parts and details. The only deviation from them now contemplated, will be the lengths of the exterior or principal girders, for skew bridges (depending on their angle of skew), and consequently the curvature of their upper and lower ribs, the length of the king bolts, and the lengths of the beams bearing on them from the abutment walls.

The fitting and general construction will be the same, and deviations under this clause will be distinctly specified in the requisitions of the chief engineer, so as to leave no uncertainty as to precise form and dimensions.

PARTICULAR SPECIFICATIONS—CAST IRON.

Girders are to be of the best No. 2 iron, remelted in the air furnace with bright open round fractures of such a mixture most applicable for the purpose as shall be approved by the engineer; no hot blast iron is to be used. All the bolt holes to be drilled, except those for receiving the wrought iron bars for bracing or tying the girders together, which are to be cast to a proper size, and then bored out true to the size of the bar, so that it will fit and stand firmly in its position; each hole to have a boss cast round it sufficient to make up the difference of iron displaced by the holes.

No cement stopping or plugging to be introduced into a joint or cavity, unless first sanctioned by the engineer; and before the girders are delivered they shall be subject to be proved by hydraulic press, or otherwise by the contractor, under the inspection of the engineer, to such extent as the form and substance are calculated to bear, each girder not less than one half of the calculated breaking weights; this proof shall be made at the establishment of the contractor, and at the expense of the contractor.

The bearing plates are to be composed of the same metal as the girders above specified.

The whole of the castings shall be correctly moulded free from air holes, and shall measure their true dimensions when ready to be fitted in place.

WROUGHT IRON.

The segmental strutting bars for the straight girders designed for bridges under the railway, as well as all the bolts, shall be made from the best fagotted iron, or from any other equally good, if approved by the engineer in writing previous to manufacture.

The bolts for tying or connecting the girders to be made so as to fit the holes correctly, after the same are reamed to receive them.

The screwed ends of the bolts and the nuts to be cut with good screwing gear, and of such a mace as may be approved by the engineer.

The nuts and heads of the bolts to be well squared and of full dimensions; no nut to be screwed on the cast iron, but to have a washer under it, well proportioned as to thickness and diameter

PROGRESS OF THE WORKS AND DELIVERIES.

The deliveries shall be made at any one of the wharfs hereafter designated.

Requisitions shall be made upon the contractor by the chief engineer for all the iron-work hereinbefore specified which may be wanted.

Such requisitions in any one month shall not exceed in amount the quantity required for three bridges complete, commencing in the month of September next, besides holding down bolts and plates for the same, which shall be furnished upon requisition (as above) for not more than three additional bridges per month.

The contractor shall complete such requisitions and shall deliver the iron-work to the extent and in the manner they shall point out, within eight weeks after their transmission to him by post, for bridges, and within five weeks for holding down bolts.

The day of delivery shall be notified to the chief engineer at Worcester, in the same manner as prescribed in the Railway Company's Contract for rails and fastenings with James Foster, Esq., the contractor for the work herein specified, dated 14th April, 1838; and the consignments shall be made in the same manner that has been practised in the deliveries of rails, &c., to the resident assistant, or to the sub-engineer on the spot.

PLACES OF DELIVERY.

The following are the points at which deliveries are to be made on or before the dates respectively specified (see page 19) in the tabular enumeration of bridges appended hereto;—viz.:

Coombe Hill,
Tewkesbury,
Twining,
Bredons Norton,
Eckington,
Defford,
Kempsey,
Lowesmoor Wharf, Worcester.
Diggli's Wharf, Worcester,
Tibberton Wharf,

Oddingley Wharf.
Oddingley Tramway Wharf,
Hanbury Wharf,
Stoke Prior Wharf,
Tardebigg Wharf.
Hopwood Wharf,
King's Norton Wharf,
Bredons Cross,
Selly Oak Wharf,
Digbeth Wharf, Birmingham.

FIXING IN PLACE.

The contractor shall provide and furnish a sufficient number of artificers. under a competent foreman or overlooker. to fit and fix in place, in a complete and workmanlike manner, the whole of the iron-work provided for each bridge, within one week after notice in writing has been given by the chief engineer, specifying the particular bridge or bridges which are ready for such fitting to proceed.

The Railway Company shall provide sufficient materials, tackle and labourers to assist the above foreman, and to be under his directions; and the Railway Company shall be liable for the additional wages of such men so provided, during any period of delay caused by the works not being thoroughly ready, after the notice of the engineer shall have been acted upon by the contractor.

It is to be distinctly understood that the fixing in place is an "Extra Work," and is to be paid for agreeably with the "Second Schedule of Prices" hereunto annexed, and that the contractor is not to be at the expense of intermediate carriage from the wharf to the place of erection.

GENERAL STIPULATIONS.

The general regulations for the observance of the contractor are set forth in the printed form of "Conditions" at the commencement of this specification, and to them the contractor is referred.

Should it become necessary in the opinion of the engineer at any time during the progress of the works to increase, diminish, or alter the form or dimensions of any part of the work, the contractor shall comply with any order he may receive to that effect in writing from the engineer; the addition, diminution, or alteration to be allowed for according to the rates stated in the "Schedule of Prices" for the particular work annexed to the tender, and the general contract not being vitiated thereby.

The contractor is to provide all the necessary machinery and materials for the works during their progress, except those specified above for fixing.

Any materials which the engineer shall deem insufficient or improper to be used shall be removed from the ground by the contractor within three days after notice has been given him in writing to that effect; and in case of his failing to remove such materials in the time above specified, the engineer shall have the power to cause them to be removed by the most convenient means, and at the contractor's expense.

The whole of the work executed under the contractor is to be of the soundest description, done in a substantial and perfect manner.

In case of any question arising as to the weight of materials supplied, which cannot be conveniently determined by weighing on the spot, the weight computed from the drawings will be allowed; and no other weight will be admitted, unless an order in writing for the extra work or alterations or diminution, as the case may be, signed by the engineer and contractor is produced as a voucher.

LIST OF GIRDER BRIDGES

On the Birmingham and Gloucester Railway, to be provided with iron-work by contract with James Foster, Esq.

	Situations.	Over or under Railway.	Square or Skew.	Drawings to regulate dimensions.	Number of Girders required.						Estimated weight complete		DATE at which required.
					Fig. 1.	Fig. 2.	Fig. 7.	Fig. 8.	Fig. 9.	Fig. 10.	Cast Tons.	Wrot. lbs.	
5.6	Cheltenham	over	skew	1	2	23	—	—	—	—	61½	2714	30 September.
27	Cheltenham	do.	do.	1	2	6	—	—	—	—	22½	1349	
87	Cheltenham	do.	do.	1	2	19	—	—	—	—	55	1928	15 November.
75	Cheltenham	do.	do.	2	—	—	4	2	—	—	14	1032	
20	Besford	do.	do.	2	—	—	4	2	—	—	14	745	
61	Bredicot	do.	do.	1	2	19	—	—	—	—	55	1928	
45	Ashchurch	do.	do.	2	—	—	4	2	—	—	14	745	31 October.
12	Tredington	do.	square	2	—	—	4	2	—	—	14	745	
3	Ashchurch	do.	do.	2	—	—	4	2	—	—	14	745	
7	Defford	do.	do.	2	—	—	4	2	—	—	14	745	31 October.
12	Norton	do.	do.	2	—	—	4	2	—	—	14	745	
28	Cheltenham	under	skew	2	—	—	—	—	4	2	8	1203	31 October.
4	Swindon	do.	square	2	—	—	—	—	4	2	8½	1032	15 November.
32	Ashchurch	do.	do.	2	—	—	—	—	4	2	8½	1032	ditto.
4	Ashchurch	do.	do.	2	—	—	—	—	4	2	8½	1032	ditto.
9	Spetchley	do.	skew	2	—	—	—	—	4	2	8½	1032	
19	Himbleton	do.	do.	2	—	—	—	—	4	2	8½	1032	March 1839
54	Hadsor	do.	square	2	—	—	—	—	4	2	8½	1032	ditto.
45	Hadsor	do.	do.	2	—	—	—	—	4	2	8½	1032	April 1839.
34	Hanbury	over	do.	2	—	—	4	2	—	—	14	745	January 1839.
60	Bromsgrove	under	skew	2	—	—	—	—	4	2	8½	1032	
26	Bromsgrove	do.	do.	2	—	—	—	—	4	2	8½	1032	
150	King's Norton	over	square	2	—	—	4	2	—	—	14	745	
1	King's Norton	under	skew	2	—	—	—	—	4	2	8½	1032	April 1839
64	Bordsley	do.	do.	2	—	—	—	—	4	2	8½	1032	May 1839.
											421½	27,466	

The following Bridges will require particular Designs :

	Situations.	Over or under Railway.	Square or Skew.	Drawings to regulate dimensions.	Number of Girders required.						Estimated weight complete		DATE at which required.
					Fig. 1.	Fig. 2.	Fig. 7.	Fig. 8.	Fig. 9.	Fig. 10.	Cast Tons.	Wrot. lbs.	
14	Himbleton	under	square	—	—	—	—	—	—	—	8	1000	March 1839.
48	Hadsor	do.	do.	—	—	—	—	—	—	—	8	1000	April 1839.
29	Hanbury Canal	do.	skew 45°	—	—	—	—	—	—	—	60	2000	Span on square 24 ft., on skew 34 ft.
117	Stoke Prior	do.	do.	—	—	—	—	—	—	—	9	1100	November 1839.
95	Stoke Prior	do.	do.	—	—	—	—	—	—	—	9	1100	November 1839.
71	Stoke Prior	do.	square	—	—	—	—	—	—	—	8	1900	
9	Stoke Prior	do.	do.	—	—	—	—	—	—	—	8	1000	
109	King's Norton	over	skew	—	—	—	—	—	—	—	15	1000	
70	Bordsley	under	do	—	—	—	—	—	—	—	5	300	May 1839.
60	Bordsley	do.	do.	—	—	—	—	—	—	—			
60	Bordsley	do.	do.	—	—	—	—	—	—	—	9	1000	May 1839.
					Approximate Estimate.						139	10,500	

SUMMARY.

456	Tons of Cast iron in beams, girders, and bearing plates,	at
107½	Ditto, ditto, in segment bars	at
17	Ditto of Wrought iron	at

£6,420 18 4

AGREEMENT.

I, of

hereby agree and undertake to execute, according to the specification hereunto annexed, and subject to the conditions prescribed, the works on the Birmingham and Gloucester Railway, comprised in the contract for "Iron-works in Bridges," amounting by computation to

more or less, at the average price of

to be paid to me according to the "Schedule of Prices" for each particular work hereunto annexed.

Dated this day of 1838.

Accepted and agreed to { ______________________
{ ______________________

Directors of the Birmingham and Gloucester Railway Company.

(Signed) JAMES FOSTER.

BIRMINGHAM AND GLOUCESTER RAILWAY.

CONTRACT, No. 15, G.

Tewkesbury Depôt.

Specification of the several works to be performed in making and completing the depôt for the railway in the town of Tewkesbury, in the parish of Tewkesbury, in the county of Gloucester.

CONDITIONS ON WHICH CONTRACTS ARE TO BE MADE.

1. The contractor is to furnish all implements and tackle that may be required during the execution of the works. But it is understood that columns, girders, balustrades for office and entry stairs, grates, coppers, and stink traps are to be supplied to the contractor on the spot free of expense.

2. The contractor is to execute the whole of the works, as described in the specifications, to the satisfaction of the company's principal engineer and resident assistant engineer, who shall have power to reject materials which are not of the best quality, and to take down imperfect workmanship. The principal engineer is to decide disputes, if any arise; and the works are to be executed within the periods limited, either in whole or in successive portions, as stated in the specification.

3. The contractor to receive fortnightly 90 per cent. of the amount due for works performed. The balance to be retained by the company until after completion of his contract, under certificate of the engineer-in-chief, and to be then paid to him.

4. The work to be measured by the engineer, and the payment to be made by the company, through their secretary or pay clerk, upon the certificates of amount due, signed by the engineer-in-chief.

5. The copies of the specification, &c., and of the tender annexed, to be deposited with the resident assistant engineer. Contractor to have access to them.

6. In case of workmen employed or materials provided by contractor not being sufficient for completion of the works within the period named, contractor shall, upon notice from the company, provide such additional workmen or materials as the principal engineer shall deem necessary; and, in default, company shall employ such additional workmen or materials at the cost of the contractor, and may also deduct their wages and cost out of monies due to the contractor, so far as the same may be sufficient for that purpose; or it shall be at the option of the engineer, in case of such deficiency of progress, to foreclose the contract, on giving to the contractor a written notice   days previously, to this effect. And if the contract is thus foreclosed, the contractor shall forfeit his claim to all monies or balance that may then be due to him, on account for it, by the Railway Company.

7. The company to have power to remove any persons in employ of contractor on the line, after notice thereof being given to the contractor.

8. The contractor is to deliver, at the office of the resident assistant engineer, or sub-assistant engineer, an account, every fortnight, of the number of artificers and other workmen employed the preceding fortnight, according to a form to be furnished, or to pay   on default; also to deliver, at the same time and place, an acknowledgment, under the hand of the sub-contractor, or foreman, or overlookers, or head-workmen, that every person engaged by or under the contractor, has received the whole amount of his demand upon the contractor up to the date of such acknowledgment, or in case of any exception, to state the reason for such exception.

9. If temporary roads be necessary, engineer to set them out; contractor not to deviate therefrom.

10. The contractor to make satisfaction and compensation, as required by the Act, to all owners and occupiers, for damages by trespass of himself or his men.

11. The contractor not to make sub-contract without the consent of the company, except as to labour only.

12. Alterations or additions to works not to be executed without written authority, signed by the engineer-in-chief or resident engineer. Works admitted by the same authority to be deducted for, according to the scale established in the "Schedule of Prices."

13. The contractor, if required by the company, is to pay the sub-contractors and workmen their full wages (vouched as stated in Clause 8) on the day

to be appointed by the company, and in presence of the company's agent, in such places as the company may appoint, and no other. The same rule to apply to all payments made by sub-contractors, and company to have power of dismissal in case of non-compliance.

14. The contractor to employ no men on Sundays, except on such works as are certified in writing by the engineer-in-chief, or resident engineer, to be absolutely necessary. The company to have power to dismiss any man found so employed on Sundays, except under this certificate.

15. The contractor not to retail, either directly or indirectly, (without permission of directors) any article of consumption to the workmen.

EXTENT OF CONTRACT.

This contract comprises the formation and completion of several artificer's works hereinafter more particularly specified for the buildings, &c., according to the accompanying drawings.

The preceding enumerated works, and the mode of execution, are described in the specification of each particular work, and their forms and dimensions are represented on the accompanying drawings, which are referred to in this specification; but should any discrepancy exist between the scale attached and the written dimensions, or between the drawings and specifications, or any ambiguity in them, the same are to be referred to the engineer-in-chief, whose decision shall be conclusive.

Also anything contained either in the drawings or specifications shall be equally binding upon the contractor, as if it were contained in both.

The written dimensions upon the drawings are to be taken in all cases in preference to the scale.

GENERAL STIPULATIONS.

The general regulations for the observance of the contractor are set forth in the printed form of "Conditions" at the commencement of this specification, and to them the contractor is referred.

Should it become necessary in the opinion of the engineer at any time during the progress of the works to increase, diminish, or alter the form or dimensions of any part of the work, the contractor shall comply with any order he may receive to that effect in writing from the engineer; the addition, diminution, or alteration to be allowed for according to the rates stated in the " Schedule of Prices" for the particular work annexed to the tender, and the general contract not being vitiated thereby.

The contractor is to provide all the necessary machinery and materials for thoroughly draining the works during their progress, whether by drifting, pumping, or other means. Also all planks, waggons, barrows, tools, and materials whatsoever for temporary ways that may be required in the execution of his contract; all of which are to be of a quality and construction approved by the engineer.

Any materials which the engineer shall deem insufficient or improper to be used shall be removed from the ground by the contractor within three days after notice has been given him in writing to that effect; and in case of his failing to remove such materials in the time above specified, the engineer shall have the power to cause them to be removed by the most convenient means, and at the contractor's expense.

The contractor will be held liable by the company for all damage to adjoining lands done by trespass of the people in his employ.

The whole of the work executed under the contractor is to be of the soundest description, done in a substantial and perfect manner.

The contractor will be at liberty to use the quantities of the several descriptions of work from which the engineer's estimates have been made, without the engineer being any further pledged for their accuracy.

In case of forclosure of the contract, the contractor shall forfeit all claim to the balance of monies, if any then due to him from the company, upon this contract.

Nett measurements only will be paid for, or allowed, without regard to any usage or custom to the contrary.

It is to be distinctly understood that the whole of the work executed under this contract is to be of the soundest and best description of each kind; and if any work of inferior description is introduced, which does not satisfy the engineer, it shall be rejected and not paid for.

PARTICULAR SPECIFICATIONS

Of the several works to be performed.

DIGGER OR EXCAVATOR

Is to excavate for the foundations of all walls that are to be built on new foundations, to level the ground and ram the same previous to commencing the footings, and to clear away all rubbish or material from the excavation according to the direction of the engineer; he is to excavate for the sewer or drain and cesspool shown on the drawings, and for all other drains or cesspools that may be required, and to clear out the wells if so ordered.

BRICKLAYER

Is to build all the walls of the several thicknesses and heights shown, leaving openings for doors, windows, &c., to the full dimensions figured on the drawings.

To build the several fire places, chimney jambs, breasts, backs, and shafts, with flues, 9 inches by 14 inches, properly gathered and pargetted, as shown on the drawings; the fire places to have each a strong iron chimney bar, $2\frac{1}{2}$ by $\frac{3}{8}$ths of an inch, with the ends turned up and down; the opening for fire places to be 3 feet high by their respective widths, and in the kitchen 4 feet high. As also all recesses, dwarf walls, piers, and retaining walls.

To dome over in 14 inch brick the wells now existing, with proper man holes, covered with forest landings and a strong iron ring; to build a 9 inch barrel drain to lead into the street sewer, forming a stink trap to former; to line in 9 inch brick the cesspool and water cisterns, and also a shaft for the water pump: to build proper stacks and spandrils for carrying the several flights of steps shown on the drawings; to build all privies and other conveniences, and generally to execute the whole of the brickwork requisite to carry out the design of the drawings, &c.; to turn 9 inch discharging arches over and under all openings, leaving a sufficient thickness for the face work.

The bricklayer is to cut all splays, rakes, and chasing, for lead flashings, and for stone or oak sills, and to make good where necessary; to form all reveals; to bed all plates, lintles and door and window frames, wooden bricks and bond timber; to do all wind pinnings and beam fitting.

The walls are to have the courses well flushed up, and they are to be carried up in even and level courses throughout, in order to settle fairly. External faces to be worked with a flat ruled joint.

The bond shall be english or flemish at the option of the engineer. The walls shall be built solid with whole bricks, bedded full in mortar, with joints not exceeding $\frac{1}{4}$th of an inch thick, the bricks being previously thoroughly soaked in water, the whole being flushed solid, the joints pointed, and then grouted full.

The bricks to be used shall be sound and hard burnt; and where worked in on the face shall be of the very best severn bricks of uniform colour, and shall be thoroughly soaked in water before being worked in. The mortar shall only be used when fresh mixed; it shall consist of three parts of clean sharp river sand and one part of strong fresh burnt lime, thoroughly slacked and mixed dry with the sand, and then thoroughly tempered with a sufficient quantity of water.

EXTRA WORKS AT ORDER OF ENGINEER.

Cast iron stink traps to be fixed to all external apertures of drains.

To set all grates and coppers, also where walls are to be built on foundations.

MASON.

The front, in High-street, is intended to be faced with stone in the most substantial manner.

The stone shall be selected of the largest possible size, carefully chiselled and dressed to the different cheeks and mouldings shown on the drawings: no joint of mortar shall exceed $\frac{1}{8}$th of an inch thick, the beds shall be full and square for the whole depth of the stone, which in no case shall be less than 18 inches, and the joints squared back for not less than 18 inches; the courses shall be so selected in height as to suit in the best manner the several panels and mouldings.

All the arrises shall be carefully protected, so that when finished the work may be sharp and perfect. The parapets and chimney shafts above the roof shall in like manner be faced with stone, the coping being dowelled together.

The backing of brick shall be carried up at the same time as the facing and bonded into it, thorough stones being inserted at proper intervals, and at the gate-door and windows jambs in every alternate course.

The piers, to which the large entrance gates are hung, must be built solid, and the gate irons must be built in, sunk and run with lead; and forest blocks shall be used for the basement of the entire front. Forest stone landings, 6 inches thick, are to be laid over the tops of the two cross walls carried up in the middle of the building from the ground; upon these landings the fire places and chimney breasts and shaft are intended to be carried up, as also the partition or cross wall between the rooms on the first floor.

Stone sills, 8 inches wide and 5 inches thick, weathered and throated, are to be provided and fixed to all the windows in the back fronts.

Forest stone steps, 12 inch treads and 6 inch risers, with rounded nosings, to be built under the entrance gateway, as shown on the drawings; the stones must be obtained of the greatest possible length, and the work must be of the most solid description.

The smaller flights of steps must in the same way be carefully and substantially built of the same material.

Large square forest stones, not less than 10 inches thick, must be fixed in the brick piers as bases to the iron columns, and as bearers for the iron girders.

Solid stone coping, not less than 4½ to 5 inches thick, showing 2 inches tomus on the outer edge in stone, not less than 3 feet long, dowelled together, must be laid on the retaining walls along the platform or stage, as also stone plancers, not less than 6 inches thick, along the ramp of the steps leading to the booking office, into which an iron railing will be sunk, the holes being cut for the balusters by the mason. Proper stone hearths, 18 inches longer than the width of the fire places, must be provided and fixed to all the fire places.

The fire places in the chambers to have plain stone mantle jambs, slips and shelves with rounded corners. Stone sinks shall be provided and fixed in the convenience and outhouse, with holes cut in them and large landings laid as pavement in a substantial manner to the privy entrance and area before it, as also to the back doors of the out buildings.

Stone imposts must be fixed to all arches exceeding 5 feet span.

PLUMBER, PAINTER AND GLAZIER

To lay all the lead gutters with 7lbs. rolled sheet lead, with 3 inch drips, to extend in all places 9 inches up the roof and 4 inches up the wall, with a lead flashing, 5lbs. to the foot, at least 5 inches deep; all the hips, vallies, and ridges to be laid with 5lb lead.

To provide and fix a pump with proper service pipes and all necessary stays and standards for the same.

To fix two rain water pumps with 2 inch suction pipes and 3½ inch cylinder, with oak standard plans, wrought iron lift and cheeks complete, using the old pumps for the purpose; if the old are rejected by the engineer as not fit, their price of providing new pumps to be extra.

To glaze with best Newcastle crown glass all windows and lights, to be well bedded and back puttied, and to make good all broken glass until the work is delivered over.

To stop, knot and paint in three coats of good oil colour all interior work usually painted, and all similar exterior work in four coats of oil.

PLASTERER.

Render, float and set kitchens, lath, plaster, float, and set fair for papering the living room and chambers, and for colouring or painting in the passages and offices.

Plain cornices, not exceeding 10 inch girth, are to be run in the chambers of the dwelling house.

The ceilings to be lath laid, and set in plaster.

SLATER.

To cover the whole of the buildings with duchess slates, nailed in two places with coper nails $2'' \times \frac{3}{4}$ deal sawn laths. Eaves to be laid double; the whole of the slates to have a sufficient overlap, not less than 3 inches, and to be carefully assorted in courses consisting of slates of equal thickness.

CARPENTER.

The whole of the timbers to be of the best sound yellow Memel, Dantzic or Riga fir, free from shakes or large loose or dead knots, and to be prepared according to the patentee's specification for Kyan's process.

No rafters, joists or quarters to be more than 12 inches apart in the clear, a tier of herring-bone struts, $2'' \times 2''$, in each room, on each of the floors. Provide and fix all necessary centreing to the arches and apertures, and support the same with proper struts and braces. Provide and fix 2 tier of bond timber in each of the stories, fir lintels, wall plates, and with wood bricks for the fixing of the joiner's work, as may be directed.

The bond and plates to be halved and dovetailed at the angles, and nailed and returned at the chimney breasts.

Lintels over all door and window openings to be $4\frac{1}{4}$ inches thick, and 18 inches longer than the width of the internal opening, and as wide as the walls will admit.

The roof, floors, and quarter partitions to be framed in a sound proper manner of the following scantlings :—

	Feet		Inches.
Bond and wood bricks	4	×	2½
Wall plates on each story	4½	×	4
Joists of lodge and sitting room, ground floor	5	×	2½
English oak sleepers	4	×	4
Joists of one pair floor	10	×	3
Framed and trussed quarter partition head	6	×	4
Counter head	4	×	4
English oak, Queen's	6	×	4
Crown piece	4½	×	4
Strutts	4	×	4
Sills, quarters, braces, and puncheons	4	×	2¼
Posts	4	×	4

ROOF.

Rafters	7	×	3

Properly secured with iron foot straps and bolts to the tie beams, and securely nailed to the collar beams where they are used.

Tie beams	9	×	3
Collars	5	×	3
Ridge pieces and hips	9	×	1½
Pitching pieces	9	×	1½
Diagonal and Dragon pieces	4½	×	4
Trimmer to sky-lights	4½	×	4

Cover the whole of the roof with ¾ yellow deal rough boarding for slates, the edges shot with all proper tilting and springing fillets.

PRIVY.

Joists	10	×	3
Trimmers	10	×	3½

Fir proper door frames, 4 × 3, tenoned into stone sill, and 1¼ ledged and beaded door, hung with 12 cross garnets and screws and norfolk thumb latch, small bolt to same; 1¼ ploughed and tongued seat, with hole cut in same, and all proper bearers; $\frac{1}{2}$ deal square skirting, 4 inches wide, round same; $1\frac{1}{2}$ deal ovolo sash hung on pivots.

Joiner.

The deals to be of the best seasoned Christiana or Stockholm.

Floors.

Lay $1\frac{1}{4}$ yellow deal floors (free of sap) to the rooms and passages on the one pair and ground floors, those on the ground floor, that are to be boarded, to be ploughed within $\frac{1}{4}$ of the bottom edge, and to be tongued with thin zinc.

Windows and Frames.

Deal cased frames, english oak sunk and weathered sills, $1\frac{3}{4}$ brass axle pullies, $1\frac{1}{2}$ deal ovolo sashes single hung, with best extra stout patent white lines and iron weights.

Those that are shown upon drawings with gothic heads, will have inch deal wrought and tongued linings or splays with backing, $\frac{7}{8}$ quirk moulding round same to all the windows, except the living rooms, which are to have $1\frac{1}{4}$ framed bead butt and square shutters, hung with $1\frac{1}{2}$ pair 3 butts and screws, with boxing to receive the same with single.

The window in the porter's room to be double hung.

Provide and fix square angle stafs, wherever required, at the chimney breasts, &c.

Doors.

The cellar doors to be $1\frac{1}{4}$ proper ledged doors, hung with 12 cross garnets, with oak proper door frames, 4 × 3, tenoned into stone sills, with 9 inch stock lock and norfolk thumb latch to same.

The doors under the spandrils of the stairs, opening on the platform for passengers, to be 2 inch panelled, as on the drawing, bead flush and square with gothic head and rabeted frame 4 × $3\frac{1}{2}$, tenoned into stone sill and beded casing 4 × $\frac{1}{2}$, fixed round the jambs, soffet to the outside, hung with 4 inch butts, with 10 inch best iron rim knob locks, and 2—10 inch bright barrel bolts to same.

Similar doors to other openings on the ground floor, except the centre one, as shown in section, which is to have moulded transom and fanlight, as drawings.

Two inch moulded and square doors to the rooms on the one pair floor, the moulded side towards the passages with $1\frac{1}{4}$ deal single rebated jamb linings, with dovetailed backings to each jamb, inch deal framed grounds, 4¼ wide, splayed at the back edge for plaster, and ⅞ moulding to same, hung with 4 inch Redmond's iron patent rising spring hinges, and 7⅝ inch mortice locks, with best knob furniture.

SKIRTINGS.

Inch deal grooved skirting grounds to the booking office, passages, and sitting room on the one-pair floor, with deal moulded skirting, 9 inches wide, the angles to be properly tongued and housed.

Inch deal square skirtings, 7 inches wide, to the other rooms that are floored.

STAIRCASE.

One and a quarter hard yellow deal nosed and 1 inch risers to stairs, with all proper brackets, carriages, &c.

One inch square bar balusters, 2 to each step, and 1 iron bar baluster upon every fourth step properly secured, 2 inch oak handrail to stairs, single moulded skirting on landings and stairs.

PROGRESS OF THE WORKS.

1. Up to the joists of the first floor throughout shall be laid by the 17th of November next.
2. Up to the wall plates throughout shall be laid by the 20th of December next.
3. The buildings shall be covered throughout by the 15th of January, 1839.
4. All the interior work shall be finished by the 28th February, 1839.

The advances, as per proposal annexed hereunto, shall be subject to 20 per cent. deducted, which 20 per cent. shall be paid on the subsequent fortnightly certificate of the engineer, provided that the above times have been duly observed; but this 20 per cent. shall be forfeited to the company, if the above times and amounts of work done have not been duly observed.

TENDER.

I,   of

do hereby propose to make and erect the depôt in the town of Tewkesbury according to the plans and specifications exhibited to me; and to maintain the same until delivered over to the engineer, on completion of this contract; and to provide all the requisite materials within the periods, and upon the terms and conditions mentioned and contained in the draft also exhibited to me, for the sum of *sixteen hundred and sixty pounds*—to be paid as follows, viz.: when the joists of the first floor throughout the building are laid £500; when the wall plates for the roof are laid throughout the building £300; when covered in throughout £200; when all interior work specified is finished £200: and the balance within one month after engineer's certificate of completion; allowance more or less being made, when the work actually performed, for any increase or diminution of work ordered as per clause 12 of the conditions hereunto annexed.

And I have in the "First Schedule," hereto annexed, set forth the prices of the different descriptions of work at which this tender is computed.

And I further propose to execute the several works in the said specification, denominated "Extra Works," at the prices affixed to each description of work in the "Second Schedule" hereto annexed.

And in case this tender shall be accepted, I hereby undertake to execute the agreement following to perform the works as above proposed, and under the conditions above referred to.

And lastly, I do hereby undertake and agree, that in case the said agreement shall not be executed by me within one week from the date hereof, the said company shall not (unless they think fit) be bound by this tender, but the same shall be absolutely void, in case the company shall so think fit; nor shall they in that case be liable to any claim by me in respect of work then already done by me upon the said railway.

Witness my hand this day of 1838.

To the Directors of the
Birmingham and Gloucester Railway.

(Signed) THOMAS P. HOLDER.

COPY OF A LETTER FROM THE CONTRACTOR TO THE ENGINEER-IN-CHIEF.

Sir,

Having examined the drawings along with you this morning, I find that the platform extends further than shown on the sketches from which I made my estimate of £1660, and that the additional quantity of work, both stone and brick, will amount to a further sum of £80, I beg to make my proposals subject to this increase for the Tewkesbury depôt.

Tewkesbury, October 11th, 1838.

(Signed) Thomas P. Holder.

ABSTRACT OF THE CONTRACTOR'S ESTIMATE.

Description of Work.	Super.		Solid.		Run.	
BRICKLAYER.	feet.	inches.	rods.	feet.	feet.	inches.
Brickwork in walls	-	-	47	187		
14 inch arches	565	6				
Cut splays in arches	152	6				
Cut quoins to do	-	-	-	-	65	0
Barrel drain	-	-	-	-	141	3
MASON.						
			15	0		
In plinths	-	-	151	4		
Moulded work on face	451	4				
Plain work on face	800	0				
Doors and windows	512	0				
3 inch landings	210½ sq. yds.					
2 inch hearths	37	6				
6 inch landings	10 yds.					
2 inch mantle and jambs	10	10				
Moulded steps	694	8				
18 inch coping	-	-	-	-	110	0
4 inch sill to privy	-	-	-	-	2	0
No. 3 plain chimney-pieces						
CARPENTER.						
Fir framed	-	-	553	10		
Ditto, in bond and lintels	-	-	171	0		
Ditto, in joists	-	-	233	2		
Gutter boards and bearers	385	3				
1¼ inch yellow deal floor	13½ sq.					
6 inch partition	2 sq. 65					
4 inch ditto	80 ft. 6					
¾ Rough boarded to roofs	14½sq.					
2 Panel square doors	82	4				
1½ inch partition	53	0				
4 Panel bead, both sides gothic head doors	97	6				
4 Panel square doors	60	0				
1½ inch proper ledged door	72	0				
Sash-doors	54	0				
Single rebated jamb linings	5	8				
Architrave linings	184	2				
Single moulding	-	-	-	-	51	0
Gothic fan-lights, No. 1						
Herringbone strutting	-	-	-	-	176	0
Deal cased frame oak sunk sills 1½ inch ovolo sashes, 1¾ brass axles, pullies, weights and lines, &c.	210	6				
Inch framed shutters	21					

Description of Work.	Super.		Solid.		Run.	
	feet.	inches.	rods.	feet.	feet.	inches.
Inch and quarter deal nosed treads and risers,	108	3				
square bar balusters	70	10				
Oak handrail	-	-	-	-	16	0
Iron bar baluster, inch square	-	-	-	-	18	0
1 inch square skirting	-	-	-	-	55	6
6 inch plain, ditto	-	-	-	-	56	6
9 inch moulded, ditto	-	-	-	-	281	0
Cut hole, and dished with cover to P., No. 1	189	0				
4 inched dresser top to corridor and drawers, handles, lock and key to dresser 2						
Iron-rimmed knob locks, No. 12.						
4 inch butts, No. 12 p						
Norfolk thumb latch, No. 7						
Woodstock locks, No. 6						
Cross garnets, No. 4, pair.						
6 inch bright bolts, No. 6						
Patent sash fastenings, No. 32						
SLATER.						
Duchess slates	15 sq.					
PLUMBER.						
Gutters and flashing lead	44 cwt.		80 lbs.			
Wall-hooks, No. 39						
Washer and waste in sink, No. 1						
2 inch lead pipe	-	-	-	-	18	0
Pump, with proper service-pipe complete, No. 1						
No. 2 rain-water pump suction pipes						
GLAZIER.						
Best Newcastle crown glass	208	0				
Skylight tops cut circular	11	0				
Fanlight over door, No. 1						
PAINTER.						
4 Oils	36½ yds.					
3 Oils	128 yds.					
4 Oils sashes and frames, No. 29						
Sash squares in 4 oils, 8 dozen and 4						
Chimney-pieces, No. 4						
PLASTERER.						
	559 yds.					
Render, float and set to walls	66½ yds.					
Lath, plaster, float and set to partition	270 yds.					
Laths lay set and white to ceilings, compo	66½ yds.					
Plain corner, 10 inch girt	-	-	-	-	169	6

FIRST SCHEDULE REFERRED TO,

Containing a list of the prices of the several descriptions of work at which the accompanying tender is computed, the whole of the work being executed and completed agreeably with the foregoing specification :—

EXCAVATOR AND BRICKLAYER.

Digging, per cubic yard
Bricklaying, per rod of 272 feet
Barrel drains, per foot
Brick flat in cellar floor, per yard superficial

MASON.

Cased and bonded stone front per foot superficial on the whole extent, opening included
6 in. forest landing, per foot superficial
Weathered and throated sills, per foot run
Forest treads and terrace steps
Ditto, risers ditto
Landings on platform forest thin, per superficial
Cube forest under columns
Blue stone hearths, per foot superficial
Weathered coping, per cube
Forest border, sills, per foot superficial
Stone jambs and mullions, per superficial
Moulded coping, per run
Ditto, cornice ditto

CARPENTER.

Memel timber, per cube
Ditto, in bond plates, lintels as per ditto
Ditto, door-frames
Oak sleepers

Extra works.

Yellow deal ploughed and tongued floors with chains, per square
Ditto, staircases, per superficial
Ditto, boarding roof, per square
Ditto, gothic door head, per superficial
Ditto, double-hung gothic head, per ditto
Deal cased frames oak sunk sills, 1¼ wide deal sashes, per super.

Ledged and beaded doors, per ditto . . . . .
Angle staff beads, per run . . . . .
Moulded skirting, per run . . . . .
Beaded linings, per superficial . . . .
Jamb linings, per superficial . . . . .
Framed and beaded box shutters, per superficial . .
Skirting, per run . . . . . .
2 inch moulded sash door, per superficial . . .
Ditto, gothic headed, per ditto . . . . .
Wrought strings, per ditto . . . . .

Slater and Plasterer.

Deal sawn lath for slating, per square . . .
Duchess slating, per square . . . . .
Plastering on walls, per yard . . . . .
Ditto, lath ceilings in plaster, per ditto . . .
Cornice plaster, per run . . . . .
Gothic arris, per ditto . . . . . .
Lath and plaster partition, 3 yards square . . .

Plumber, Glazier and Painter.

Lead flashing, per cwt . . . . .
Ditto, gutters . . . .
Best Newcastle glass, per superficial . . . .

AGREEMENT.

I, of

hereby agree and undertake to execute according to the specifications hereunto annexed, and subject to the conditions prescribed, the works on the Birmingham and Gloucester Railway, comprised in the contract *Tewkesbury depôt*, hereunto annexed, amounting to the sum of *one thousand seven hundred and forty pounds*, exclusive of "Extra Works" and alterations regularly ordered by the engineer, as contemplated in clause 12th of the conditions hereunto annexed, which are to be paid to me according to the "Schedule of Prices" for each particular work hereunto annexed.

Dated this day of 1838.

Accepted and agreed to { ______________
{ ______________

Directors of the Birmingham and Gloucester Railway Company.

(Signed) THOMAS P. HOLDER.

DETAILS OF THE

SWING BRIDGE, LONDON DOCKS.

H. R. PALMER, Esq., Engineer:

Plate 12.—Elevation and Transverse Sections of bridge, and Details of friction rollers.
Plate 13.—Longitudinal Section and Plan of bridge, showing framing.

Explanation of References on Plates.

a . . Iron post cased with steel, turned and polished.
b . . Iron socket cast hard in a metal mould and ground.
c . . The four adjusting screws.
d . . The inside of the ring turned true for the rollers to run in.
e . . The soil-plate cast solid.
f . . The arms having four adjusting screws.

The rack is secured to the tail of the bridge, and the projecting part is supported by a cast-iron bracket, screwed to external rib.

MANCHESTER AND BIRMINGHAM RAILWAY.

G. W. BUCK, Esq., Engineer.

Plate 14.—Plans, Elevations and Sections of the Stockport Viaduct, *(see Specification of same).*

Plate 15.—Ditto, Details of Construction.

Plate 16.—Elevations, Sections and Details of the Cangleton Viaduct.

Specification for the erection of the Viaduct over the River Mersey, at Stockport.

The viaduct will be constructed of 22 semi-circular arches, each of 63 feet span; the particulars of which are exhibited in the drawings, and herein further described.

The whole of the foundations of the abutments and piers are to be laid upon the solid sand-stone rock. It is presumed that the rock will be met with at the respective depths shown in the drawings; and if otherwise, the foundations must be laid either higher or lower, as the case may require, in the judgment of the engineer.

The rock must be dressed off to a uniform level surface, equal in extent to the bottom course of the masonry of each foundation.

The contractors are to excavate all the foundations, to the depths shown in the drawing; to construct dams, to keep out or pump out the water, and provide all centreing-planks and tools of every description necessary to the perfect execution of the work, at their own expense, and to be included in the amount of their tender; and in case any of the foundations shall, in the opinion of the engineer, require to be laid lower than is shown in the drawings, the contractors are to make the required additional or other contingent works, incident thereto, at the rate specified in the second list of prices.

The increase of the excavation, masonry, or brick-work, or other matter constituting the foundation caused by such additional depth, will be paid for as additional work, at the rate specified in the second list of prices.

The earth, or other material, which it may be necessary to fill in round the brick-work or masonry of the foundations, must be well punned, pounded, or puddled-in, as the case may require, or as may be directed by the engineer; and the expense of performing it is to be borne by the contractors, and not to be charged as additional or extra work.

The value of such filling-in round the foundations of the piers and abutments, is to be included in the price for the excavations, where additional excavation is necessary, and to be included in the contract where additional excavation is not necessary.

The filling-in is to extend from the bottom of the foundation to the level of the surface of the ground. The surplus earth arising from the excavation of the foundations must be removed into the embankments surrounding the abutments, by and at the cost of the contractors.

BRICK.

The bricks to be made use of in the inside work shall be such as are known in Manchester by the name of "common bricks," of good quality, well shaped, and hard burnt.

The whole external face of the brick-work of the viaduct is to be built with second-stock bricks, of the best quality; and the whole depth or thickness of all the arches of the viaduct must be entirely built with the said second-stock bricks. In the arches the bricks must be laid by a line, and each brick firmly bedded with a mallet. No broken bricks shall be used, and no joint of mortar shall exceed a quarter of an inch in thickness. No difference of workmanship will be allowed in outside and inside work, except so far as herein specified; and the whole of the joints shall be flushed up solid with mortar, and the outside joint neatly drawn with a trowel, and struck with a straight edge.

The bond will be either English or Flemish, as the engineer may direct.

The contractors will not be allowed to build any of the outside work overhanded; but they must, in every case, lay it from the outside, and provide all scaffolding or stages necessary for the same.

The arches are to be backed with solid brick-work, up to the height shown in the drawing, and the spandrils are to be carried up with the backing to the same height before the centres are eased; and the remaining or upper portion of the spandrils is not to be built until the centres are eased quite clear of the arches, and all the arches are turned and backed to the height shown in the drawing.

All the joints of the soffits of all the arches must be raked and neatly pointed.

After all the arches shall have been turned, and the centres eased or struck, and after so much time shall have elapsed as shall be sufficient, in the opinion of the engineer, to ensure no further subsidence of any of the arches, then, and not till then, shall the remaining portion of the spandril walls be built up to the level of the under side of the stone parapet.

No brick-work, or stone-work, to be set during frosty weather.

MORTAR.

The mortar to be made use of in the foundations in all those parts below the surface of the ground, in all the arches, and in the piers which stand in the River Mersey, to the height of the uppermost course of the stone-work of the base, must be laid in Artbury lime mortar, or in mortar made with hydraulic lime of equally good quality, such as shall be approved by the engineer.

The mortar to be used in the other parts of the work may be made with Burton lime, or any other lime such as shall be approved of by the engineer. The lime is to be mixed with clean sharp sand, in the proportion of three measures of sand to one of lime. The lime and sand must be intimately mixed and well tempered, by being ground together under edge-stones with a proper quantity of water.

STONE.

All the stone to be used in or for the viaduct, is to be stone of the best quality, from the Cloud Hill, or Runcorn Quarries; or other stone equally good, and approved of by the engineer.

The stone-work of the piers and abutments is to be of solid ashlar work throughout, from the foundations to the height shown in the drawings. Each course to be 2 feet thick. The outside courses to measure 2 feet 6 inches, and 4 feet alternately in the bed. No stone in the outside courses to be less than 4 feet long; and no stone, either in the inside or outside work, to break joint less than 18 inches.

The outside courses of the bases of the piers and abutments are to have 3 inch champered joints, with a tool-draft or margin 2 inches wide, and the remaining space pick-dressed. All the beds of the stones are to be accurately worked into true plane surfaces without any winde or hollow, and set with as close a joint as possible. Each course to be completed before the next is begun, and drafted and pick-dressed to a true horizontal bed.

The imposts are to be 3 feet thick, in two courses; and the stones of which they are composed are to measure 4 feet long in the face, and alternately 4 feet and 6 feet deep in the bed, exclusive of the projection; by this arrangement the long stones will break joint with each other two feet, and in each cross joint a 3 inch square joggle of hard stone, or of well burnt staffordshire brick earth, is to be inserted throughout the whole thickness of the impost (as shown in the drawing), and set in fluid roman cement of the best quality.

The imposts are to be moulded (as shown in the drawing), and their whole external surface fair tooled.

After the spandril walls shall have been built to the height shown in the drawings, then the stone parapet is to be erected (of the form and dimensions shown in the drawings). The whole of the internal and external surfaces of the parapet are to be fair tooled. No stone in the parapet to be less than 5 feet long. All the beds and cross-joints to be perfect planes, and set with close joints.

In each cross-joint of the parapet there must be a vertical joggle through the whole height or thickness of the course; and in each joggle a piece of hard stone, or of well burnt staffordshire brick earth, is to be inserted, 3 inches square, set in fluid roman cement of the best quality.

To carry off the water from the railway a 4 inch cast-iron pipe is to be built horizontally into the centre of each pier, and of each abutment, to discharge the water 1 foot above the level of the surface of the ground; the discharging end must project 4 inches beyond the face of the masonry, and be terminated with a $\frac{3}{4}$ of an inch bead, the inner end of each horizontal pipe must have a faucit joint, the bottom of which must be 6 inches above the upper surface of the horizontal pipe; the pipe is to have a quarter bend at this end; the faucit joint is to receive a 3 inch cast-iron pipe, which is to be built in the centre of each pier, and in each abutment, up to the level of the backing (as shown in the drawing).

The uppermost length of the 3 inch pipe is to finish in a cesspool made in a stone block, into which the water is to be brought by the drains (shown in the drawing.)

After any one of the arches shall have been turned and backed to the proper height, the arch and backing are to be coated with coal-tar, in the following manner, as soon as the weather will permit:—

The whole of the upper surface of the arch and backing must be freed from all dirt, dust, loose materials, or any other extraneous matter, by being thoroughly swept, or by other efficient means; and the work, after being thus cleaned, must be covered with coal-tar, prepared and put on in the following manner:—The coal-tar is to be boiled a sufficient length of time, to evaporate its water and ammoniacal liquor, to such an extent that when the remainder is suffered to cool it will set moderately hard, and without cracking: the requisite time for boiling is about ten or twelve hours.

The coal-tar, when thus prepared, is to be poured upon the brick-work by means of ladles or cans, and well rubbed into the surface of the brick-work with stiff brushes; and after the tar has been thus brushed into the surface and joints of the brick-work, another coat is to be poured upon it and suffered to cool thereon, to the thickness of, and not less than, a quarter of an inch.

After the erection of the spandril walls, they must be carefully coated with prepared tar, to the extent of 18 inches in height above the arch and backing; and great care must be taken to make perfect the connection between the coating of the arches and the spandrils.

The purport of the coating is to render the arches impervious to water; and it is proper to add, that the operation cannot be performed except in dry weather.

It is now known by experience, that when this work is well executed, the arches are rendered perfectly drop dry, and the contractor will be held responsible to make them so.

All the centreing must be constructed to the satisfaction of the engineer, for which purpose the contractor must lay before the engineer drawings of the centres which he purposes to make use of, and which must have the engineer's approval before the centres are constructed.

The contractor must commence turning the arches at one end of the viaduct, and proceed onwards to the other end; and he will not be allowed to remove or to ease any one centre until he shall have not fewer than eight arches turned, after which, the centre next the abutment may be removed, and be placed in advance, to serve the purpose of turning the next succeeding arch upon, and so on regularly in succession.

Provided nevertheless that the contractor shall not, in any case, be permitted to strike, remove, or ease a centre, without having the written permission of the engineer-in-chief for that purpose; and if the contractor shall persist in acting in opposition to this provision of the specification, he shall be liable to the expense of all accidents or damages arising therefrom; and shall, in addition thereto, forfeit and pay to the company the sum of one thousand pounds for any violation thereof.

After the arches shall be turned back and coated, and the spandril walls shall have been carried to the proper height for the parapet, the contractor must fill the spaces between the arches, and also cover the whole of the arches with sand, up to the height of 1 foot above the level of the tops of the arches.

This must be done from one end of the viaduct to the other, and embrace the whole breadth between the parapets. The contractor will be required to fix as many vertical earthen drain-pipes in the ballasting between the arches as the engineer may direct.

These pipes will be furnished by the railway company.

PARIS AND VERSAILLES RAILWAY.

M. PERDONNET, ENGINEER.

PLATE 17.—Plan, Elevation and Details of the Viaduct across the Vale of Fleury.

This design, it is presumed, will be reviewed with particular interest, as it contains some deviations from the usual mode of construction adopted in this country.

GLASGOW, GREENOCK, AND PAISLEY RAILWAY.

JOSEPH LOCKE, Esq., Engineer.

Plate 18.—Plans, Elevations and Sections of the Bridge over the River Cart, at Paisley,* *(see Specification of same).*

Plate 19.—Bridge over South Croft Street, *(see Specification of same).*

Plate 20.—Plans, Elevations and Sections of the Bridge over Cook Street.

Plate 21.—Ditto. Details of Construction.

Plate 22.—Plans, Elevations and Sections of the Bridge over the Pallack and Govan railway.

Plate 23.—Ditto, Details of Construction.

Specification of Bridge for crossing the River Cart, at Paisley.

This bridge of one arch, for carrying the railway across the River Cart, shall be built according to the form and of the dimensions represented on the drawing.

The foundations of the abutments shall be laid at the depths shown on the drawing, and shall be 33 feet long and 23 feet 6 inches thick, stepping off in three courses (1 foot each) to 28 feet long and 18 feet 6 inches thick. From this point to the springing of the arch, being a height of 25 feet 10 inches, the face of the abutment shall be built perpendicular, while at the back the curve of the arch being carried to the foundation, the abutment will gradually decrease in thickness to the springing, where it shall be 6 feet 6 inches thick, and 28 feet long. The courses in the abutment shall be radiated in the same manner, and from the same centre as the arch stones—the face stones being set square and bounded at every alternate course to the radiated arch of the abutment, as shown on the drawing.

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* A clause in the Act of Parliament for the railway required this bridge to span the river in one arch, and that the foundations shall be 10 feet below high water-mark. The cost of it amounted to about £4,000.

The foundation courses, and for 10 feet in height from the base, shall be set in water lime.

As the dimensions are written on the drawing, it will not be necessary to insert them here: the following, however, are the principles:—

The impost shall be 1 foot 6 inches thick, and shall project and be wrought into the torus form, shown on the drawing; the arch shall be 85 feet span at the impost, and the rise from the springing to the soffit must be 18 feet. The arch stones must be 3 feet deep at the crown, increasing in thickness to 5 feet at the springing; they shall be 18 inches thick at the under side, and not less than 3½ feet long. The exterior ring of arch stones shall have a torus moulding course, 1 foot thick, dressed into the form shown on the drawing. The string course shall be 15 inches thick, 4 feet on the bed, with a projection of 2 feet. Each stone shall not be less than 3 feet long. It shall be throated or undercut for the drop.

The parapet shall be 4 feet high, consisting of a plinth course, 15 inches in depth, 1 foot 9 inches wide; and one course 2 feet deep, 1 foot 6 inches thick; and a coping 9 inches deep, and 1 foot 10 inches wide. No stone in the parapet shall be less than 3 feet long. The upper edges of the plinth shall be chamfered. Each stone in the parapet shall be doweled together with iron dowels run in with lead.

A layer of good puddle, 18 inches thick, shall be laid over the arch for the full width of the bridge.

For the abutments, no stone in the outside courses shall be less than 2 feet by 3 feet by 14 inches; and every joint shall be broken by at least 1 foot of overlap.

The interior work shall consist of stones in courses equal in thickness to those on the outside, and not less in their other dimensions than 2 feet by 2 feet. The arch stones shall not be less than 2 feet 6 inches deep; but every alternate course, where the thickening of the arch will admit of two of these sized stones, shall be of the full depth shown on the drawing.

The exterior of the abutments to the springing shall be rough rusticated, as shall also the quoins of the pilasters, with a cleanly dressed joint, showing a clear edge of 1½ inch at the front. The pilasters, impost, spandrils, string course, parapet, coping and caps, shall be tool-dressed. The underside of the arch stones to be neat pick-dressed.

The bridge shall be built of the best freestone, free from beds, shivers, flaws, or iron bands. Every stone shall be truly squared, jointed, and bedded, for the full dimensions given. No pinning will be allowed.

The mortar shall be ground in a pug-mill; and each course, after having been set in mortar, shall be well grouted.

The spandrils and arch stones shall be dressed off for the space of 2 feet, to receive the string or cornice, which shall be worked into the form shown on the drawing.

The pilasters shall be dressed off for the space of 2 feet, to receive the blocks and bands, which shall be finished with a moulding, as shown on the drawing.

Each block shall be 3 feet on the bed, 1 foot 6 inches in depth, 9 inches wide, and shall project at the top 1 foot beyond the band, which shall be formed of stones between each block, 1 foot 6 inches deep, 1 foot three inches wide, and 2 feet on the bed.

Relieving arches shall be built in between the spandrils, of the form and dimensions shown on the drawing. The piers or sleeper walls shall be 1 foot 6 inches thick, and shall be properly bonded to the cross wall, which shall also be 1 foot 6 inches thick, and 17 feet 6 inches high, built from spandril to spandril. and properly bonded thereto. These walls may be either of brick or rubble. The arches shall be of brick, 9 inches thick (as shown on the drawing).

All proper centreing, piling, dams, &c., to be formed by the contractor.

SPECIFICATION of Bridge for carrying the Railway over South Croft-street, in Paisley.

The cast-iron bridge represented in this drawing is intended to carry the railway over South Croft-street. It shall be built of the form and dimensions shown on the drawing. It will require to be built askew, the line of the railway making with that of the street an angle of about 17°.

The roadway arch shall be 15 feet wide on the square, and have 21 feet 4 inches in clear height, from the present surface of the street to the underside of the arch at its highest point. The side or footway arches shall be 5 feet wide on the square, and 16 feet 2 inches high.

The abutments shall be built of brick, with stone pilasters and quoins. 3 feet by 2 feet, which shall correspond in thickness with four or five courses of bricks.

The piers shall be of brick or of solid ashlar, with chamfered joints, showing a clear edge to the front. They shall be of rough rustic-work, with a plinth-course 2 feet deep, projecting 1½ inch. This course shall be tool-dressed.

Grooves shall be cut in the masonry for the flange of each rib, 9 inches deep and 3 inches wide.

The imposts, pilasters, coping, string course, and plinth, shall be of stone, neatly and truly dressed, in lengths not less than 3 feet.

The stones in the pilasters shall average 1 foot 6 inches thick, and shall be laid header and stretcher, and the quoins shall not be less than 18 inches on the bed.

The counterforts shall be built 3 feet wide and 4 feet deep, of brick or rubble, in the form shown on the drawing.

In the rubble work, stones of a large size, as large as a man can conveniently lift, shall be used, and every course shall be flushed up with scabblings and well grouted.

The footway arches shall be built of brick; and in order to finish the extreme angles of the face, a 3 inch flange must be cast on to the inside of the footway beams, on to which the bricks shall be bedded.

On the top of these arches, and in line with the ribs and counterforts, brick walls shall be built, 1 foot 2 inches wide on the square, and of the height and in the manner shown by the cross section of the abutment in the drawing. The strength of the counterforts, piers and abutments, together with the position of the bed-plate and rib, as let into the masonry, is also described thereon. The course of masonry for receiving the bed-plate, shall, at the springing of each beam, be 2 feet 6 inches in thickness and 3 feet on the bed; in other parts the skew-back and impost may be in two courses, they shall be properly bevelled to receive the bed-plate, which shall be firmly fixed therein. The bed-plate shall be cast in convenient lengths, 1 foot 9 inches wide, and 2 inches thick, and shall be provided with suitable recesses for receiving the ribs; the ends of each piece shall be provided with an overlap flange to bolt them together, and to the masonry.

The span of the arch on the skew is 35 feet 6 inches, with a rise of 7 feet 6 inches; and the roadway of this main arch is to be supported by six cast-iron ribs, of the dimensions shown on the drawing. If it be found inconvenient to cast the ribs in one piece, the contractor shall provide, at the end of the beams, flanges 1½ inch thick, for the full depth of the rib, which shall be strengthened by three brackets on each side; and the ends of the ribs shall be bolted together with eight bolts, 1¼ inch square; the face of this flange shall be chipped smooth for its whole depth, so as to bear the pressure equally, for which purpose it shall be provided with chipping pieces; a key-plate shall be provided for the outer ribs to cover the bolts.

The covering plates shal be 6 feet long for the space between the roads; they shall be 5 feet long for the space between the rails, and 4 feet 9 inches for the space between the rail and the outer rib. They shall be bolted together with five bolts, and to the ribs by bolts passing through the chair and oak bearer, as shown on the drawing.

The cornice shall be cast hollow, of the form shown on the drawing, 9 inches deep, and projecting 11 inches from the face of the rib; it shall be $\frac{3}{4}$ of an inch in thickness. The plinth plate shall form part of this casting, and shall be 8 inches above the cornice, with a top flange 4 inches wide. Upon the inside face of the cornice, at points 3 feet apart, sockets shall be cast to receive the fastening pins from each length of the iron railing. The socket holes shall be 2 inches by $1\frac{1}{2}$ inch inside, and $\frac{3}{4}$ of an inch thick; the socket shall have holes cast at the points shown on the drawing, to receive a key, which shall pass through a corresponding hole in the fastening pins of the railing. A covering-plate shall be screwed on at the back of the cornice, to form a plinth course to the roadway. The cornice shall have a flange at the bottom, which shall be bolted to the top web of the rib; and on the inside the bolts shall pass also through the covering plate, so as to tie them firmly together.

The ballusters shall be 3 feet 6 inches above the plinth, and shall be 2 inches by 1 inch and 5 inches apart, and finished off at the top and bottom, as shown on the drawing. The top rail shall be $1\frac{1}{2}$ inch by 3 inches.

The span of the footway arches shall be 19 feet 2 inches on the skew, with a rise of 2 feet 6 inches; the ribs shall be 1 foot 9 inches deep, 2 inches thick, and shall be cast of one length, of the form shown on the drawing. Four of these ribs will be required; namely, one for each face of the footway arches. The roadway over those parts of the footway arches, from the face to the first spandrel wall, shall be covered with oak planks, 4 inches thick, as shown on the plan at B. The remaining space over these arches shall be filled in with ballast to the level of the roadway.

The bolts for connecting the ribs, roadway, and cornice-plate, shall be made of the best wrought iron, 1 inch square, and provided with proper washers.

All the ribs and plates shall be cast perfectly sound, from the second melting of metal, either from the cupola or air furnace; and each rib shall be tested with a load of forty tons, applied uniformly along its whole length before leaving the works.

All the joints of the plates shall be made good with gaskin, well saturated in the best tar, and filled up with iron borings, mixed to a proper consistency with sulphur and sal ammoniac, so as to make the whole impervious to water. The external part of the iron-work shall have three coats of good mineral paint, the colour of which will be fixed upon by the engineer at the time.

LEEDS AND SELBY RAILWAY.

JAMES WALKER, Esq., Engineer.

Plate 24.—Plans, Elevations and Sections of the "Accommodation Bridge." built for Shippen Farm.

Plate 25.—Ditto, ditto, Details of Construction.

This bridge is distinguished for its lightness of construction. there being no immoderate use of metal, as is frequently the case in cast-iron bridges.

BRIDGE OVER THE CLYDE, AT MILTON.

GEO. BUCHANAN, Esq., Engineer.

Plate 26.—Plans, Elevations and Sections of the Bridge over the Clyde, at Milton, *(see Specification)*.

Specification for building a Bridge over the Clyde, at Milton.

The south side of the bridge to run in a line between the north-west corner of the old mill, marked A on the plan, No. 1; and at point B, 79 feet from the east angle of the Duke of Hamilton's mill at C (the distance being taken square with the proposed direction of the bridge,) and thence continued in the same straight line. The north side to run parallel with the south side, and 14 feet distant, that being the intended breadth of the bridge, including the outside walls.

The bridge to consist of three semi-circular arches, each 47 feet span and 14 feet across the soffit. The face of the north abutment pier above the offsets to be about 23 feet from the corner of the old mill, at A, and exactly as marked off by the engineer, in presence of the two contractors; and the distance of the other piers to be determined from this. The foundation of the south abutment to be excavated 6 feet below the level of the springing of the arches, and also the rock between that and the middle pier (as shown in the elevation,) and the materials taken to fill up the space between the wing walls, or in building any of the rubble, if it shall be thought fit for it.

The body of each of the middle piers to be 8 feet thick and 14 feet long, exclusive of the cutwaters on each end, which are to project 5 feet in the middle, and to consist of segments of circles, tangents to the extremity of the pier on each side.

The abutment piers to be each 7 feet thick and 14 feet long, to be rounded off, and terminated at each end with a quadrant of a circle 2½ feet radius, prolonged into a straight line running 18 inches parallel with the direction of the bridge, and terminating in the pilaster which projects 8 inches, and is 3 feet 4 inches broad, beyond which the wing wall commences. The pilaster rises perpendicular up to the springing, and then batters in a regular sweep along with the wing walls; the inside of the pier is prolonged into the wing walls and middle abutment wall; the corners at D and E next the wing walls, in plan No. 2, to be rounded off, as shown.

The wing walls on the south end of the bridge to run from the extremity of the abutment pier in the arch, of a circle 40 feet radius, setting off a tangent to the direction of the bridge, and extending 15 feet along the circle; to be then continued 30 feet further in the arch of another circle 65 feet radius, and touching the former at the point where they meet, the walls terminating in a point 40 feet from the inside of the pier, measuring along the direction of the bridge, and 24 feet from the line of the outside wall. The wing walls on the north side to run in the same manner, but to terminate in a point 50 feet from the inside of the pier, in the direction of the bridge, and 40 feet from the line of the outside walls; the radius of the circle being 45 and 70 feet respectively.

The wing walls, where they commence at the extremity of the bridge, to batter with a regular curve from the foundation to the top, where they stand on a line with the outside walls of the bridge, and this batter to diminish gradually till it terminates at about half the distance where the wall is carried straight up. The walls where they commence to be raised to a level with the roadway which is on the same level with the top of the cornice; to be continued at this level 15 feet, and then as they recede from the roadway, to diminish in such a manner that there be in every part a slope of 1½ foot horizontal to 1 foot perpendicular, from the side of the roadway to the top of the wall; the roadway being 25 feet wide.

Raise a sufficient iron railing on the level part, on the top of the wall next the bridge, extending 15 feet from the extremity of the parapet where it declines, and terminates in the arch of a circle. The foundation of the wing walls at the said commencement to be 4 feet thick, and to diminish gradually to 18 inches at its extremity. At the top under the coping it is to be 2 feet thick, and the coping to be 12 inches high, and to project 3 inches on each side. Each wall to terminate in a square pillar, projecting where it appears 3 inches all round, and the coping also to project 3 inches.

The middle abutment wall to be 3 feet thick at the bridge, to be raised to a level with the covers on the spandrel walls, and to diminish gradually in the arch of a circle, 45 feet radius, till it be 4 feet high.

where it terminates in a pillar 4 feet square; the upper course to form a cope of 12 inches thick, and projecting 3 inches on each side. In the middle piers, the coping under the springing of the arches to project 12 inches at the extreme points below this, and including the space for the moulding to be 12 inches thick; and above it on the top of the cutwater to rise 2 feet at the pilasters, and to be rounded to two spheres of 13 feet radius, and intersecting each other above the middle of the cutwaters.

The piers below the coping to be 8 feet thick for 12 feet, to be then enlarged by three offsets, each 6 inches broad and 12 inches thick, and below that is the foundation course of the same breadth and thickness, with the last and sunk level into the rock as far as necessary. The abutment piers to have the same coping and moulding continued round as far as the wing walls; above, the cutwaters to be rounded off to a sphere 6½ feet radius above the curved part of the pier, and to a cylinder 6½ feet radius above the flat part, and both terminating in a flat at the pilaster. The arches to spring 1 inch within the body of the piers, so that the piers will be separated 2 inches more than the span of the arch.

The arches to be composed each of four ribs, running at equal distances between springing, and the intermediate spaces to be filled up with a course of covers 6 inches thick running between each rib. The two outside ribs to be 2 feet deep in the arch, and 2 feet broad across the soffit, and the mouldings cut out of them, as shown in the section. The two middle ribs to be 18 inches deep in the arch, and 20 inches broad across the soffit, and to have the under corners bevelled off and rounded, as in the section.

The stones in all the ribs to be from 2 feet to 15 inches thick, diminishing regularly from the springing to the crown, the covers to rest on the top of the middle ribs, and to meet in the centre; but at every 6 or 8 feet one of the stones to project above the covers 9 inches or more, and to be 12 inches broad, leaving 4 inches of a check on each side for receiving the ends of the covers. The side walls to be perpendicular from the outside ribs, and to rise 16 inches above them at the crown, and to be at an average 2 feet thick.

Above the wall a course to run, 12 inches thick, and to project 1 inch; above this the cornice, 12 inches deep, and above it the parapet walls, consisting of a base 12 inches high and 12 inches broad, a dado course 18 inches high and 10 inches thick, and a coping 12 inches high, and projecting, as shown in the section.

Above each abutment pier a pilaster is to rise behind the outside ribs, 3 feet 4 inches broad, projecting 8 inches from the side walls, and the projection continued to the top of the parapet, with mouldings similar to the cornice, and running on the same level; also projections similar to those on the parapet, the stones in the pilaster to be 2 feet 8 inches thick at an average. Between the side walls, and directly over the two middle ribs, two spandrel walls to run parallel with the side walls to the crown of the arch, 2 feet thick, and rising to the level of the top of the arch stones at the crown; to be closed in at the top with covers, at least 8 inches thick, and of such a length as to meet in the middle of each wall, the covers to run across the crown of the arch uniting and resting on the ribs.

Above the piers the spandrel walls to be united by a cross wall rising above the middle of the pier, filling up the space between the opposite arches, and at the abutment piers uniting with the wing walls and middle abutment walls. Between the arches this wall to be 4 feet thick at the springing, and to increase as the arches recede to 8 feet, and to continue of this breadth to the top; and at the abutments to be 5 feet at the springing, to increase with the spreading of the arch to 7 feet, and to continue at this thickness to the top.

The masonry of the middle piers and abutment piers to be on the outside of ashlar, laid in courses, from 12 to 15 inches thick, well bedded in the best lime mortar, and pointed on the outside with roman cement; the outside stones to be all broached in the face with good broached work, and to be well squared, drafted, and scabelled, in the joints and beds, at least 6 inches within the face; to be laid with headers and stretchers alternately, the headers not less than 3½ feet long, nor less than 18 inches or 2 feet broad; the stretchers not less than 2½ feet, nor more than 4½ feet in length, and not less than from 18 inches to 2 feet in the bed.

The stones of the interior packing to be of the same thickness as the ashlar, of as large materials as can be introduced, laid so as to bond well with each other, as well as with the outside stones, and each course to be grouted with lime, and to be levelled throughout before the succeeding one is laid on.

The arch stones of the outside ribs to be droved on the outside and mouldings. The remaining inside and under side broached, and the middle ribs to be broached throughout, where they appear projecting from under the covers; the covers to be hammer-dressed on the under side. The stones in all the ribs to be levelled in the joints towards the centre of the arch; the joints draughted throughout and well scabelled between the draughts, so as to form the joints as smooth and close as possible; the checks in the ribs, and the back of the middle ribs where the covers rest, to be also draughted and scabelled; the covers to be all levelled and dressed in the joints the same as the ribs; and all the covers and ribs laid in the best lime mortar. The outside walls to be built in courses from 12 to 15 inches thick, well bonded together with headers and stretchers, and bedded in lime, to be broached in the face, and to be squared, draughted, and scabelled in the beds and joints 6 inches within the face.

The projecting course below the cornice to be droved and scabelled in the joints and beds at least 6 inches within the face. The stones in the cornice to be not less than 2½ feet in breadth along the cornice, and not less than 3 feet in the wall. The space under them, and above the covers of the spandrel walls and crown of the arch, to be filled up with good rubble laid in lime; the joints and beds of the cornice course well squared and draughted, and scabelled at least 6 inches within the wall, and the outside and mouldings droved; the base of the parapet wall, and the coping, to be droved on the outside and inside; the dado course to be broached outside, and the inside to be broached similarly to the work now executing on the front wall of the house; the stones in the base to be not less than 3 feet in length, and the dado course and coping the same, and not less than 9 inches of regular band. The spandrel walls to be of good rubble, and of as large materials as possible, laid in courses, and well bedded in lime.

About 15 feet above the springing of the arches a course to be carried horizontally in each spandrel wall, between the ribs, consisting of stones 2 feet long, set on edge and well packed together, and butted against one of the projecting stones in each rib; the middle abutment wall to be of the same kind of work with the spandrels, the wing walls to be also of good coursed rubble, of large materials, and the outside neatly laid and pointed. The coping of the wing walls to be hammer-dressed on the outside and half way over the top. The covers above the spandrels to be well jointed and bedded in lime.

Above the covers a stratum of clay to be laid, 9 inches thick, well puddled and beat down to a smooth surface. Above this, the space for 18 inches to be filled up with shivers of stones, laid with a regular surface on the top, 3 inches higher in the middle than the sides. Lastly, above all, a coat of good road metal of whinstone, 8 inches thick, extending between the walls, the stones broke to 8 ounces weight each.

The space between the wing walls and abutment walls on each end of the bridge to be filled up with chippings of stones, as far as they can be procured, and the remainder at the top with earth; the roadway to be also continued by an embankment of earth, gravel, or stones, to the Glasgow and Lanark turnpike, on the south, and to the Milton approach on the north, and running level as far as the termination of the wing walls, and then rising regularly to each road; at the junction with the turnpike the sides to be rounded off, as shown in the plan, No. 1.

The top of the embankment for the roadway to be every where 20 feet broad, and to be regularly formed and laid with metal, similar to the roadway in the bridge, 12 feet broad and 8 inches thick, and rising 3 inches in the centre.

The side slopes of the embankment beyond the wing walls to be 2½ feet horizontal to 1 foot perpendicular.

(Signed) GEO. BUCHANAN

25th Feb 1830.

GRAND WESTERN CANAL.

JOSEPH GREEN, Esq., Civil Engineer.

Plate 27.—Plans, Elevations and Sections of a Swing Bridge over the Canal.
Plate 28.—Ditto, ditto, Details of Construction.

Bridges of this description afford a very ready means of communicating between the opposite sides of small canals, as they may be very speedily opened; the framing also being light, and equally balanced, causes it to turn freely upon the centre pivot, upon the application of a very small degree of force.

NEWCASTLE-UPON-TYNE AND NORTH SHIELDS RAILWAY

ROBERT NICHOLSON, Esq., Engineer.

Plate 29.—Plans, Elevations and Sections of the Bridge over the turnpike road to North Shields, *(see Specification.)*

Plate 30.—Ditto, ditto, Details of Construction.

The adoption of timber bridges on railways, instead of stone and brick, is now becoming very frequent; and they may be described as very well fitted for oblique crossings on account of their economy, and this bridge is a very good specimen of this style of construction.

Specification and description of work to be done in the erection of a bridge over the branch turnpike road from Percy Main, High Row, to North Shields, on the line of the Newcastle-upon-Tyne and North Shields Railway.

The masonry to consist of two stone abutments, and wing walls, having parapets and copings thereon. The carpentry of a timber arch, of two ribs, and a timber roadway; the span of the arch, in the direction of the line of railway, to be 52 feet 6 inches, clear of the abutments; and the breadth of roadway, clear of the ribs at right angles to the line of railway, to be 22 feet.

MASONRY.

All the stone to be used in this bridge to be of a strong and durable nature, similar to that from Byker Hill, or White House Quarries.

The lime mortar to be composed of the best stone lime, well burnt, and mixed with clean sharp sand, using not less than one cart load of clod lime to three cart loads of sand.

The iron cramps, dowels, &c., to be made from the very best scrap iron.

MANNER OF WORKMANSHIP.

Proper trenches for the foundations will be dug out by the Railway Company; but when once dug out, the contractor of the mason's work of the bridge to take out any earth that may afterwards fall into them; the contractor also to keep the foundations clear of water.

All the foundations to be built 2 footings in height each. The lowest footing to project 4 inches on each side beyond the one above it, and to be laid with large bedded stones, broached to an uniform thickness of 14 inches. The faces to be drafted, and left rough as from the quarry. The stones to be jointed perpendicularly, and bedded solid.

The second, or upper footing, to project the same as the lower footing, and to be built of the same description of masonry as hereafter described for the abutments.

The abutments to be 8 feet thick above the footings, to be built of solid ashlar work; in front, averaging 2 feet broad in the bed, and in courses from 14 to 18 inches in height, backed with good rubble masonry, carried up vertically behind to the top of the facia course. The acute angles of each abutment to be built of solid ashlar work, the whole height to the dotted lines, as shown on the plan of the abutment.

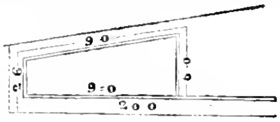
The buttresses to be carried up with, and properly bonded to, the abutments, and to be built of solid ashlar work.

The offsets, mouldings, and chamfers, to be worked agreeably to the plans, elevations, and sections, hereunto referred.

The wing walls to be 5 feet thick above the footings, and diminished by offsets to 4 feet at the top of the facia course. The faces to be ashlar work, averaging 16 inches thick, backed with good rubble masonry; the whole to be built in courses from 14 to 18 inches in height.

The facia course, parapet, coping pillars, and caps, to be of the several dimensions and descriptions shown on the drawings, and all solid ashlar work.

Wrought-iron bars, thus:— $2\frac{1}{2} \times \frac{3}{4}$ inches to be let in the stone-work at the acute angles of the abutments, with a bolt through the bar into each stone, thus, and a nut on the top. Five courses in each abutment, to the extent above shown, to be thus cramped, omitting each alternate course, and commencing from the top.



GENERAL DESCRIPTION OF MASONRY.

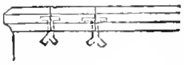
All the beds of the ashlar work to be broached; the joints to be squared back 12 inches from the face at least, and the face of all the ashlar work, excepting so much as will be hid by the embankment, (as per elevation), to be broached and drafted.

The faces of the abutments to batter, as shown on the drawings.

The stones to be set on their natural beds.

The ashlar work that will be covered by the embankment need not be broached on the face; but, with this exception, it must be similar to the other ashlar work.

The rubble masonry to be of the best description, and one-sixth of its contents to be thorough stones, to be joined to, and carried up with the ashlar work forming the front of the walls.

The parapet walls and pillars to be drafted and broached on both sides to an uniform thickness, and the coping and caps to be dowelled and cramped at the joints, thus,  and run with lead.

A seat for the wall-plate, 12 inches broad and 4 inches thick, to be cut in the masonry, along the top of the abutments, 1 foot from the face.

CONDITIONS.

The contractor to find all labour, lime, sand, stones, quarrying the same, leading, lead for dowels and cramps, machinery, planks, implements, materials, pumps, scaffolding, and every other thing necessary for commencing, carrying on, and completing the mason work; and in case it should be deemed advisable by the engineer to the Railway Company, for the time being, to make any alterations from the plans, sections, elevations, or details hereunto referred, (which said plans, sections, elevations, or details, are to be signed by the engineer, and the contractors for the masonry, to signify that they are the same referred to in the foregoing specification,) such alterations are not to vitiate the contract; but the addition to, or reduction from, the masonry which may arise from such alterations, in case of non-agreement between the contractor and engineer, shall be left to arbitration in the usual way.

All the iron-work specified with the preceding masonry is to be included in the tender for the masonry.

The masonry is to be wholly completed and finished within three months from the date of the Railway Company accepting the tender.

CARPENTRY.

Two longitudinal beams, 66½ feet long each, to be laid across the opening on each side of the bridge, the ends of the beams resting on corbels 14 feet long each. The cast-metal saddles are to be set into these beams, and secured to them by bolts passing through both the beams and corbel; and the two segmental timber ribs, composed of three inch deals trenailed together, are to be fixed in these saddles, as shown in the plans.

The longitudinal beams are to be suspended from the arched ribs, and the whole trussed, framed, and strapped; as shown on the elevation, and according to the dimensions and scantlings marked.

The ends of the transverse joists are to rest upon the longitudinal timbers first described, and the ends to project 12 inches beyond the timbers; eight of the transverse joists, nearest the centre of the bridge, omitting each alternate joist, are to be trussed with a bar of iron 1½ inch square, having three upright struts in the same, and the ends properly keyed on a metal plate 6 inches square and ½ an inch thick, as shown in the transverse section.

The planking to be laid longitudinally across the transverse joists, and trenailed thereon.

Each side of the bridge to be closely boarded to the height of the top of the coping on the walls; the inside of the boards being flush with the inside of the parapet—the boards to be 1 inch thick, nailed to the framing and ribs.

MATERIALS.

All the timber to be from Memel, of the very best quality, and of such scantlings as are described in the drawings.

The deals forming the arched ribs, and the roadway, and all other deals, to be from Dantzic, of such lengths as may be required, and to be of the quality called "best middling," which is understood to be the best description of deals brought into the port of the Tyne. The whole of the timber and deals to be as free from sap, shakes, and loose knots, as possible.

All the trenails used in forming the arched ribs to be of English oak, or such other as may be approved of.

The iron straps, bolts, spikes, nails, and all other malleable iron-work, to be manufactured from the best scrap iron, or from iron of equal quality.

Each longitudinal beam to stretch between the abutments, and extend 7 feet upon each; to be 13 inches by 13 inches. Two beams in depth to be laid upon corbels, extending the same distance upon the abutments, and 7 feet from the face: these beams and corbles to be bolted together by 1¼ inch bolts, nuts, and screws. Two of the bolts at the end of each rib to pass through the cast-metal saddles. The beams to be laid to the gradient line of the railway, and proper mortices to be made in them for the insertion of the tenons of the upright posts of the trussing.

A wall-plate 43 feet long, 13 inches by 4 inches, to be laid along the top of each abutment, 12 inches from the face, and sunk its full depth into the masonry; the cross joists have to be laid upon, and spiked down to, this wall-plate, as hereafter described.

The joists of the roadway to be of the following scantling, viz., eight of the joists nearest the centre of the bridge, omitting each alternate joist, to be 13 inches by 13 inches, and the remainder 13 inches by 6½ inches; the whole to be laid 3 feet apart, middle and middle, upon the longitudinal beams. The joists, 13 inches by 13 inches, to be trussed with a malleable iron bar 1½ inch square, having upright struts resting upon the bar, of the dimensions, and affixed to the joists, in the manner shown in the drawings; the ends of the iron bar to be keyed upon a metal plate 6 inches square, and ¾ of an inch thick, resting upon the ends of the joists.

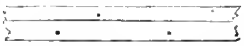
Ten 1¼ inch bolts (five at each side of the bridge) to pass through the smaller joists and the two longitudinal beams, to bolt the whole firmly together, and six of the other joists, viz., three at each side of the bridge, to be spiked down with iron spikes, 21 inches long and ¾ of an inch diameter, upon the longitudinal beams; the other ends of the joists being in each case spiked down upon the wall-plate by an iron spike 17 inches long by ¾ of an inch diameter.

The ends of the whole of the joists to be rounded off, as shown.

A horizontal deal strut, 13 inches by 3 inches, to be laid edgewise between each joist on the longitudinal beam, (as shown,) and secured with strong nails.

The two arched ribs are to be made to the proper radius, 1 foot 9 inches deep by 1 foot 6 inches broad, formed with Dantzic deals, 12 inches broad by 3 inches thick, laid flat, and dressed on the sides and edges, and of such lengths, varying from 20 feet to 50 feet long, as may best suit. The deal above to be bent over the one below, breaking the joint alternately both ways, and so that two end joints may never come fair over each other.

A layer of strong brown paper, laid on with the best Stockholm tar, to be put between each layer of deals.

The whole of the deals to be properly fixed together with the best oak trenails, placed 4 feet apart, thus,  ; each trenail to pass through three deals.

The upper side of the ribs to be weathered by a projecting deal on each side, sloped on the top, and a coping over and above.

The ends of the ribs, where they are fixed into the cast-iron abutment-plates, hereafter described, and the plates also, to have a good coating of tar.

Mortices are to be made in the under side of the ribs, for the insertion of the tenons of the upright posts of the trussing.

The abutment-plates to be 13 cwt. each, and of the description shown in the drawing; they are to be sunk their full depth into the longitudinal beams, and secured to them by two bolts $1\frac{1}{4}$ inch diameter, passing through both beams and corbels as shown; that portion of the plate which does not rest upon the beam is to be sunk into the masonry on each side, the same depth, and the whole of the plate to be firmly bedded on tar and oakum.

The ends of each rib are to be further secured to the longitudinal beams by an iron strap, 3 inches by $\frac{3}{4}$ of an inch, passing round the beams and ribs, and properly keyed, as shown in the drawings.

The timber for the trussing is all to be of the scantlings marked on the drawings. The upright posts are to be properly tenoned and fixed into the mortices of the longitudinal beams, and the arched ribs; they are also to be morticed for the reception of the tenons of the struts, and holed for the reception of the keys of the iron straps hereafter mentioned. These struts are to be of the scantlings marked, and tenoned into the upright posts; each alternate strut being tenoned into the opposite side of the centre of the posts, they will pass each other without reducing the scantling. The struts are to be bolted to each other when they pass, with five-eigths of an inch bolt, having proper nuts and screws.

An iron strap, 3 inches by $\frac{3}{4}$ of an inch, is to pass over the arched ribs at each upright post, and to be properly keyed through the posts on iron plates, as shown in the drawing; and a similar strap, keyed in the same way, is also to pass underneath the two longitudinal beams.

The planking is to be of 3-inch deals, of the quality before described, to be fixed to the joists by oak trenails, having two trenails in every deal at each joist; the planking to be laid down in such a manner that the ends may always break joints, and that two end-joints may never be opposite to each other, thus, 

The boarding for the sides of the bridge is to be of 1-inch deal; the inside of the boarding is to range flush with the inside of the parapet walls, and to be carried up to the height of the top of the parapet, and fixed to the framing of the bridge by double tack-nails, having two nails in each board where it passes every part of the framing.

All the timber for this bridge, after being cut into the proper scantlings, is to be led by the contractor to the Railway Company's tank-yard, on the line of railway near the Red Barns, Newcastle, where it will be put through a preparation for the prevention of rot, at the expense of the Railway Company: after being dried, it must be led away from the said tank-yard by the contractor, to the site of the bridge, free of all expense. The iron to be used in this bridge must be heated to about a blue heat, and the surface then struck over with raw linseed oil to prevent rust.

CONDITIONS.

The contractor to find all labour, wood, deals, iron, metal, cartage, machinery, tools, implements, scaffolding, centreing, planking, and every other thing whatever for commencing, carrying on, and completing the timber-work; and in case the engineer to the Railway Company for the time being, shall deem it advisable to make any alterations from the plans, sections, elevations, or detailed drawings, or in the construction of the timber or iron-work, which said plans, sections, and detailed drawings, are to be signed by the engineer to the Railway Company, and the contractors of the bridge, to signify that they are the same referred to in the preceding specification, such alterations shall not vitiate the contract; but the additional or decreased expense consequent upon such alterations as aforesaid, in case of non-agreement between the contractors and the Railway Company's engineer, shall be left to arbitration in the usual way.

All the malleable and cast-iron work specified with the carpentry, and all other iron-work, to be included in the tender for the carpentry.

The carpentry to be wholly completed and finished within one month from the time that the mason's work is in such a state of forwardness as to allow the carpentry to be commenced.

(Signed) ROBERT NICHOLSON,
Newcastle-upon-Tyne.

FORTH AND CART JUNCTION CANAL.

Plate 31.—Plan and Longitudinal Section of Lock.
Plate 32.—Ditto, Transverse Section and Elevation.

Explanation Letters of Reference worked on the Plate.

A. A. . .	The side culverts, or puddle cloughs.
B. B. . .	The overflow weirs.
C. C. . .	The paddle frames.
D. D. . .	The paddle wells.

Plate 33.—Ditto, Plan and Elevation of Lock Gates.
Plate 34.—Ditto, ditto, Details of Lock Gates.
Plate 35.—Ditto, ditto, Details of Paddle, Rack, Pinion, &c.

(For Descriptions see Specification).

Specification of sundry Artificer's Work required to be done, in cutting, completing, and making navigable the intended branch from the Forth and Clyde Canal to the River Clyde, opposite the River Cart.

This intended branch will commence at Whitecrook, near Mr. Black's house, and will proceed from thence in a straight line to the River Clyde, opposite to the River Cart. The line of proposed canal is marked out upon the ground; but the contractor must construct the several works according to the several drawings, and the specification. As the embankment between lock, No. 1, and lock, No. 2, has been increased in height since the ground was staked out, the ground required for the canal will consequently be wider than the space marked out upon the site.

With respect to the several lengths and heights, marked and figured upon the plan and section, the contractor must satisfy himself of their accuracy, as no claim will be allowed for extra work on account of any inaccuracy that may appear upon the drawings.

GENERAL CONDITIONS.

The following conditions and observations are to be strictly attended to by the different parties tendering for the execution of the proposed work:—

The whole of the materials provided are to be the best in quality of their respective kinds, sound, and well seasoned, and to be applied in the most substantial manner, under the direction and to the entire satisfaction of John Macneill, C.E., and the resident engineer appointed to superintend the works.

The drawings are to be equally binding with the specification; and should any thing appear to have been omitted in either or both, which is usually considered necessary for the completing of the several works, the contractor is to execute the same as if it had been particularly described, and is not to obtain any advantage whatever from such omission, but shall apply what may be wanting to complete the whole, and the works are to be left in a complete state, according to the true intent and meaning of the drawings and specification; and the directions for their correct performance, as given from time to time by the resident engineer, are in all cases to be strictly attended to.

The whole of the stone, timber, iron, and other materials, are to be delivered on the premises, and to be examined by the resident engineer previous to their being worked or used.

It shall be in the power of the resident engineer to reject any part of the materials which he may consider unfit for the work, and cause any part of the work to be altered which, in his opinion, is unsound or unworkmanlike, and not according to the contract, upon three days' notice having been given in writing for that purpose by the resident engineer; and in case the contractor shall refuse, or delay to rectify, or comply with the orders that may be given to him in writing, and shall perform all or any part of the work in an improper manner; or in case the works do not proceed with proper dispatch, the resident engineer shall have power and be at full liberty to suspend the further execution of the works by the said contractor, to take it out of his hands and employ or engage any other person or persons to perform or execute, and to find proper materials for the same, in which case all the costs and charges thereof shall be paid or allowed to the Forth and Clyde Junction Canal Company, by the contractor or his sureties, or allowed or deducted out of the monies which may be then or become due to the said contractor, the amount of which shall be valued and decided by the engineer, whose award in this and all other cases respecting the works shall be final and binding.

It is also to be in the power of the engineer to direct such alterations to be made in the work during its progress as may be found expedient, which alterations shall not vacate or make void the contract, but shall be performed by the contractor according to the directions he may receive; and the value of the same, whether an addition or a deduction, shall be ascertained by the engineer, and be added to or deducted from the amount of such contract, according to the rate at which such work was undertaken; the award of the engineer, in such case, to be final and binding.

No allowance will be made to the contractor for extra or additional work unless the same shall be ordered, in writing, by the engineer, and unless a correct account or voucher of the said work is delivered to the engineer within three days of its performance.

The contractor to provide himself with all manner of labour tools, moulds, implements, scaffolding, centreing planks, ropes, ladders, hoisting tackle, and materials of every description; carriage, freightage, and every requisite for the completion of the works: he is also to make good any damage done by his workmen to any part of the works, through carelessness or otherwise; likewise to clear away all rubbish or waste that may arise, when desired to do so by the resident engineer.

To excavate for the foundations of all locks, bridges, culverts, as well as the other necessary works for the proposed canal, keeping out the water by placing dams, if required, &c.

Should it be deemed necessary at any time to suspend the progress of the works on account of the weather, or any other cause, the engineer shall be at full liberty to do so, and no extra charge shall be made on this account by the contractor.

The resident engineer to be at full liberty to order the discharge of, or dismiss from the works, any man or men for incompetency or misconduct; and the contractor shall not replace them without the written approbation of the resident engineer.

Should any of the materials be lost or stolen from the premises, no allowance can be made for the same.

The works shall be begun as soon as the contracts are signed, and the whole completed within under the penalty of for the non-fulfilment of same, to be recovered as liquidated damages in any of Her Majesty's courts of law. In case of extra works, additional time will be allowed for same.

To deliver in a paper containing a copy of the estimate, with the quantities and prices upon which such estimate was founded, in order to show that it is a *bonâ fide* calculation, the same to be left with the engineer, in order that he may be enabled to value any additions or deductions that may arise, according to the prices of such estimate.

The contractor must enter into a bond, with two proper and approved sureties, for the performance of his contract.

The contractor will receive payments, upon producing a certificate from the engineer.

The contractor will have to keep the canal and works in proper repair and order for the space of twelve months after the completion of the same.

To keep an experienced foreman on the works, who is to be approved of by the resident engineer.

CUTTINGS AND EMBANKMENTS, AND FORMATION OF CANAL.

The extent of the several cuttings and embankments is shown upon the plan and section: the line shaded red represents the natural surface of the ground; and the space enclosed, and coloured blue, represents the proposed canal branch.

The slopes of both cuttings and embankments, except where otherwise described, will be 2 to 1—that is to say, when the height is 2 feet its base shall be 4 feet. The width of the canal being 40 feet, and a towing-path of 10 feet on each side, will give a base throughout of 60 feet, except at the open cut into the River Clyde, and the space between the stone bridge over the road from Glasgow to Dumbarton, and lock, No. 3, where the base will be 34 feet, also except at the locks generally.

The embankments to be carried forward as near the finished heights and widths as the due allowance for shrinking will admit of.

Great care must be taken to prevent water settling upon the embankments and cuttings during the progress of execution.

In the event of any springs or streams of water appearing from the face of the slopes, or otherwise, the contractor will be required to make such drains or water-courses as shall completely and effectually prevent such springs or streams from injuring the slopes during the progress of the works, and shall convey the whole of such water into proper drains.

The contractor shall also open or make any new drains, which the engineer may direct, for the exclusion of any water.

The space between the River Clyde and lock, No. 1, to be properly excavated, to a slope of 2 to 1; the whole of these slopes and tops of same banked up with, and to have a covering of rubble stone pitching, similar to the banks of the Clyde.

Dig for, and fill in, a good vertical puddle to same, 2 feet at top and 3 feet at bottom, to go at least 1 foot beneath the bottom of cut. Include 100 yards run of side and bottom puddle lining, as shown upon drawing, 1 foot thick. properly protected by suitable materials (as gravel, 6 inches thick) next the lock, or equal to the same in depth.

The circular ends to canal next the river must be pitched, 2 feet thick, with rubble stone, properly bonded together, and well backed up.

On the spots marked upon plan carry up circular dolphins, or water-marks, 7 feet diameter, and 3 feet above the flood tides, to be of hewn stone, domed over at top similar to the water-marks upon the banks of the Clyde.

The canal will be formed in embankment between lock, No. 1, and lock. No. 2, where it will be 7 feet 6 inches deep, with double towing-paths, and executed as shown upon drawing. The slope of water banks for canal to be 1½ to 1, all the rest 2 to 1.

The whole of the embankment will be made with side and bottom puddle lining, 2 feet thick; the upper towing-paths will have a lining of puddle, 2 feet thick.

Form a ditch upon each side of embankment, properly laid to a current. and having all the water-courses directed to same; the size to be 4 feet at the top by 2 feet at the bottom. and 1 foot 6 inches deep.

The cutting between lock, No. 2. and lock, No. 3, to be as shown upon the drawings, and to be executed entirely with vertical puddles, except where otherwise described. There will be a ditch, the high side of ground. 1 foot 6 inches deep, 3 feet at the top and 2 feet at the bottom, at the largest part, having the several water-courses properly diverted into the same: there will also be a small ditch on the other side of the cutting.

The remaining portion of the canal will be formed in a similar manner.

One-third of the deepest part of the line is intended to have side and bottom puddle linings, and the remainder vertical ; the remaining portion of side and bottom puddle lining provided for as above stated, will be used in this embankment. There will be small ditches, as before described, to the embankment; and large ditto, as before described, to the cutting.

SOILING OF THE SLOPES.

The outside slopes of the banks to be neatly dressed to the required slopes, and soiled over with at least 6 inches of good vegetable soil, which is to be saved for that purpose : the slopes thus covered with vegetable soil are to be sown with good grass seeds, at the proper season.

APPROACHES TO STONE BRIDGE ON THE ROAD FROM GLASGOW TO DUMBARTON.

The rate of acclivity to the bridge to be 1 in 30.

The embankment of approach to be formed to a slope of 2 to 1, and similar to the other embankments upon the canal. The fence, and hedge and ditch, must be properly reinstated and re-planted.

There must be gates at each side of the road across the towing-path. The gates must have good Scotch oak 12-inch square posts, and five straight bars and two diagonal bars, 6″ × 3″, to be hung upon proper strong gate hinges, 2 feet 6 inches long, and proper spring catch and staple ; the whole well painted, two coats, lead colour; the ends of the posts to be properly charred.

Four other gates, of this description, are to be provided for other parts of the line.

Previous to any of the works connected with the bridges being begun, a proper well-made temporary road shall be prepared and made ; and in the case of the road before mentioned, it must be sufficient to afford a free and uninterrupted passage for carriages of all descriptions. Every caution being taken by the contractor, during the alteration, to erect proper fencing, and fix lights, as the Company will not be held liable for any injury which may ensue from neglect to these precautions.

The approach to the timber bridge over the towing-path of the Forth and Clyde Canal to be formed as before described, the acclivity of the road being in the proportion of 4 to 1; and any extra stuff arising from the works to be given to this approach.

The general conditions to be as described to the stone bridge.

FORMATION OF ROAD FROM GLASGOW TO DUMBARTON.

Lay a coating of stones, 6 inches thick, over bridge and approach to bridge. properly spread and levelled; size of the stones about 2 inches diameter.

The traffic of the road shall then be allowed to proceed upon it until the works are completed, when a layer of fine stones, or gravel, shall be spread over the same, 6 inches thick, due allowance being made for the sinking and compression of the materials.

This metaling to be continued the whole length of approach, and the footpath must be properly continued throughout.

TOWING-PATHS.

Towing-paths are to be 10 feet in width, and to be formed by first leveling the canal bank to a height of 6 inches above the surface of the water, and then turning the same, and forming the road in a similar manner as described, to the road, from Glasgow to Dumbarton: proper drains must be made to carry the water off from the tail of the cuttings, and where required, of stones and tiles, set in strong mortar.

FENCING, &c.

The towing-path and boundaries of the Company's premises generally to be fenced with larch, or Scotch oak, as drawing; the posts to be 6 inches square, 3 feet 6 inches out of the ground, and 2 feet 6 inches in the ground, and two rails, 6″ × 3″, of the same wood, to be properly morticed into the same, the posts to be 7 feet apart.

Quicks will be planted on the outside of the fences; the quicks to be three years old, strong and healthy, and nine planted in each lineal yard, in a suitable soil provided from the excavations.

A proper ditch must enclose the whole, as before described.

To provide whatever temporary fencing may be required during the execution of the works.

The whole of the fences, hedges, and ditches, also roads, and the like, that may be disturbed by the proposed works, to be properly reinstated, and connected to the new portions of the same.

Whatever stones, sand, and gravel, and whatever may be found in digging and opening the cut, is not to be sold or taken from the work, but to be used or deposited where the resident engineer may direct.

The puddles to be composed of good stiff clay and a small quantity of gravel, well mixed together, and the whole of it is to be laid in courses or layers, about 9 inches in width, the whole rendered thoroughly impervious, or water-tight.

The concrete used in the foundations, and where ordered, is to be mixed in the proportion of seven measures of gravel to one of ground lime, of approved quality; they are to be well mixed, by manual labour, after which a sufficient quantity of water is to be added and well mixed in; it is then to be pitched from barrows, from a height of at least 10 feet, in regular layers, and brought perfectly level.

LOCKS.

The locks to be constructed according to the several drawings.

The lock chambers to be 68 feet long, out and out, and 15 feet wide at the gates, and 17 feet in the centre of the lock at the coping.

A space of 33 feet is to be included on each side of the lock chamber (taken from each side of the gates, a width of 15 feet), and the embankment and cuttings to this space of ground to have slopes 2 to 1, similar to other embankments, and proper ditches and fencing.

The ground around lock, No. 1, will be laid out as shown upon drawing, having circular embankments; the whole surface of terrace and embankment will be laid with puddle, 2 feet thick, and then properly metalled and ballasted, similar to the towing-path.

The ground around the other locks will likewise be metalled and ballasted.

A plot of ground next the road from Glasgow to Dumbarton is marked out on the site, for the lock-keeper's house, &c., which is to be fenced and ditched in a similar manner to the rest of the works.

After the requisite excavation is formed, the lock chamber, and counterforts, to be carried up in good freestone, free from all flaws and defects, the whole laid in its natural or quarry bed, and of good even colour; the upper and lower breadth of every stone to carry its full thickness from front to back, so that the bearing, both above and below, may be perfectly square and level throughout. No pinning in levelling will be allowed; and each stone is to be brought firmly to its bed by a wooden mallet.

The walls to be carried up to the required curve and batters, in courses varying from 12 to 15 inches in thickness; the headers to be the whole thickness of wall, and the stretchers to be half the thickness of wall in width, to be laid one header to two stretchers, properly bonded, and breaking joint together.

The course of stone immediately under the coping to be laid all headers.

The top course of stone to wall, forming coping, to be good whinstone, 12 inches thick, and rounded on the top edge, and to be alternately about 1 foot 8 inches and 2 feet in width, and in long lengths, as shown upon drawing. The stones next the lock-gates to be in large sizes, the quoin-stones being 7 feet by 6 feet, as shown upon drawing; and the curb to lock-head will be of whinstone, 12 inches thick, and rounded on the top edge, and of the sizes shown upon the drawings.

The invert to be formed of freestone, as shown upon drawing, the centre course being 15 inches thick.

Carry up the paddle-wells and culverts the several thicknesses shown and figured on the drawing, the paddle-frame being properly let into the wall. Set whinstone coping round the same. The culvert will be quite unconnected with the wall of the chamber, and it will be laid with a slight fall.

Form waste weirs, or overflow drains, in masonry, from the upper level, into culverts, as shown upon drawings.

The wing walls to be carried up the several thicknesses and dimensions shown and figured upon drawings, with a winding batter; the counterfort to be plumb: cope the same with whinstone coping alternately 1 foot 7 inches and 1 foot 10 inches wide, and 12 inches thick.

The retaining walls next the lower level to extend 20 feet on each side of the lock chamber, to be carried up in freestone, with whinstone coping, 12 inches thick, of the several thicknesses shown and figured on drawing, with the required batter.

There will be a wall of freestone, 2 feet thick, with whinstone coping, 12 inches thick, at the lower entrance into the lock, to protect and support the bottom of the canal at this point. Fill in puddle, 2 feet thick, properly protected by gravel, between this wall and platform.

The whole of the walls and masonry above described will be backed with stiff puddle, 2 feet in thickness, where the foundation is not good; the ground must be laid with concrete, properly levelled, to receive the walls.

In all cases there must be bottom and side puddle lining to the bottom of the canal, to 10 feet beyond all wing walls.

The whole of the whinstone coping and curb to be well joggled together, by a groove in the centre of each joint, into which a whinstone block will be fixed, properly grouted with mortar, and worked with chisel-drafts round their faces, beds, and joints, and picked between the joints, so that, upon applying a ruler upon the face, no part shall be above them, and no more space than ⅛th of an inch below them, the outside faces being marked with exact regularity and neatness.

The freestone is to be of the best description, and from Netherwood, Brighton, or Dobbie's Quarries, and to be fair dressed on the faces, backs, and joints.

The whole of the stones are to be worked on the ground, and set with lewises and proper tackle.

The whole of the stone-work throughout is to be laid on a thick bed of mortar, of the following description: one measure of good stone-lime, one measure of mine-dust, and one measure of sharp clear sand, free from rubbish, dirt, and other impurities. The mortar is to be well tempered and worked to a tough and proper consistency, and properly ground; and no more is to be made at one time than can be consumed in the day's work.

The lime is also to be brought in small quantities, and to be kept under an inclosed shed, so as not to be injured by exposure to the air or weather.

The lime is to be slacked, and mixed with mine-dust and sand; they are then to be pressed together in a dry state through screens, and the water added.

THE UPPER LOCK-GATES AND PLATFORM.

The gates to rest upon a proper timber platform, as shown and figured upon drawings, having No. 4 cross bearers, 12″ × 9″, resting upon plates, 10″ × 5″. Planking, 4 inches thick, will be laid down upon the cross bearers, and 3 inch planking laid in a diagonal direction upon the same: the clap cill, 14″ × 12″, and frame, 12″ × 12″, will also be laid upon the 4 inch planking: the frames will be strengthened by wrought-iron ties, 2½″ × ¾″, properly bolted to cross bearers and planking: there will be one tier of 2½ sheet piling, 8 feet deep, to protect platform. The whole of the timber above described to be of sound elm, and properly bolted and secured together.

	Ins. Ins.		Ins. Ins.	
The gates will have top rails,	12 × 10,	at one end, and	11 × 10	at the other,
,, bottom rails,	12 × 10,	ditto,	11 × 10	ditto,
,, middle rails,	10 × 9½,	ditto,	10 × 8½	ditto,
,, heel posts,	14 × 12			
,, meeting posts,	11 × 11			
,, planking.	2½			
,, balance beams,	13 × 13,	ditto,	9 × 9	ditto.

having a moulded lining to the same, properly loaded.

There will be a foot-bridge attached to each gate, as shown upon drawing, having brackets, 5″ × 4″, upon which 2 inch planking is laid, 1 foot 9 inches wide, with hand-rail and posts, 3″ × 3″, to complete the whole, properly secured.

The whole of the above-mentioned timbers are to be of good sound oak, and to be properly morticed and tenoned into each other, and further stiffened by a wrought-iron stay at back, 2½″ × ¾″, continued the whole height of gate, and extending upon the rails, as shown upon drawing, properly bolted.

PIVOTS TO GATES.

The heel-posts of gates are to be secured by a hoop of wrought-iron, ¾ of an inch thick and 2½ inches wide, laid on top; a 3 inch cast-iron pivot to be secured to the same, having a 7½ inch shoulder, and a plug, 2¼ inches square, and let into the post 12 inches; a cast-iron socket-plate of 1¼ inch metal, the socket being 2½ inches above the face of the plate, is to be prepared to receive pivot; the plate is to be let 1½ inch into a stone carried up from the wall beneath the planking, being cut to fit the same.

GATE-ANCHORS AND COLLARS.

The gates to be secured to anchors by wrought-iron collars, 5 inches wide and 1¼ inch thick at the swing, and 3 inches wide and 1½ inch thick at the ends, with 1 inch wrought keys to anchor, which is to be of wrought metal, the arms 1½ inch wide, and let into stone coping 2½ inches, and well run with lead; at the extremities of the latter will be cross pieces, let into stone 5 inches, and well run with lead; the cross piece, having eyes to receive the ends of collar, will be 3 inches thick, and will stand up above face of coping 5 inches; a shoulder must be formed for the keys to pass through, as shown upon drawing; the anchors will be further secured by $\frac{3}{4}$ inch bolts, let into stone 12 inches, and well run with lead; a wrought-iron hoop will be dropped upon the top of post, which will be tenoned into the balance beams, and the latter will be tenoned into the mitre-posts, these posts having a $\frac{3}{4}$ inch wrought hoop of iron at both ends.

PADDLE AND FRAME, RACK, PINION, &c.

Build an oak frame, 9″ × 9″, in the masonry, for paddle, having a lintel and sill 9″ × 9″, projecting 12 inches beyond frame on each side, properly morticed for the same; there will be another cross timber, 9″ × 9″, tenoned into frame for paddle iron-frame. Line between the last timber and lintel, with 3 inch elm lining, well caulked and pitched, the framing being properly prepared for the same.

The paddle to be of cast metal, $1\frac{1}{2}$ inch thick, having 2 inch bordering on both sides, the bordering will be 1 inch thick; also cross bars, $\frac{1}{2}$ inch thick, to eye of paddle, as shown upon drawing.

The iron paddle-frame to be 1 inch thick on the face, which is 4 inches wide, the bottom rail excepted, which is but 2 inches wide, having studs, through which the bolts are passed; the return will be $\frac{1}{2}$ inch thick, and showing a face of $2\frac{3}{4}$ inches, it is let in flush with the oak frame $1\frac{1}{4}$ inch slides of cast metal, $2\frac{1}{3}$ inch on the face, having studs cast upon the same; $\frac{1}{2}$ inch bolts are passed through these studs and through the frames, and properly bolted; a $\frac{3}{4}$ inch cast metal stop is to be bolted on the bottom of frame, as shown on drawing.

The several joints in the paddle and frame must be made perfectly true and water-tight, by rubbing them together.

There is a wrough-iron rod, 1 inch diameter, attached to the paddle by the two eyes cast for the same, and secured by wrought keys, being properly shouldered at the upper eye, through which it is dropped square instead of circular, as the remaining portion; this rod is secured at the upper end to the rack, where it is again shouldered and let in square, and secured by a wrought key.

The rack is to be $3\frac{1}{2}$ inches on the face and $1\frac{1}{2}$ inch thick, having a fillet cast on the back, which runs on a friction roller to keep it straight; a groove will be left in the centre of front, $\frac{3}{8}$ inch wide, and the teeth will be reversed on each side of the same; the teeth will be 1 inch pitch, or from centre to centre.

The pinion to be 3½ inches wide and 4 inches diameter, the teeth properly fitting into the rack with groove, &c.

The pivot is supported at each end by cast cheeks, 1 inch thick and 1¼ inch at the eye, having a ¾ inch wrought-iron spindle passed through the same, to which the handle, properly shouldered, is attached by a square socket; the cheeks are secured to the cap of the oak post, 6″ × 6″, by ½ inch bolts and nuts, the capping of the post is ⅝ of an inch, cast metal, as shown on drawing; the friction roller, 2 inches diameter, is allowed to run in sockets left for same in the back of the cap.

The well is covered at the top by a 3 inch proper ledged oak flap, in a rebated oak frame, 6″ × 6″, for which the coping must be properly prepared; the flap must have strong flap hinges, staple, asp, and strong padlock.

The gates must be made perfectly water-tight at the joints, by sand and water being worked through the hinge-joints; the mitre-joints to be made exactly true; the platform must also be well paid with tar, the joints being properly stopped, as the resident engineer may direct

LOWER LOCK-GATES.

These gates will have rails, posts, and planking, and foot bridges similar to the other gates, and as before described.

Each gate will have a paddle at the bottom of same, the muntins of which will be 9″ × 6″.

The paddle must be similar to the other, and have a cast-iron frame complete, as before described.

The rack, pinion, &c., will also be similar.

The platform, also, will be of similar scantlings and descriptions, and according to the several drawings, except that there will be two tier of 2¼ inch sheet piling, 8 feet deep.

Fix, properly secured in chamber wall of lock No. 1, two fender-piles, 6 feet above coping, and 5 feet below it, to secure the lock-gates to when open; provide all proper chains and staples for same.

Build up solid with front retaining wall of the same lock, an oak step-ladder, having 2 inch treads 9 inches apart, and 6 inch sides, with the proper iron run and guide-ropes.

The retaining wall must be built to the required skew.

Provide eight oak mooring-posts, 2 feet out of the ground and 4 feet in it, to be fixed where directed.

STONE BRIDGE AT ROAD FROM GLASGOW TO DUMBARTON.

This bridge to be built of the several heights, widths, and thicknesses, shown and figured on the drawings.

The general description of the stone and materials, and also the method of working, to be similar to that described for the erection of the locks. The bridge will be built of freestone, in courses of about 12 inches wide; the coping and blocking courses forming the plinth of bridge upon the inside, to be of whinstone, worked as before described.

The wing walls will also be as those described for the locks, having puddle backing, &c.

The backing of arch, and the excavation formed in putting in the walls, to be filled up with concrete.

The bridge to be built to the required skew, to suit the direction of the road.

And the arch stones must likewise be built in spiral courses, to suit according to the skew.

TIMBER BRIDGE FOR THE TOWING-PATH OF FORTH AND CLYDE CANAL, AND WING RETAINING-WALLS.

The wing retaining-walls to be as described, to the lock wing-wall, with whinstone coping, &c.

The timber for bridge to be Memel, Riga, or Dantzic, free from flaws and defects.

Throw over two beams, 12″ × 6″, as shown, well struted by struts, 12″ × 6″, notched into beams, upon which the handrail and posts, 6″ × 4″, will rest; wrought-iron straps and bottom plates, 2″ × $\frac{3}{8}$″, with nuts and screws complete, must be provided to tie the whole together, as shown on drawing. The centre tie-iron will be 2 inches square, to which the heads and shoes will be secured by wrought pins; the posts at each end of the longest truss will be secured on the outside of same, by $\frac{3}{4}$ inch screw-bolts.

Two good stiff struts, 6″ × 4″, will be bolted to hand-rail at each end, well footed at their extremities. Lay upon beams 4 inch planking, properly fastened to same.

The beams will lay upon Scotch oak plates, 12″ × 9″, and the struts upon

Scotch oak plates, 9″ by 6″, properly let in flush with wall, and extending over 4 feet on each side of bridge.

This bridge must also be built to the required skew, which will also regulate the situation of the wing-walls.

CULVERTS.

The culverts must be built to the necessary angle, according to the situation, and each culvert is to be placed so as to afford a free and uninterrupted passage for the water.

The foundations must be cut out as nearly the size of the culvert as possible, and the vacant space must be punned up.

All the several culverts to be well punned over with clay, in uniform layers, before the earth is filled in over same.

In all cases the streams must be properly diverted into the culverts.

They are to be built with a stone that will stand well under water, and to be set in good water-lime mortar.

The canal, its banks, and puddles, will continue over them without any variation or difference being made.

The precise spot or scite of the culverts may be varied according to circumstances, by the resident engineer.

There will be a culvert, 3 feet wide and 4 feet high, between lock, No. 1, and lock, No. 2, at the situation shown on the drawing. The extrados of the arch is to be at least 3 feet below the bottom of the canal, it will be turned in arch stones, 15 inches thick, the sides will be 1 foot 6 inches thick, and the invert 9 inches, the whole well backed and fair dressed.

Erect a proper apron and wing walls at the entrances, as will be directed.

There will be another culvert, 3 feet wide and 4 feet high, between lock, No. 2, and lock, No. 3, similar in construction to the last.

There will also be another culvert, 4 feet wide and 4 feet 6 inches high, near the canal, at the spot marked on section; the crown to be 1 foot 8 inches thick, and the sides 2 feet thick, the invert being 12 inches thick, of the general description as before described, with apron and wing walls.

If, upon opening the ground, more or less depth is found advisable for the several works, additions or deductions are to take place, according to the schedule of prices which shall be delivered in.

LIST OF THE DRAWINGS.

EMBANKMENT WALL OF THE

NEW HOUSES OF PARLIAMENT, LONDON.

JAMES WALKER AND ALFRED BURGESS, Esqrs., Engineers.

Plate 36.—Plan, Elevations and Details of the Pile-driving Machines employed in forming the Coffer-dam.

The machine is composed of strong framework: two pieces of wood, from about 30 to 35 feet long, are placed in an upright position, and rested upon sill pieces at the bottom, the space between them constituting the slide or gauge for the iron ram to be drawn up and run down, and the slide is edged with iron, as shown on the plate; a shoring piece is placed on each side, a ladder is also connected with them in the opposite direction, with horizontal ties at different heights, and the whole is further secured by stays and chains at different parts. There are two cross pieces laid athwart the sills, upon which the crab is placed, by which the ram is drawn up; and an apparatus is situated immediately above the latter, usually called a monkey, for disengaging and again securing the ram after each fall, a chain being attached to it, which is carried over a pulley fixed at the top of the framing, and passed down again on the other side to the crab; and the length of the fall is regulated at pleasure by means of a rope fastened to the monkey, which allows of its moving upwards to a certain extent, when its disengagement from the monkey is effected.

DETAILS OF THE

SWING-BRIDGE, SAINT KATHERINE'S DOCKS

THOMAS TELFORD, Esq., Engineer.

Plate 37.—General Plan and Section of bridge, and Details of construction.

Plate 38.—Ditto, Longitudinal Elevation and Section of bridge, to an enlarged scale.

Plate 39.—Ditto, ditto, Plan showing ribs and framing.

Plate 40.—Ditto, ditto, Transverse Sections.

Plate 41.—Ditto, ditto, Details of iron-work.

The section at A—.—.—B, shows the connection with the circular part of the abutment plates; and the Section C—.—.—D shows the connection of the ribs with the straight part of the abutment plates.

Plate 42.—Ditto, ditto, Details of iron-work.

Explanation of Letters of Reference marked on the Plates.

a, Cast-iron plates situated in the carriage way, and secured to the stone-work, at the tail of the bridge, by bolts and nuts keyed into the stone.

b, Cast-iron guide plates attached to the stone-work at each end of bridge.

c, c, c, c, Flanches cast on to the ribs, with cast-iron plates laid across, to support the ballasting. The planks are bolted to these flanches with $\frac{1}{2}$ inch bolts and nuts, and $4\frac{1}{2}$ inches apart in the clear.

The tail plate is cast in three pieces, with joints at the third ribs, d, d.

e, e, Flanches to attach arms of wheels.

f, f. In the plan of abutment plates are flanches for ribs to be bolted to.

Plate 43.—Ditto, Details of working gear to bridge.

Explanation of Letters of Reference marked on this Plate.

a, The cap of the post which lifts off.

b, The cross to carry the upper end of the shaft.

c, The bolts which secure the post to stone-work, of which there are six.

MANCHESTER AND LEEDS RAILWAY.

THOMAS L. GOOCH, Esq., Engineer.

Plate 44.—Plans of construction and Elevation of bridge over the Rochdale Canal at Scowcroft.

Plate 45.—Ditto, Plans showing foundations and Sections through wing walls and arches.

Plate 46.—Ditto, ditto, details of iron girders and framing.

Weight of the Cast Iron-work used in the construction of the Bridge.

	Tons.	cwt.	qrs.	lbs.
4 Main ribs	68	18	0	0
26 Bracing frames	9	9	0	0
4 End, ditto	1	17	0	0
17 Roadway girders	50	8	0	19
Cornice to main ribs	11	0	0	0
Brackets for carrying tension bolts . .	0	10	0	0
Spandrels	13	0	0	0
	155	2	0	19

Wrought Iron-work.

	Cwt.	qrs.	lbs.
26 Suspension bolts	26	2	0
Gibs and cottrels for ditto	4	0	14
8 Tension rods	191	2	0
16 Coupling boxes for ditto	33	1	15
Gibs and cottrels for ditto	10	1	3
	265	3	4
Total weight of screw bolts	17	1	19

LONDON AND SOUTHAMPTON RAILWAY.

Details of the Locomotive Engines employed on the Line, and constructed by,

GEORGE AND JOHN RENNIE, Esqrs., Engineers.

Plate 47.—Side Elevation of engine.
Plate 48.—Longitudinal Section of ditto.
Plate 49.—End Elevation of ditto.

Diameter of cylinder	13 inches.
Length of stroke	18 ,,
Area of each of the cylinders	132.73 ,,
Steam required in each cylinder, per stroke	1.4 cubic feet
Area of fire-grate for the admission of air	588 square inches.
Total area of fire-grate	1344 or 9.3 square feet
Fuel contained in fire-box	14 cubic feet
Number of brass tubes	118 ,, ,,
Heating surface of ditto	492.78 square feet.
Water evaporated in one hour, with steam equal to 50 ℔. pressure on the safety-valve	63.466 cubic feet
Water contained below average water line	36.4 ,,
Steam room	32.5 ,,
Water supplied by each pump, per stroke	56.5 cubic inches.
Number of wheels	6
Diameter of driving wheels	5ft. 6in.
Ditto of small wheels	3ft. 6in.
Cubic content of water in tender tank	118.8 cubic feet.
Weight of ditto when full	3.3 tons.
Time which the water in tender will supply engine	1.87 hours.
Coke fuel necessary to evaporate all the water in the tank	9½ cwt.

Number of revolutions of driving-wheel per minute, at 30 miles per hour	152.76	
Velocity of each piston in feet, per minute, at the average speed of 3 miles per hour	458.28	
Area of steam pipe	9.62	square inches.
Ditto of steam ports	9.56	,,
Ditto of eduction ports	14.87	,,
Ditto of blast-pipe mouth	7.06	,,
Ditto of chimney	159	,,
Ditto of radiating surface	6696	,,
Ditto of communicative surface	70960	,,
Ditto of total heating surface	77650	,,
Total resistance to the motion of the pistons, per square inch of its surface	38.4 lb.	
Volume which the whole steam produced per hour will occupy at the reduced pressure of the preceding resistance	46695	cubic feet.
Ratio of the preceding volume to that expended in effecting a single stroke of one piston	32427	num. of strokes per hr.
Corresponding number of revolutions of driving-wheel, per hour	8106.75	,,
Distance travelled, per hour	26½	miles.
Weight of the engine without water	11½	tons.
Ditto of tender	5½	,,

The safety valve is constructed so as to liberate the steam more freely than by the old mode, the principle being to diminish the resistance in proportion to the opening of the valve, whereas by all previous methods, whether by springs or levers, the resistance is increased 3 feet, and the improved valve is capable of being regulated to any intensity of resistance.

The velocity of the engines have frequently exceeded 41 miles per hour, with light trains.*

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* Similar engines were also constructed by Messrs. Rennie for the London and Croydon Railway.

GRANGEMOUTH HARBOUR.

JOHN MACNEILL, Esq., Engineer.

Plate 50.—Transverse Section of Quay wall and coffer-dam, *(see Specification of same.)*

Plate 51.—Ditto Plans of superstructure and foundations.

Plate 52.—Elevation and Sections of timber Pier, *(see Specification of same.)*

Plate 53.—Ditto, Plans of superstructure and Sections of details.

Specification of sundry artificer's work required to be done in erecting and building complete a Quay wall, 100 feet long, including the coffer-dam, steam-engine, and works attendant thereon, upon the banks of the Frith of Forth, situate at Grangemouth Harbour.

GENERAL CONDITIONS.

The following conditions and observations are to be strictly attended to by the different parties tendering for the execution of the proposed work:—

The whole of the materials provided are to be the best in quality of their respective kinds, sound, and well seasoned, and to be applied in the most substantial manner, under the direction and to the entire satisfaction of John Macneill, C.E., and the resident engineer appointed to superintend the works.

The drawings are to be equally binding with the specification; and should anything appear to have been omitted in either or both, which is usually considered necessary for the completing of the several works, the contractor is to execute the same as if it had been particularly described, and is not to obtain any advantage whatever from such omission, but shall apply what may be wanting to complete the whole, and the works are to be left in a complete state, according to the true intent and meaning of the drawings and specification; and the directions for their correct performance, as given from time to time by the resident engineer, are in all cases to be strictly attended to.

The whole of the stone, timber, iron, and other materials, are to be delivered on the premises, and to be examined by the resident engineer previous to their being worked or used.

It shall be in the power of the resident engineer to reject any part of the materials which he may consider unfit for the work, and cause any part of the work to be altered which, in his opinion, is unsound or unworkmanlike, and not according to the contract, upon three days' notice having been given in writing for that purpose by the resident engineer; and in case the contractor shall refuse, or delay to rectify, or comply with the orders that may be given to him in writing, and shall perform all or any part of the work in an improper manner, or in case the works do not proceed with proper dispatch, the resident engineer shall have power and be at full liberty to suspend the further execution of the works by the said contractor, to take it out of his hands and employ or engage any other person or persons to perform or execute, and to find proper materials for the same, in which case all the costs and charges thereof shall be paid or allowed for by the contractor or his sureties, or allowed or deducted out of the moneys which may be then or become due to the said contractor, the amount of which shall be valued and decided by the engineer, whose award in this and all other cases respecting the works shall be final and binding.

It is also to be in the power of the engineer to direct such alterations to be made in the work during its progress as may be found expedient, which alterations shall not vacate or make void the contract, but shall be performed by the contractor according to the directions he may receive; and the value of the same, whether an addition or a deduction, shall be ascertained by the engineer, and be added to or deducted from the amount of such contract, according to the rate at which such work was undertaken; the award of the engineer, in such case, to be final and binding.

No allowance will be made to the contractor for extra or additional work, unless the same shall be ordered, in writing, by the engineer, and unless a correct account or voucher of the said work is delivered to the engineer within three days of its performance.

The contractor to provide himself with all manner of labour, tools, moulds, implements, scaffolding, centreing-planks, ropes, ladders, hoisting tackle, and materials of every description; carriage, freightage, and every requisite for the completion of the works: he is also to make good any damage done by his workmen to any part of the works, through carelessness or otherwise; likewise to clear away all rubbish or waste that may arise, when desired to do so by the resident engineer.

To excavate for the foundations of the wall, and all other requisite works as may be found necessary, keeping out the water by placing proper dams, if required, &c.

Should it be deemed necessary at any time to suspend the progress of the works on account of the weather, or any other cause, the engineer shall be at full liberty to do so, and no extra charge shall be made on this account by the contractor.

The resident engineer to be at full liberty to order the discharge of, or dismiss from the works, any man or men for incompetency or misconduct; and the contractor shall not replace them without the written approbation of the resident engineer.

Should any of the materials be lost or stolen from the premises, no allowance can be made for the same.

The works shall be begun as soon as the contracts are signed, and the whole completed within under the penalty of for the non-fulfilment of same, to be recovered as liquidated damages in any of Her Majesty's courts of law. In case of extra works, additional time will be allowed for same.

To deliver in a paper containing a copy of the estimate, with the quantities and prices upon which such estimate was founded, in order to show that it is a *boná fide* calculation; the same to be left with the engineer, in order that he may be enabled to value any additions or deductions that may arise, according to the prices of such estimate.

The contractor must enter into a bond, with two proper and approved sureties, for the performance of his contract.

The contractor will receive payments, upon producing a certificate from the engineer.

To keep an experienced foreman on the works, who is to be approved of by the resident engineer.

The contractor must include for making good and filling into all irregularities of ground, for the before mentioned length of wall, also for any extra depth of piling at the different parts of the river.

In the event of the ground requiring extra piling under the foundation of wall, for the sleepers to rest upon, it will be allowed for by the engineer, according to the "Schedule of Prices" hereto attached.

COFFER-DAM, &c.

The coffer-dam is to be constructed according to the several drawings and instructions, properly returned at each end, and connected to banks of river by a secure and water tight method.

Dredge a proper trench, of a sufficient depth, to facilitate the drainage of the piles: after the latter are driven, it is to be filled up solid.

SCANTLING OF THE SEVERAL TIMBERS.

	Ins.		Ins.	
Main piles	12	×	12,	or whole timbers.
Waling pieces	12	×	12,	halved ditto.
Outer sheet piling	12	×	12,	ditto, ditto.
Inner sheet piling	12	×	6,	or half timbers.
Filling in planking upon ditto . .	12	×	6.	ditto.
Furring pieces to ditto	12	×	12.	or whole timbers.
Brace piles	12	×	12.	ditto.
Braces, shoring pieces, ties, &c. . .	12	×	6,	or half timbers.
Fender piles	12	×	12,	ditto.
Booms	12	×	12,	ditto.

The main or gauge piles are to be driven to the required depths, and at least 2 feet home, into a solid material.

The waling pieces to be in two thicknesses, breaking joint with each other, and bolted to main piles by 2 inch wrought-iron bolts, (these bolts to pass through the sheet piling, out and out) and washers complete.

The ends or extremities of dam are to be splayed off, instead of square, and the waling of same will be in whole timber in one length, strapped upon and secured to side waling, and bolted to the outer gauge-piles, similar to the others, and blocked where required.

The outer sheet piling to be driven to the same depth as the main piles, and exactly square and close to each other; and every pile to be bolted to the waling by an inch wrought-iron bolt.

The inner sheet piling is to be cut off level at the height shown on drawings, and horizontal pieces to be filled in on ditto, and securely bolted by $\frac{3}{4}$ inch screw bolts to furring-pieces, the which are to be strapped to each gauge-pile; the sheet piling will be splayed and fitted together at the angles at each end of the dam.

The brace piles are to be of the same length, and driven with an inclination, as shown on drawings; having a waling piece of whole timber, bolted with a $\frac{3}{4}$ inch wrought-iron bolt, at a level with the bottom of the river, for the diagonal and raking braces to rest upon.

The upright shoring pieces to be two in number to each brace pile, and 2 diagonal shores or braces to each brace pile, secured by 1 inch wrought-iron bolts, and washers at each end.

There will be two 3 inch planks upon both sides of brace piles, bolted to same and shores, secured by 3 inch stirrups, and $\frac{3}{4}$ inch wrought-iron bolts, and 1 raking plank on each, fastened as the others.

Provide all necessary cleats and wedges, to be properly spiked against piles.

The braces at the angles of returns to be in whole timber, and each return will have an additional brace pile and brace, and whatever extra piling and struting may be deemed expedient.

The fender piles to be driven similar to other piles, and to be 6 in number at each end of dam; having booms to same, properly chained, to allow of their free rising or sinking according to the tides.

The greatest care must be taken in the pile driving, to ensure its true direction; all that are improperly driven must be taken up and redrove, and if split or injured they must not be used a second time: wrought-iron hooping to be fitted on the head of every pile.

All the whole piles are to be shod with a wrought-iron shoe, not less than 25 lb. in weight, and the half timber piles with a similar shoe, 20 lb. in weight.

Upon the whole of the piles and sheet piling being driven, and the timbering properly secured and braced, the soil enclosed between the sheet piling is to be thoroughly removed, and the space is then to be filled in with good stiff clay, having a portion of gravel mixed with it, or good puddle: the whole worked together, and puddled-in and rendered impervious or water-tight, and as the substance consolidates and sinks, fresh stuff must be filled in and rammed down, always keeping it above the top of the sheet piling.

The base of the dam, both inside and outside, is to have a mass of proper materials constantly piled up against it, with dwarf piling to support same, if required.

PIPES.

Provide and fix two trunks or shoots, consisting of 5 feet of cast-iron pipe, fitted in with proper water-tight valves, and fixed with water-tight joints; the situation and level of same to be pointed out by the resident engineer.

PUMPING.

The contractor to provide and fix complete by the time the dam is constructed, and keep constantly at work, a good low-pressure engine of sufficient power (the power to be of at least 8 horses), to which pumps of sufficient size are to be attached; also pumping apparatus, and all other necessary machinery, to be approved of by the resident engineer.

The engine will be erected in the centre of seite, or where directed, upon a proper foundation and staging; the whole having a temporary engine-house and shed over, and the same over the mill-stones, which will be required for grinding the lime.

QUAY WALL.

Excavate to the depths required for the foundation of proposed wall, as shown upon drawings, the bottom of same being perfectly flat to receive the sleepers, &c.; and working room is to be allowed on both sides; if the soil should be bad and will not stand, sheet piling or planking must be driven to support same.

All the soil and material arising from the excavations or works, that cannot be used for same, are to be removed or carted away.

FOUNDATION.

The foundation of proposed wall to be laid upon 6″ planking, supported by sleepers 12″×8″; the sheet piling will be of red pine timber 8″ thick, having an 18 lb. shoe to each, and it must be driven in the most careful manner, with waling pieces 15″ × 8″, bolted to them by 1 inch wrought-iron bolts.

CONCRETE.

The concrete used in the founding of the walls, &c., to be mixed in the proportion of 7 measures of gravel to 1 of ground stone lime, of approved quality, the stone lime to be ground to powder by mill-stones attached by a gear to the steam-engine; the materials above stated are to be well mixed without any water, but by mere manual labour, when this is done a sufficiency of water is to be added, and the whole well mixed together, it is then to be wheeled away in barrows, and pitched from a height of at least 10 feet in all its stages and layers; where it cannot be pitched, it is to be well puddled and trodden down by men, and well cemented together, and brought to a solid bearing to receive the sleepers, planking, &c.

The filling in concrete to be of similar materials, mixed in a like manner, in the proportions of 1 of lime to 10 of gravel, pitched and laid in layers of 9 or 10 inches in thickness.

The concrete is to be kept perfectly clear of the water.

STONE WORK.

The wall and counterforts to be carried up of the several dimensions shown and figured on the drawings.

The footings of proposed wall to be in large sizes, the stones not less than from 4 to 5 feet by 2 to 3 feet, and 12 inches thick, of good tough quality, from the quarry, squared and fair worked and laid in mortar; the courses properly breaking joint with each other, and according to the drawings.

The wall to be carried up in courses varying from 12 to 15 inches in thickness, and the sizes to be about 3 feet 2 inches by 2 foot for headers, and 3 feet by 1 foot 6 inches for stretchers, and to be laid 2 stretchers to 1 header, and properly bonded together.

If the engineer should think fit to have the stone from some other quarry, instead of from the quarry, and the distance should be greater, it will be allowed for extra.

The whole of the outside stone to be carefully selected as to colour and quality, and to be laid in its natural or quarry bed, the upper and lower bed of every stone to carry its full thickness from front to back, so that the bearing both above and below may be perfectly square and level throughout: no pinning in levelling will be allowed; each stone is to be brought firmly to its bed by a wooden mallet.

The top course of stone to wall forming the curb to be good whinstone, and to be 12 inches thick, in large sizes, and rounded on the edge, and to be placed round the whole width of wall, and well joggled together; the pitching or paving is likewise to be of whinstone.

All the masonry to be worked with chisel drafts round their faces, beds, joints, and backs, and to be picked between the drafts, so that upon applying a ruler upon the face no part shall be above them, and no more space than $\frac{1}{8}$th of an inch below them ; the outside faces being worked with exact regularity and neatness.

The whole of the stones are to be worked on the ground, and to be set with lewises and proper tackle.

The whole of the stone-work is to be laid throughout on a thick bed of mortar, of the following description—one measure of good stone lime, one measure of puzzolana, and two measures of sharp clear sand, free from rubbish, dirt, and other impurities.

The lime is to be slacked and mixed with puzzolana and sand, they are then to be passed together in a dry state through screens, and the water added.

The mortar is to be well tempered and worked to a tough and proper consistency, and ground by edge stones, worked by a gear from the steam-engine.

No more mortar is to be made at a time than can be consumed in the day's work.

The lime to be brought in small quantities, and to be kept under an enclosed shed, so as not to be injured by exposure to the weather.

The wall to be properly returned for a space of 30 feet from the face in similar masonry, and to be carried as deep as the nature of the ground may require; the space enclosed by the walls to be properly pitched or paved with whinstone, 12 inches in thickness, as before described.

Lay in wall 3 tier of oak plates, 12″ × 9″, to secure fenders to; the top plate is to have a return piece, dovetailed and spiked to same at every 10 feet.

The fenders are to be of oak 9 inches wide, and projecting 7 inches from face of wall, and to be bolted on with inch screw bolts, having oak cleats, &c., morticed and tenoned on each side, and spiked to plates; and fix iron rings to same in a secure manner.

SPECIFICATION of the timber Pier, to be erected on the Frith of Forth, at Grangemouth Harbour.

GENERAL CONDITIONS.

The following conditions and observations are to be strictly attended to by the different parties tendering for the execution of the proposed work:—

The whole of the materials provided are to be the best in quality of their respective kinds, sound, and well seasoned, and to be applied in the most substantial manner, under the direction and to the entire satisfaction of John Macneill, C.E., and the resident engineer appointed to superintend the works.

The drawings are to be equally binding with the specification; and should anything appear to have been omitted in either or both, which is usually considered necessary for the completing of the several works, the contractor is to execute the same as if it had been particularly described, and is not to obtain any advantage whatever from such omission, but shall apply what may be wanting to complete the whole, and the works are to be left in a complete state, according to the true intent and meaning of the drawings and specification; and the directions for their correct performance, as given from time to time by the resident engineer, are in all cases to be strictly attended to.

The whole of the stone, timber, iron, and other materials, are to be delivered on the premises, and to be examined by the resident engineer previous to their being worked or used.

It shall be in the power of the resident engineer to reject any part of the materials which he may consider unfit for the work, and cause any part of the work to be altered which, in his opinion, is unsound or unworkmanlike, and not according to the contract, upon three days' notice having been given in writing for that purpose by the resident engineer; and in case the contractor shall refuse, or delay to rectify, or comply with the orders that may be given to him in writing, and shall perform all or any part of the work in an improper manner, or in case the works do not proceed with proper dispatch, the resident engineer shall have power and be at full liberty to suspend the further execution of the works by the said contractor, to take it out of his hands and employ or engage any other person or persons to perform or execute, and to find proper materials for the same, in which case all the costs and charges thereof shall be paid or allowed for by the contractor or his sureties, or allowed or deducted out of the moneys which may be then or become due to the said contractor, the amount of which shall be valued and decided by the engineer, whose award in this and all other cases respecting the works shall be final and binding.

It is also to be in the power of the engineer to direct such alterations to be made in the work during its progress as may be found expedient, which alterations shall not vacate or make void the contract, but shall be performed by the contractor according to the directions he may receive; and the value of the same, whether an addition or a deduction, shall be ascertained by the engineer, and be added to or deducted from the amount of such contract, according to the rate at which such work was undertaken; the award of the engineer, in such case, to be final and binding.

No allowance will be made to the contractor for extra or additional work, unless the same shall be ordered, in writing, by the engineer, and unless a correct account or voucher of the said work is delivered to the engineer within three days of its performance.

The contractor to provide himself with all manner of labour, tools, moulds, implements, scaffolding, centreing, planks, ropes, ladders, hoisting tackle, and materials of every description; carriage, freightage, and every requisite for the completion of the works: he is also to make good any damage done by his workmen to any part of the works, through carelessness or otherwise; likewise to clear away all rubbish or waste that may arise, when desired to do so by the resident engineer.

To excavate for the foundations of the wall, and all other requisite works as may be found necessary, keeping out the water by placing proper dams, if required, &c.

To excavate for the foundations of all works that may be required, placing dams, &c., if found necessary.

Should it be deemed necessary at any time to suspend the progress of the works on account of the weather, or any other cause, the engineer shall be at full liberty to do so, and no extra charge shall be made on this account by the contractor.

The resident engineer to be at full liberty to order the discharge of, or dismiss from the works, any man or men for incompetency or misconduct; and the contractor shall not replace them without the written approbation of the resident engineer.

Should any of the materials be lost or stolen from the premises, no allowance can be made for the same.

The works shall be begun as soon as the contracts are signed, and the whole completed within under the penalty of for the non-fulfilment of same, to be recovered as liquidated damages in any of Her Majesty's courts of law. In case of extra works, additional time will be allowed for same.

To deliver in a paper containing a copy of the estimate, with the quantities and prices upon which such estimate was founded, in order to show that it is a *bonâ fide* calculation; the same to be left with the engineer, in order that he may be enabled to value any additions or deductions that may arise, according to the prices of such estimate.

The contractor must enter into a bond, with two proper and approved sureties, for the performance of his contract.

The contractor will receive payments, upon producing a certificate from the engineer.

To keep an experienced foreman on the works, who is to be approved of by the resident engineer.

The timber, unless otherwise described, is to be of the best Memel, Riga, or Dantzic, free from sap, shakes, and defects, also large, loose, or dead knots.

All the iron to be wrought, and of the best merchant's iron, which is to be properly tested, as the resident engineer may direct.

The work will consist of 5 bays, of 19 feet 5 inches each, leaving 1 foot 6 inches on the outside at each end, making in all about 100 feet.

The contractor to prepare for the driving of the piling, as may be found necessary.

SCANTLINGS OF THE TIMBERS.

	Ins.		Ins.
Front and side piles	12	×	12
Ditto, ditto, walls	12	×	6
Cross beams	12	×	12
Top beams	12	×	9
3 pair of front braces	9	×	9
Side braces	12	×	6

Straining pieces	9	×	9
Struts to same	9	×	9
Diagonal struts to same	6	×	6
Cross sleepers or sills situated on the banks	12	×	3
Longitudinal sleepers at top of bank	12	×	6
Fenders	12	×	6

The whole of the piles to be driven, until a good solid and sufficient foundation is found.

The front piles to be two in number to each pier, being properly connected to side wales by wrought-iron straps, 4″ × 1″ round both piles and bolts; these straps will also have a hole wrought in same with a proper shoulder to receive the bolt, which secures front wale; the heads of the piles are to be properly morticed 6 inches into cross beams.

The side piles to be in a single row, and in a line with the centre of front piles, and they will be morticed 3 inches into bolsters upon top of same, 12″ × 6″, upon which the cross beams are laid; all the piles are to be shod with a proper wrought-iron shoe, not less than 25 lb. in weight.

The front wales are to be secured to the straps round front piles, by an inch wrought-iron bolt; the strap being properly prepared to receive same, as before described. The side wales to be notched on and secured to front main piles by straps and bolts, as before described, and to braces and side piles by inch wrought-iron bolts, nuts and washers, the ends of same resting upon sills; to have cleats drove tight upon them, running from one sill to the other, and screwed to same with $\frac{3}{4}$ inch bolts and nuts, as shown on drawing; these cleats likewise support the ends of the braces.

The cross beams to be secured to front piles and bolsters by mortices and tenons, as before described.

The top beams to be secured to bolsters and cross beams by inch wrought bolts and nuts, running right through each of them, and to straining pieces by two 1 inch wrought screw bolts.

The three front top beams to be bolted together by $1\frac{1}{4}$ inch wrought bolts and nuts, having a loose ring attached on the outside face of beam, as shown on drawings. And 3 inch planking will be laid upon top beams, properly fastened with jagged spikes.

The front, or face braces, to be as shown on drawings, having 3 inches notched out of each at the crossing, where they are to be halved and fastened with an inch bolt and nut; the bolts to the first pair passing through the front waling, the lower end to be let into the pile and secured by 2 inch straps and bolts, the upper ends also to be morticed and tenoned into piles, and spiked, and to have a cleat bolted on to top of same, which likewise supports the struts to straining pieces: the second pair from the front to be bolted together at their intersection, and secured to side piles by mortices and tenons, and connecting irons and bolts at the lower end, and having cleats bolted on the upper end: the third pair of braces from the front to be morticed and tenoned into piles, and secured to side piles by 1 inch wrought screw bolts, they will rest upon, and be morticed and screwed into a sleeper, 6 inches thick, laid on bank to receive same.

The side, or framed braces, to be secured to side piles by bolts, as before described; the upper end being fastened to the cross beams by 2 inch stirrup irons, properly wedged and spiked, to obviate any deficiencies in the different thicknesses of the timbers; the end resting on the sleepers or sills to be spiked to same: they will likewise be supported by cleats, as before mentioned.

The straining pieces to top beams to be bolted to same, as before described; the struts to same to be tapered off or reduced at the end, to allow the diagonal struts to fit close to them, and they will each be morticed, tenoned, and spiked into piles; cleats will be bolted on immediately under and fitting to them, the bolts passing from wale to wale.

The diagonal pieces will likewise be bolted together at their heads by $\frac{3}{4}$ inch bolts.

The scarfings to the several timbers to be at least 2 feet long, and thoroughly strong, and secured together by bolts and irons properly wedged.

The paving of the surface of the platform to be laid with pitching stones, 12 inches in thickness, upon planking to receive same, having a wrought curb, as shown on drawing; the whole to be of tough whinstone, set with mortar, composed of good stone lime, gravel, and puzzolana; the curb will have irons, 3 inches by 1 inch, let into the joints, and well run with lead, and screwed on to planking to prevent their being shaken.

The banks to be properly consolidated and rammed with hard rubbish, to receive pitching stones, 12 inches in thickness; the said pitching to be properly laid, and the bottom course to be well secured and cramped together.

LAND-TIES.

Drive a pile 25 feet deep of whole timber opposite each pier, shod similar to the other piles, and 60 feet from face of front piles, secure to same a $1\frac{1}{2}$ inch tie bolt, with nuts and washers, the other end will be fastened to an iron strap, which is fastened to cross beam.

The strap to be 1½ inches thick at the sides, and 2 inches in front, and 4 inches wide, it will be 5 inches in centre of front, properly shouldered with inch bolt to same ; the tie-bolt will be coupled at every 10 feet, having a mooring-ring fastened to the outer extremity : should the tie-bolt swag, so as to require any supports in its length, stirrup-irons must be provided in order to keep it in its place. The whole of the iron to be wrought.

The fenders to be as shown on drawings, having their several heads properly tenoned into the beams, and fastened to walls and piles by 1 inch bolts and nuts.

The cross sleepers will be properly secured to timbers at each end, as may be found necessary, also properly spiked to longitudinal sleeper at top of bank. The ground is to be well rammed and secured for same, and all the sleepers must lay upon proper stone landings in large sizes, 12 inches in thickness.

The longitudinal sleeper to be properly supported, and well secured to the framing; fillets, 18 inches apart, will be nailed to same, for the planking to be secured to ; the latter being made 3 inches thick, and spiked as may be found necessary.

The whole of the framing effecting, and immediately connected with the surface or platform, must be framed so as to give an inclination or fall towards the river.

The greatest care must be taken in the pile-driving to ensure their true direction, as all piles improperly driven must be taken up and redrove, and all that are split or injured will not be allowed to remain ; iron hooping must be fitted to the head of each pile in the driving, and generally frame and fasten the timbering properly together finding all bolts, mortices, and tenons, where required.*

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* It is proper to mention, that the Quay wall was not erected precisely according to either of these plans.—EDITOR

MIDLAND COUNTIES RAILWAY.

CHARLES VIGNOLES, Esq., Engineer.

Plate 54.—Plans and Elevation of the bridge over the River Soad, at Stamford.*

Plate 55.—Ditto, Details of the iron piles, girders, &c.

This bridge is constructed principally of cast-iron, and forms a very interesting subject, being almost an imitation of the timber pile bridges in common use for crossing rivers; and we believe it is the first instance of the application of iron piles for such a purpose.

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* This bridge was designed by T. J. Woodhouse, Esq., the Resident Engineer.

LONDON AND BIRMINGHAM RAILWAY.

ROBERT STEPHENSON, Esq., Engineer.

Plate 56.—Plans and Elevation of bridge for road from Banbury to Luterworth. *(See Specification of same.)*
Plate 57.—Ditto, Details of Iron-work.
Plate 58.—Ditto, ditto.

Specification of bridge for road from Banbury to Luterworth.

This road passes over the railway at an angle of 28°, at a point where the depth of cutting is 26 feet 6 inches.

The bridge consists of a central opening, with three small archways on each side; the slopes ending in wing-walls, which extend to the edge of the cutting.

The central opening is 30 feet wide on the square, and is spanned by six trussed frames or ribs of iron, resting on piers at each side.

Each frame consists of 2 cast-iron main ribs, abutting at the crown and having three ends attached to 2 wrought-iron ties, which are stretched beneath them, and united in the middle.

The ribs and ties are kept at the proper distance from each other by cast-iron open work placed between them, and acting the part of struts.

The main ribs of the upper sides are horizontal, and have flanges projecting on each side, to admit of the roadway plates (hereinafter described) being bolted to them: the under sides are curved with a flat circular curvature, and have tables projecting on each side in the form of rounded mouldings, their breadth being greatest in the middle of the rib, and gradually decreasing to nothing at each end.

Similar mouldings run along the ribs at the distance of 2 feet from the bottom, and the thickness of metal between them is 1 inch.

At the meeting at the crown the ribs present a section of 2 feet in depth, with a uniform thickness of 4 inches; their ends are rounded into circular arcs, which fit into corresponding sockets in the sides of the cast-iron key, hereinafter described.

The ends of the ribs resting on the bearing piers are cast with circular holes, to admit the bolts which attach the wrought-iron ties; round these holes the metal is swelled into bosses, 4 inches thick, and the same thickness is continued to the bottom of the ribs, which is slightly rounded.

The ends of the ribs just described rest in chairs, forming part of a cast-iron plate, which extends along the whole length of the piers, which is run with Roman cement, and firmly bolted to a course of stone, hereinafter described.

The wrought-iron ties are attached to the ribs by bolts passing through the holes above-mentioned, and are united in the middle by a connecting link and bolts. On this joint, which it encloses in a kind of box, rests the main strut.

It consists of a cast-iron pillar, with fins projecting from the sides; the upper part is cast hollow, in the form of a rectangular pipe, to admit of a strong bar of wrought-iron being inserted, and firmly riveted in its place.

This bar extends through a hole in the key, and by means of a strong thread screw and nut working against the underside of the key admits of an adjustment of the length of the strut.

The cast-iron open work, between main ribs and the ties, are shown on the drawings. The top rests firmly against the bottom of the ribs, and is attached to them by means of feet projecting at intervals and fastened by wrought-iron wedges into corresponding sockets cast on the side of the ribs.

The bottom is cast in the shape of a three-sided box, the top resting on the ties, the sides enclosing them; and the box is completed by pieces of boiler-plate being screwed on beneath, neatly fitted to the edges of the box and cut to the exact width.

The ties are kept at the proper distance from each other by pieces cast at intervals on the top of the above-mentioned box, and fitting accurately between them.

The meeting-plate consists of a cast-iron plate, extending the whole width of the bridge, with the keys of the different ribs cast on it at the proper intervals.

The parts between the keys are strengthened by fins projecting from each side.

The keys themselves, against which the ribs abut, are cast with sockets on each edge, for the reception of the rounded ends of the main ribs, and with holes through the centre, to admit the wrought-iron bar of the main strut, before described.

The outside key has its face cast with a sunk panel, the edges of which are neatly rounded; it has also a plate falling beneath the general level of the bottom, in order to hide from view the top part of main street.

A long strip of boiler-plate, $1\frac{1}{2}$ inches thick, and 1 foot wide, is to extend the whole width of the bridge, at the point where the main ties unite, and it must be firmly secured to the under edges of the main struts.

The roadway-plates are of two sizes, the one to extend over four ribs, the other over two; and they must be so arranged that the smaller plates may break joint alternately with the larger.

At the points where they rest upon the main ribs they are to have projecting cleats, fitting exactly to the sides of the upper tables of the ribs, to which they must be bolted down by wrought-iron bolts alternately on each side.

They are also to have diagonal flanges cast on their under sides between each of the ribs, and projecting to the extent shown on the drawings.

The whole of the joints of the roadway plates are to be accurately fitted and caulked with oakum, so as to be perfectly water-tight; and a layer of concrete, 6 inches thick, is to be laid over the whole surface.

A string course of cast-iron, in the form of a torus moulding and plinth, is to be bolted to the top of the exterior ribs, and to the road-plates by lugs occuring at intervals of 2 feet.

It is further steadied by wrought-iron stays attached at one end to these lugs, and at the other to the inner sides of the plinth.

Sockets, as shown, are to be cast on the interior at every 2 feet, for the reception of the standard of the cast-iron railing hereinafter described, and the inside plate is to be cast loose, and afterwards screwed on.

The railing is to be of cast-iron, in lengths of 10 feet, as near as may be.

The standards of the railing are to be fastened into the sockets of the string-course, above described, with wrought-iron wedges, and the middle standard of each length is to be steadied by a bracket, or knee, riveted to it and to the top of the torus moulding.

The joints of this railway are to be made with half-laps, and neatly and accurately riveted together.

The form and dimensions of the brickwork and masonry of the bridge are shown on drawing.

The main piers, on which rest the iron frames, are to be of brick faced with stone toothing into the brickwork, alternately to the depth of 2 feet and 2 feet 6 inches.

The faces of these piers are broken by stone pilasters, standing forward 9 inches from the general face; the whole is carried to a height of 4 feet 6 inches above the surface of the roadway, and is crowned by a large stone cap, which must be formed of a single stone.

A course of Bramley Fall stone, 2 feet deep, and bedded in the brickwork 3 feet 6 inches, runs along the whole length of the pier at the part where the iron frames rest.

None of the stone forming this course are to be less than 3 feet long; and they are to be firmly dowelled together and cramped on the top with 2 wrought-iron cramps to each joint. 1 square inch in section, 14 inches long, and leaded into the stones to the depth of 3 inches.

A brick wall, 3 feet thick, is to be built between the ribs up to the level of their tops.

The arches on the slopes are of brick, 8 feet span on the square, and 1 foot 6 inches thick, with stone quoins or voussoirs on the face, toothing into the brickwork alternately to the depth of 2 feet and 2 feet 6 inches.

The whole of the arches must be laid with spiral courses at right angles to the face.

A solid backing of brickwork must be carried up to the height shown by the dotted lines.

The arches rest on brick piers, faced with stone to the depth alternately of 2 feet and 1 foot 6 inches; they are to have stone imposts, as shown, from which the arches spring.

The wing-walls begin to batter at the rate of 1 inch per foot at the set off, shown on drawings; they are stepped up the slopes in the manner shown by the dotted lines, and are carried out to the edge of the cutting, where they end in pilasters of ½ brick projection, and are crowned with caps of stone 9 inches deep in the middle.

A torus moulding of stone, and a brick plinth of the exact form and dimensions of that specified over the iron ribs, runs along the whole extent of this bridge.

The torus must return round the pilasters, and the corners must in every case be formed of whole stones cut to the proper form.

All the castings of this bridge must be of No. 1 iron, and the malleable iron must be of the best scrap iron.

Great care must be exercised in making all the joints and fittings of the iron-work perfectly true and accurate, and every part must be brought to an equal and uniform bearing before the centreing or supports are removed, so that there shall be no risk of any part being subjected to unequal or cross strains.

The whole of the iron must be submitted to such trials of its strength as the engineer may consider necessary, and the contractor must be at the expense of all the means or apparatus required; and should any part of the iron-work fail, or be damaged, he must replace them by others fully capable of undergoing the trial.

The whole of the iron-work must be painted with 2 coats of paint, after it is erected.

For other particulars of materials and workmanship see "General Stipulations."

SECHILL RAILWAY.

ROBERT NICHOLSON, Esq., Engineer.

Plate 59.—Plan and Elevation of bridge over the Cramlington Railway.
Plate 60.—Ditto, Details of timber arch and iron-work.

This bridge is of similar description to a bridge on the North Shields Railway, by the same engineer, and represented in another part of the work; but the span in this case is much greater, and it has been found to answer every purpose.

DETAILS OF

LOCK ON THE RIVER CAM.

Plate 61.—Plans, Elevations, Sections, and Details of the lock.

List of Plates.

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* Plate 15 is stated in the description to be "Details of the *Stockport* Viaduct," whereas it is the "*Congleton*," as corrected in this list.

PLATE 29.—*Newcastle-upon-Tyne and North Shields Railway.*—Plans, Elevations, and Sections of the Bridge over the Turnpike Road to North Shields.

,, 30.— ,, ,, Ditto, ditto, Details of construction.

,, 31.—*Forth and Cart Junction Canal.*—Plan, and Longitudinal Section of Lock, No. 3.

,, 32.— ,, ,, Ditto, Transverse Section and Elevation.

,, 33.— ,, ,, Ditto, Plan and Elevation of Lock-gates.

,, 34.— ,, ,, Ditto, ditto, Details of Lock-gates

,, 35.— ,, ,, Ditto, ditto, Details of Paddle, Rack, Pinion, &c.

,, 36.—*New Houses of Parliament*—Plans, Elevations, and Details of the Pile-driving machines employed in forming the Coffer-dam for the Embankment Wall.

,, 37.—*Saint Katharine's Docks.*—Details of Swing Bridge, general Plan and Sections of Bridge, and Details of construction.

,, 38.— ,, ,, Ditto, Longitudinal Elevation and Section of Bridge to an enlarged scale.

,, 39.— ,, ,, Ditto, ditto, Plan showing ribs and framing.

,, 40.— ,, ,, Ditto, ditto, Transverse Sections.

,, 41.— ,, ,, Ditto, ditto, Details of Iron-work.

,, 42.— ,, ,, Ditto, ditto, Details of Iron-work.

,, 43.— ,, ,, Ditto, Details of Working gear to Bridge.

,, 44.—*Manchester and Leeds Railway.*—Plans of construction and Elevation of Bridge over the Rochdale Canal, at Scowcroft.

,, 45.— ,, ,, Ditto, Plans showing foundations and Sections through wing walls and land arches.

,, 46.— ,, ,, Ditto, details of iron girders and framing.

,, 47.—*Locomotive Engines employed on the London and Southampton Railway.*—Side Elevation of Engine.

,, 48.— ,, ,, Longitudinal Section of ditto.

,, 49.— ,, ,, End Elevation of ditto.

,, 50.—*Grangemouth Harbour.*—Transverse Section of Quay wall and Coffer-dam.

,, 51.— ,, ,, Ditto, Plans showing superstructure and construction.

,, 52.— ,, ,, Elevations and Sections of Timber Pier.

,, 53.— ,, ,, Ditto, Plans of superstructure; also Sections and Details.

,, 54.—*Midland Counties Railway.*—Plans and Elevations of the Bridge over the River Soad, at Stamford.

,, 55.— ,, ,, Ditto, Details of the iron piles, girders, &c.

,, 56.—*London and Birmingham Railway.*—Plans and Elevations of Bridge for road from Banbury to Luterworth.

,, 57.— ,, ,, Ditto, Details of Iron-work.

,, 58.— ,, ,, Ditto, ditto, ditto.

,, 59.—*Sechill Railway.*—Plan and Elevation of the Bridge over the Cramlington Railway.

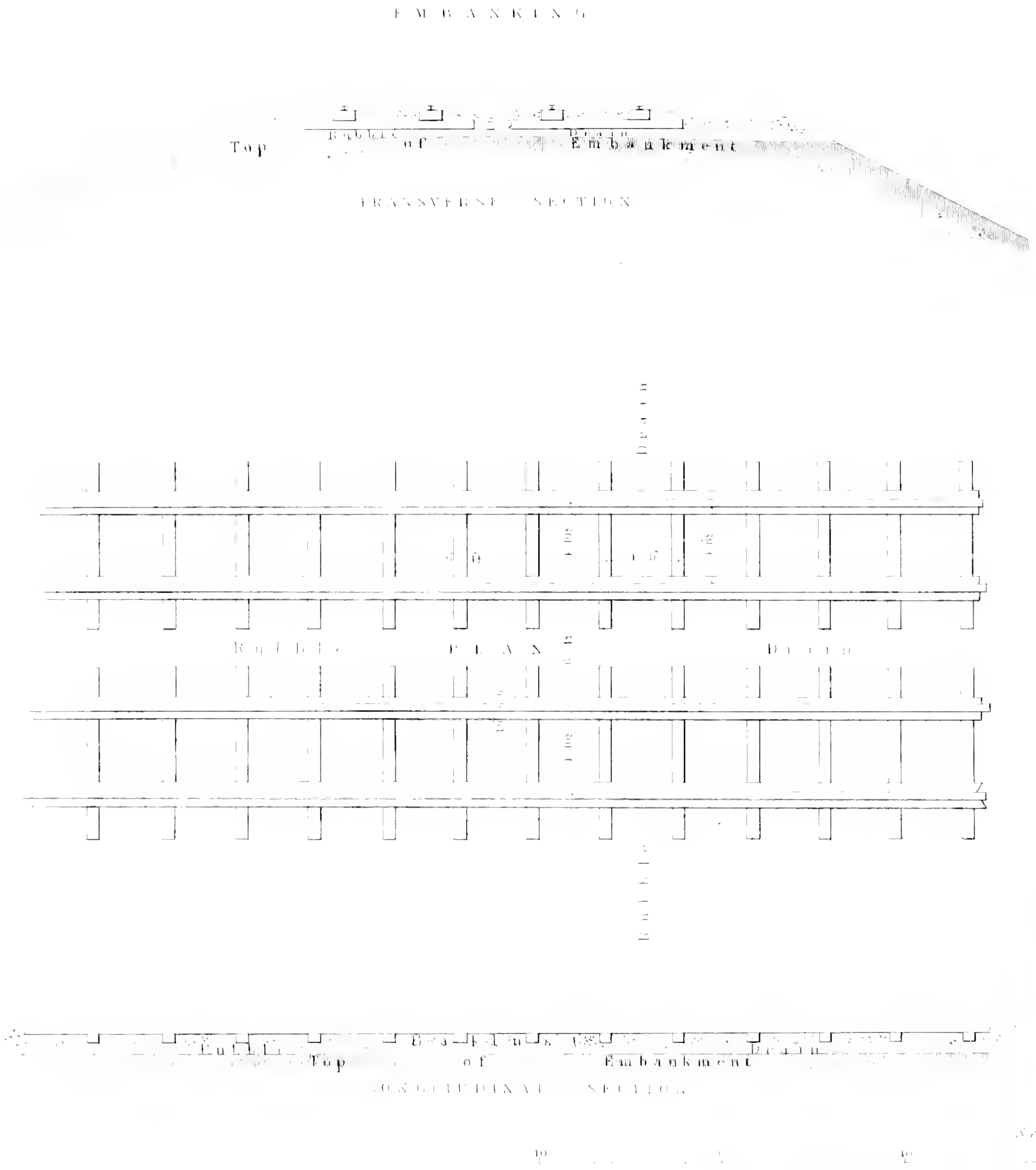
,, 60.— ,, ,, Ditto, Details of Timber Arch and iron-work.

,, 61.—*River Cam.*—Plans, Elevation, and Sections of Lock upon River Cam.

DRURY, PRINTER,
7, Bridgewater Square, Barbican, London.

RAILWAY

METHOD OF LAY



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PRACTICE

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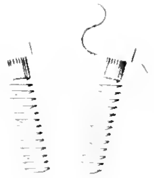
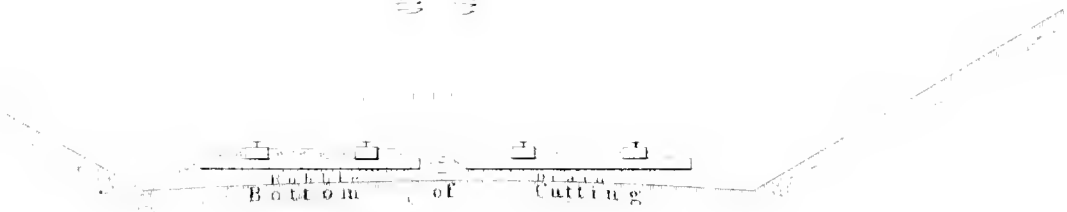
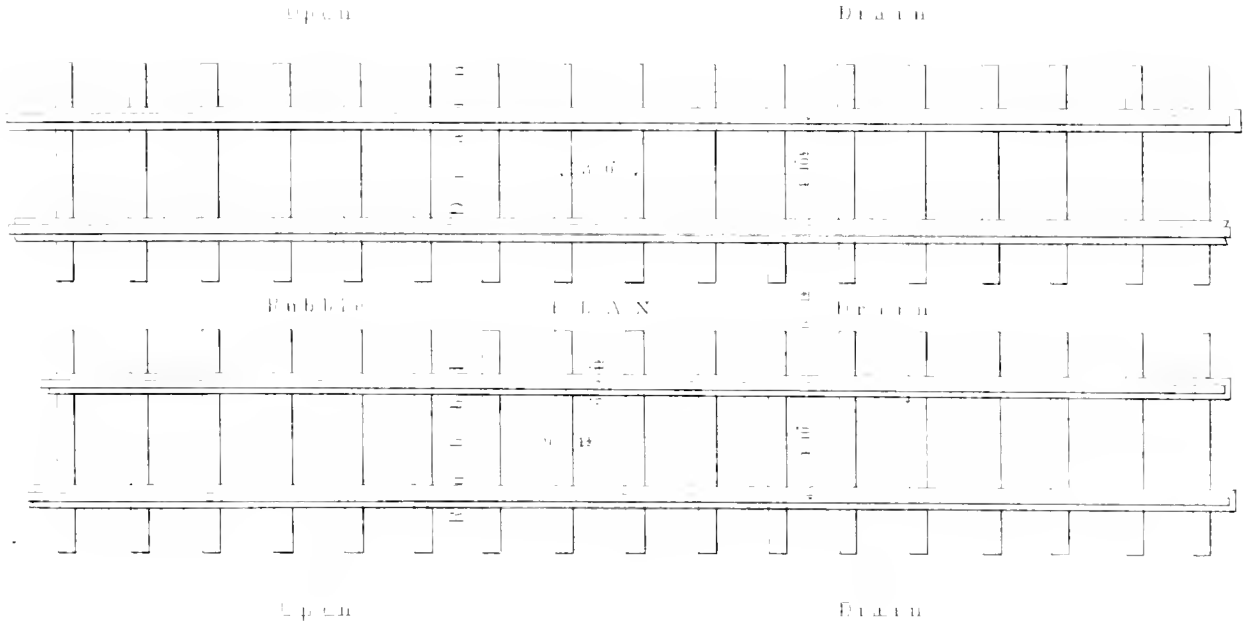




TRANSVERSE SECTION



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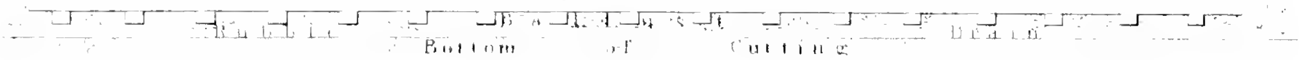
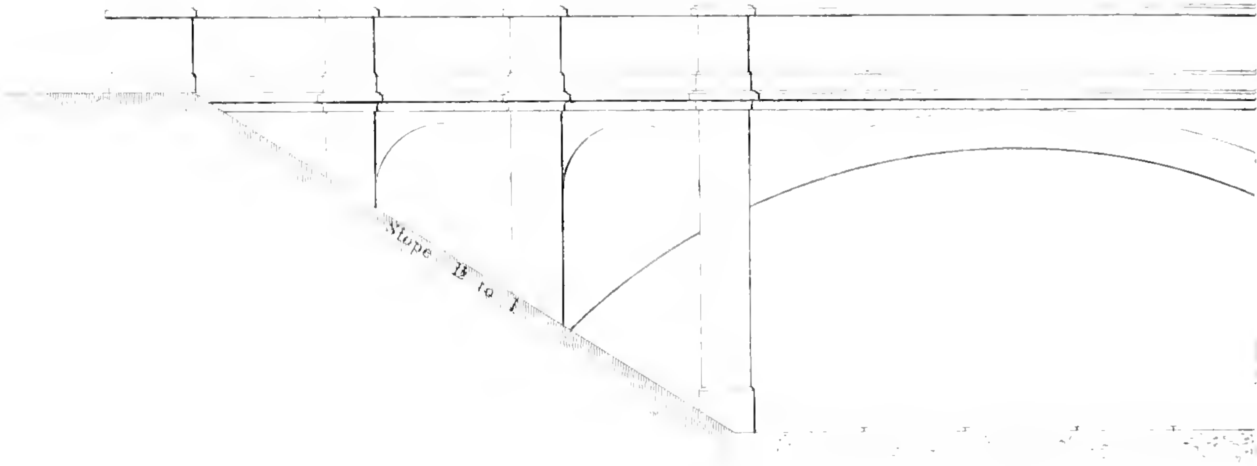
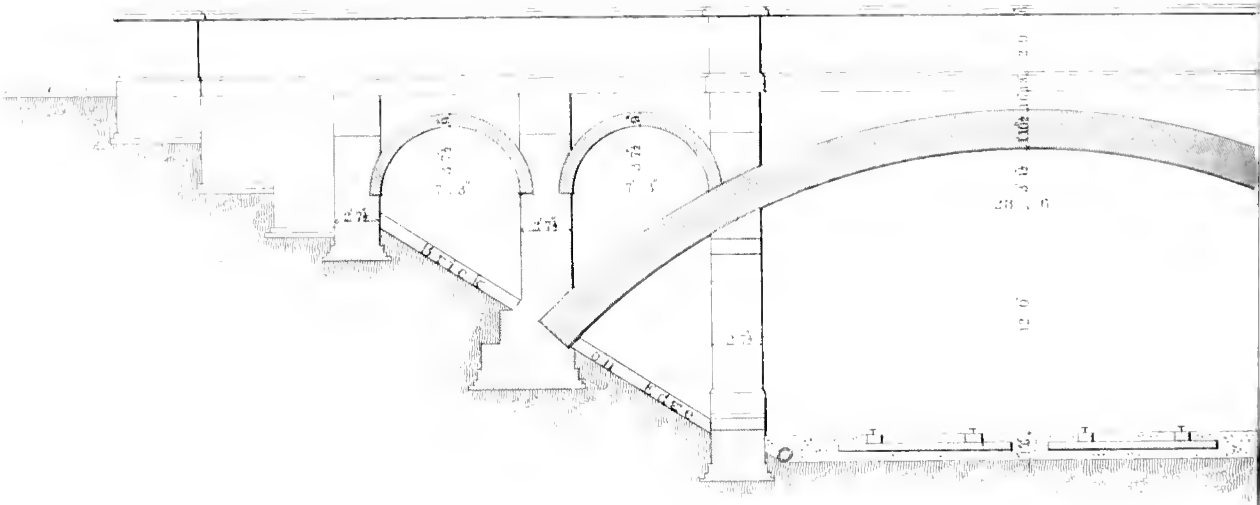


LONGITUDINAL SECTION

RAILWAY



ELEVATION



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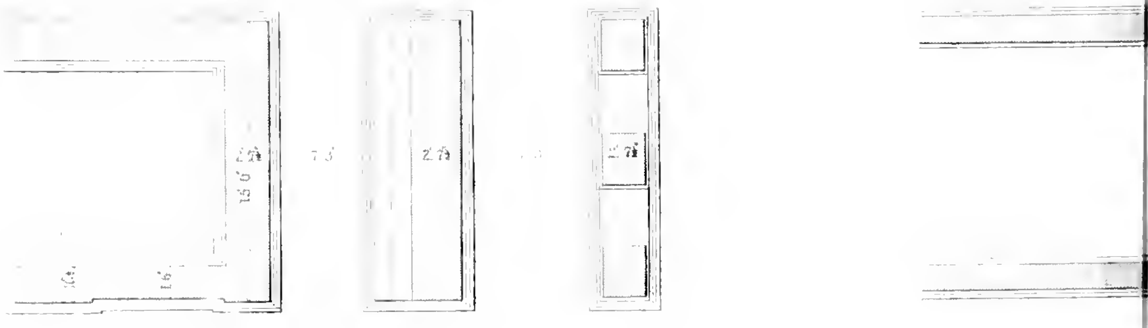

PLAN OF FOUNDATIONS

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John Weale's Library of Scien

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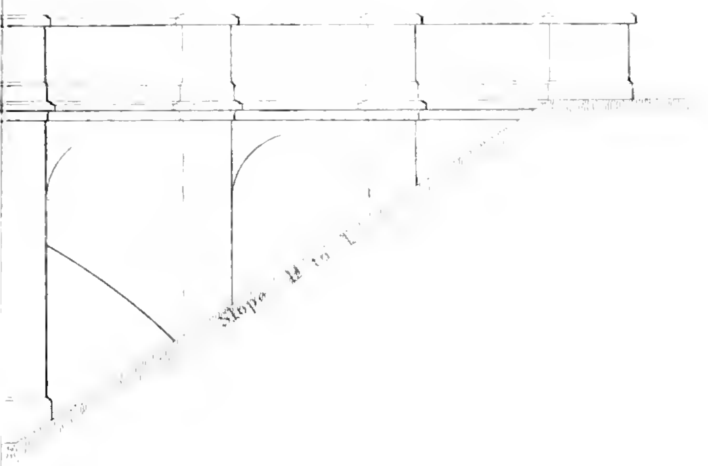

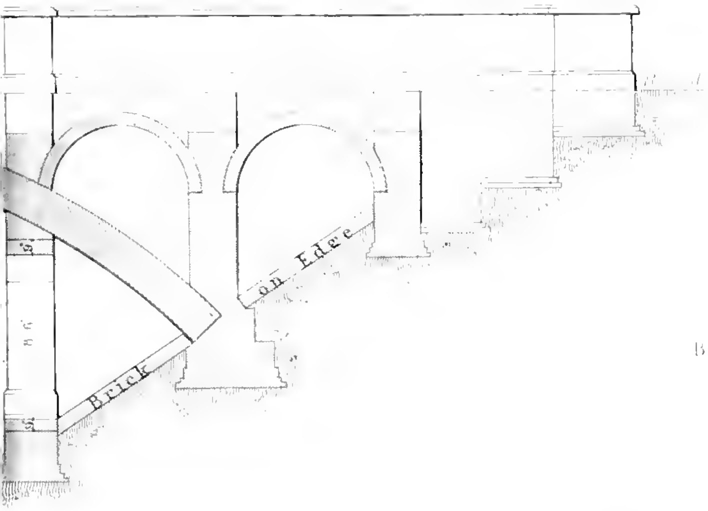

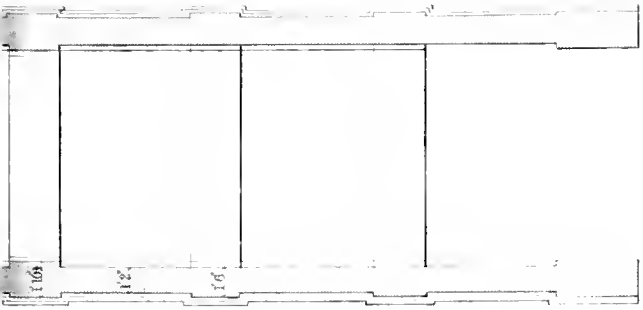

ALF PLAN ABOVE ARCHES

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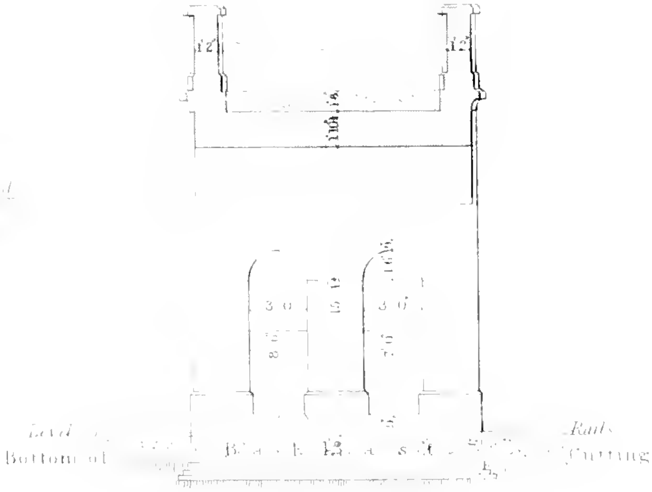

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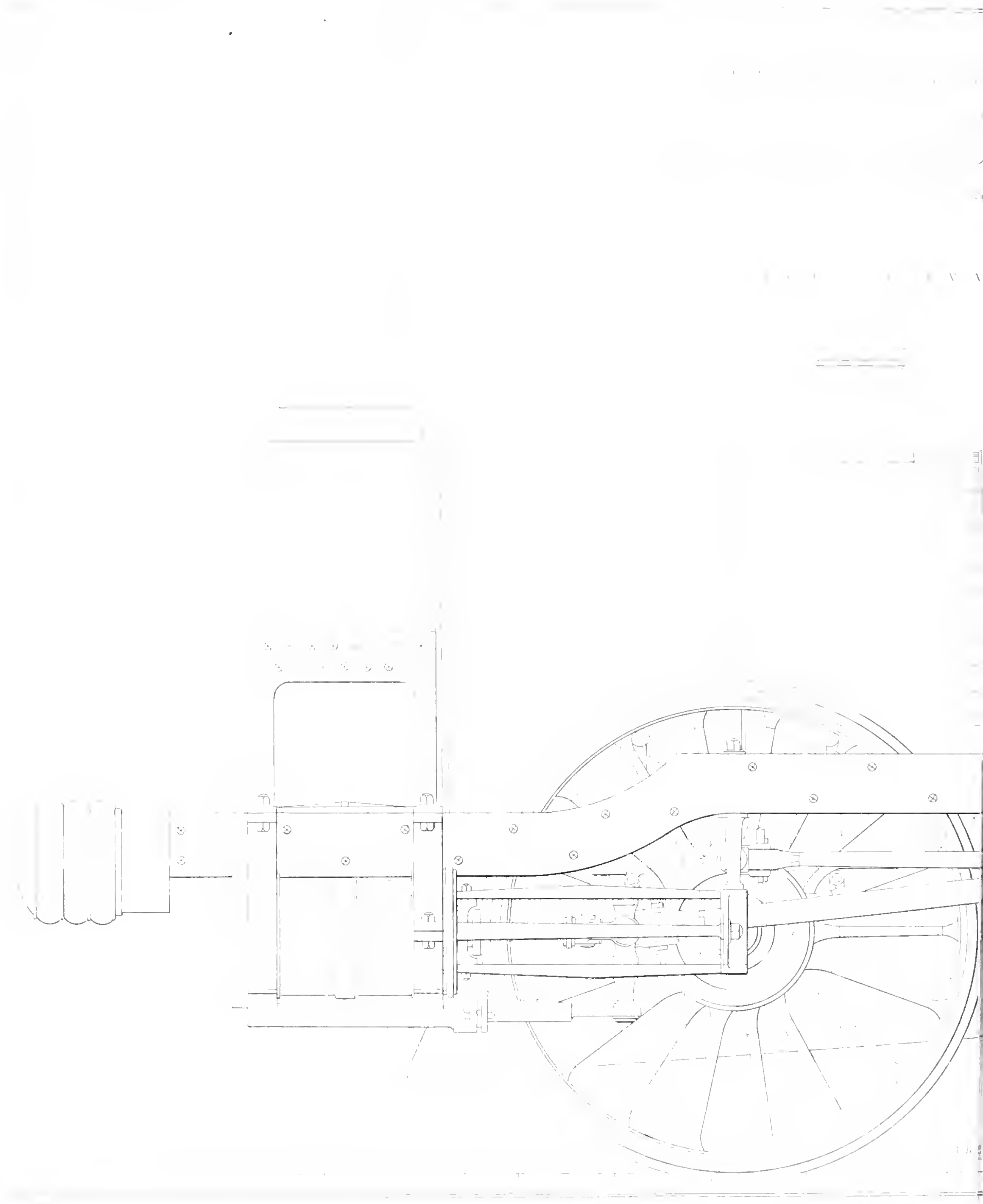

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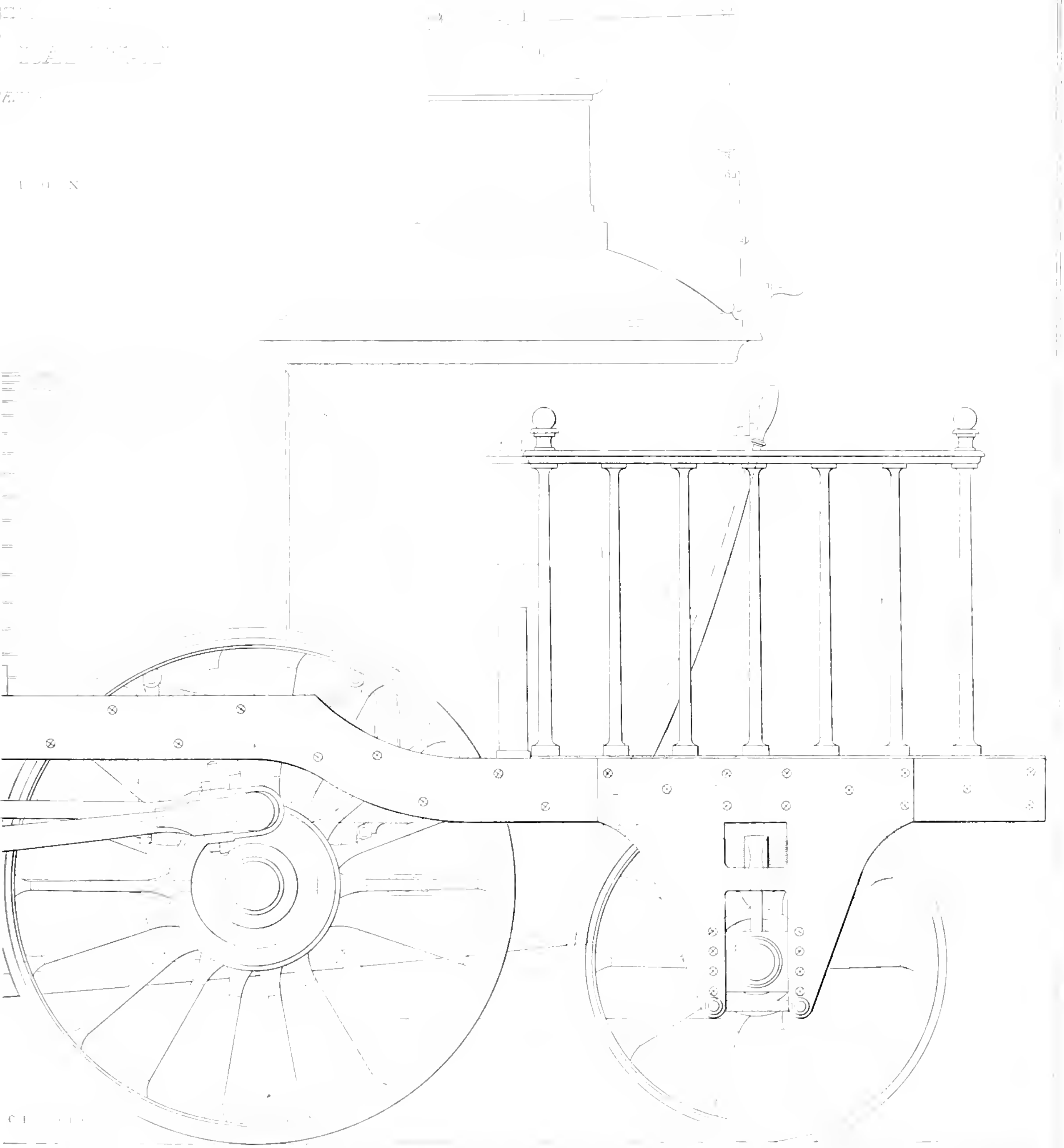

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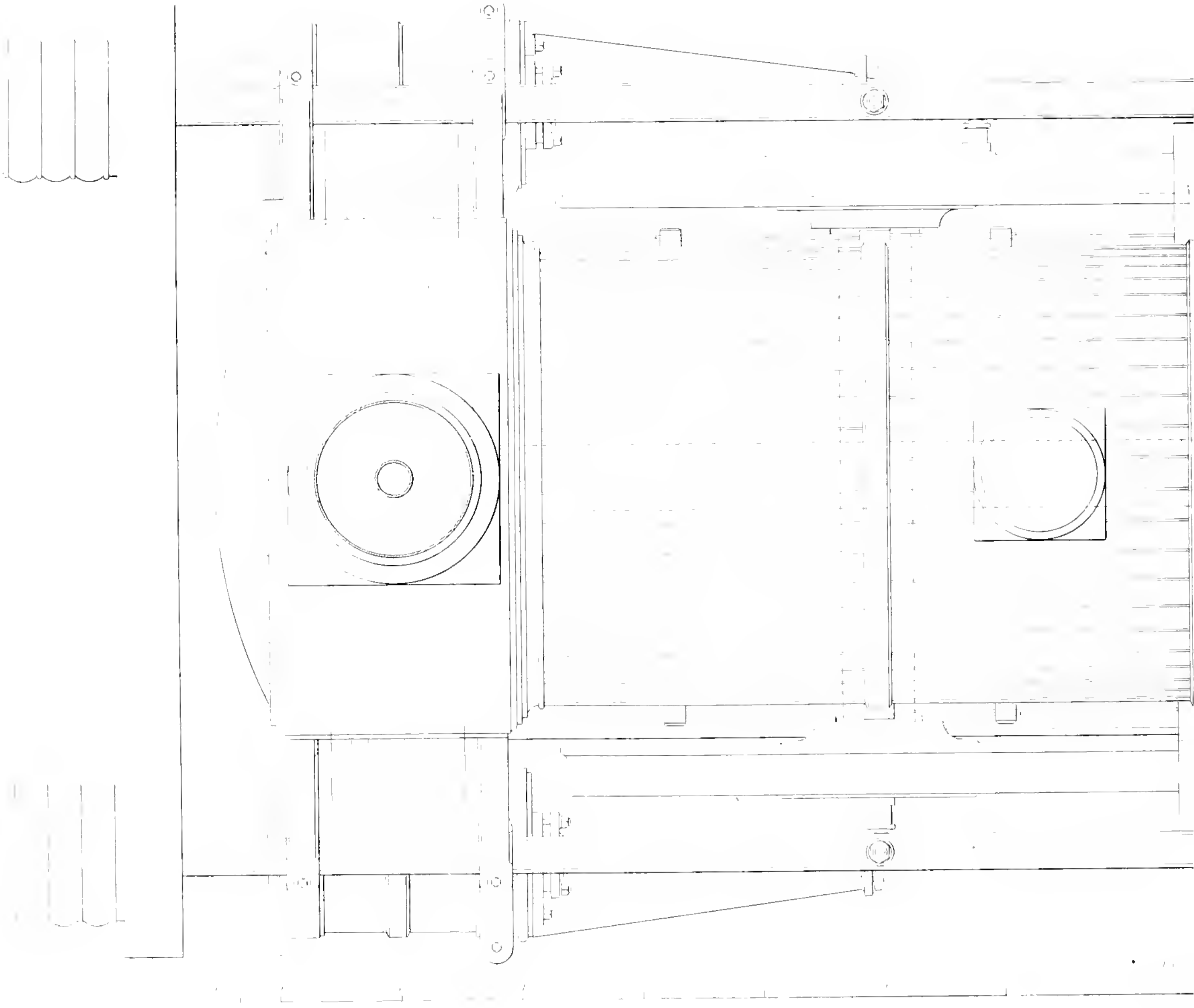

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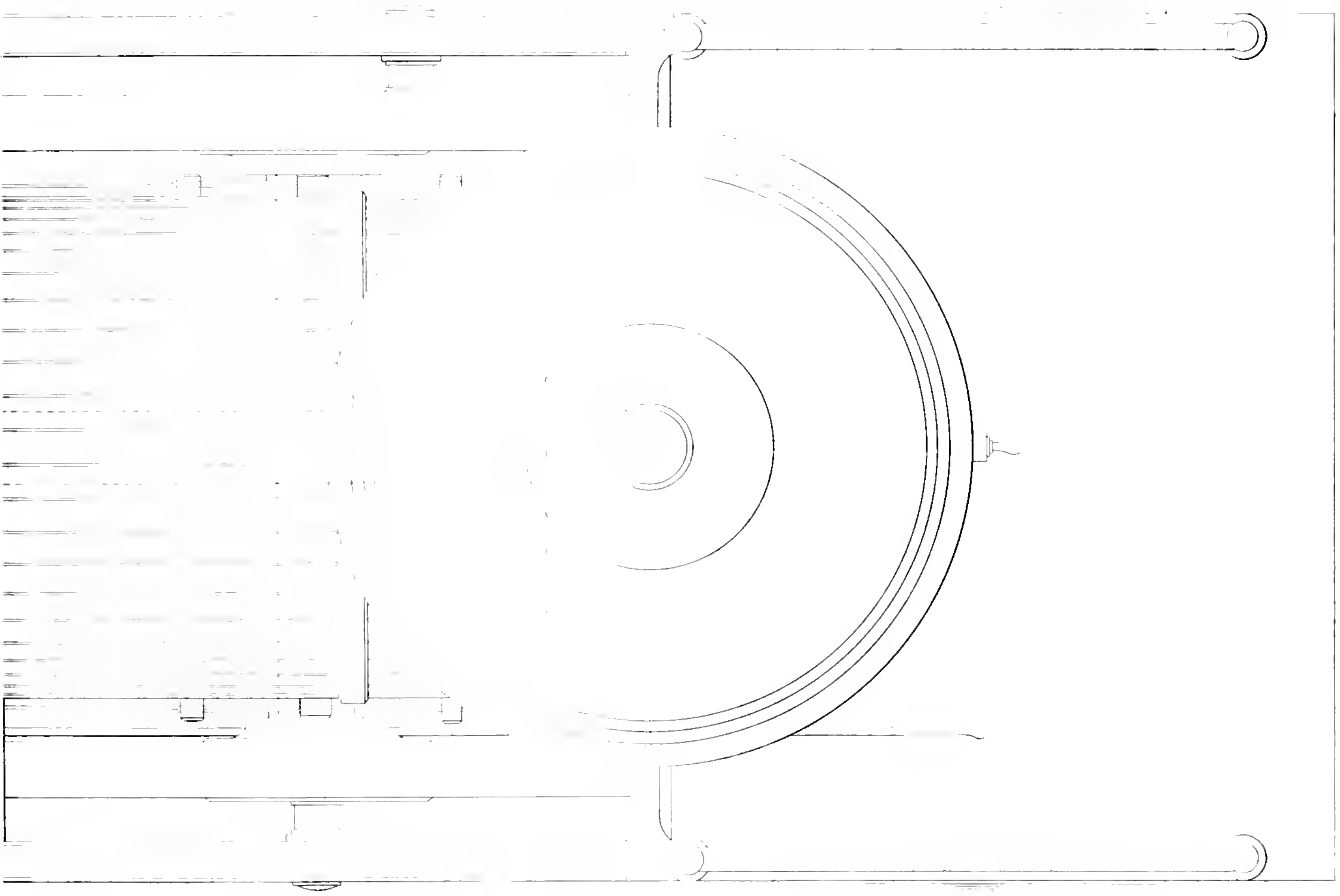

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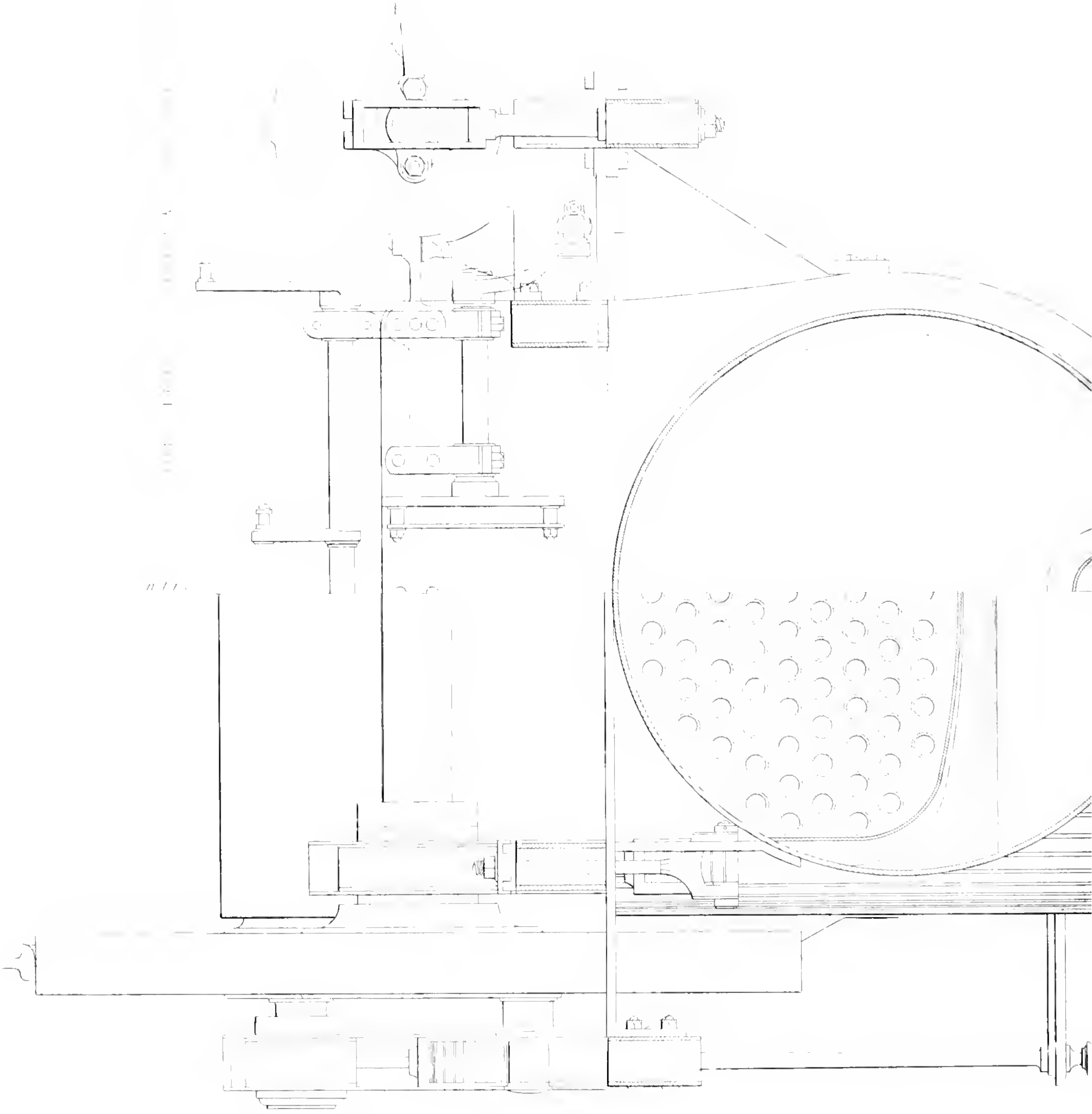

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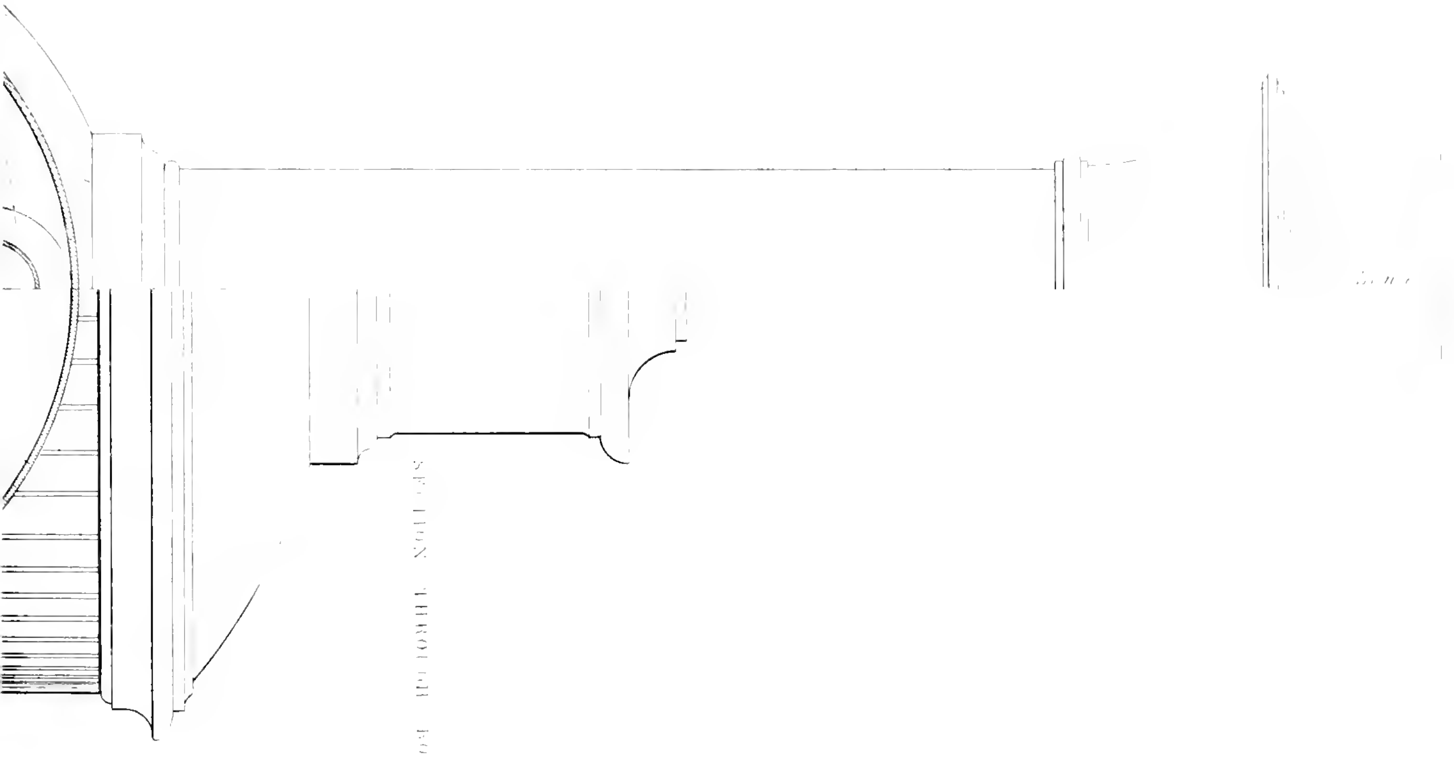
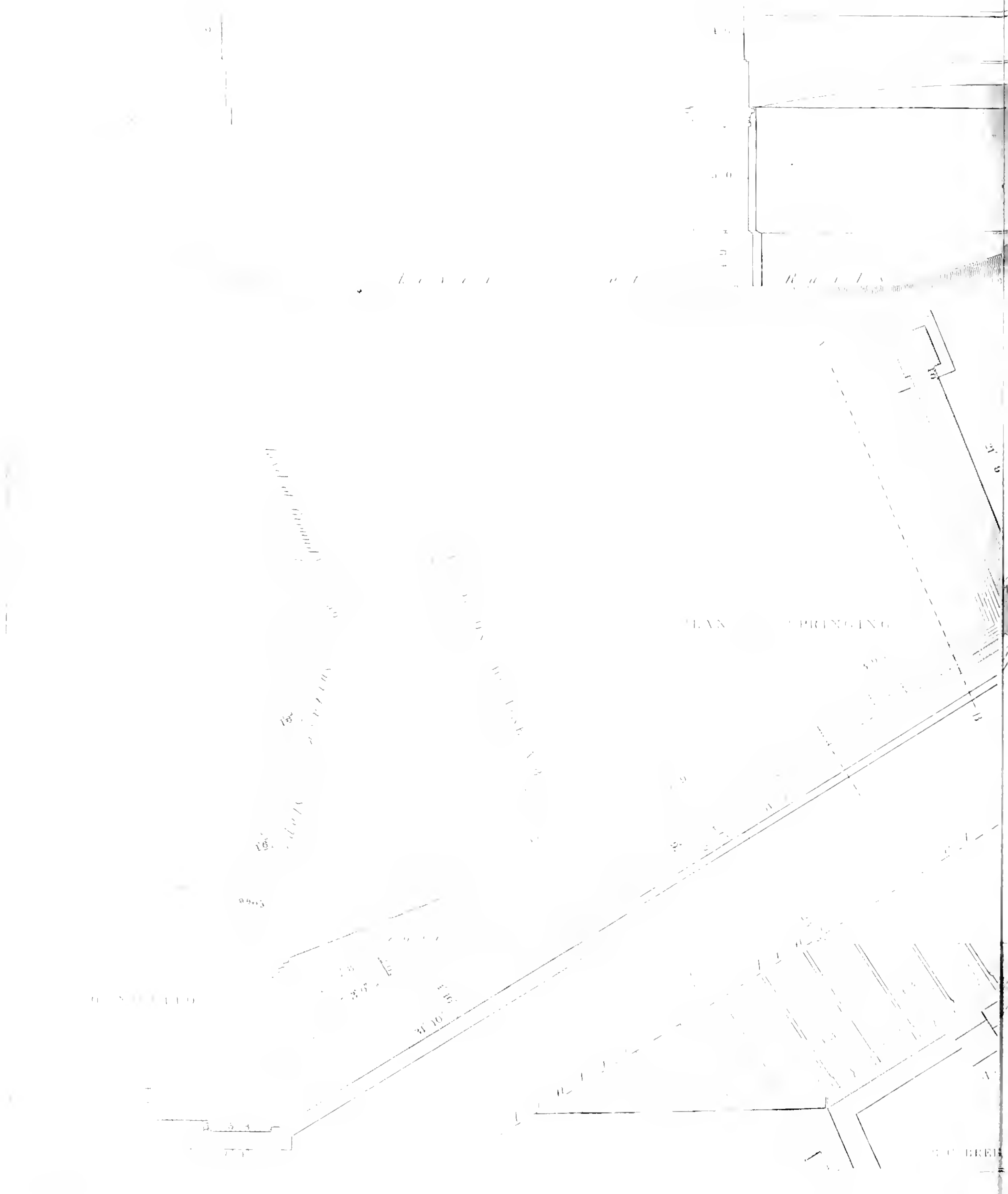
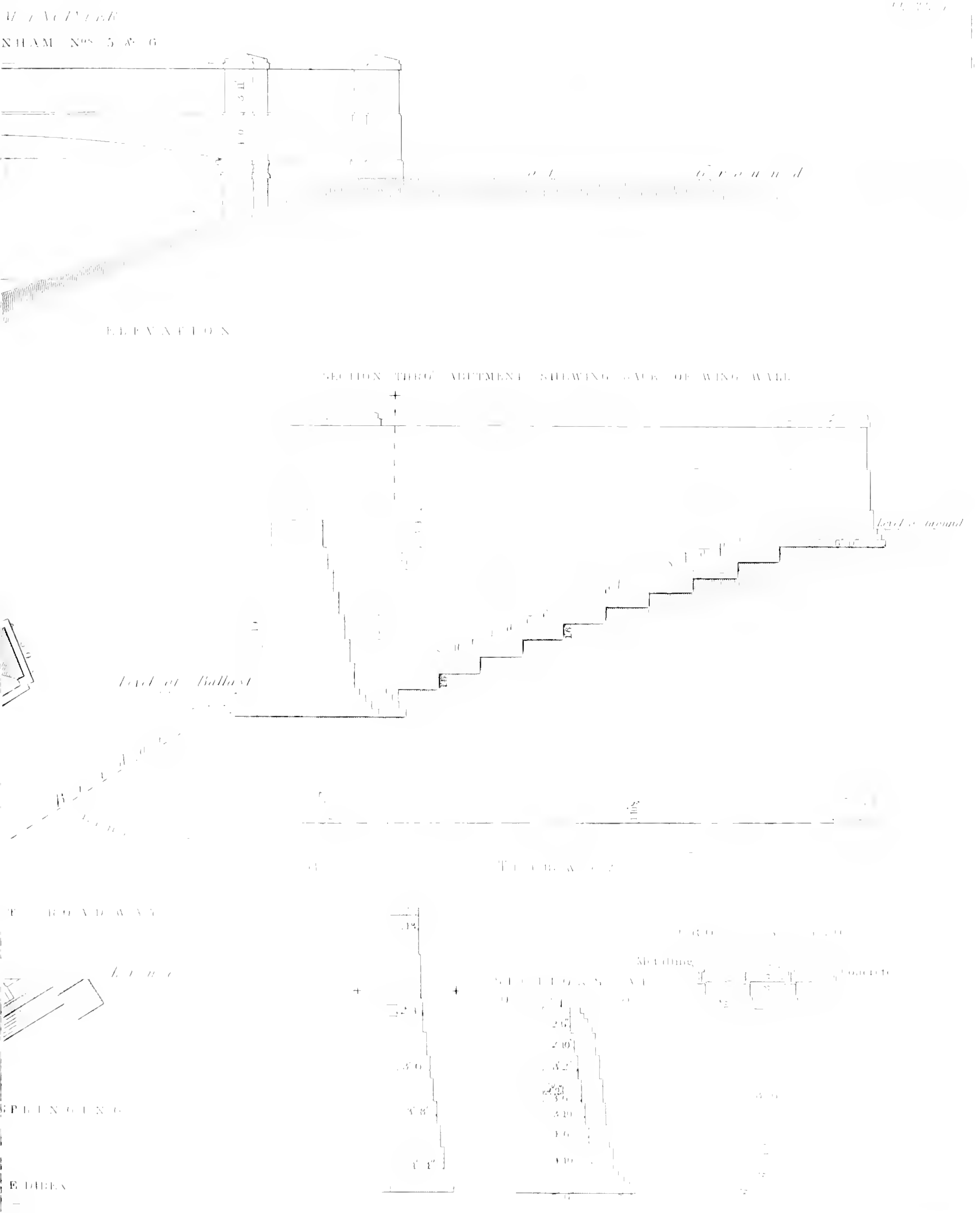

SECTION THROUGH BOILER

der 106 Gt Russel Street near the Museum

RAILWAY

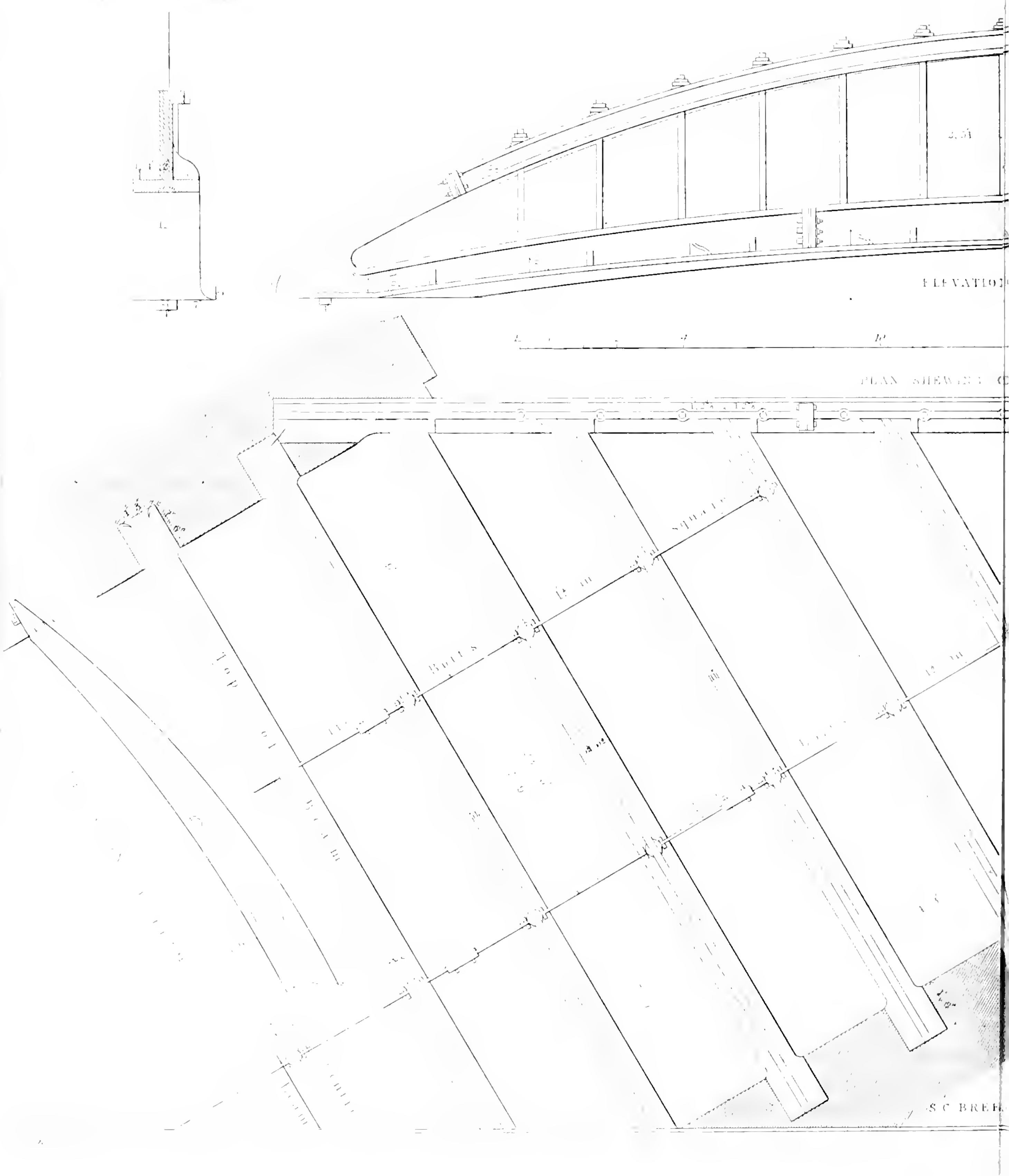


P R A C T I C E.



Russel Street

R A I L W A Y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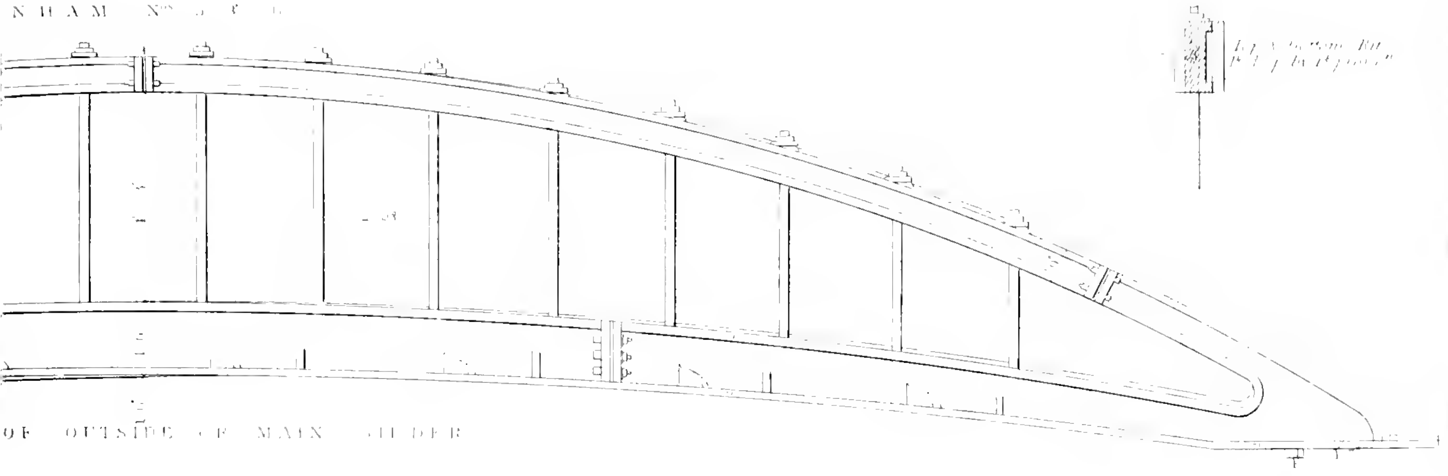
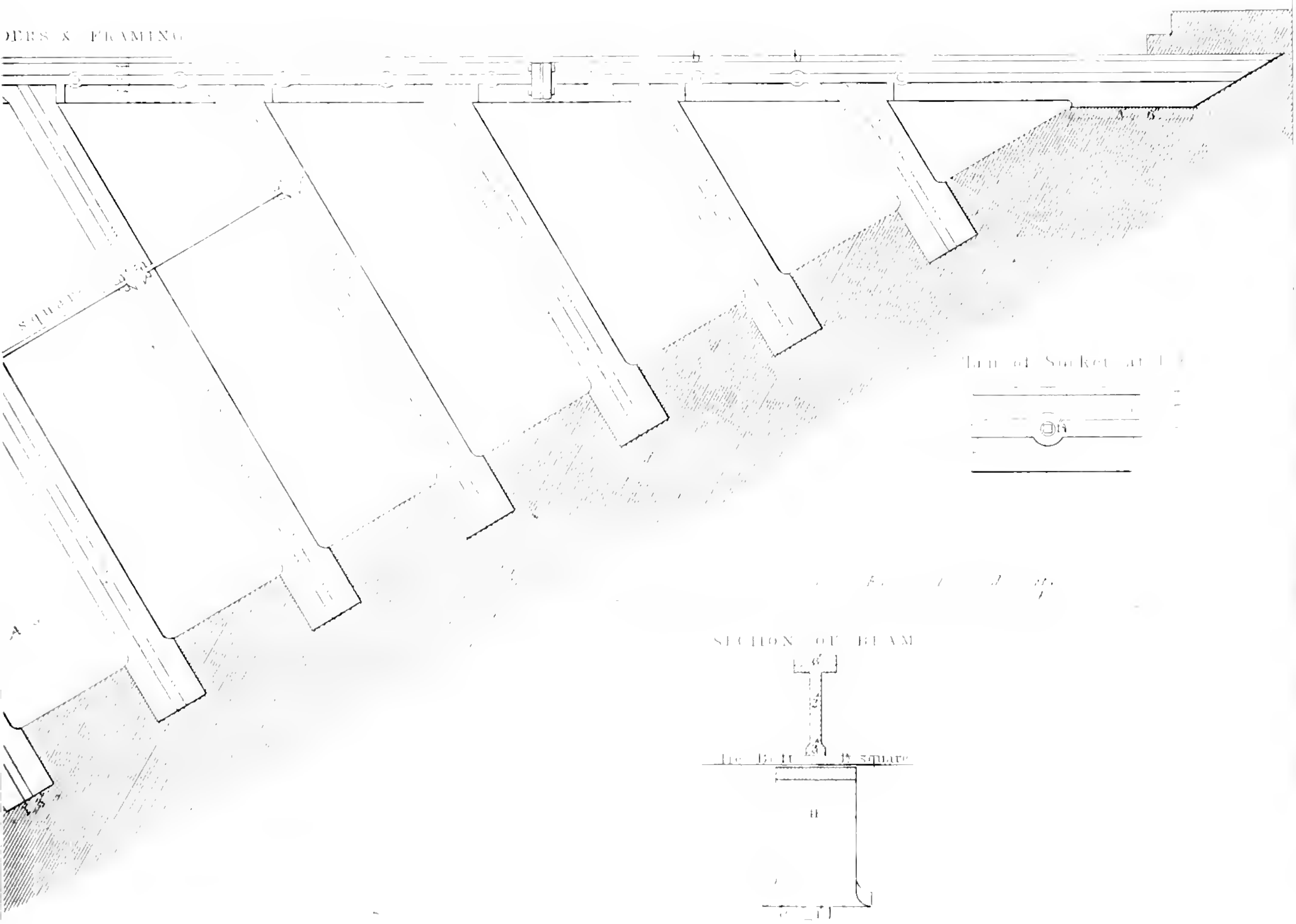


OF OUTSIDE OF MAIN GIRDER

Scale of Feet

DERS & FRAMING



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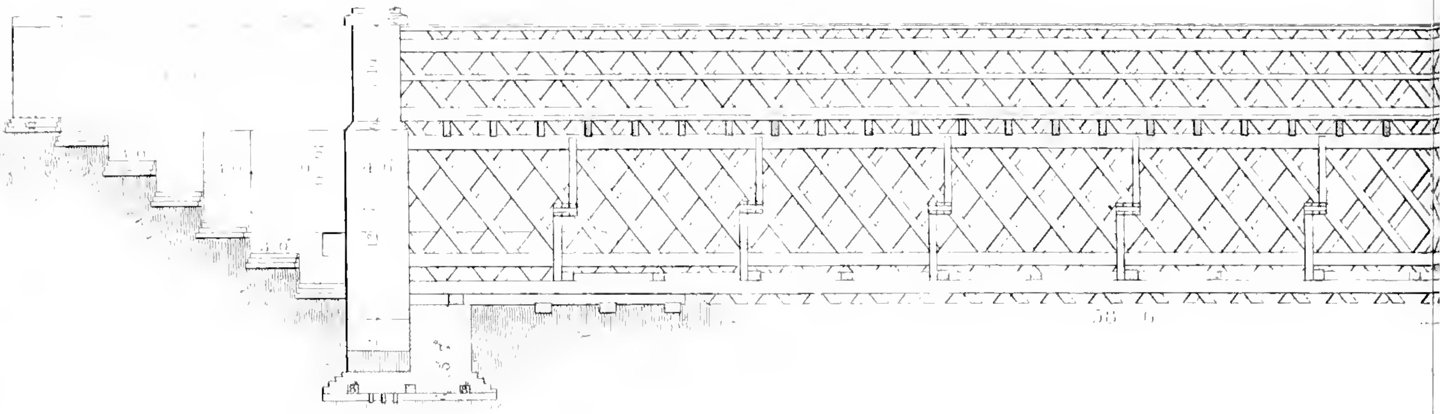
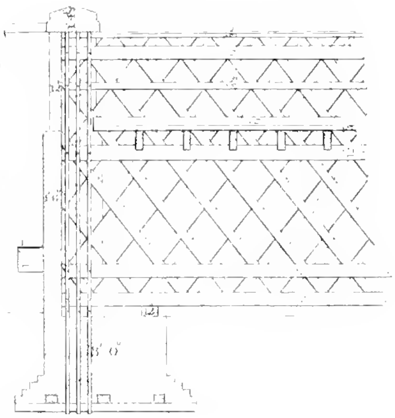
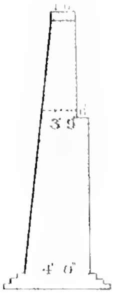
LONGITUDINAL SECTION



SECTION THROUGH PIER



SECTION THROUGH WING WALL



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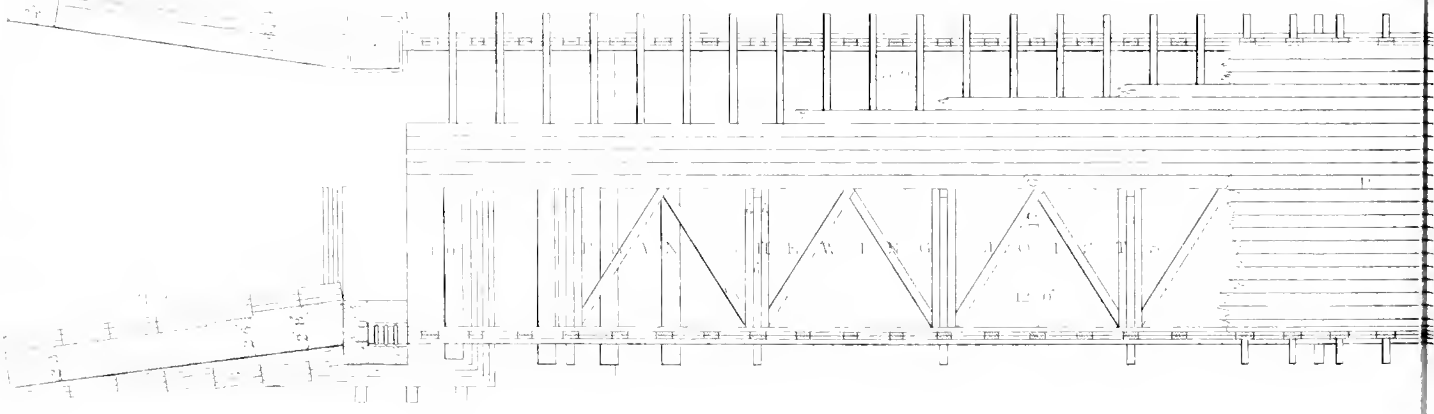

PLAN AT FOUNDATION

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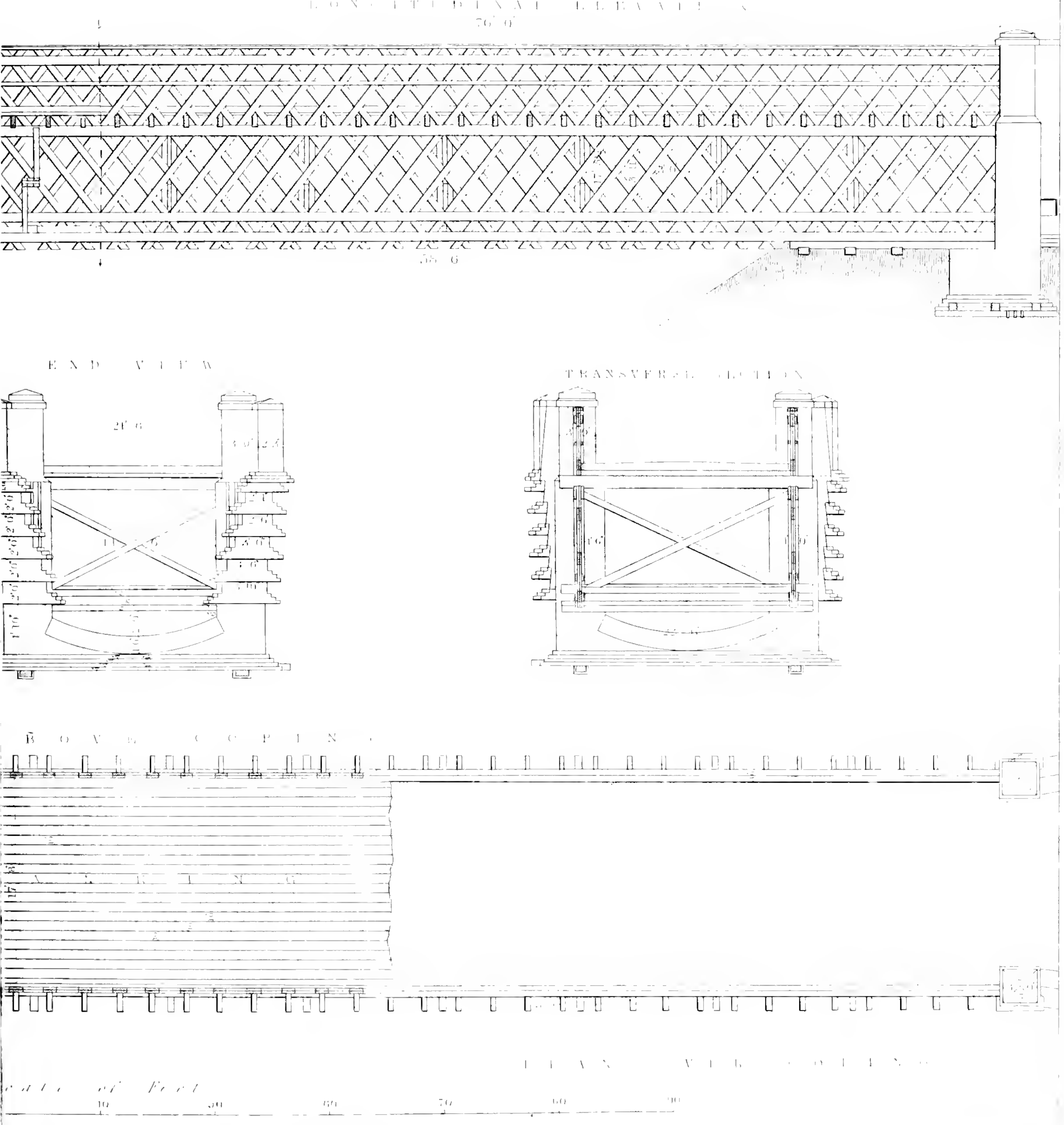

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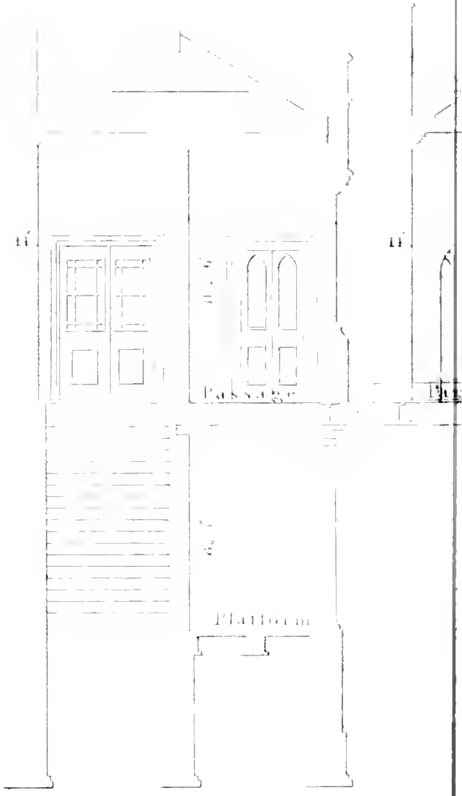
RAILWAY

FRONT ELEVATION

SECTION AT



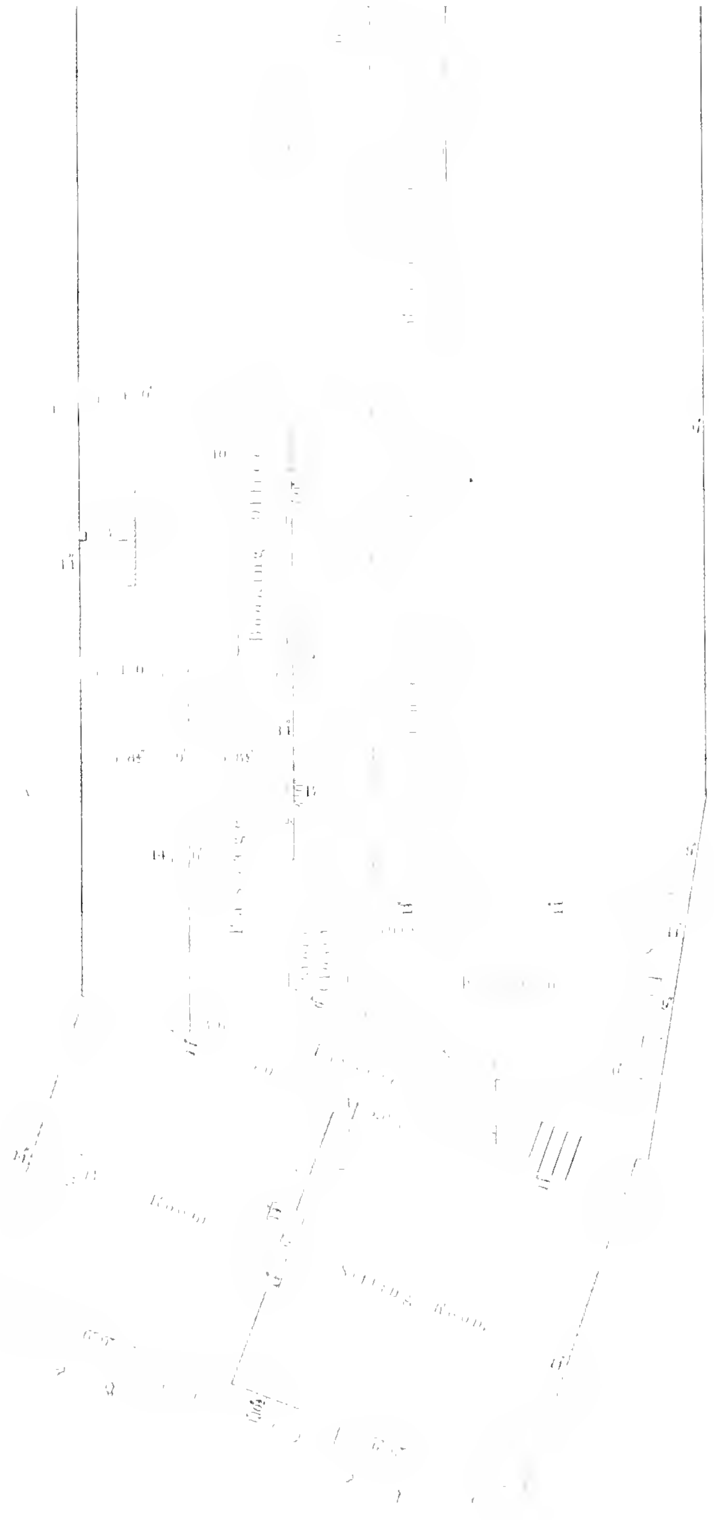
PRACTICE.

DEPOT

SECTION ON THE LINE

DUBLIN

R A I L W A Y



OF FIRST FLOOR

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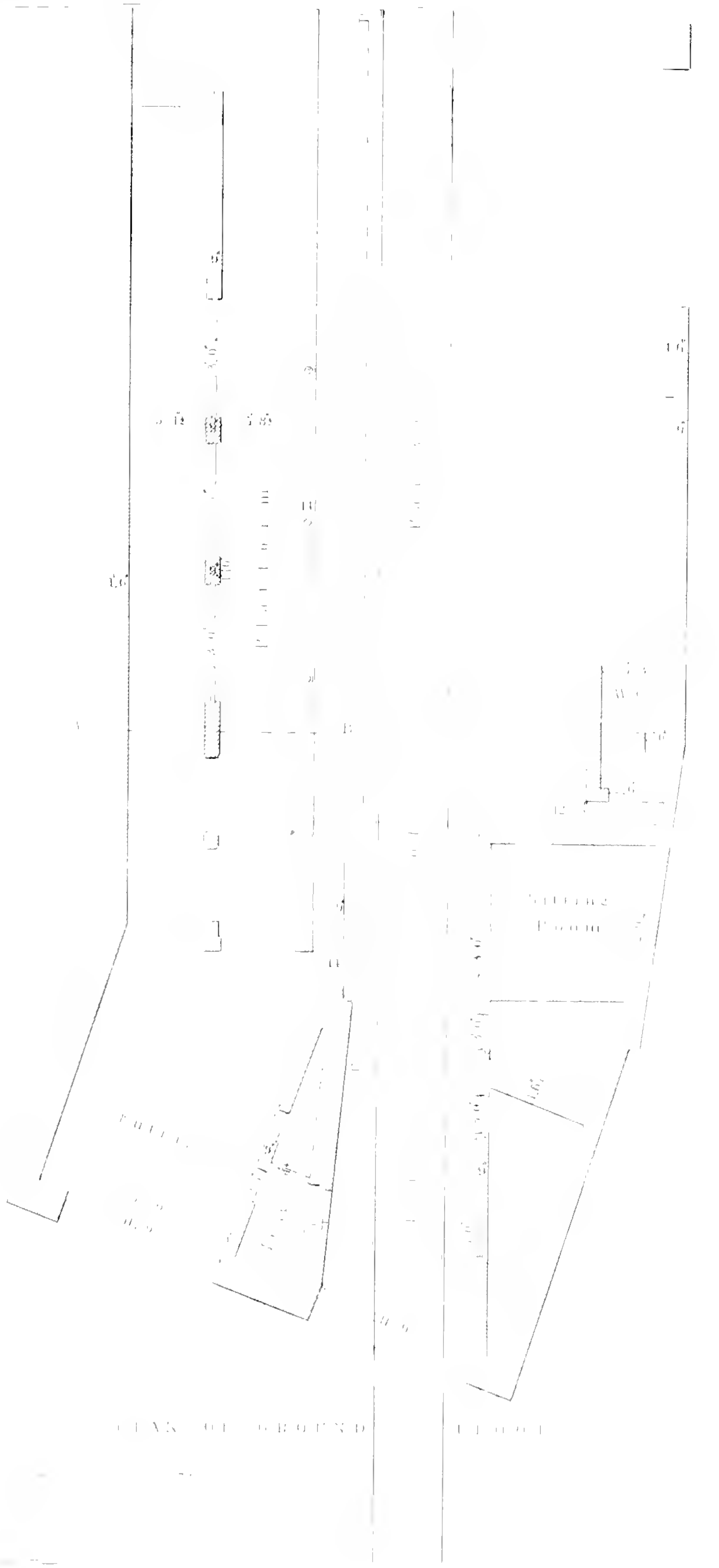

Gt Russell street near the Museum

RAILWAY

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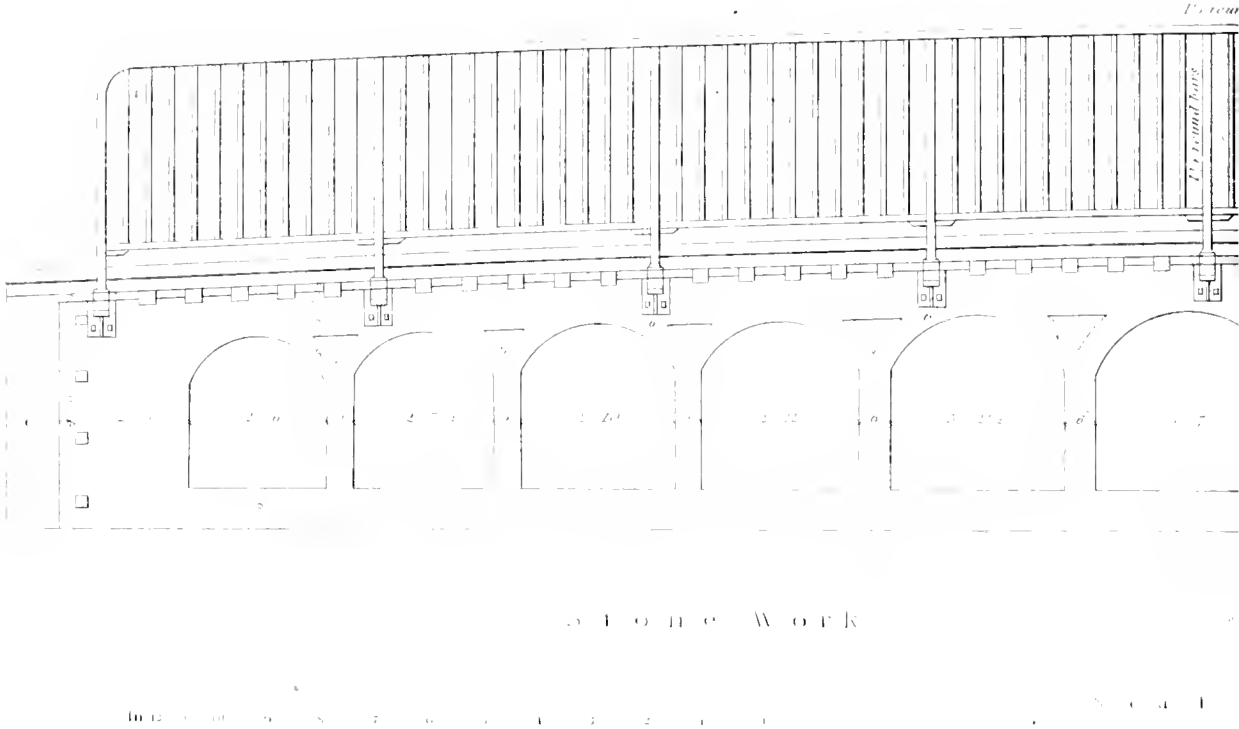
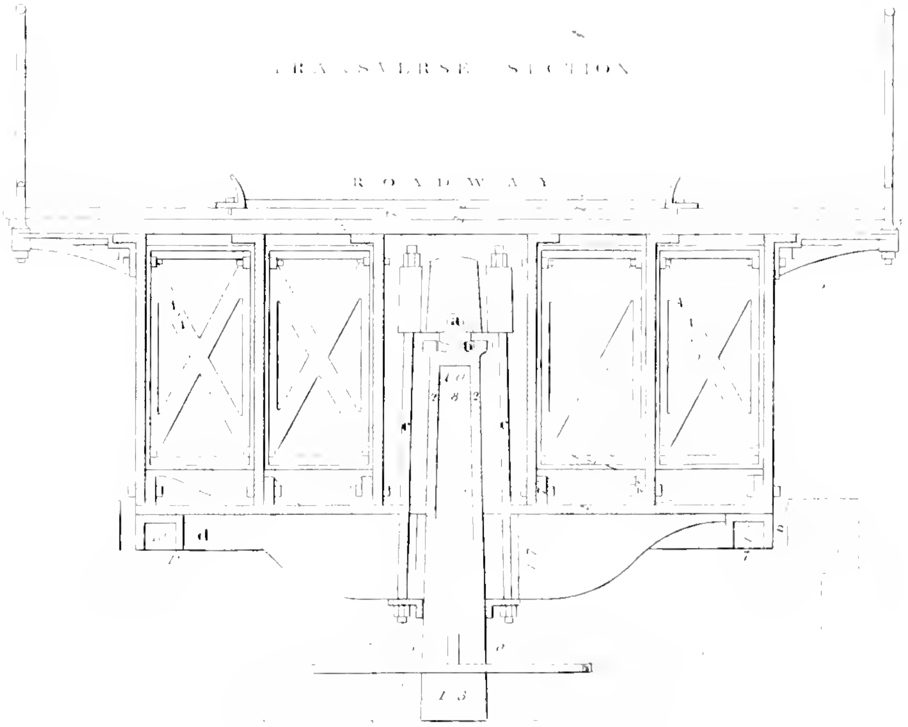


TRANSVERSE SECTION



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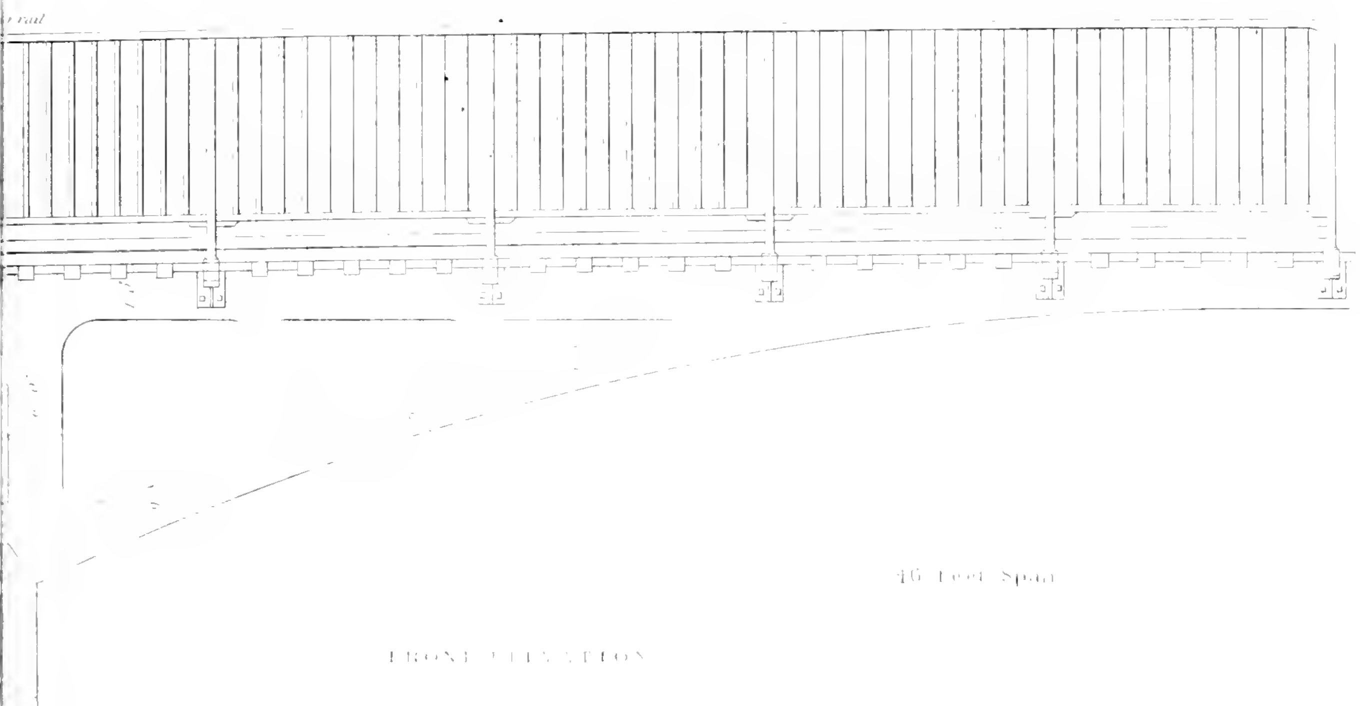

FRONT ELEVATION

of Feet
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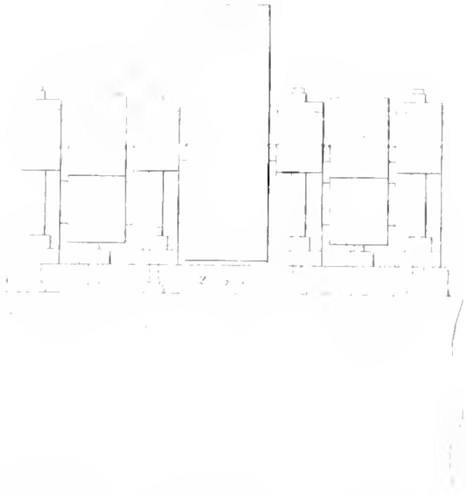
FRICTION ROLLERS



END ELEVATION

TRANSVERSE SECTION

Scale 1 inch to the foot
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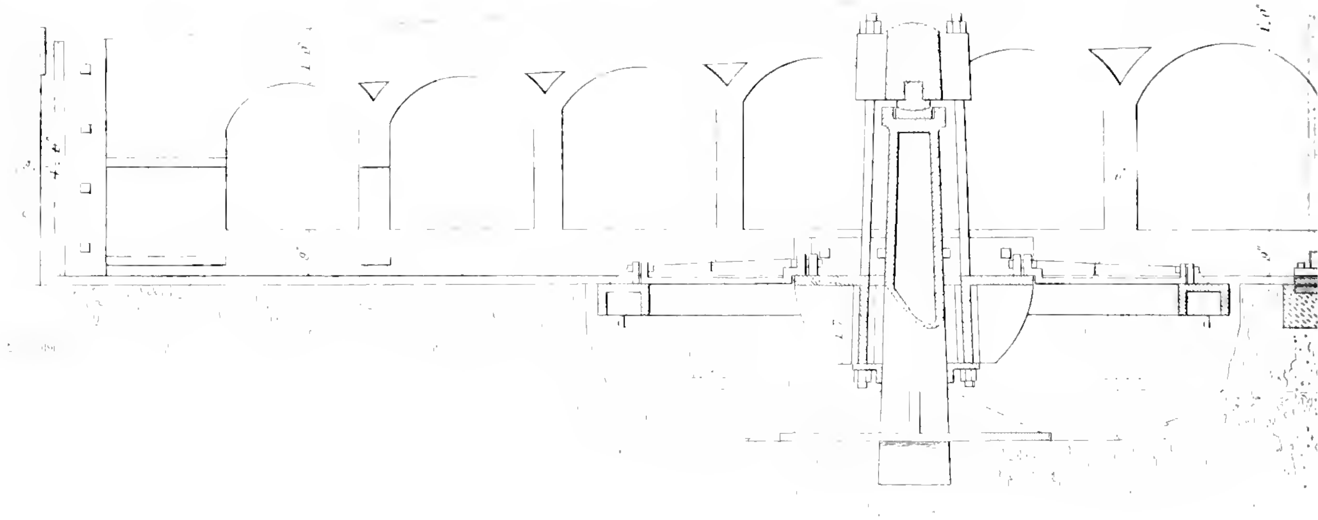
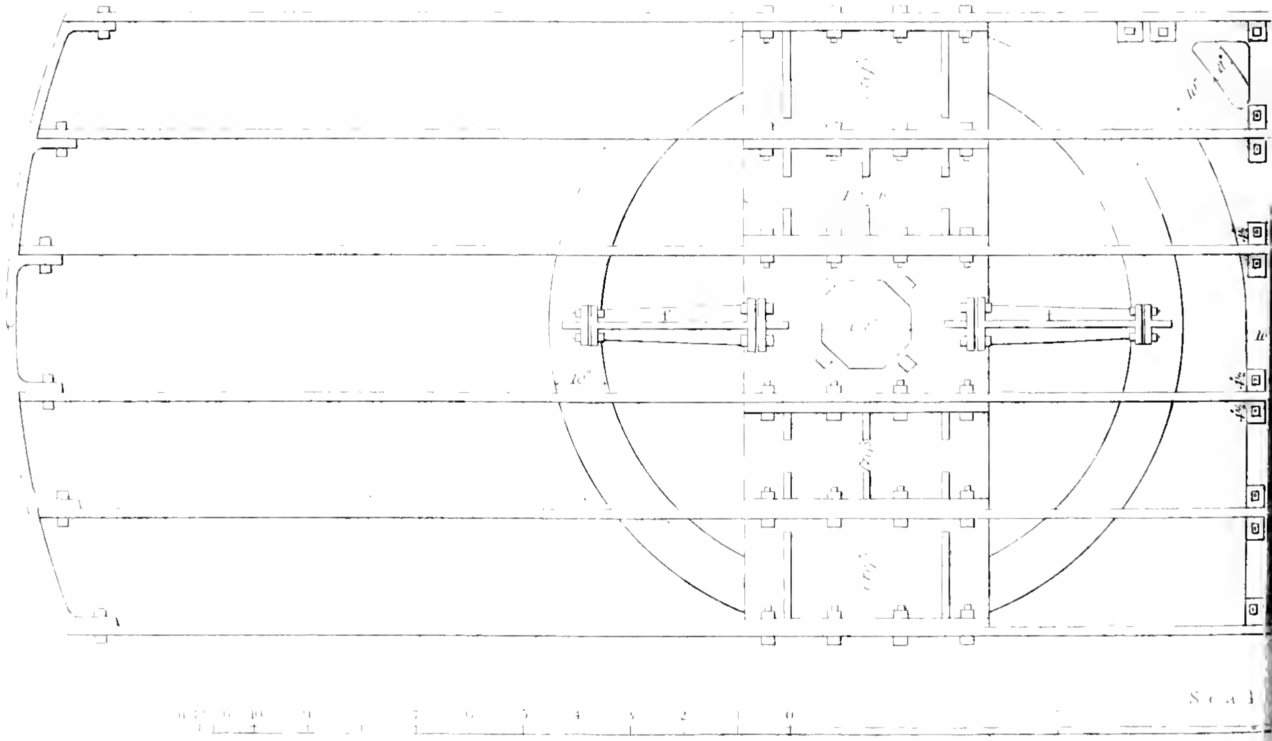
RAILWAY

GENE





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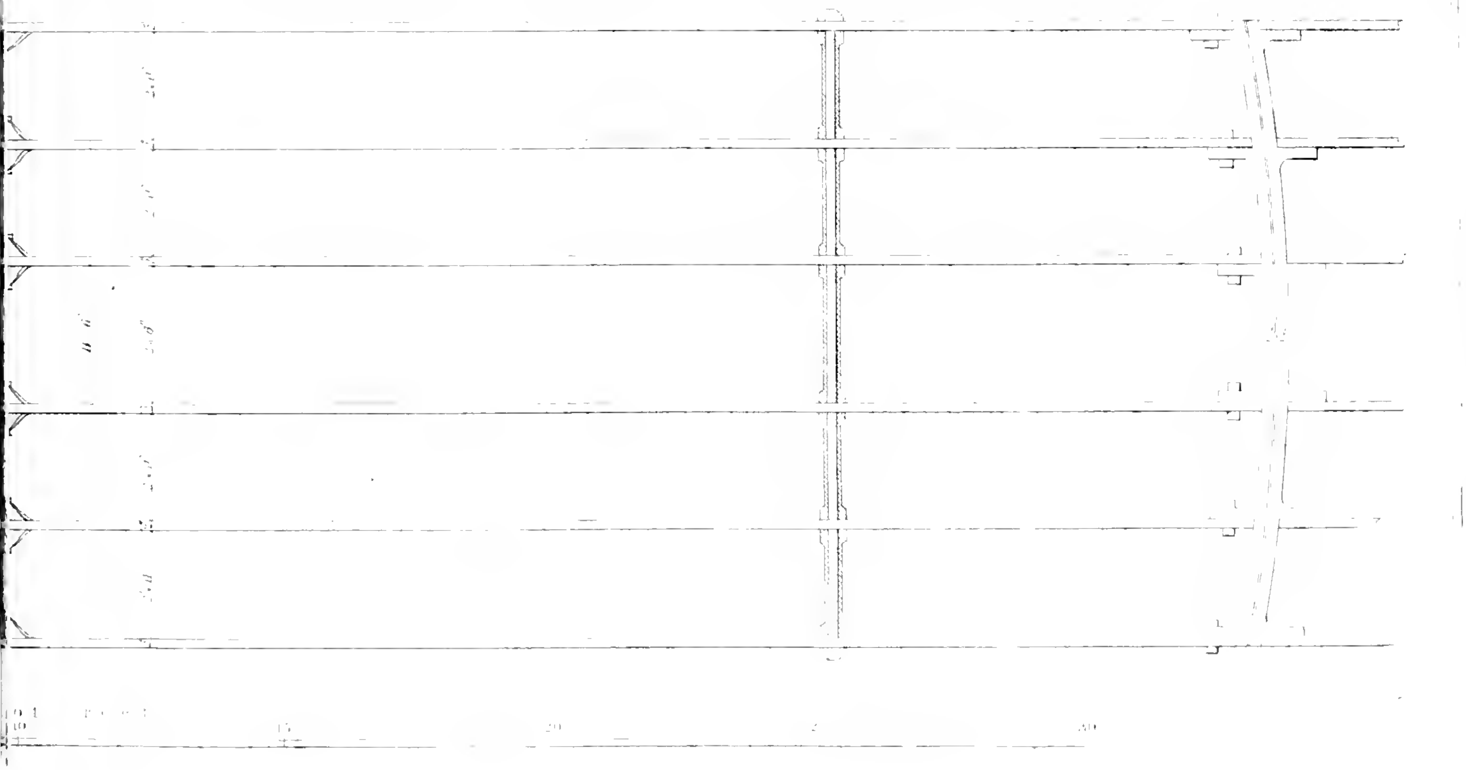
John Williams, Library

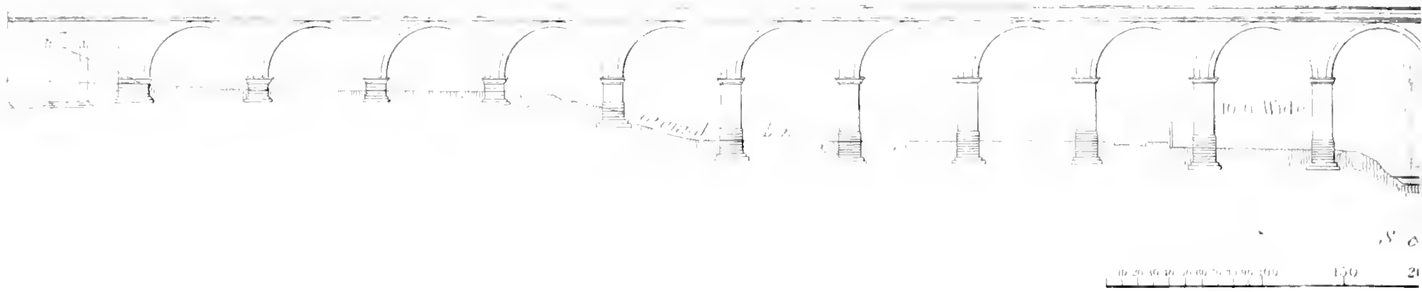
LONGITUDINAL SECTION



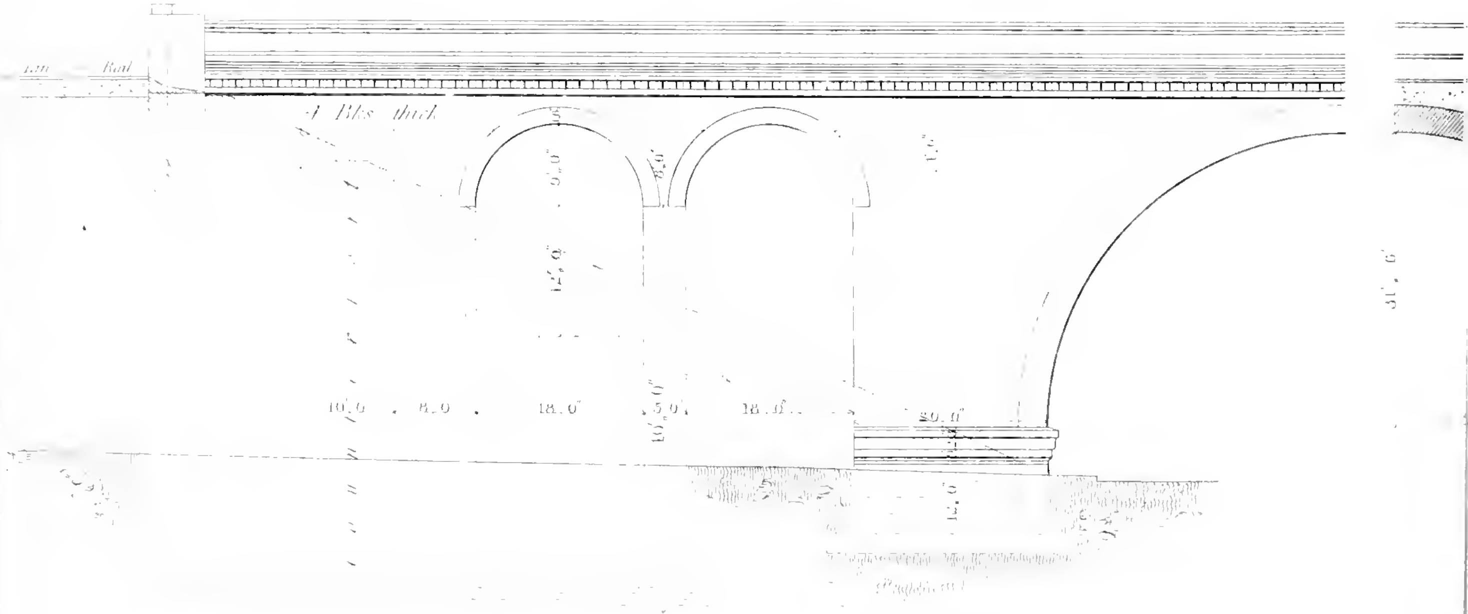
RAILWAY

G. W. BUCK

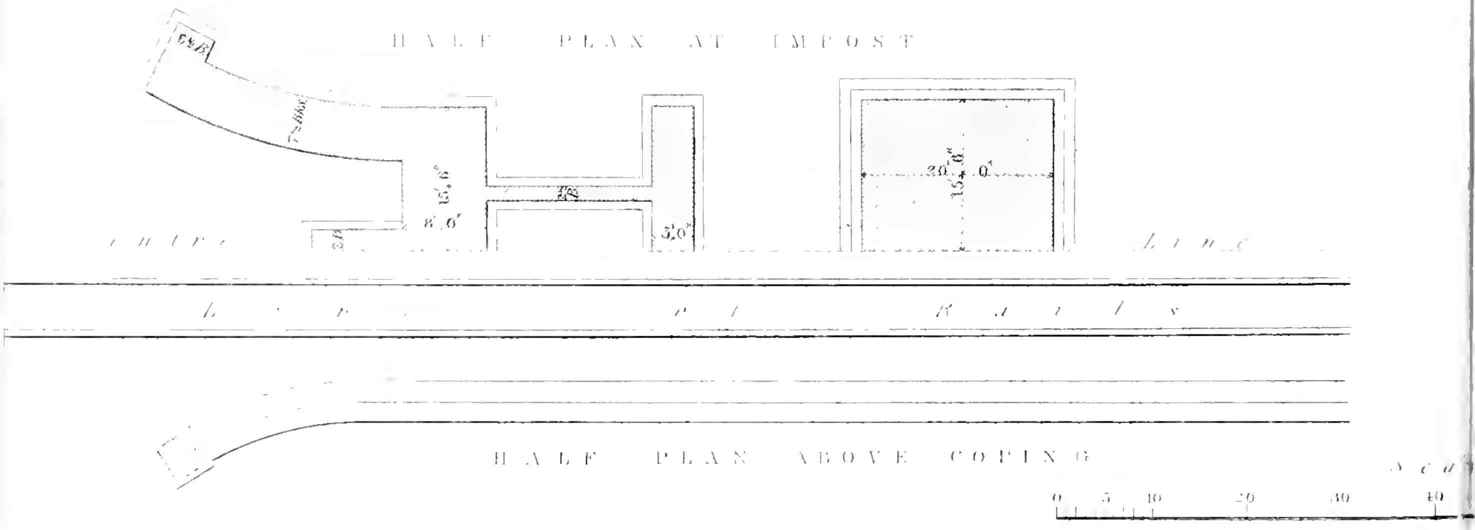
ELEVATION OF ST



ELEVATION OF WING WALL



HALF PLAN AT IMPOST



HALF PLAN ABOVE COPING

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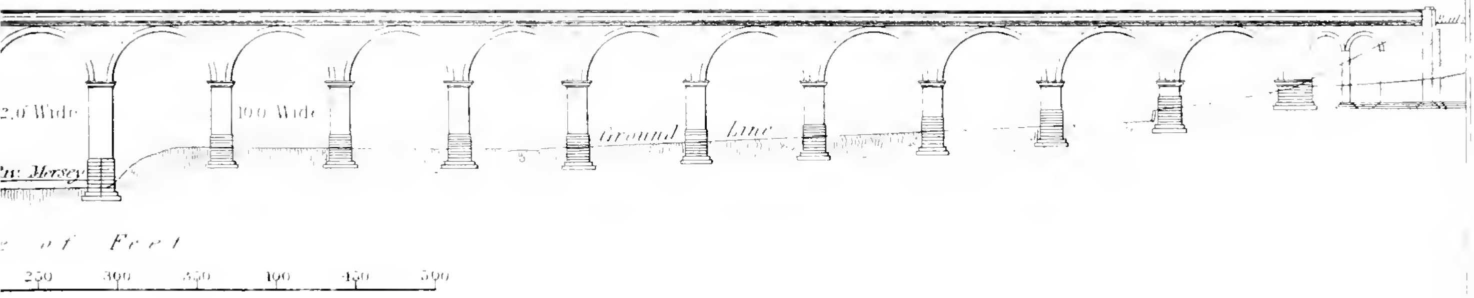
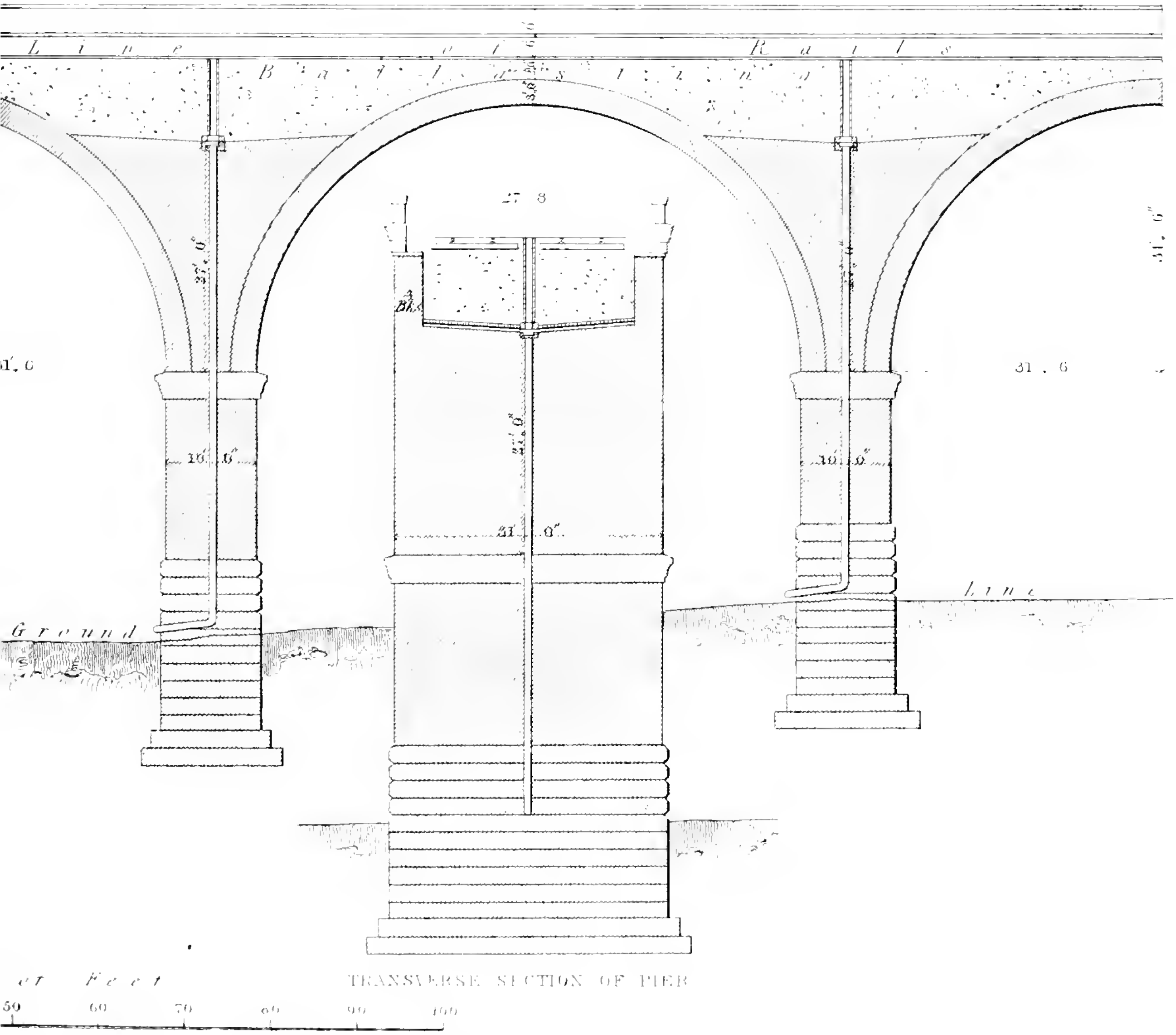


SECTION OF AN ARCH & PIERS



TRANSVERSE SECTION OF PIER

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R A I L W A Y

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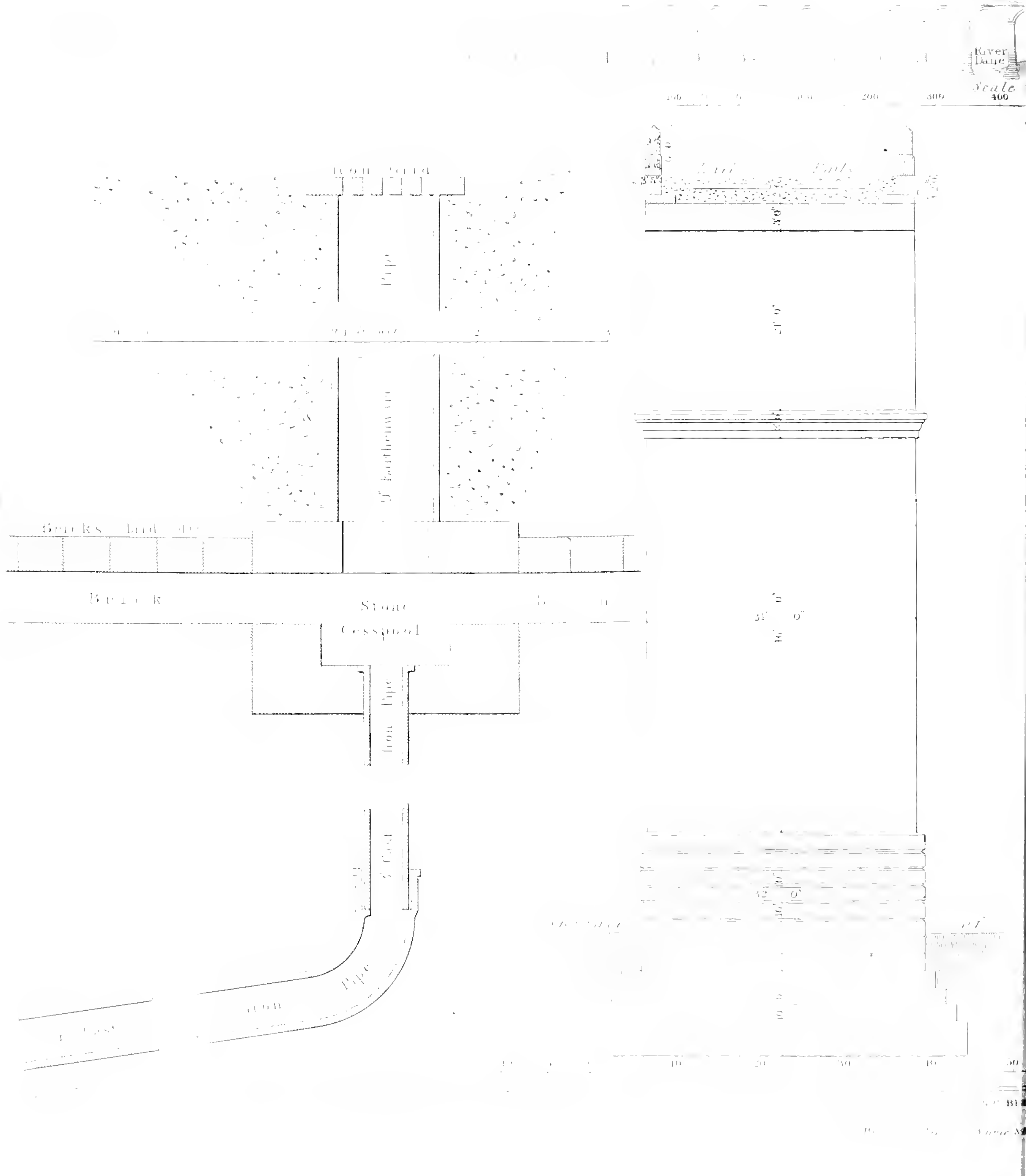


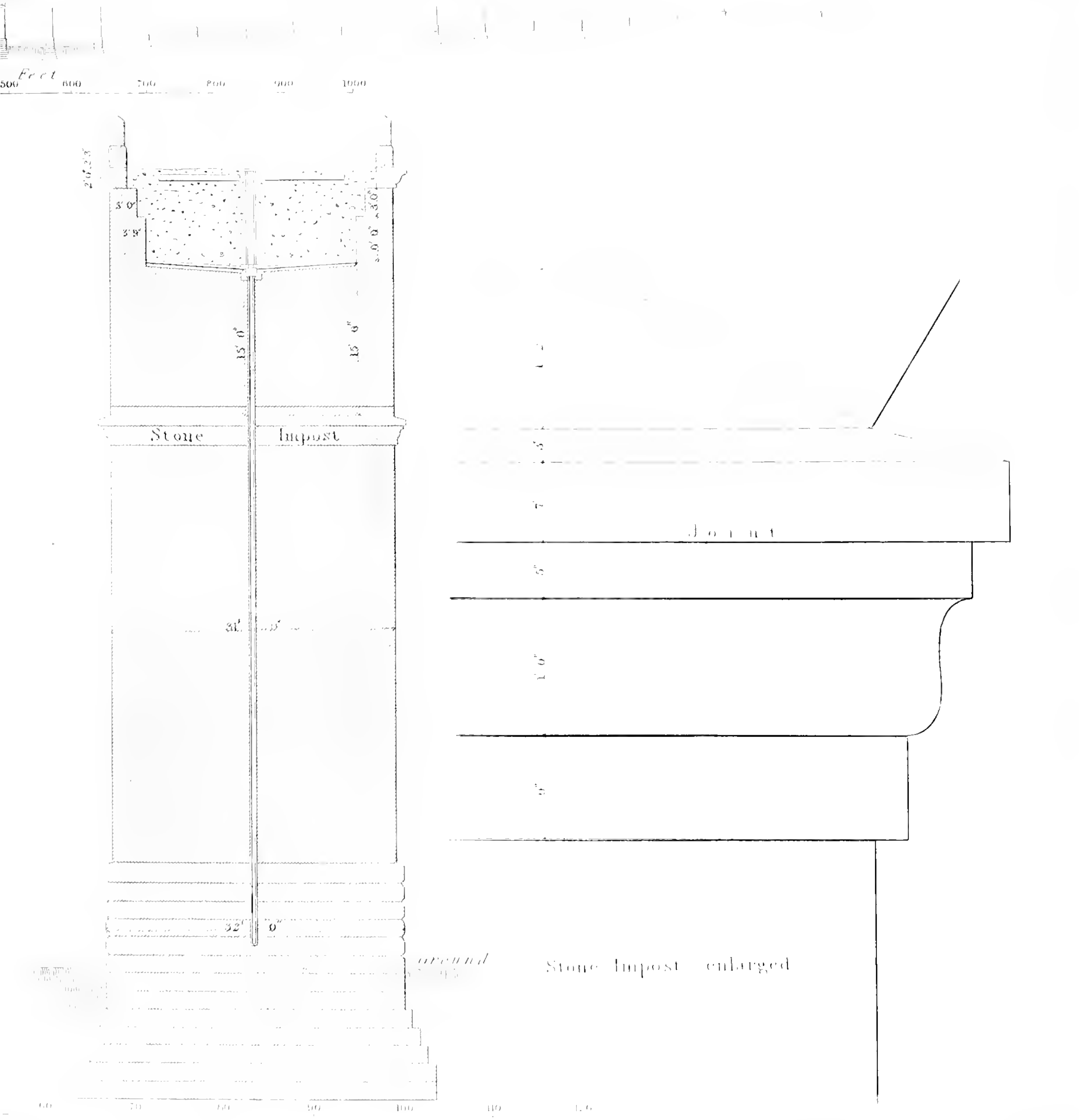
P R A C T I C E.

Plate 53

ENGINEER

V I A D U C T

T I O N



Stone Impost enlarged

E. DIEFN

G. Hoskin

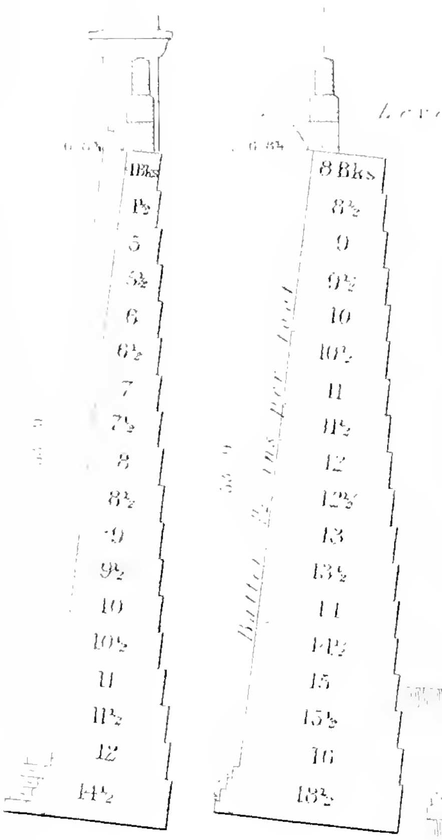
on 1 Russel Street over the Museum

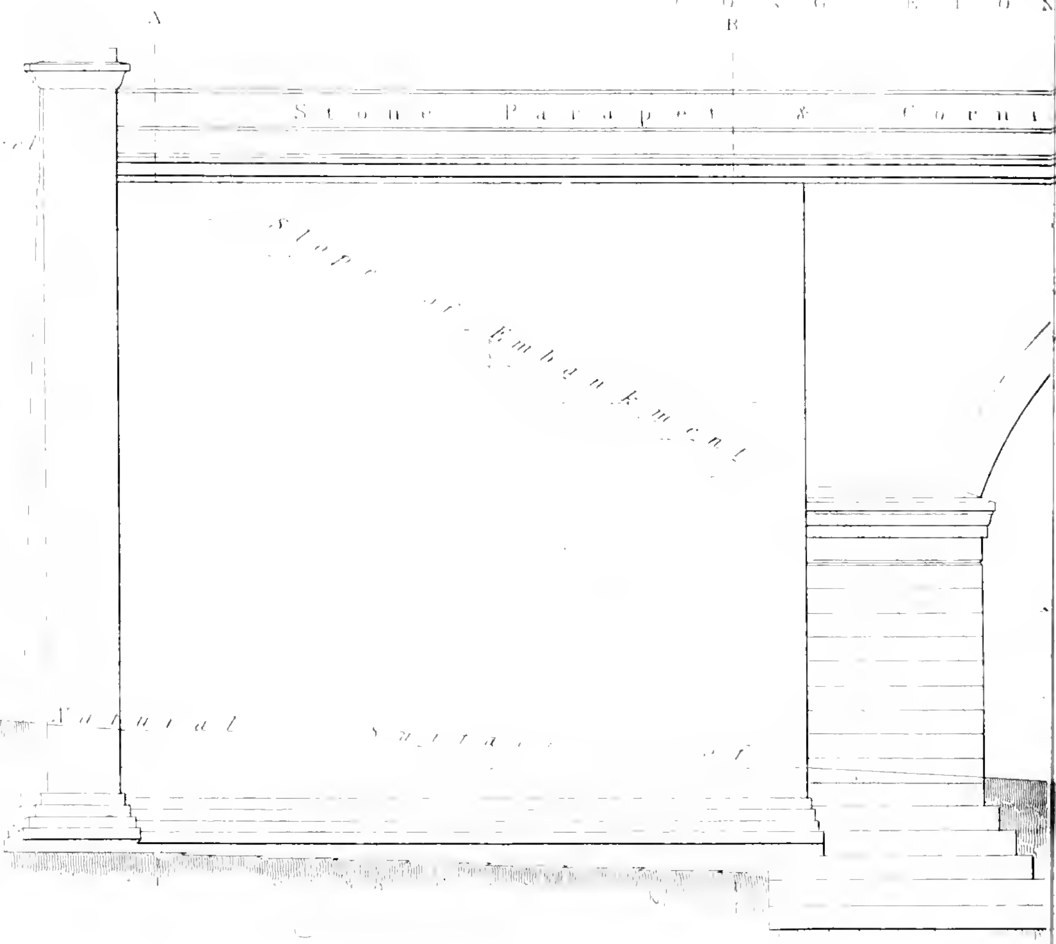
RAILWAY

CH BUCK

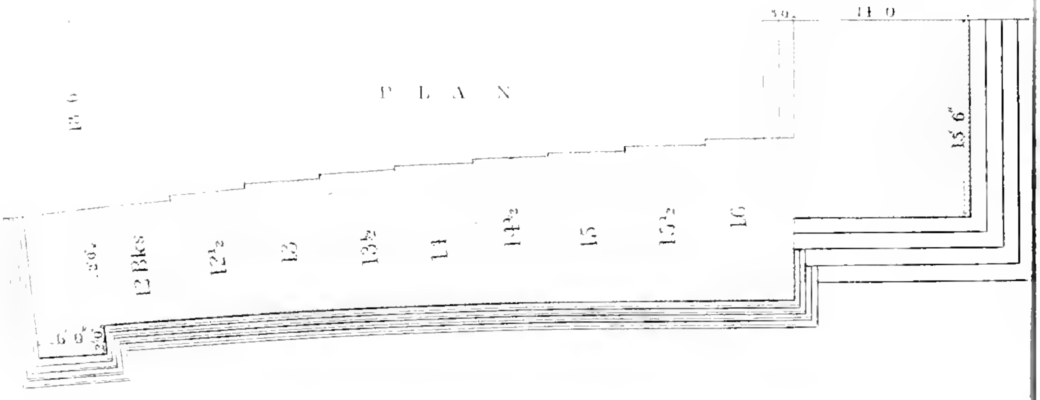
CONGLETON

SECTIONS OF WING WALL AT





ELEVATION OF NORTH ABUTMENT



Scale

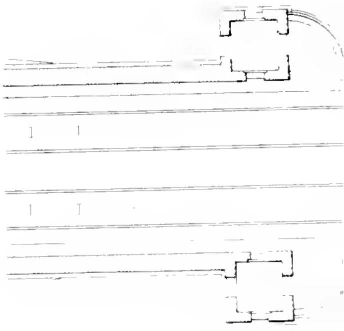
S. C. BRES

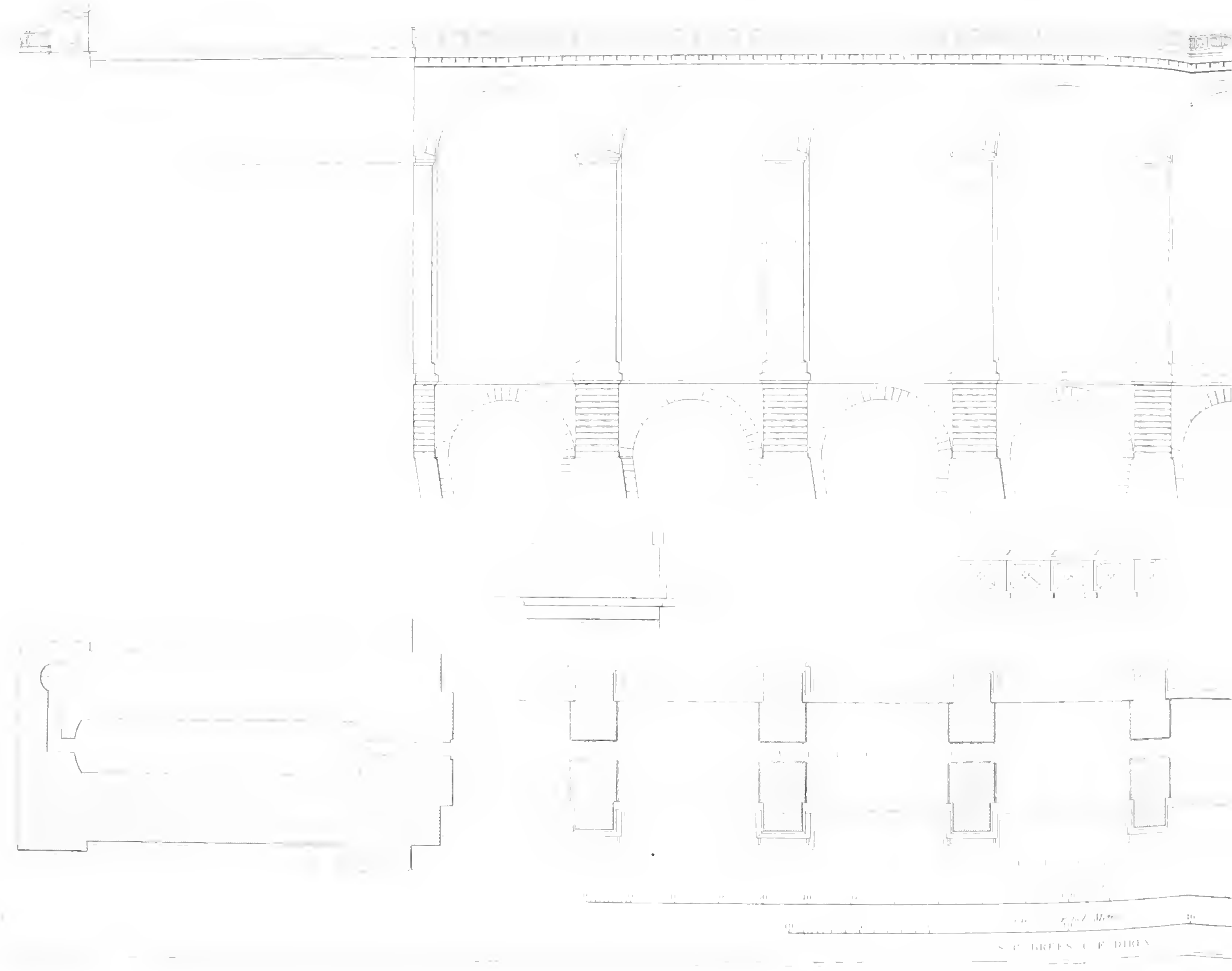
John Williams's Library of Science &

P R A C T I C E.

LONGITUDINAL SECTION OF AN ARCH

...llo o^t^ Ruſsel Street near the Museum.





S. C. GREES C. F. DIRON

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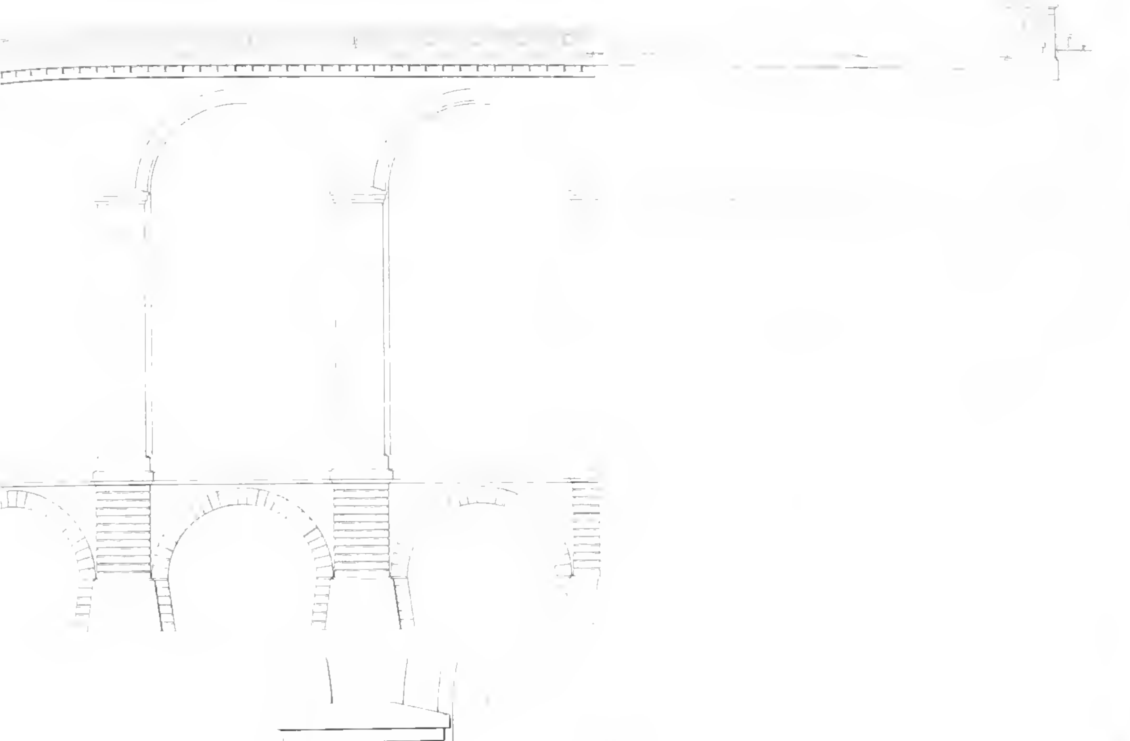
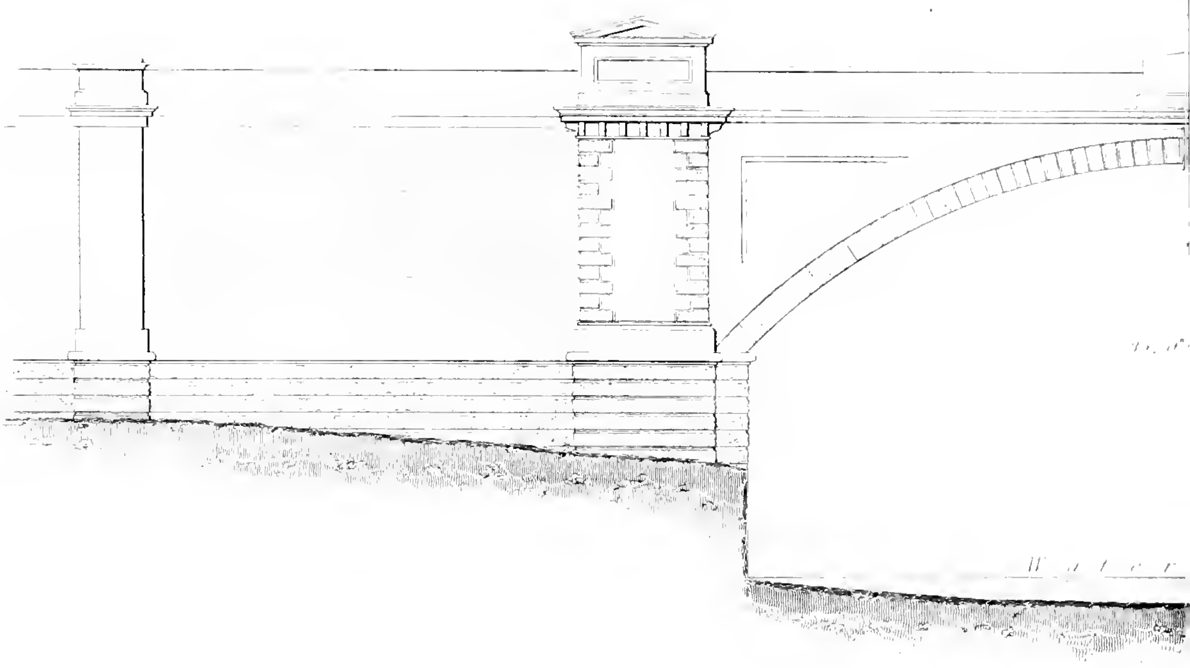


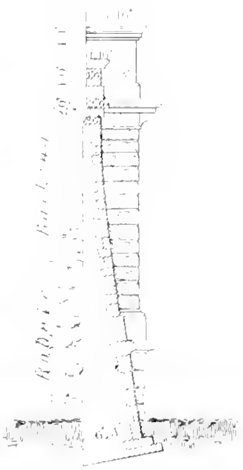
RAILWAY

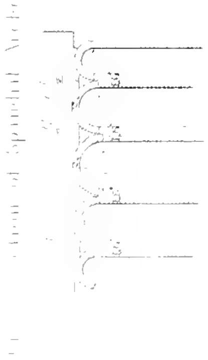
BRIDGE OVER



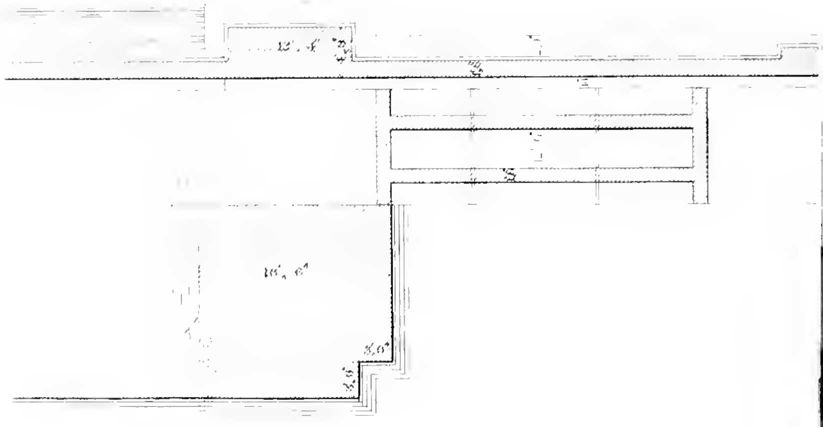
E L E V

TION OF WING WALL





PLAN OF ABUTMENTS PARAPET &c



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PRACTICE.

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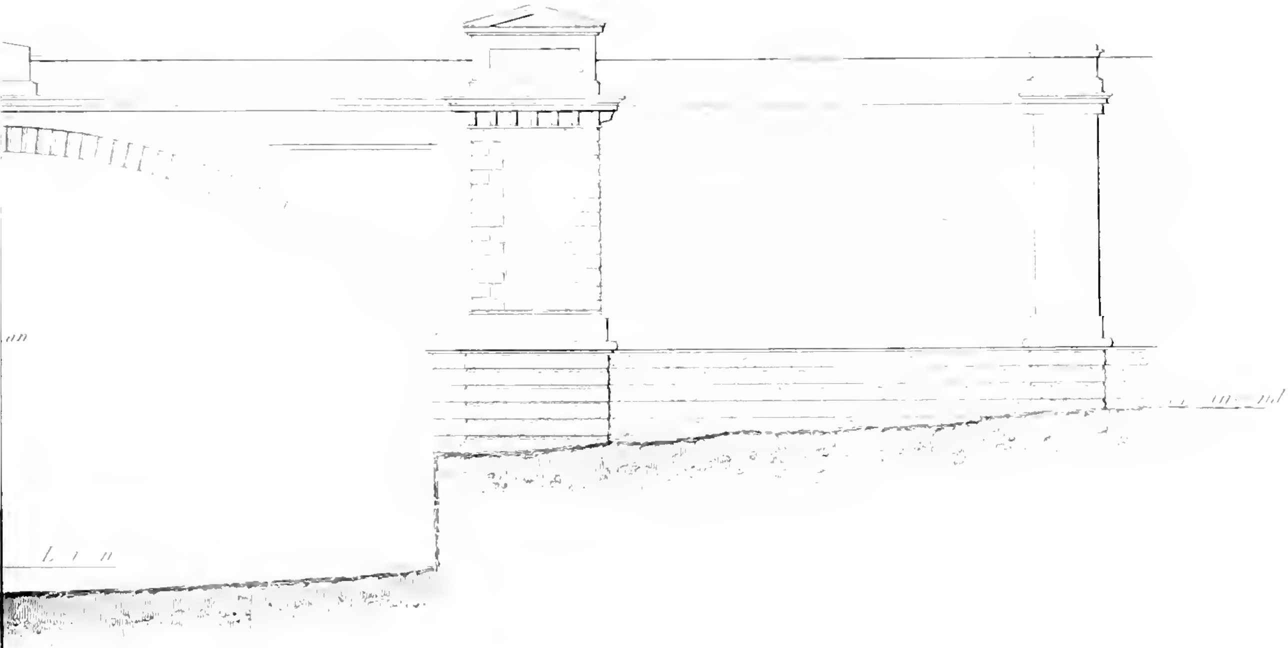

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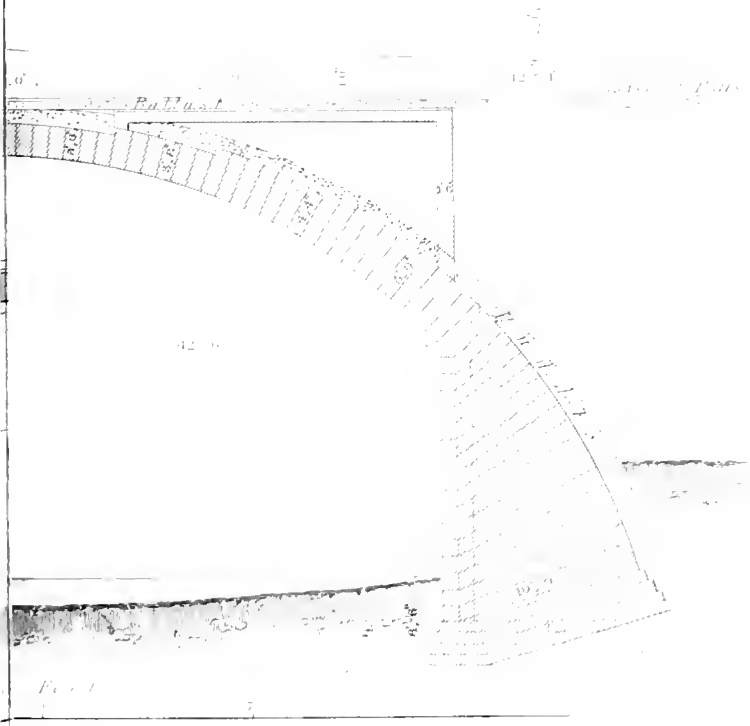
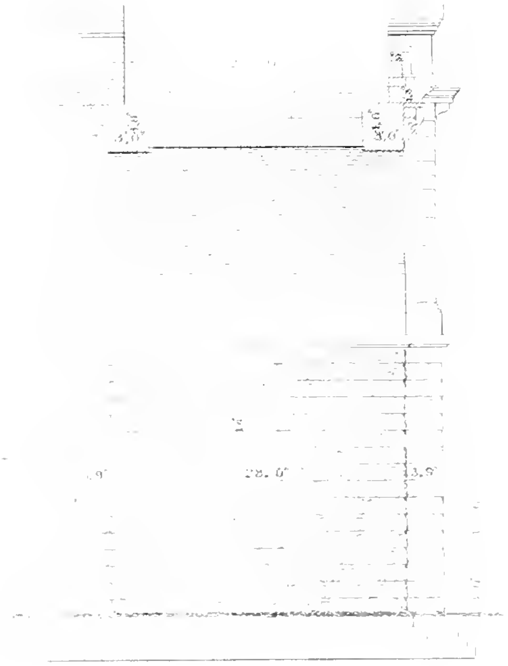
LONGITUDINAL SECTION



SECTION THRO' CROWN OF ARCH



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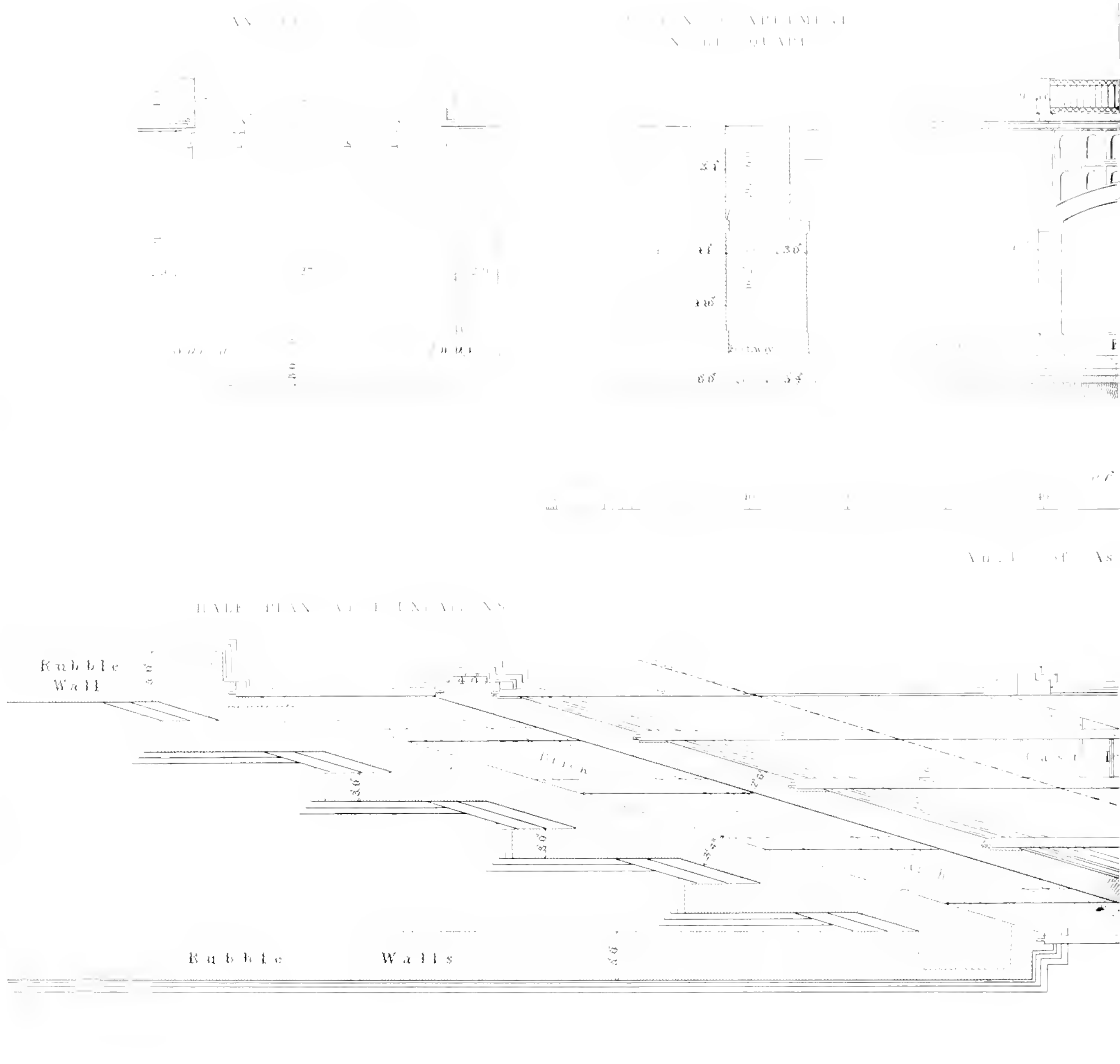
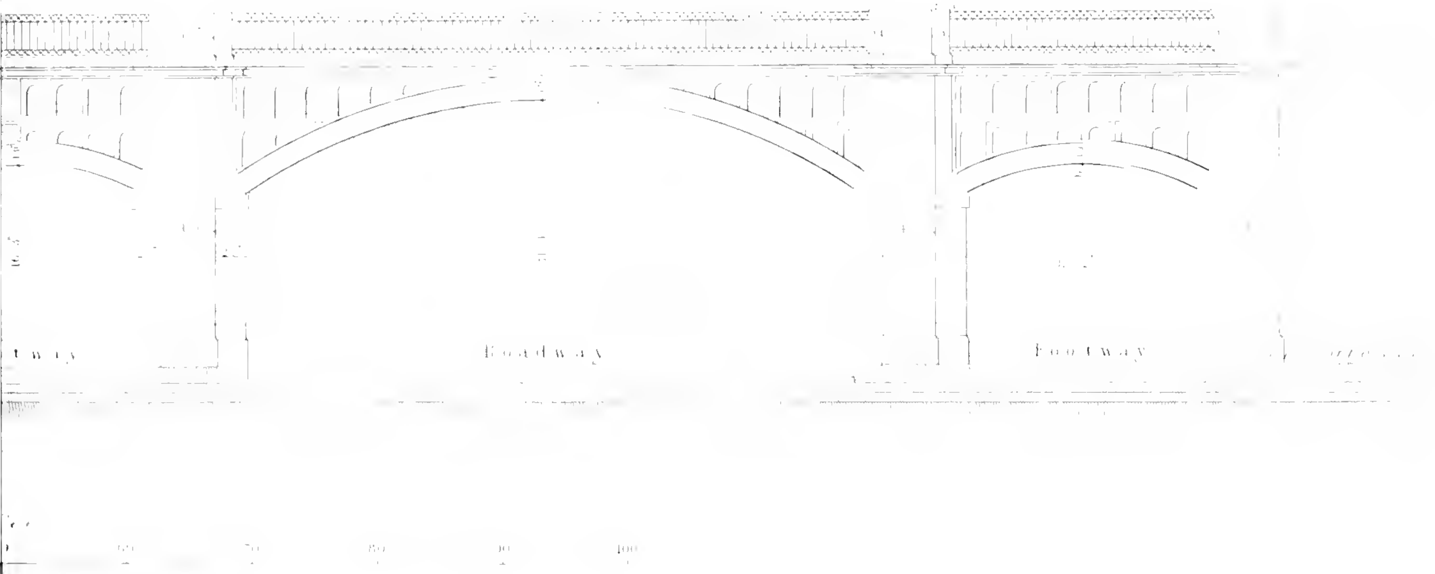
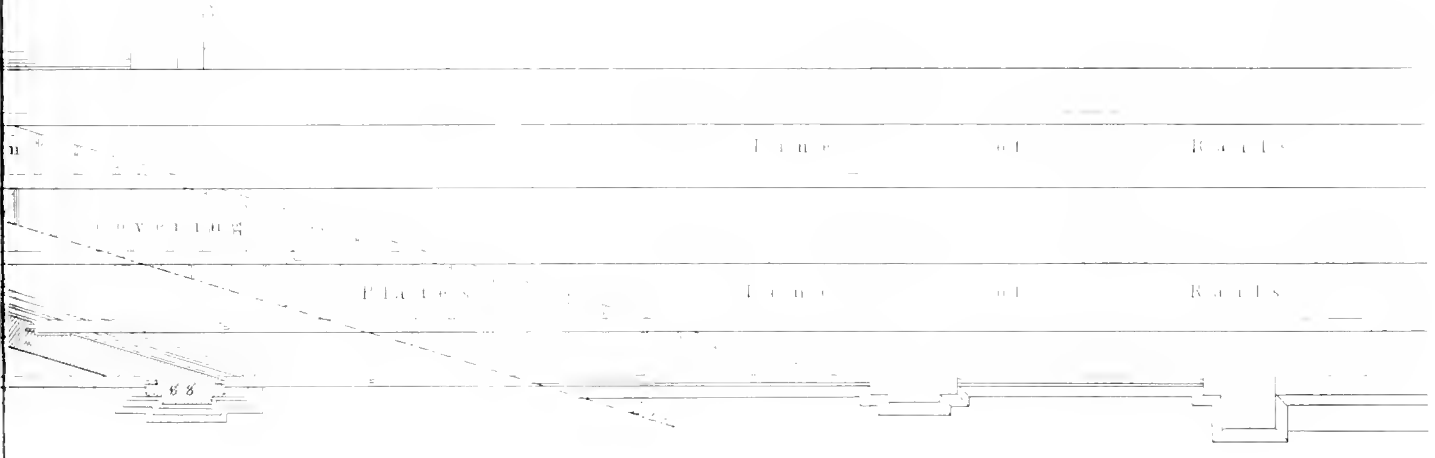
RAILWAY



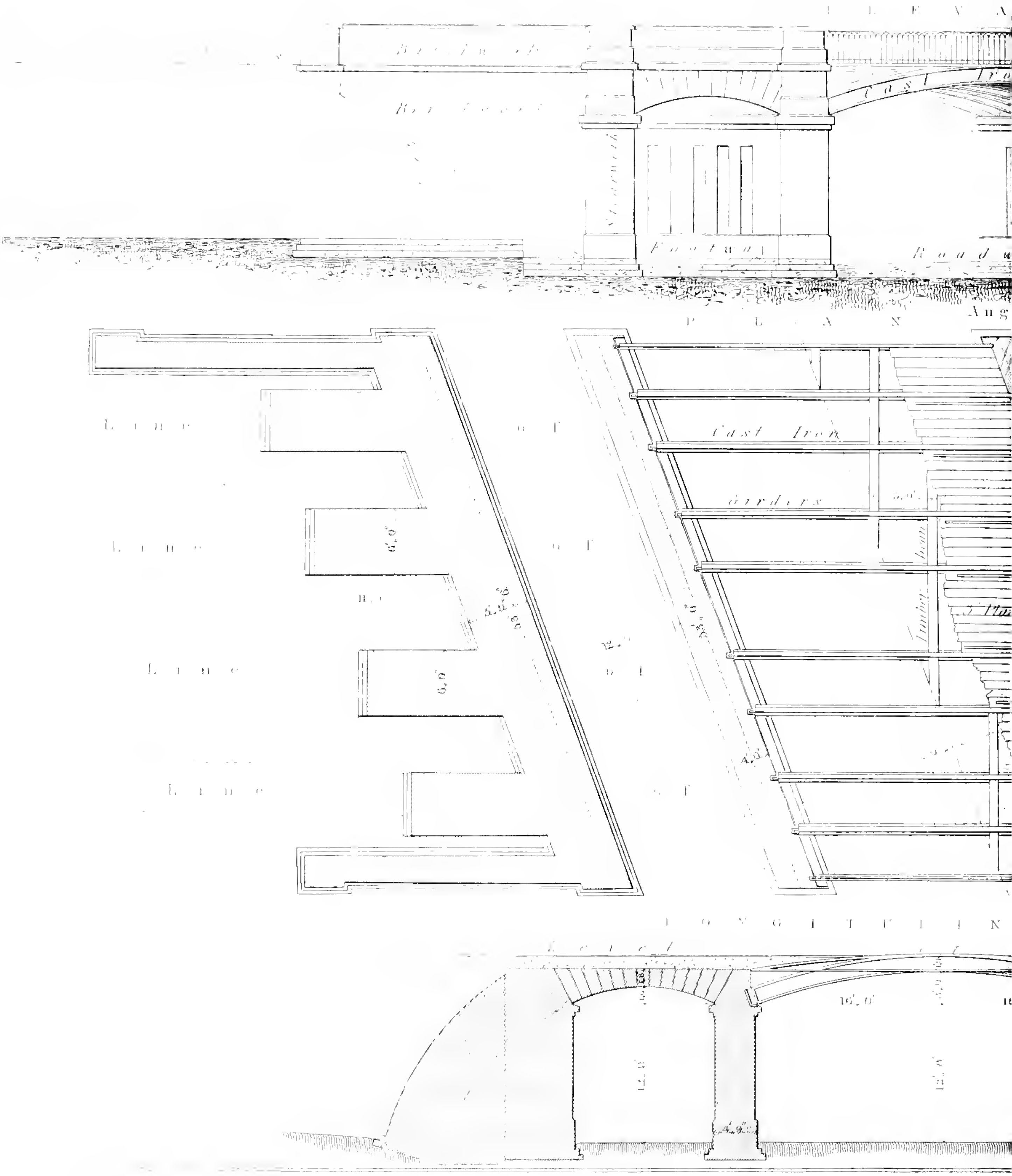
PRACTICE.


Footway
Roadway
Footway


Line of Rails
Covering
Plates
Line of Rails

RAILWAY

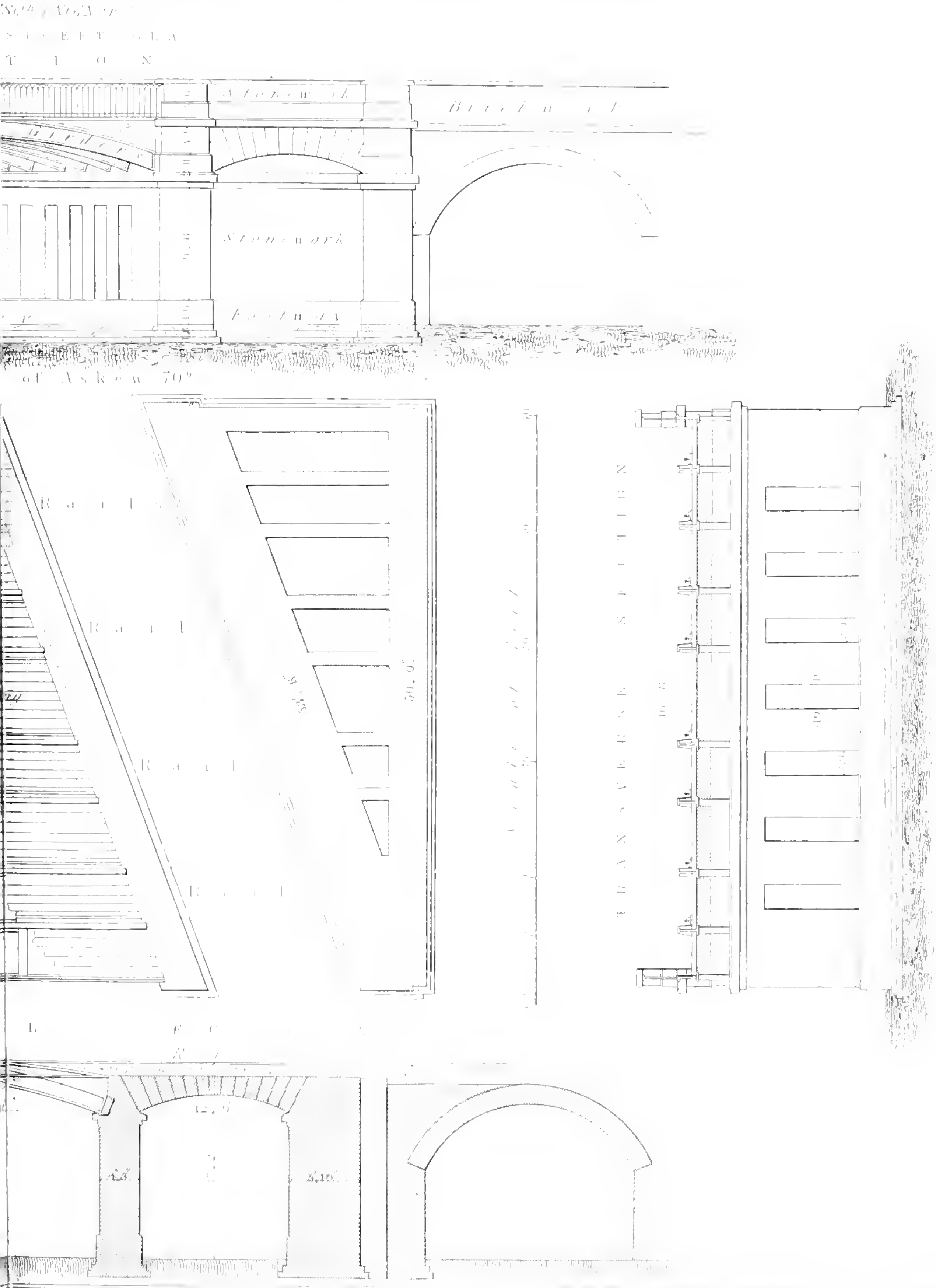
JOSEPH LOCKE



S C BREES,

Williams Library of Science & Ar

PRACTICE.

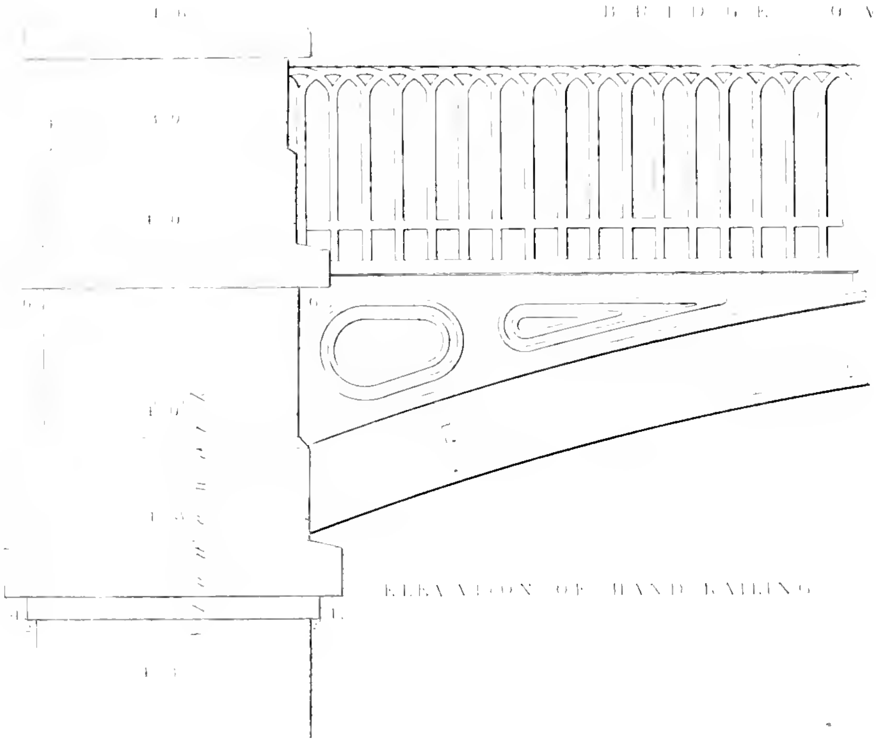


DIREX

R A I L W A Y

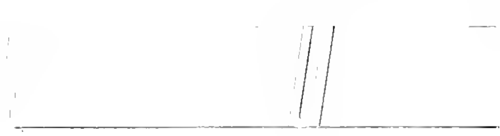
JOSEPH LOCKE

BRIDGE OVER COQ



ELEVATION OF HAND RAILING

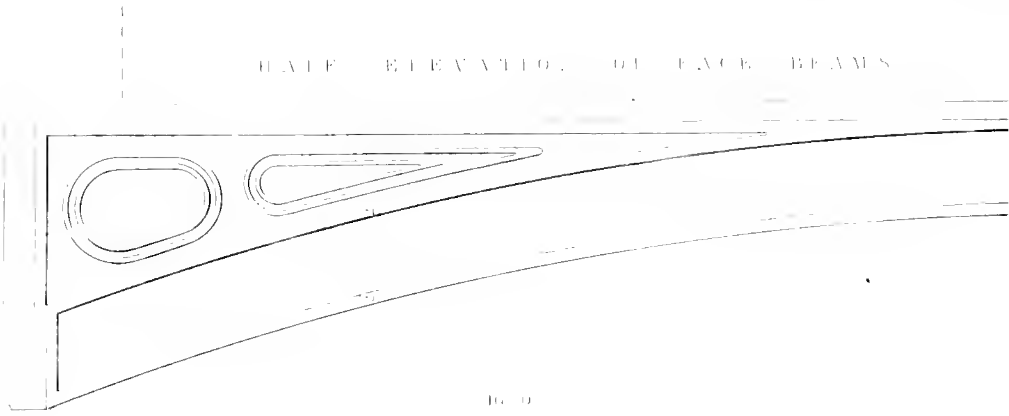
ELEVATION



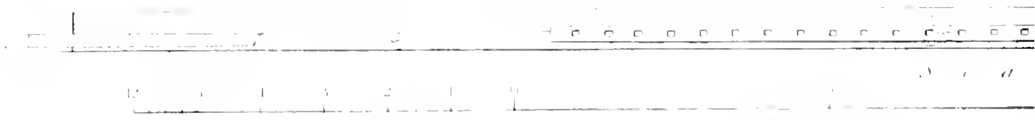
SECTION

SECTION AT A

HALF ELEVATION OF FACE BEAMS



HALF PLAN OF FACE BEAMS

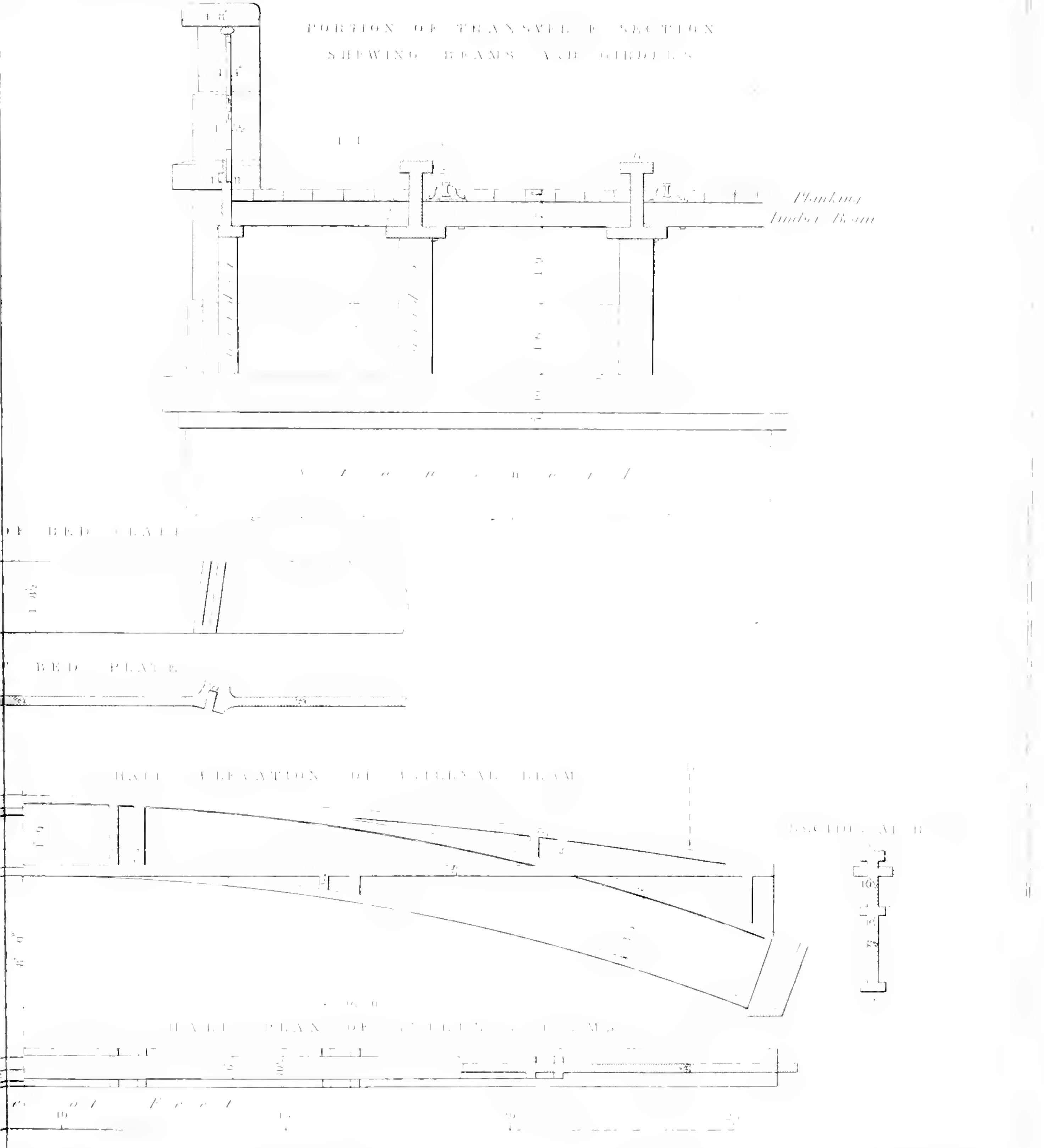


N. C. BREE

PRACTICE.

ESQ^R ENGINEER

STREET GLASGOW

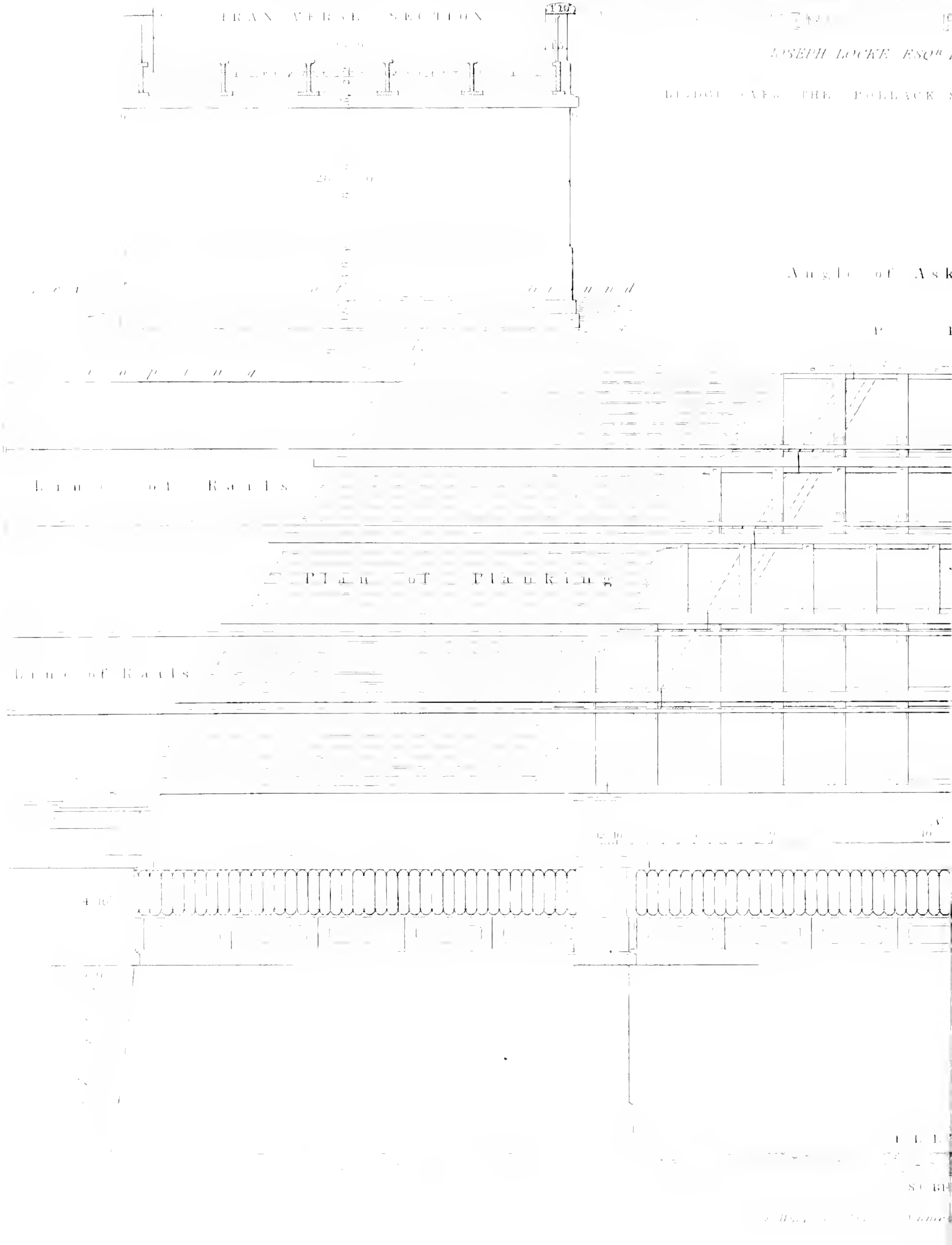


TE DIREC.

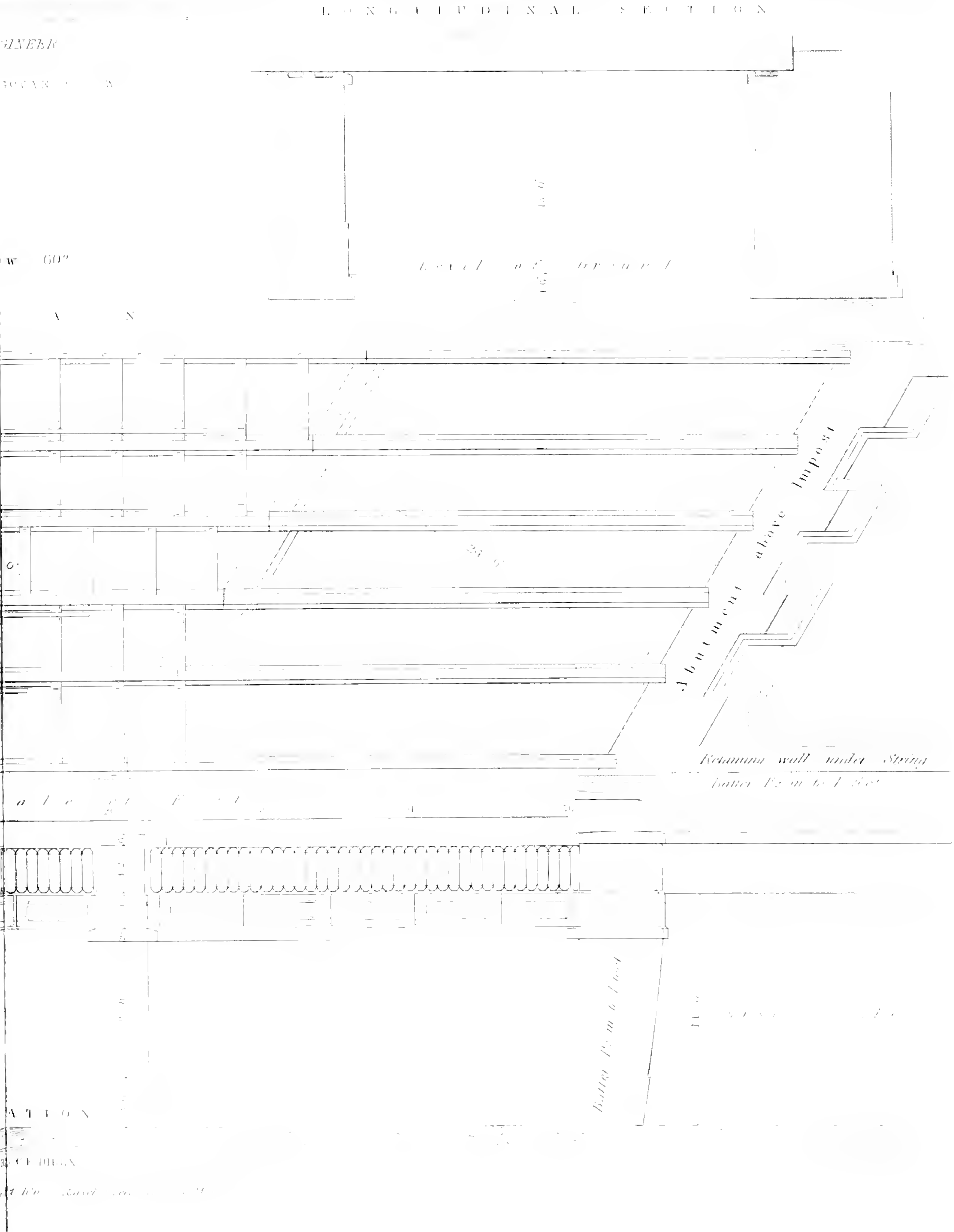
RAILWAY

JOSEPH LOCKE ESQR

BRIDGE OVER THE POLLACK



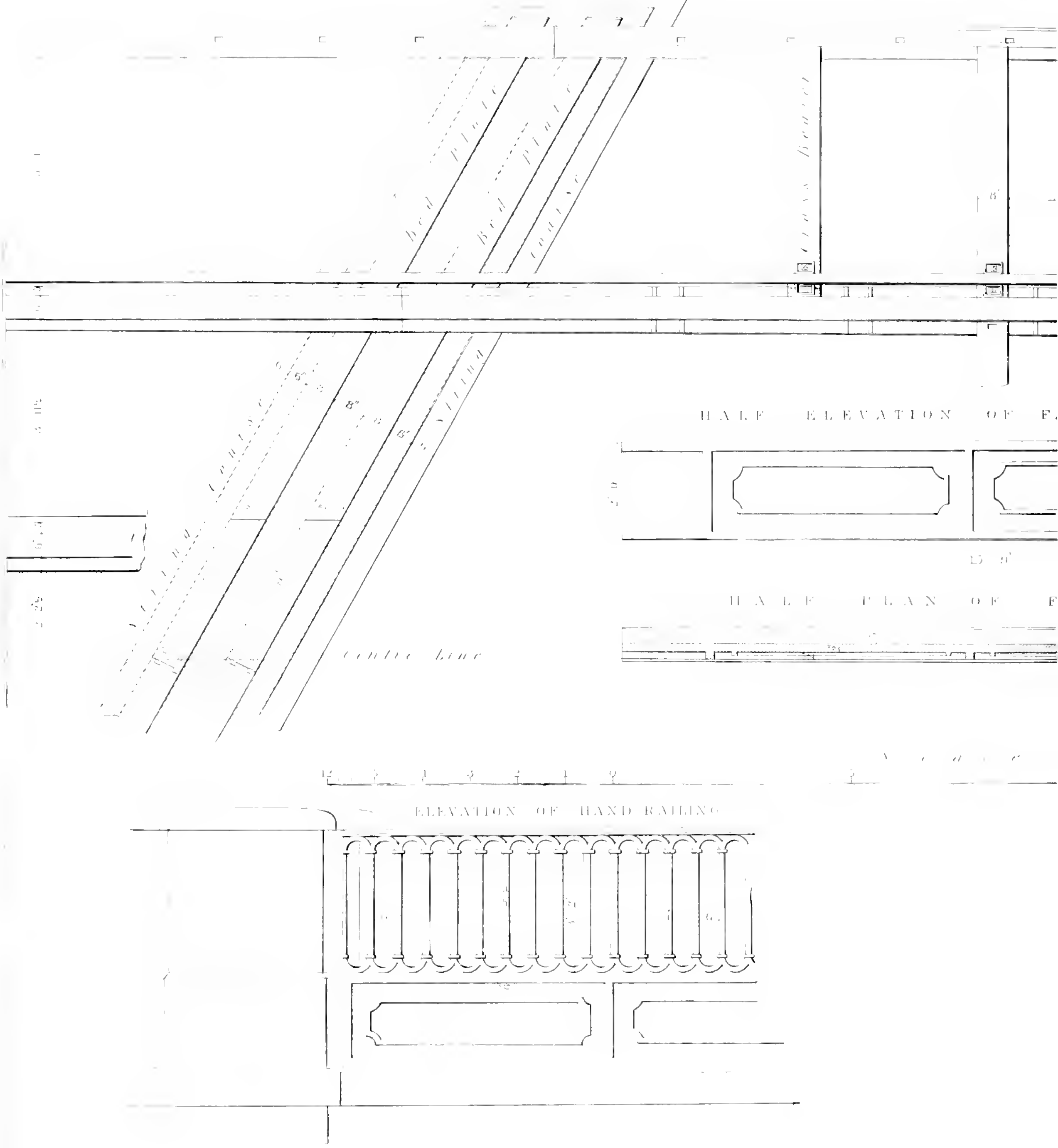
PRACTICE.


LONGITUDINAL SECTION
GINEER
w 60°
Level of ground
AN
Abutment above Impost
Retaining wall under String
batter 1½ in to 1 foot
Scale of Feet
Batter 1 in to 1 foot
ATION

RAILWAY

SEPH LOCKE

BRIDGE OVER THE POL



S C BRE

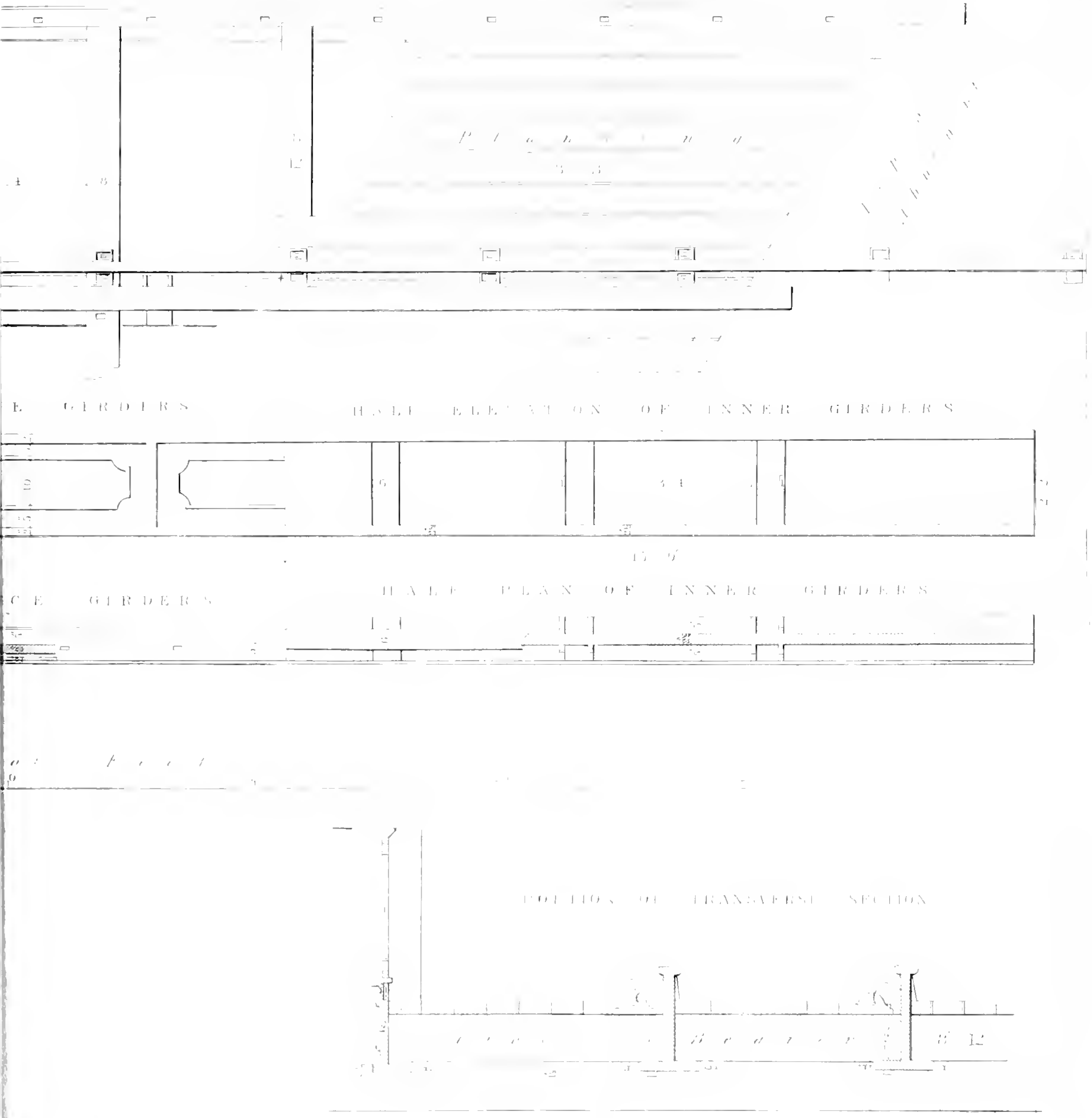
Williams Library of Science &

PRACTICE,

SQ^R ENGINEER

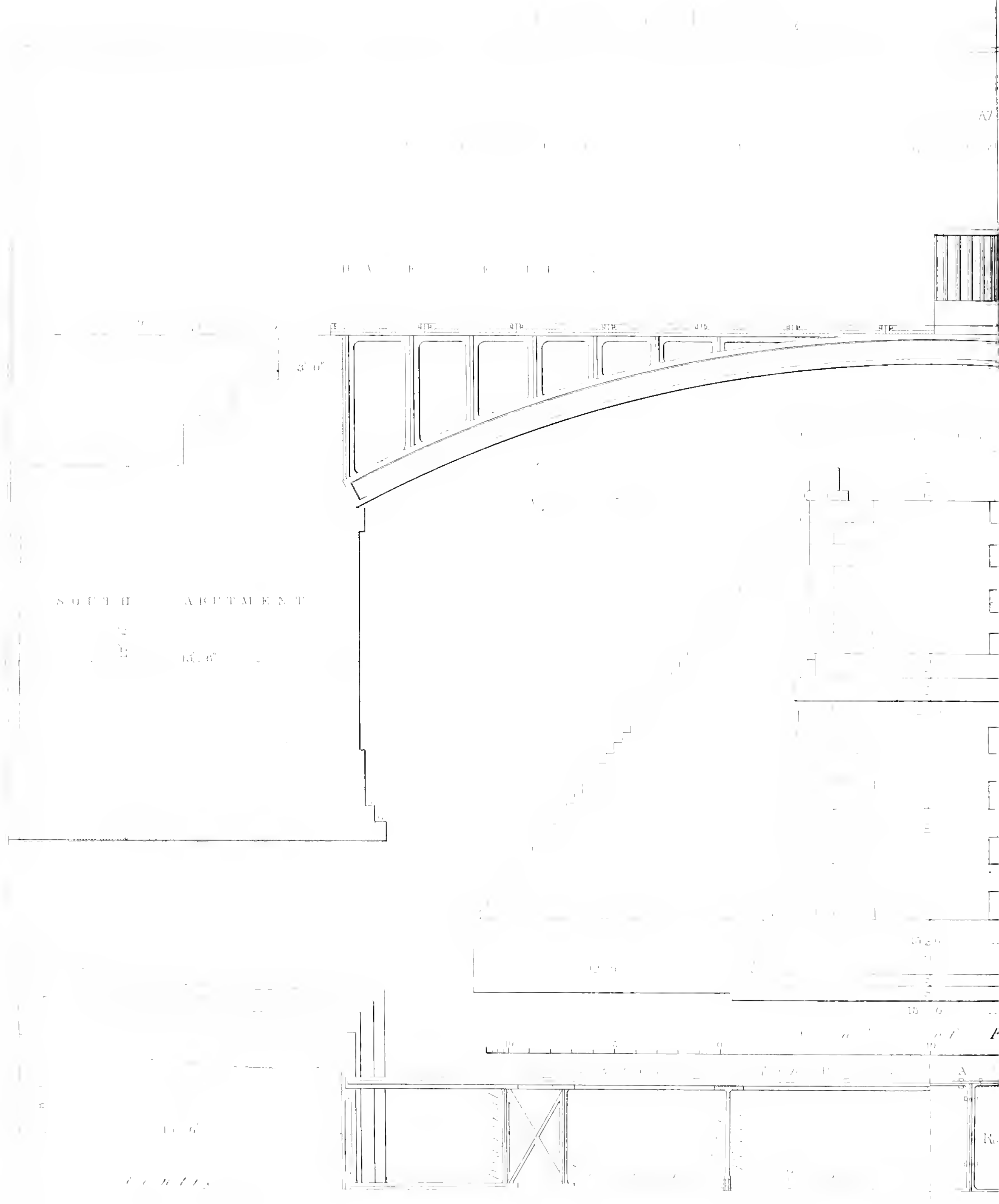
CK & GOVAN RAILWAY

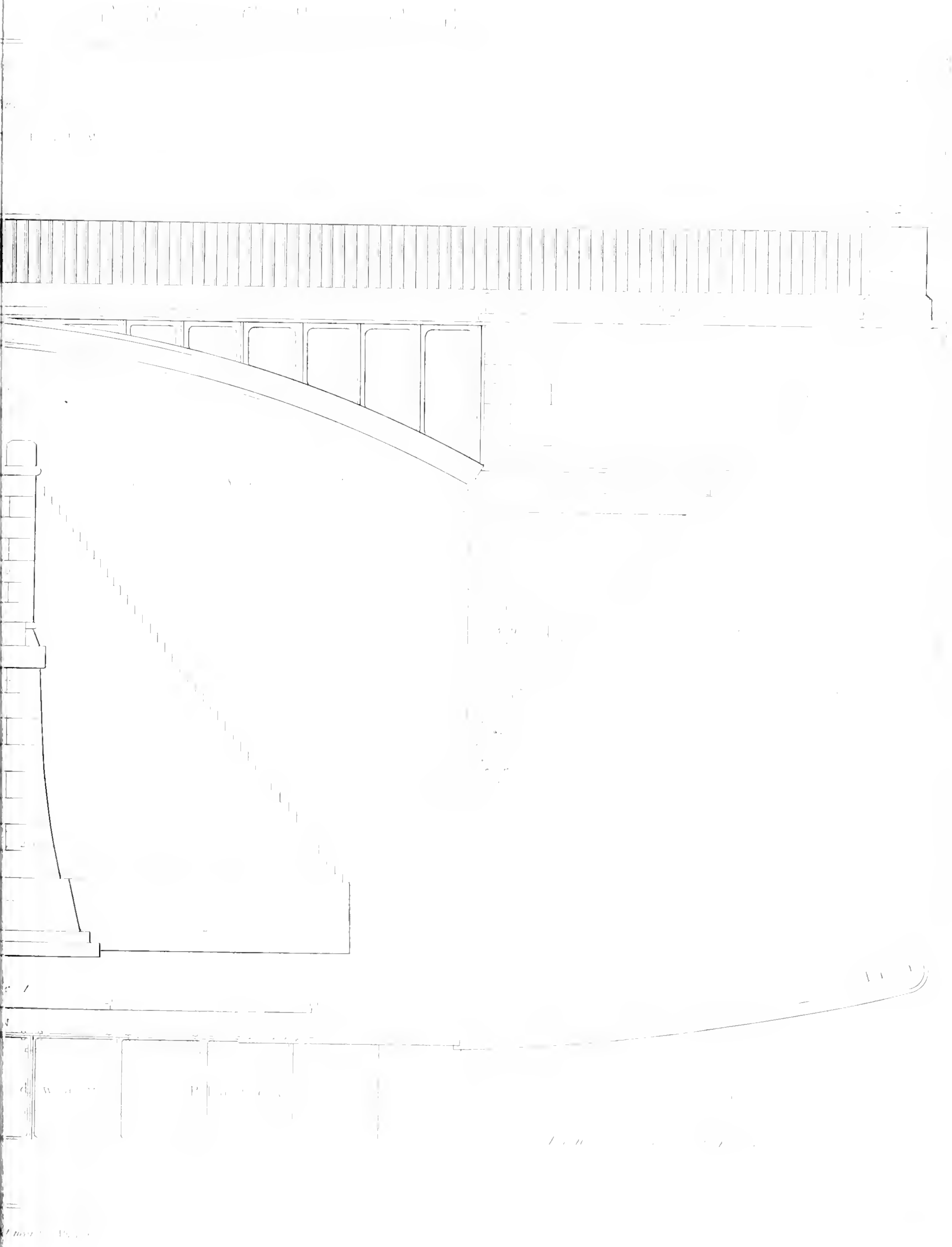
A N



E. DIH

Rafael Street near the Museum


3' 0"
SOUTH ABUTMENT
15' 6"

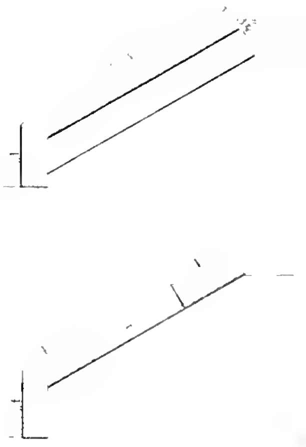


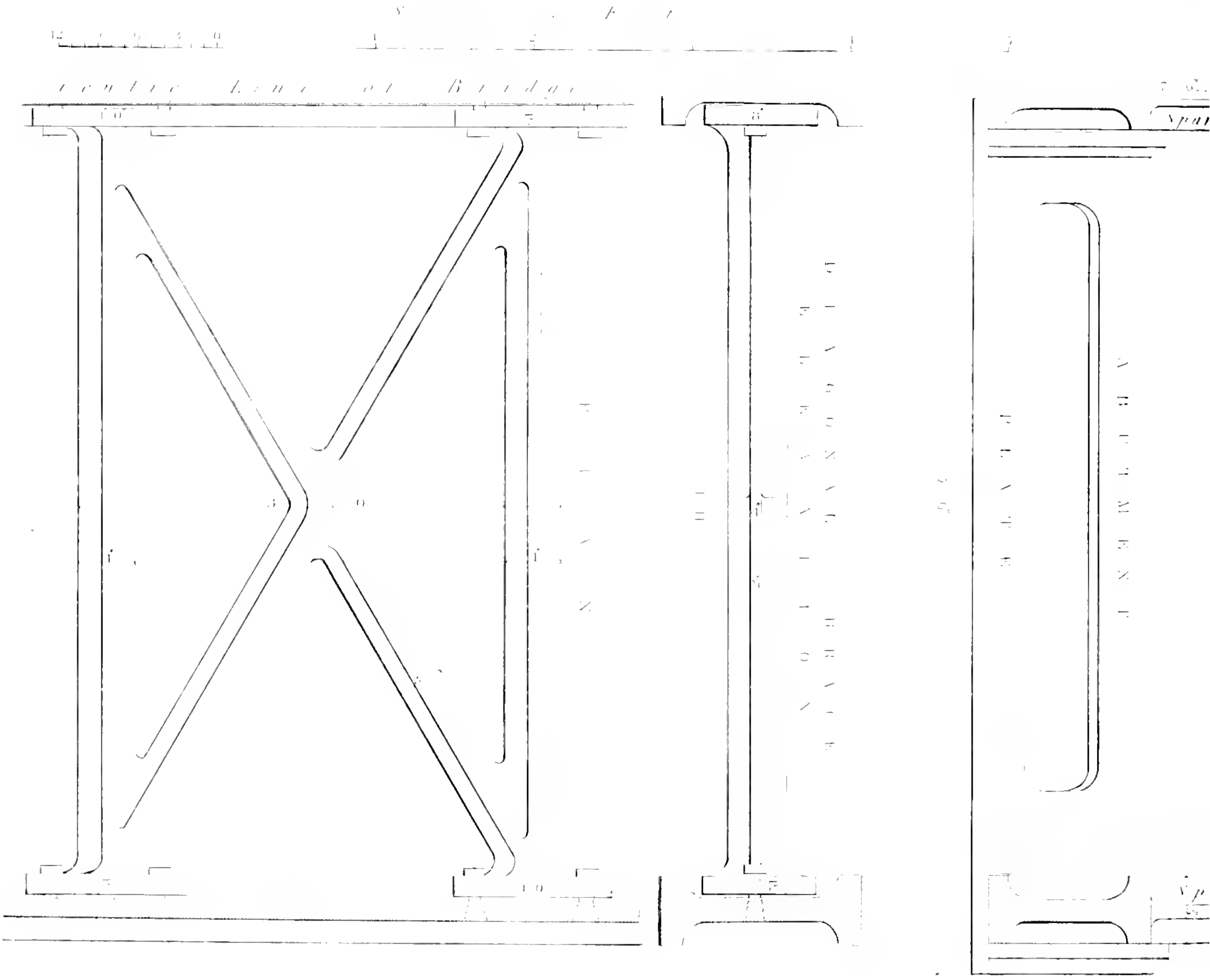
RAILWAY

JAMES WALKER ESQ^R ENGINEER

ACCOMODATION BRIDGE FOR SHIPPEN FARM

DETAILS OF IRONWORK

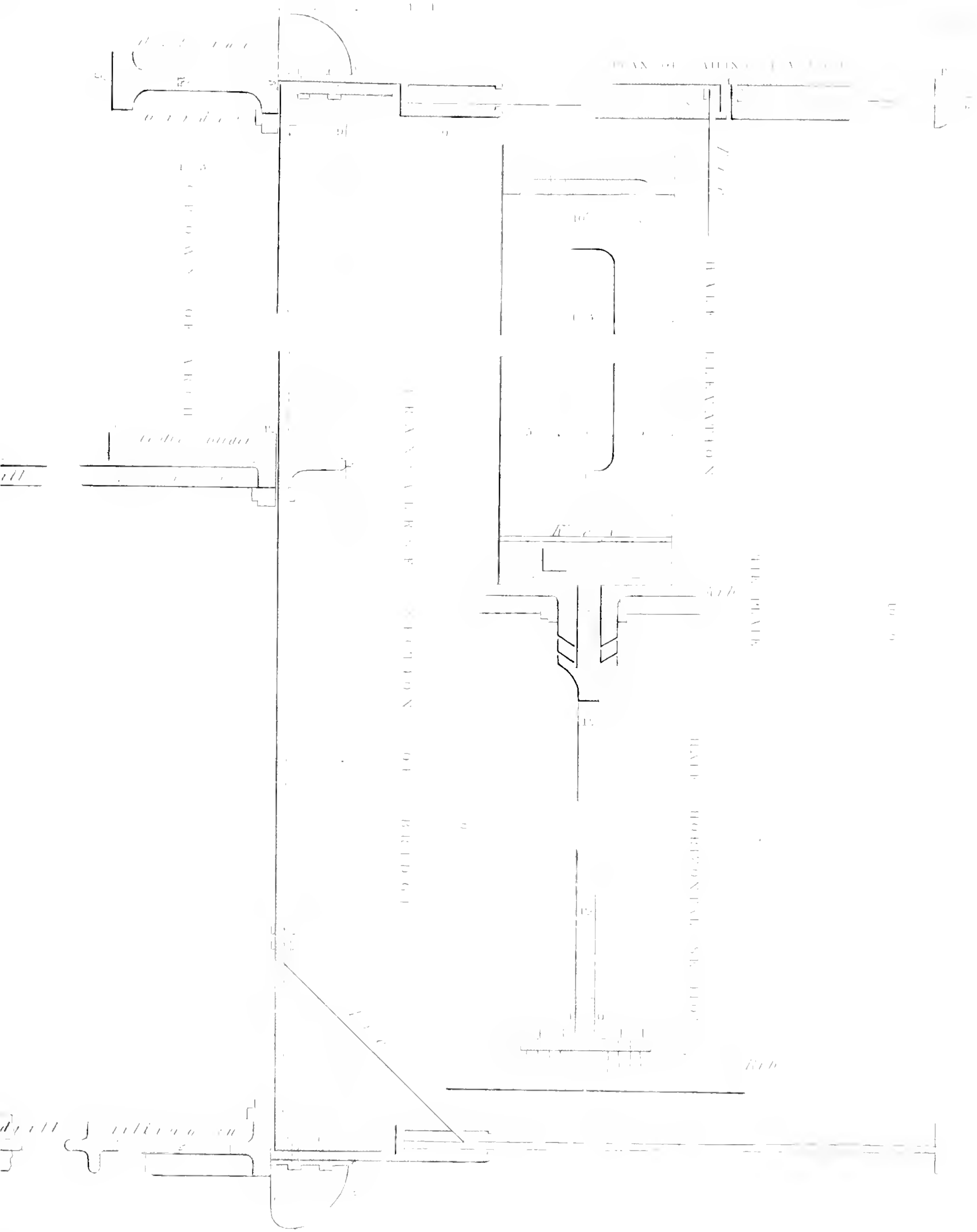




S C BRE

Weale's Library of Science

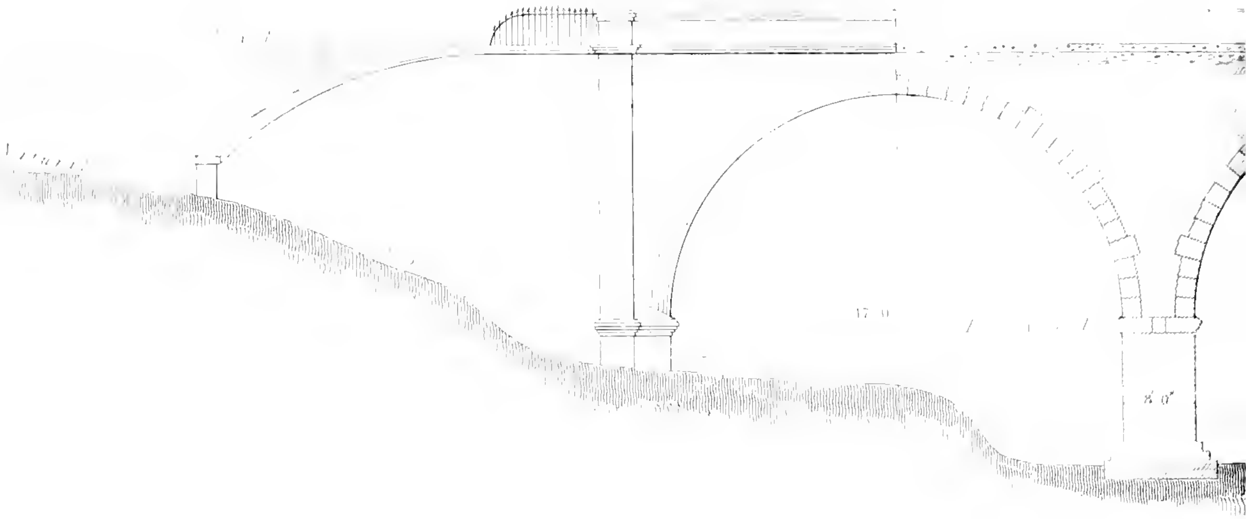
PRACTICE.

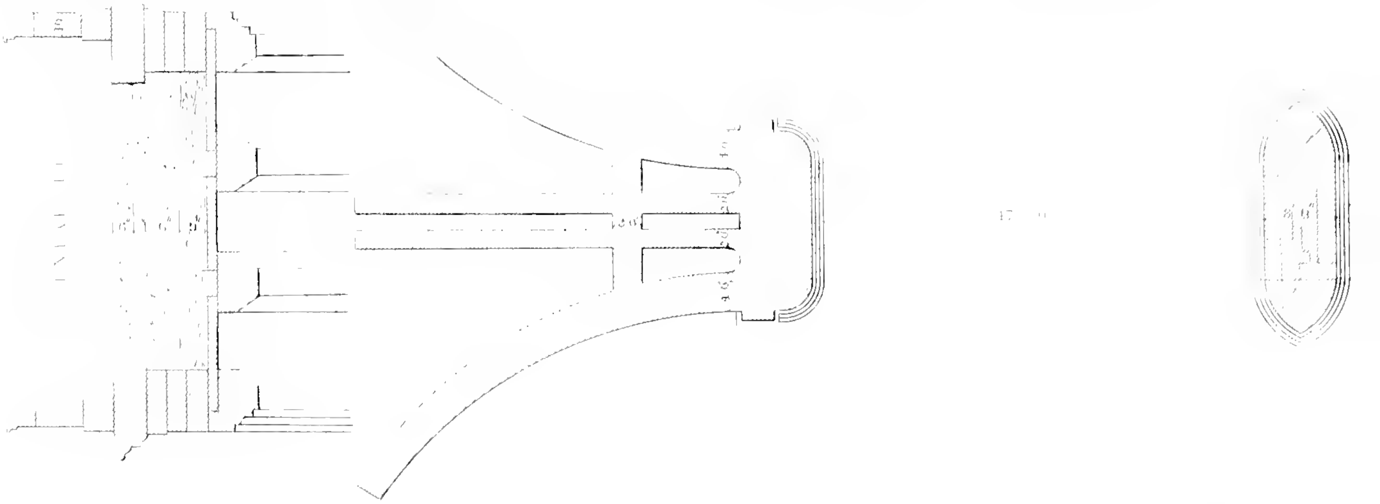


E. DIRLN

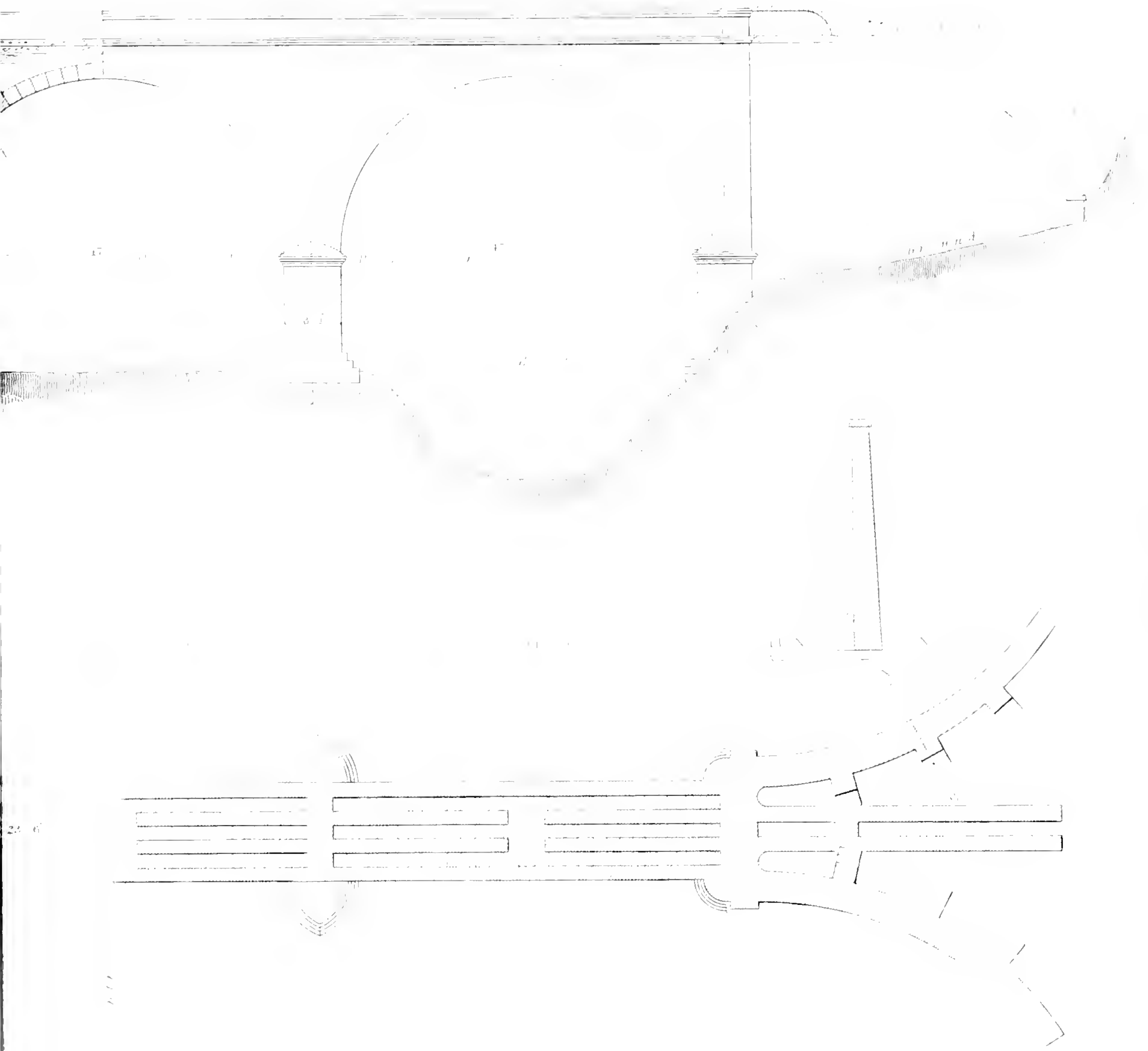
lle at Russel Street near B. Museum

RAILWAY

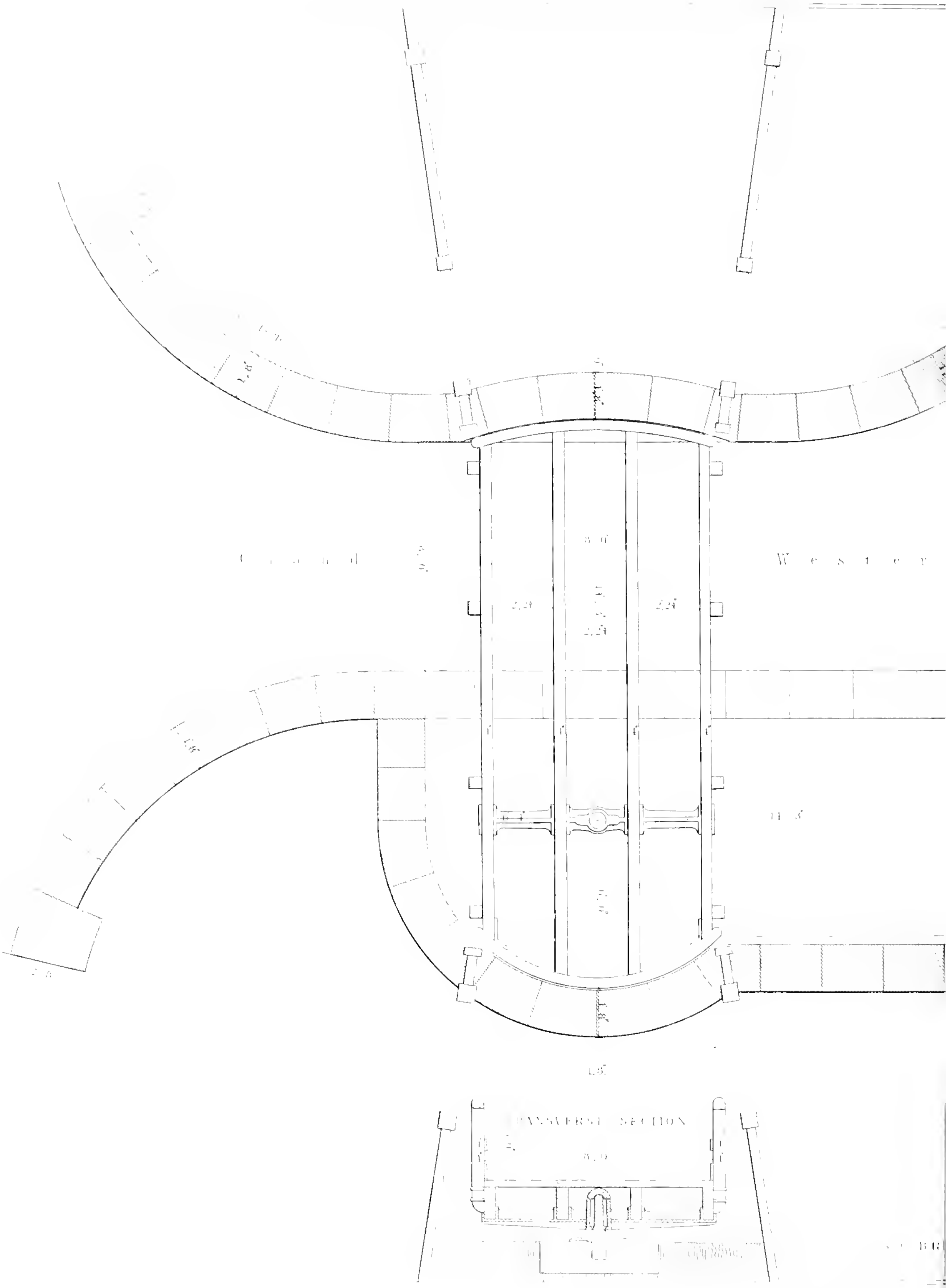




PRACTICE

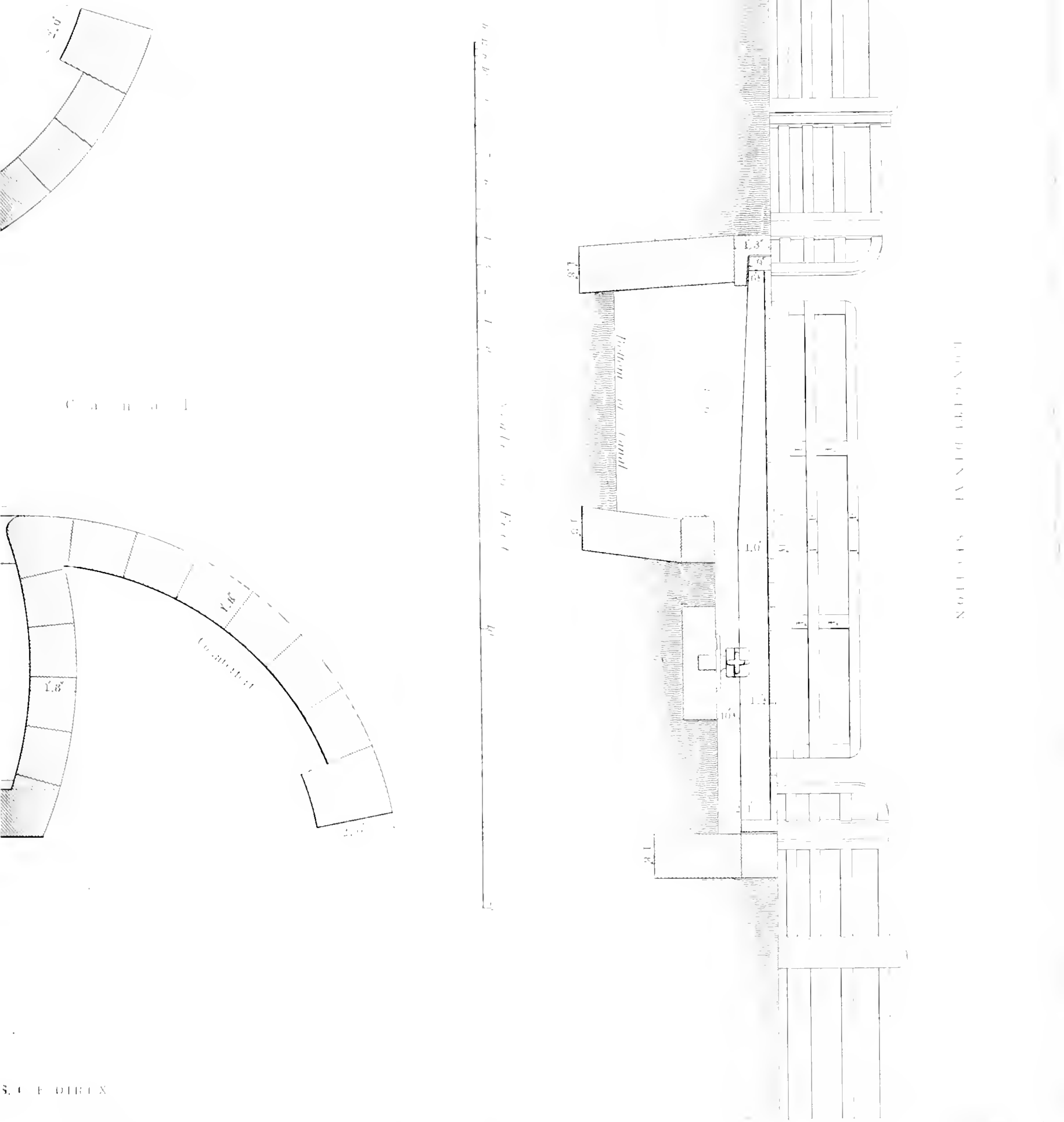


RAILWAY



John Williams, Library

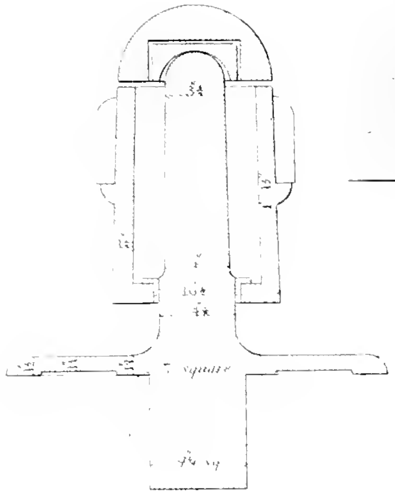
SWING BRIDGE.

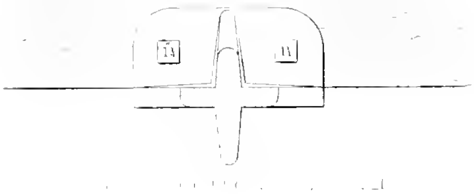


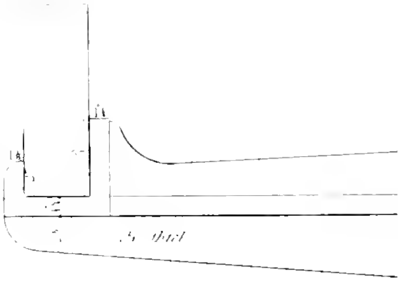
S. C. E. DIRCX

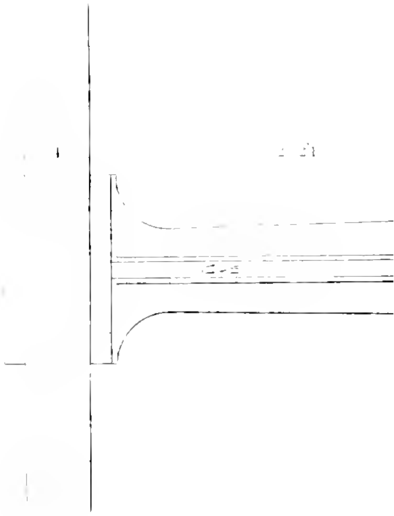
...Art, late of Russel street near the Museum

RAILWAY





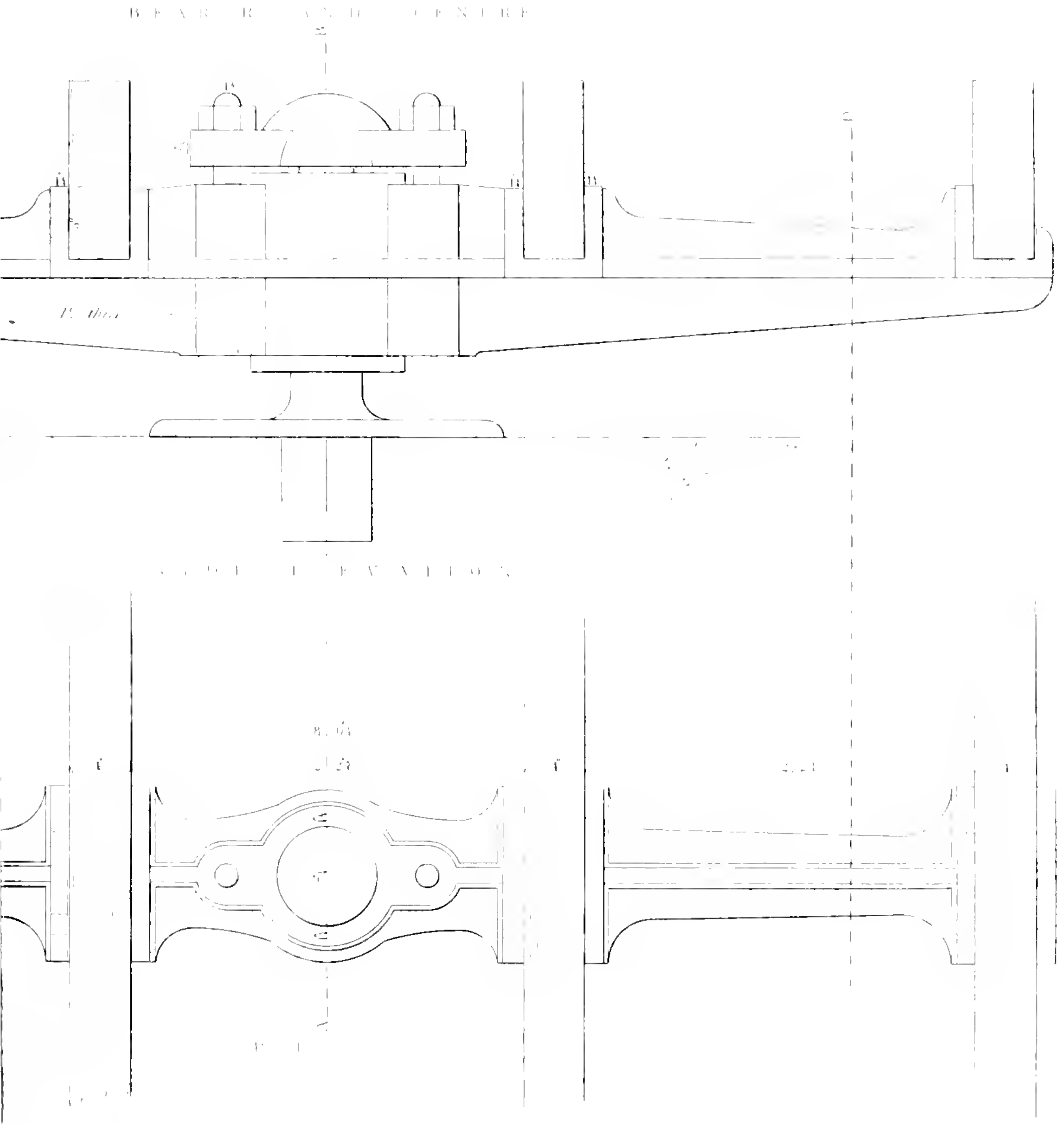




John Weale's Library

PRACTICE.

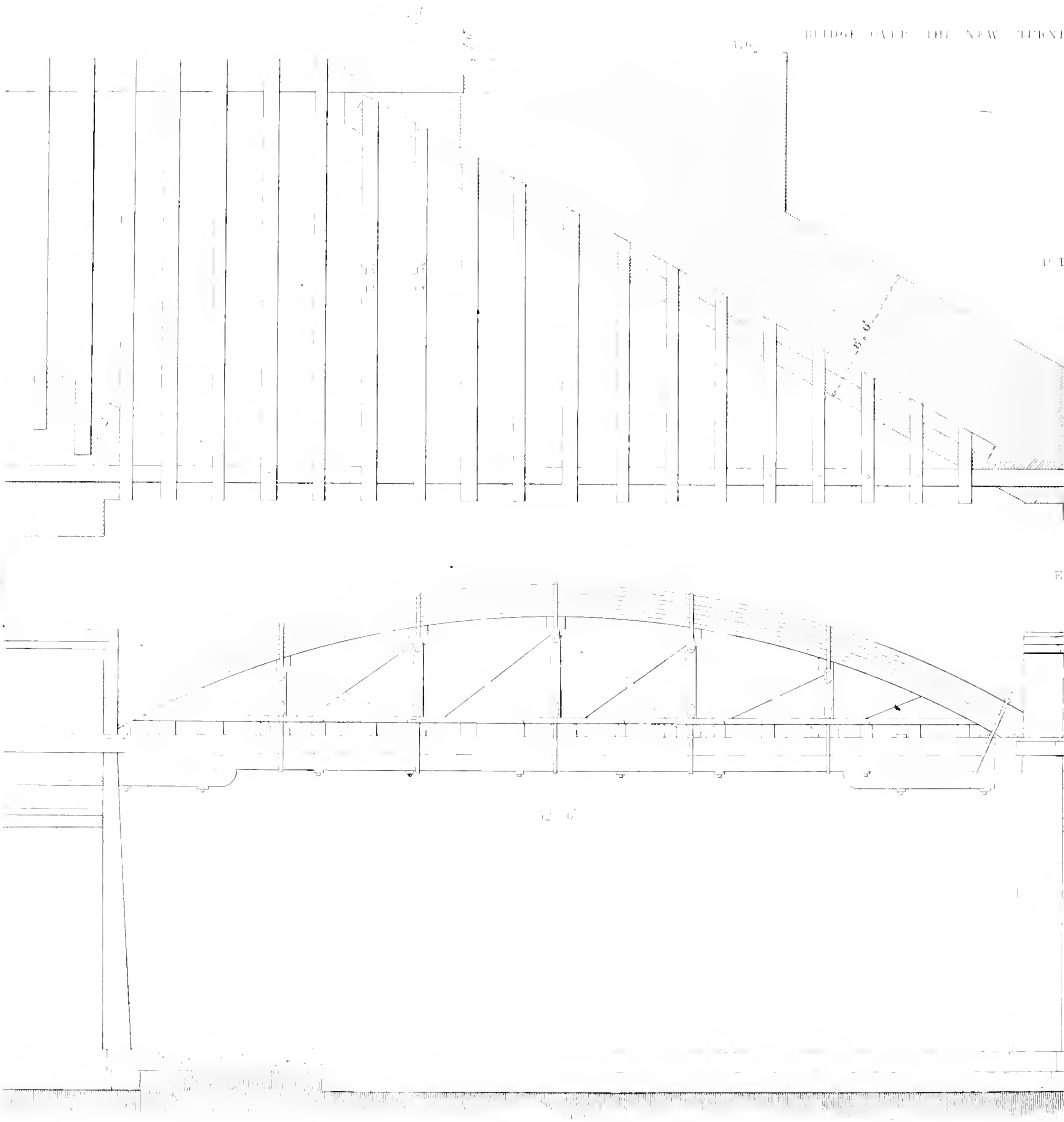
RIDGE



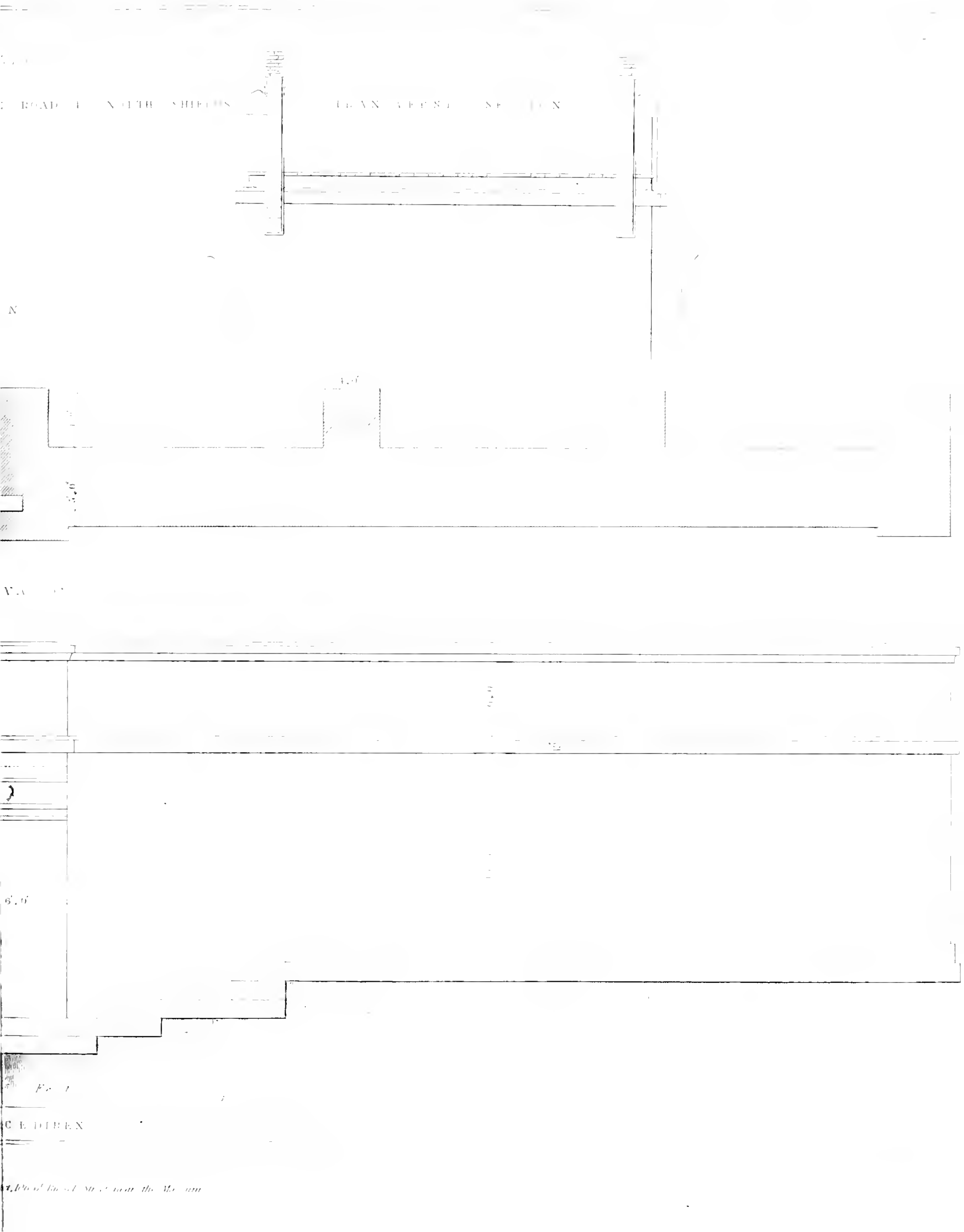
E DIREX

Great Russell Street near the Museum

R A I L W A Y



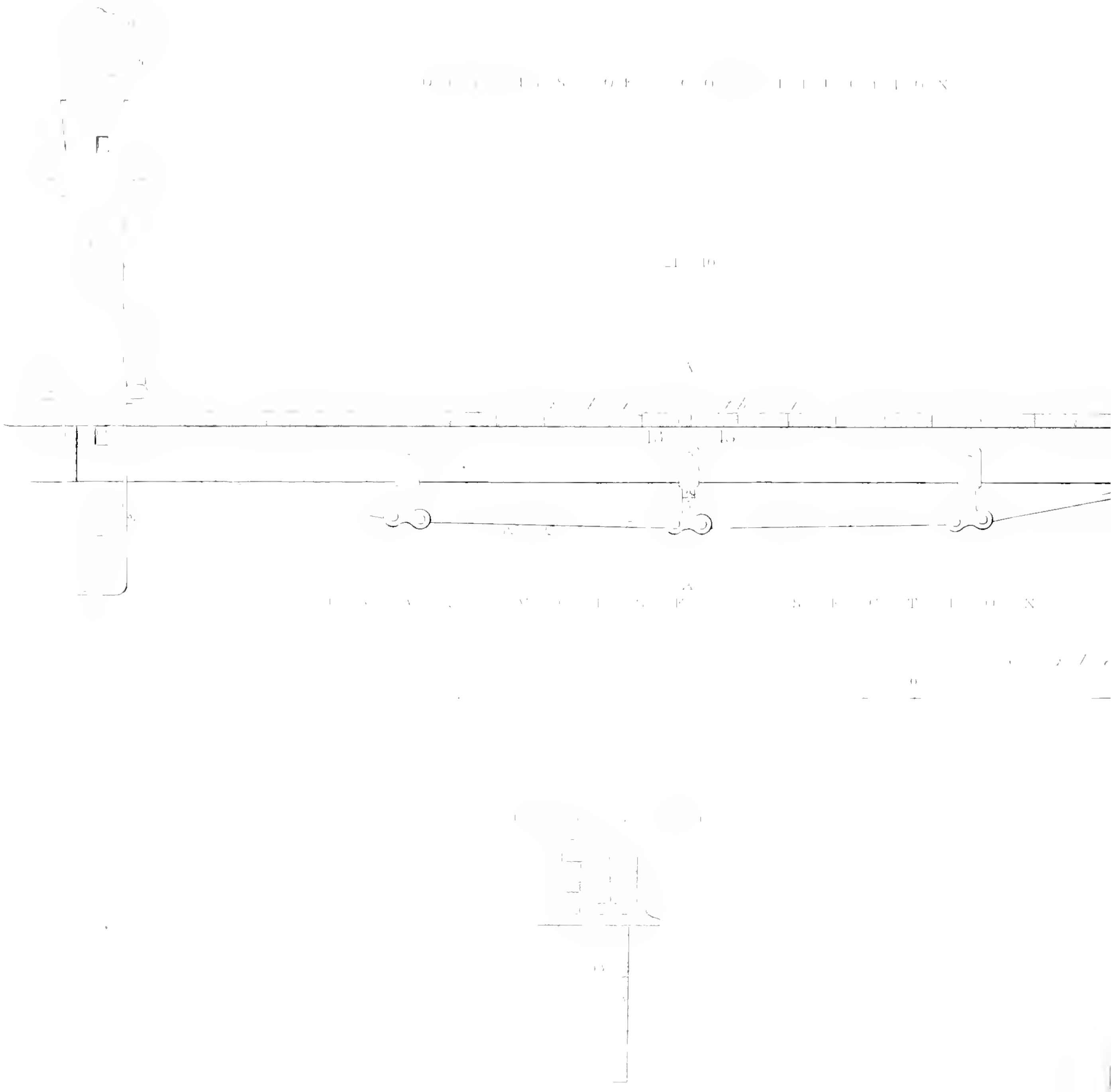
PRACTICE.



RAILWAY

BRIDGE OVER THE NEW TUR

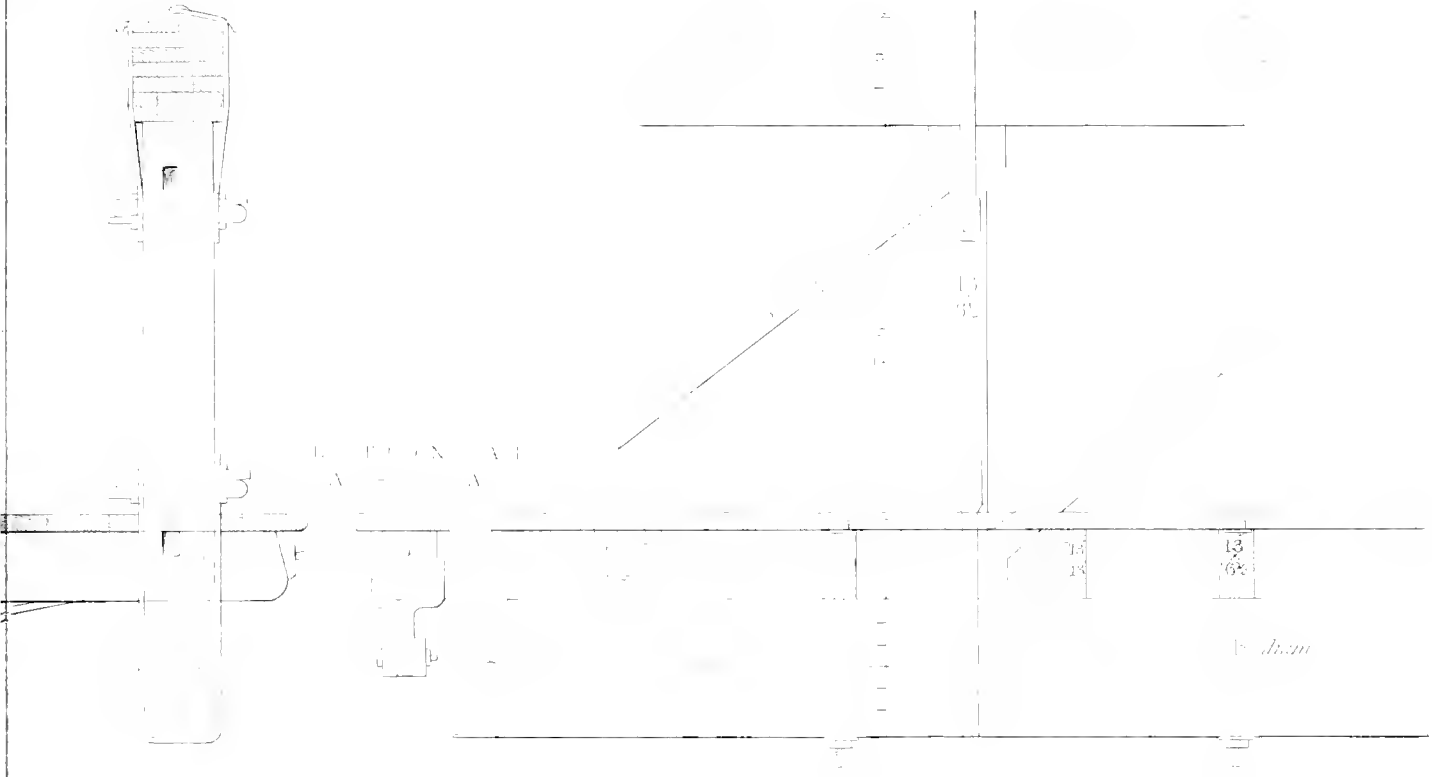
DETAILS OF CONSTRUCTION

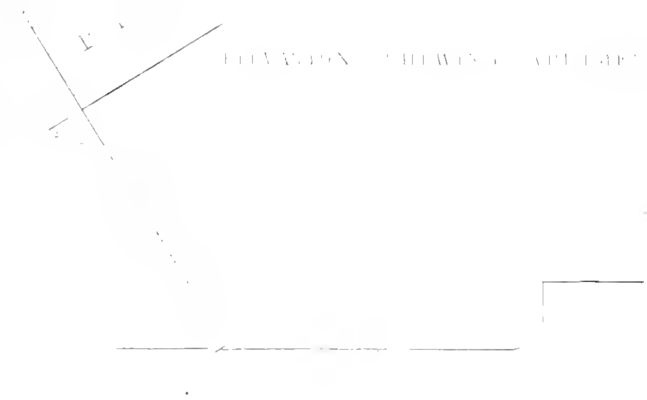


LONGITUDINAL SECTION

PRACTICE.

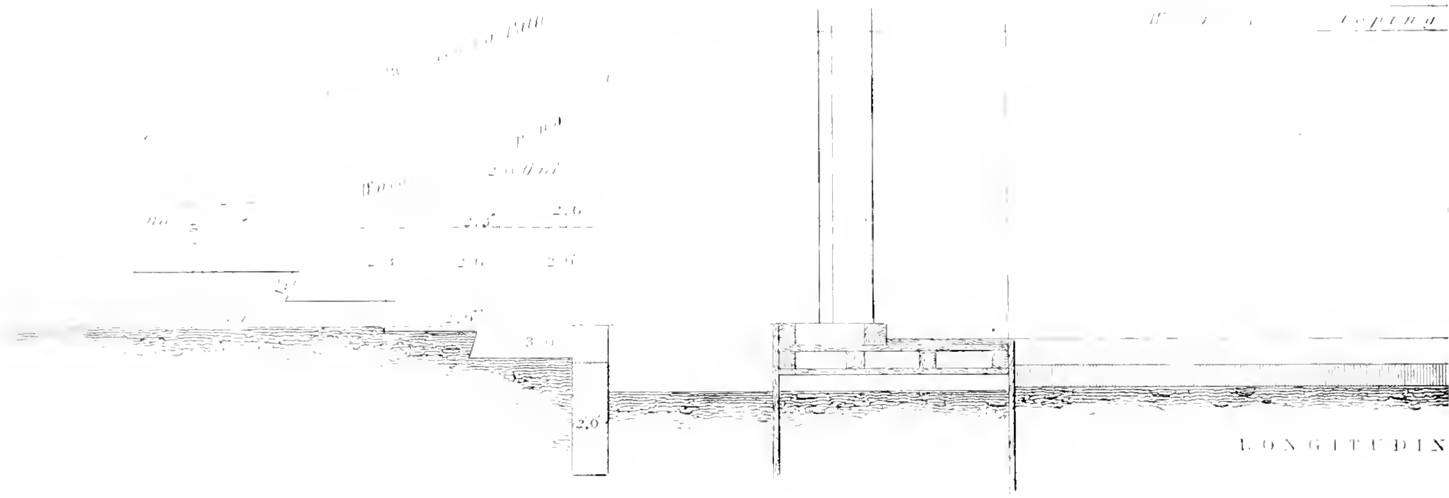
KE ROAD TO NORTH SHIELDS



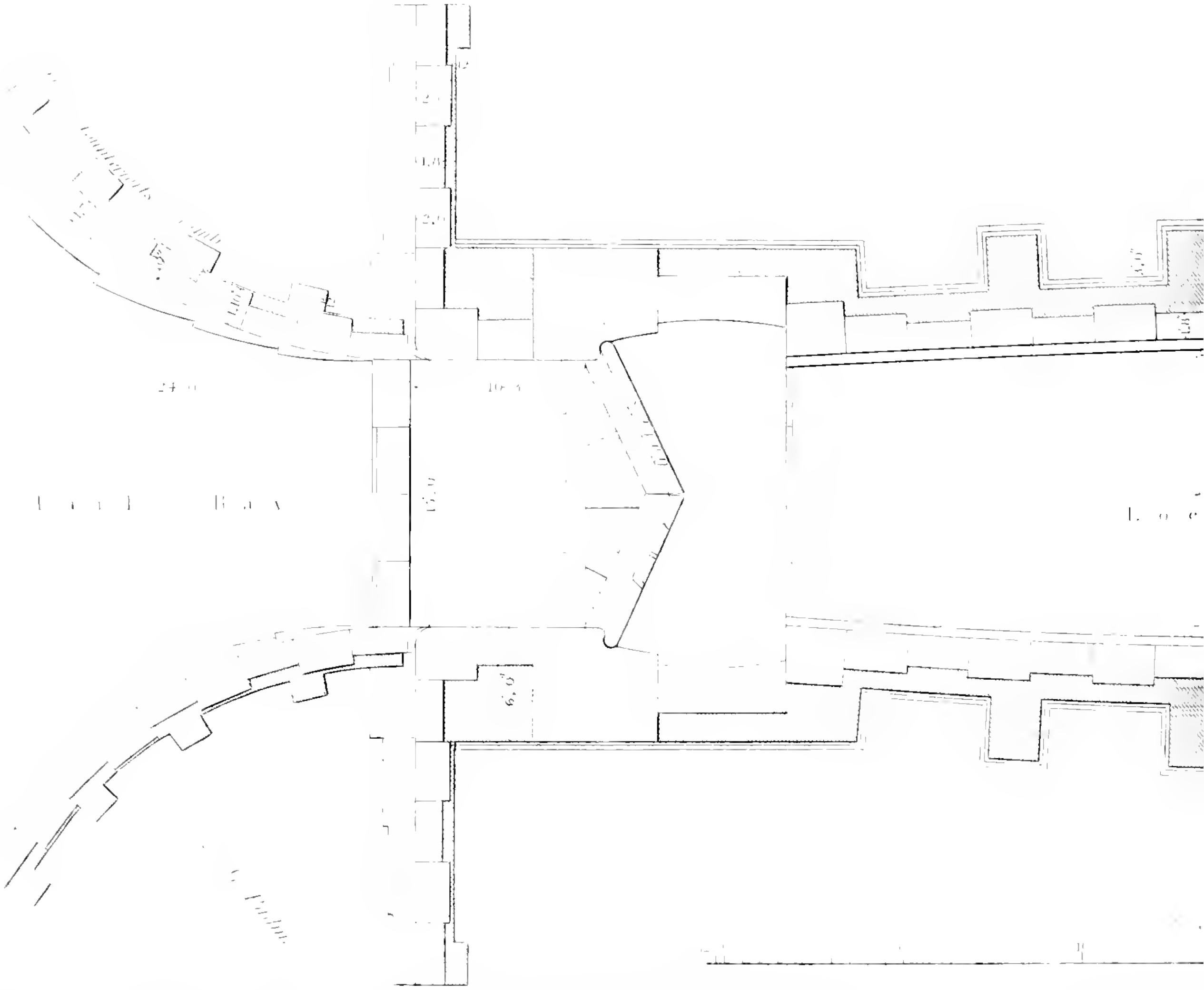


106 Gt Russel Street near the Museum

DETAILS OF

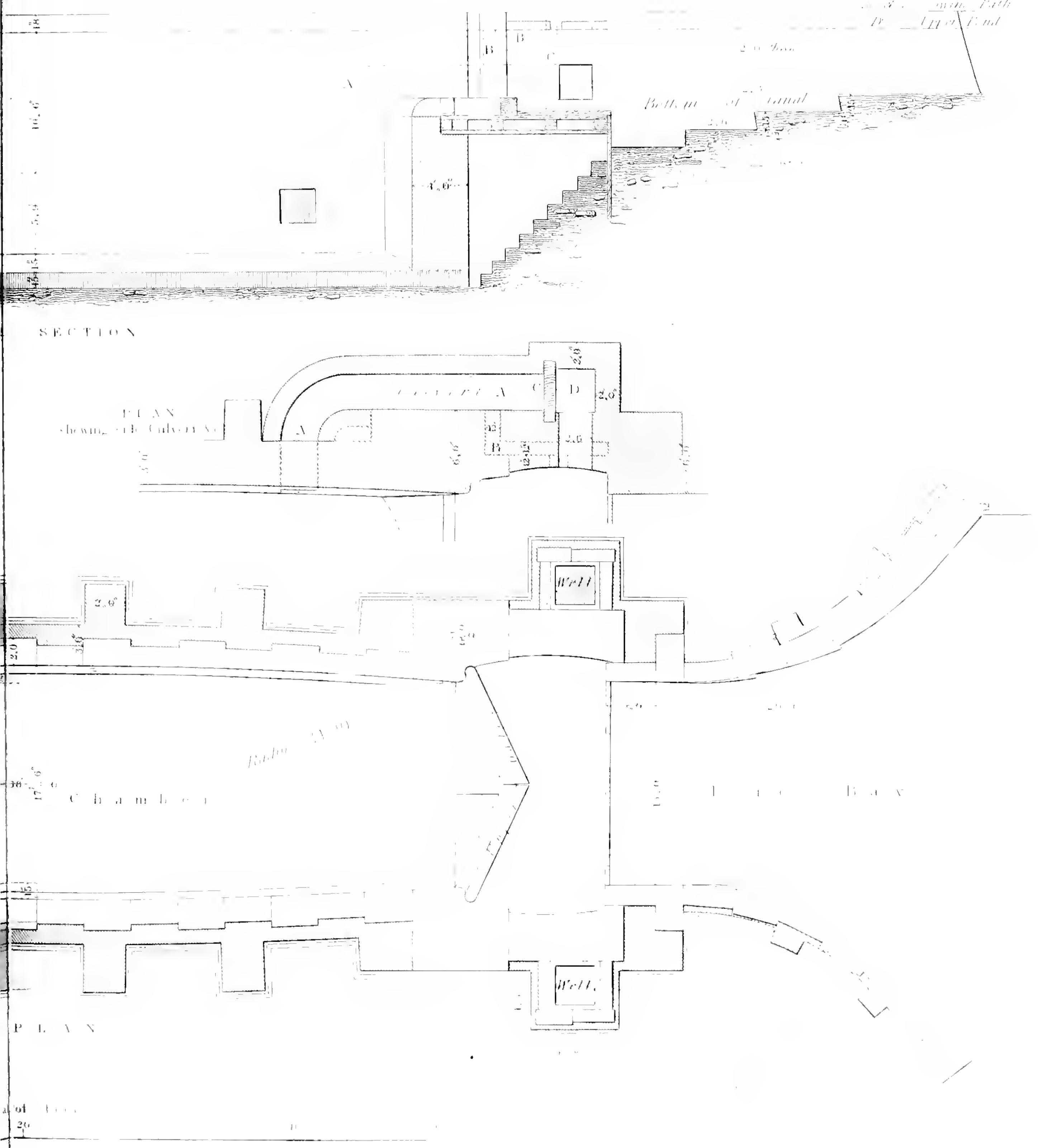


LONGITUDIN

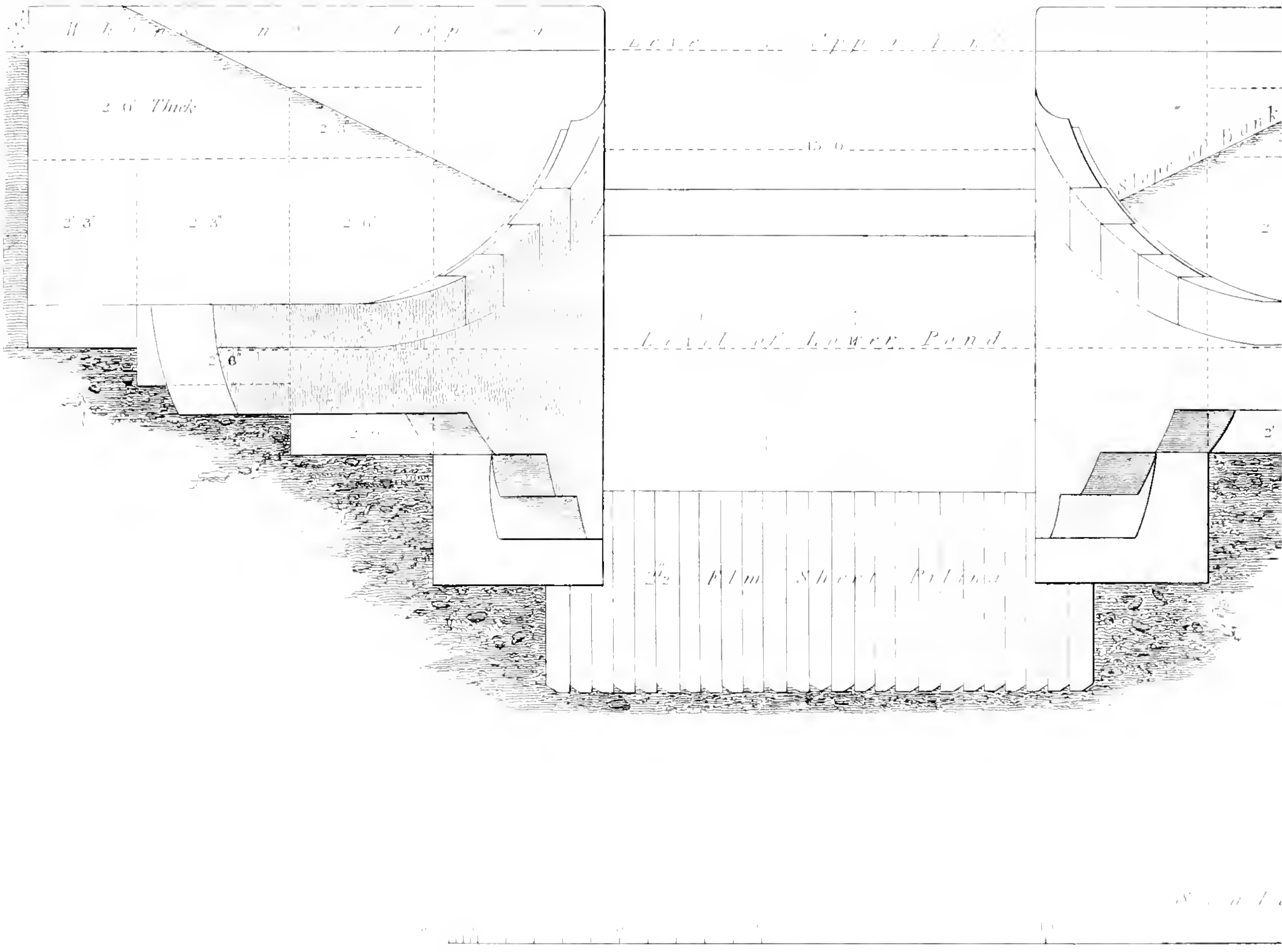


PRACTICE

LOCK N° 3

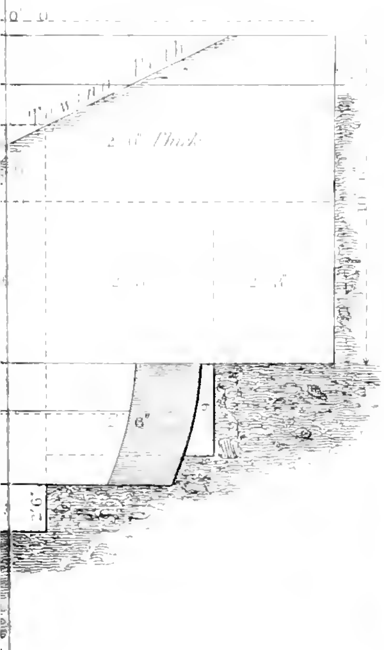


[illegible] DIREX

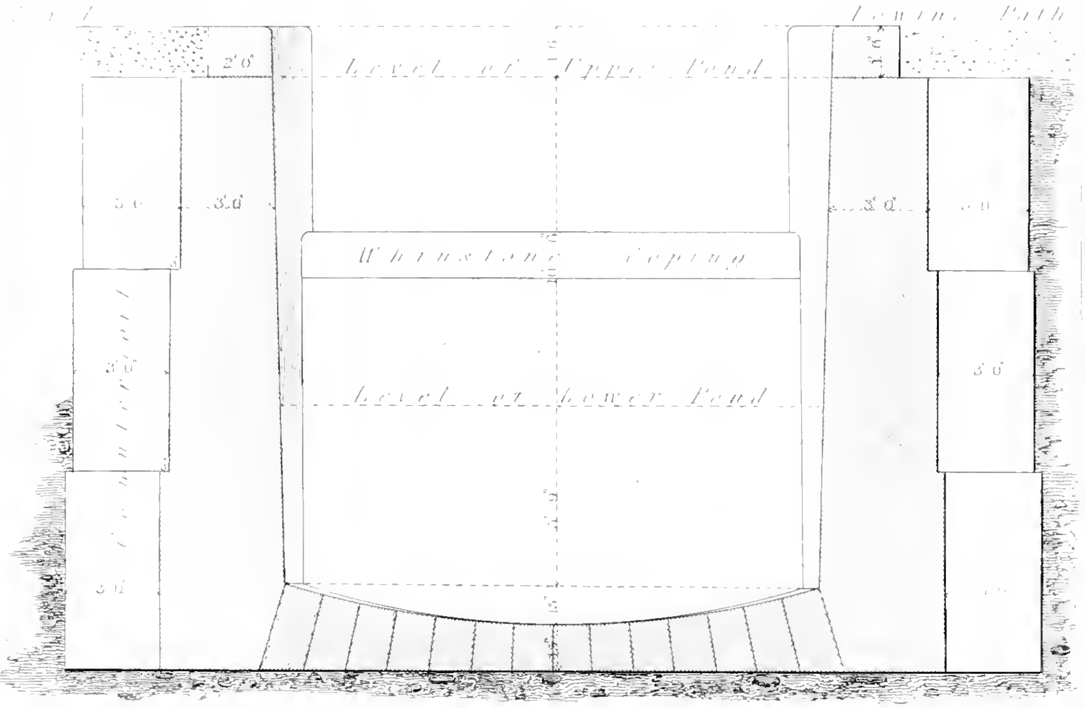

2' 6" Thick
2' 3"
2' 3"
2' 3"
2' 6"
15' 0
Level of Lower Pond
6"
2½ Elm Sheet Piling
Slope of Bank

PRACTICE

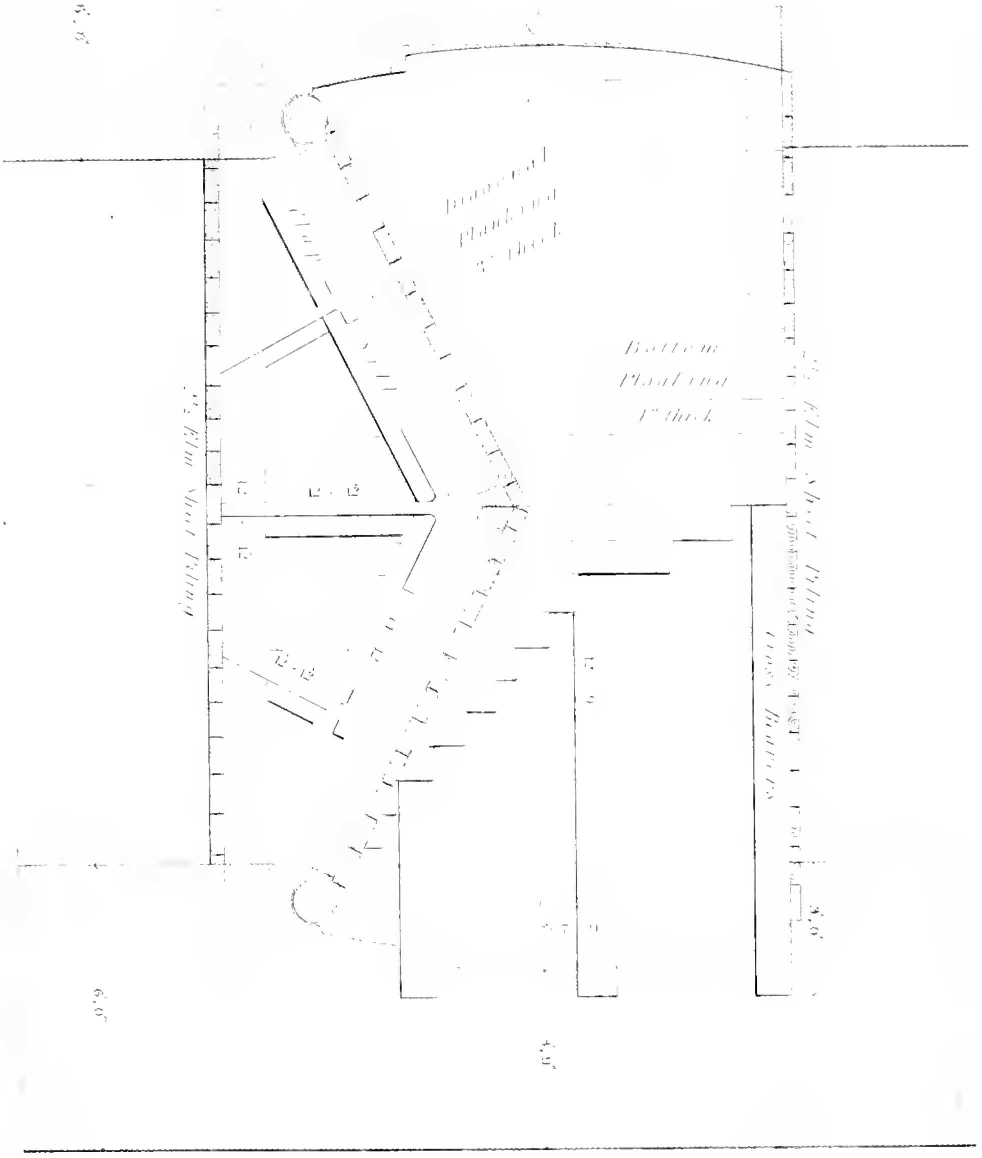
LOCK N



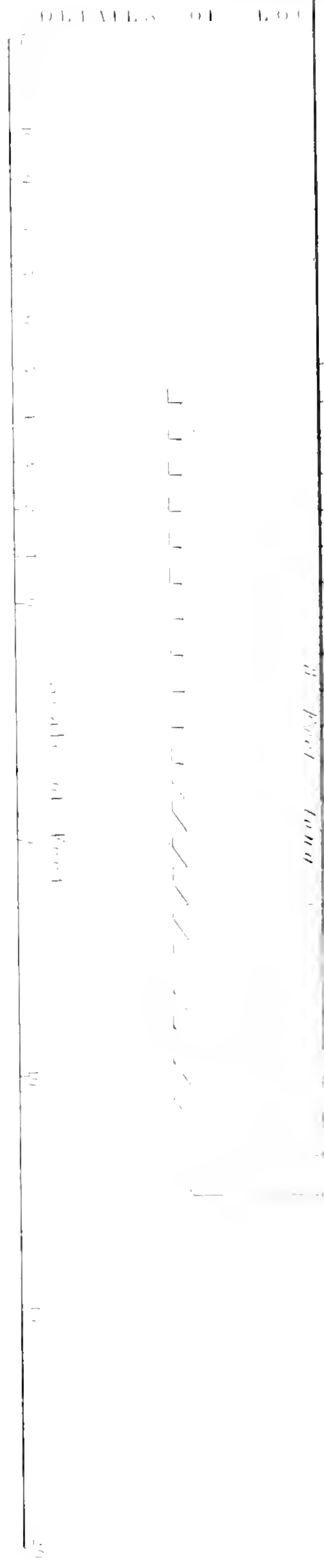
TRANSVERSE SECTION TAKEN THROUGH CENTRE OF LOCK CHAMBER



M. C. L. DIELN

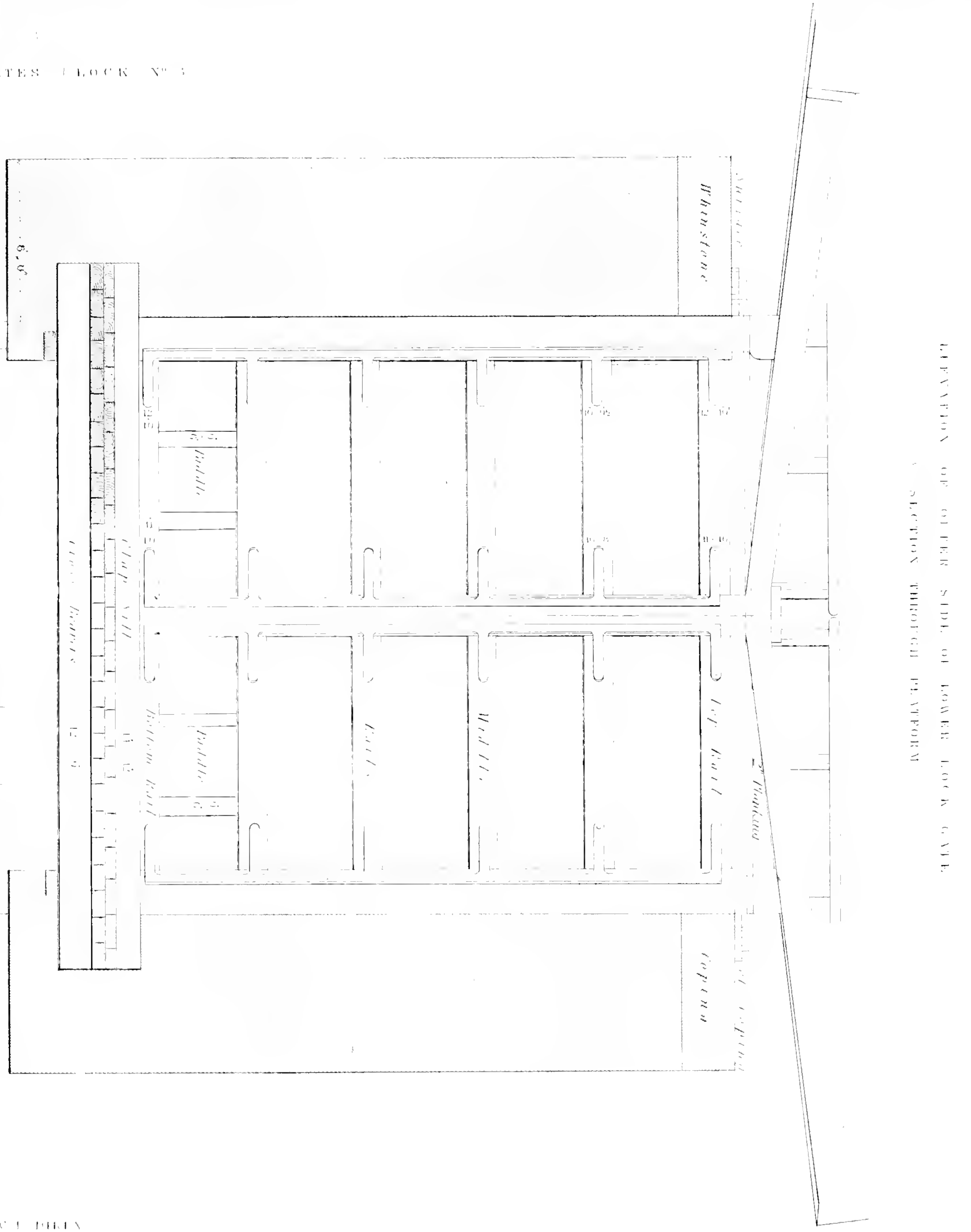


DETAILS OF LOC



PRACTICE

GATES OF LOCK No 3



ELEVATION OF OUTER SIDE OF LOWER LOCK GATE.

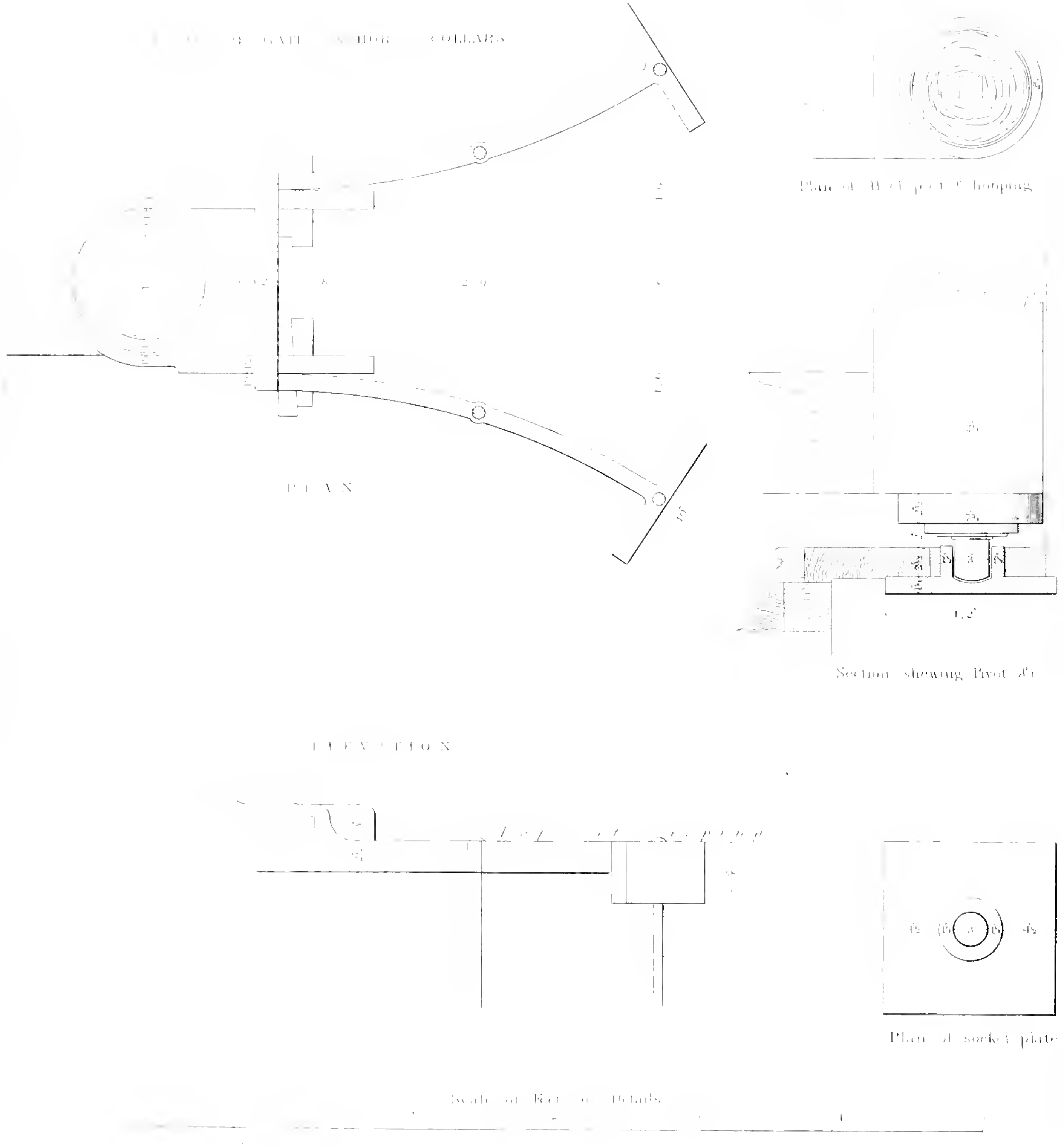
SECTION THROUGH PLATFORM

S C I PIRIN

Russel Street near the Museum

DETAILS OF LOWER L

DETAILS OF PIVOT TO GATES

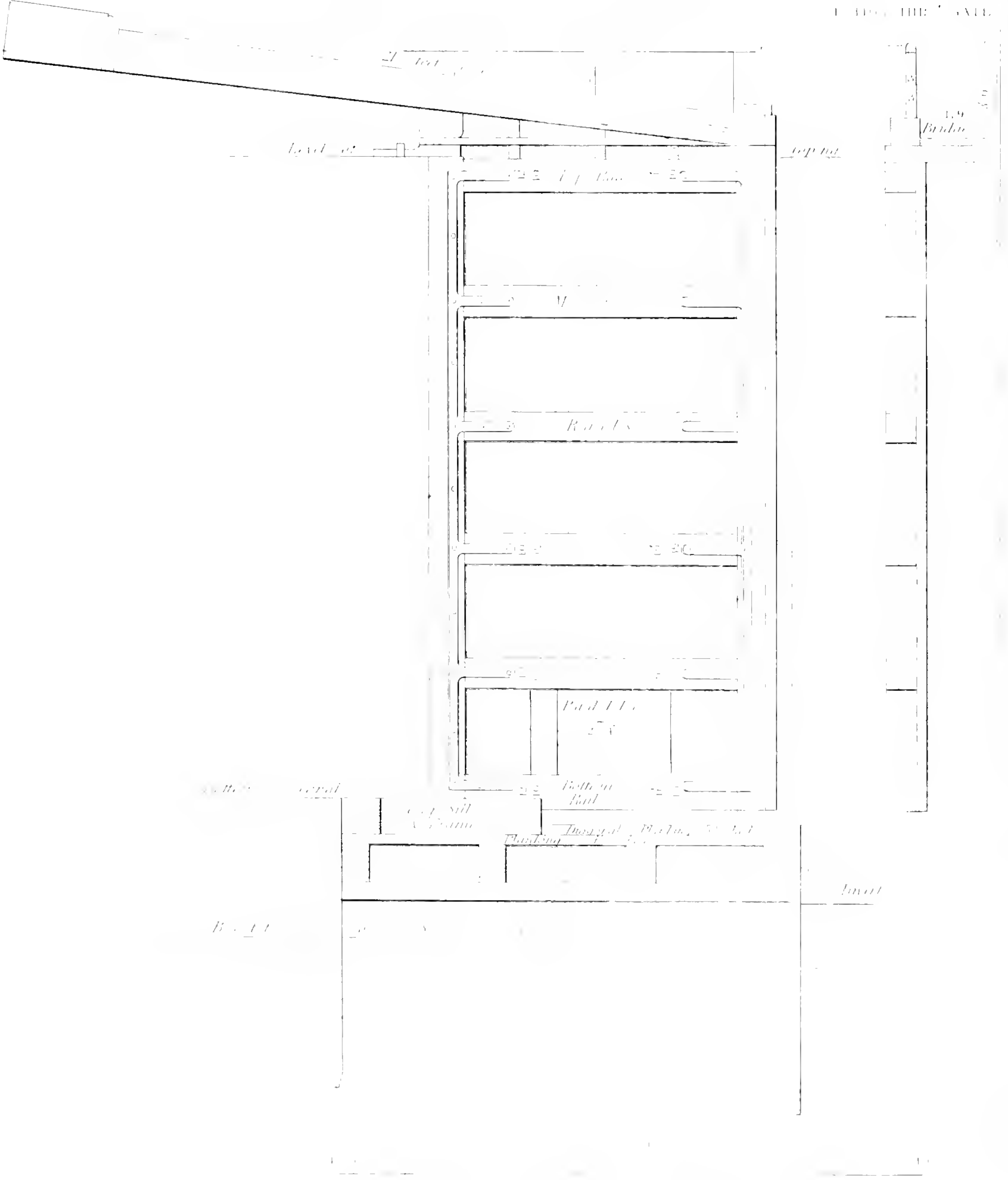


Scale of Feet for Details

P L A T E [illegible]

K GATES LOCK N° 3

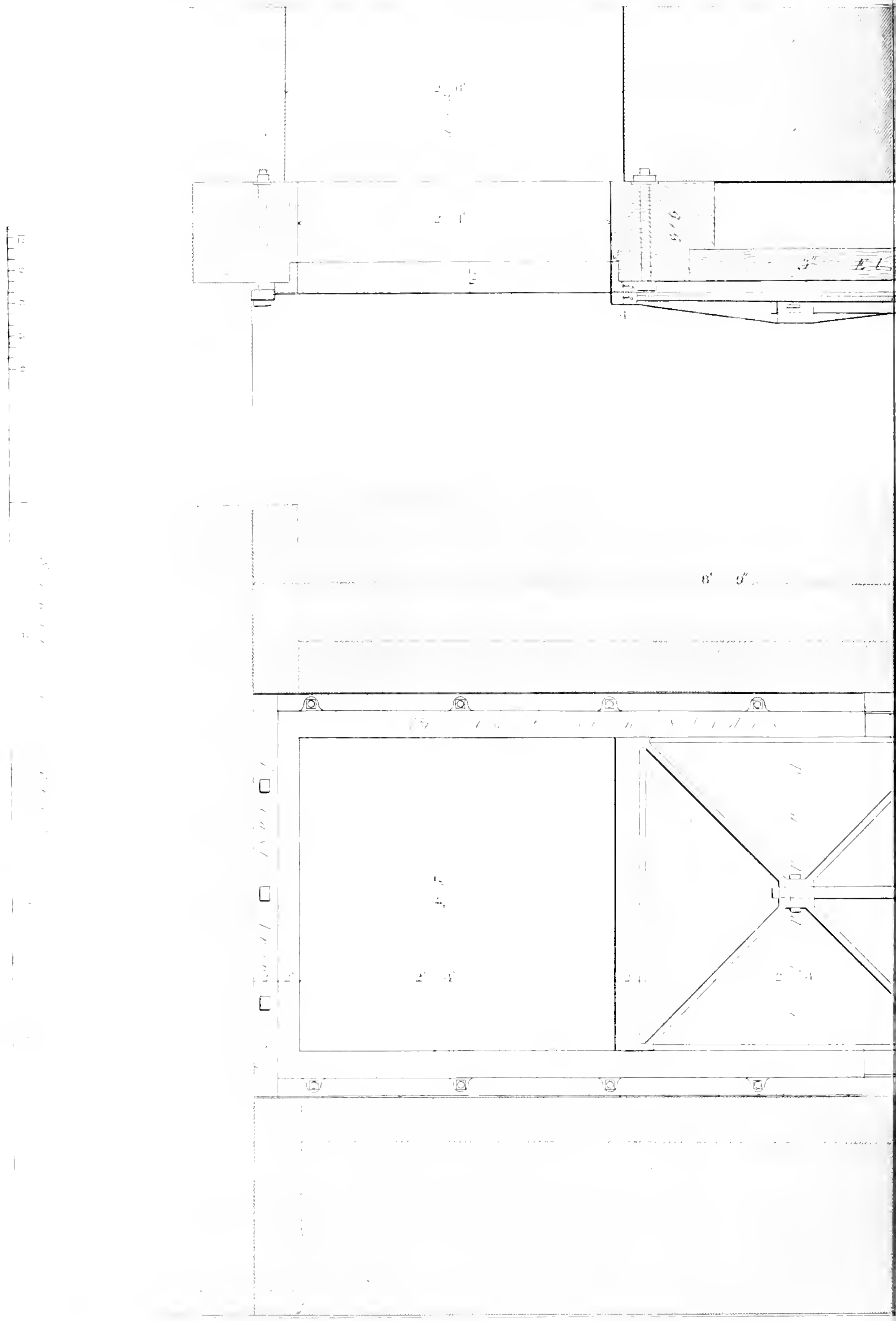
ELEVATION [illegible]



C.E. DIREN

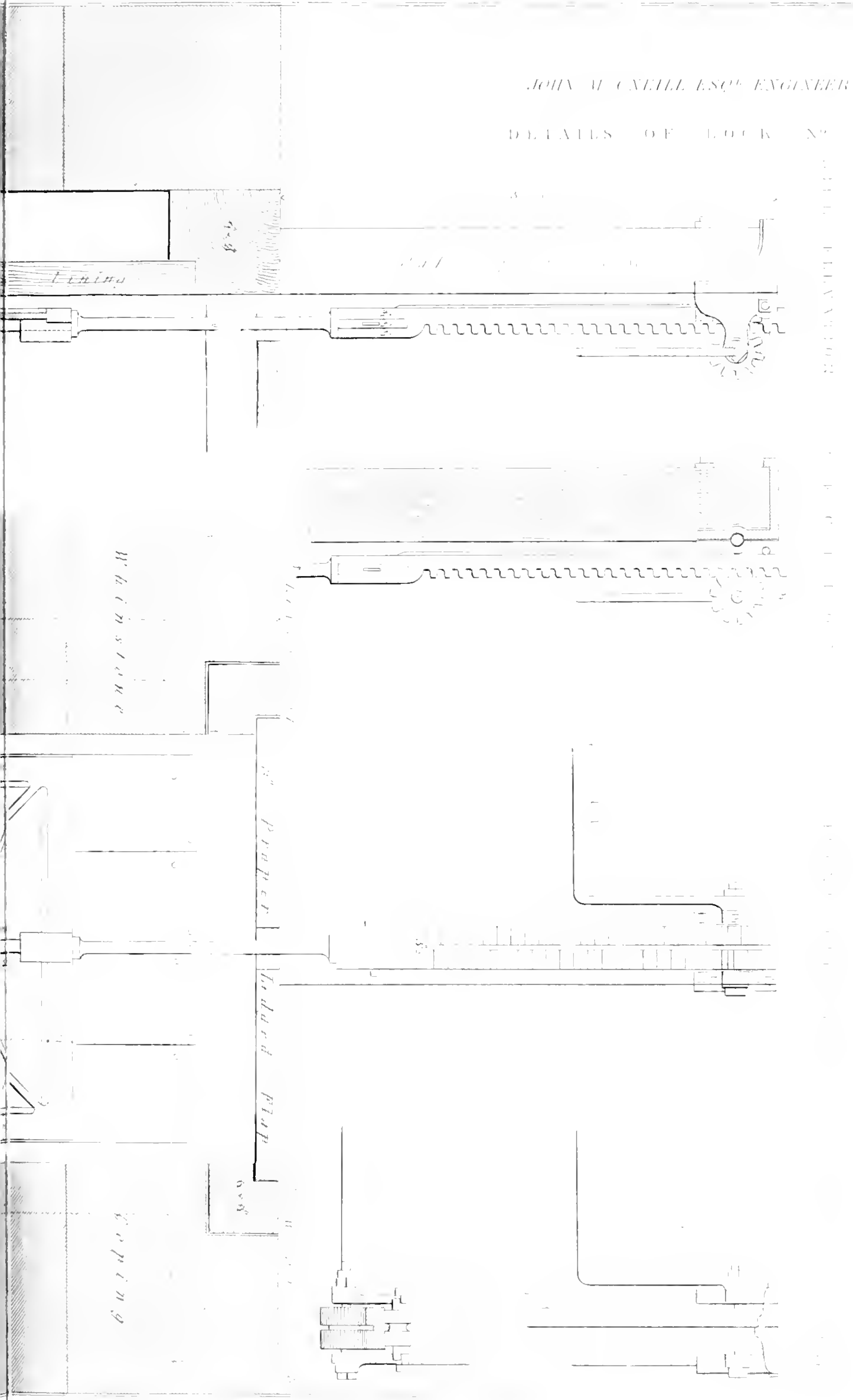
[illegible]

RAILWAY

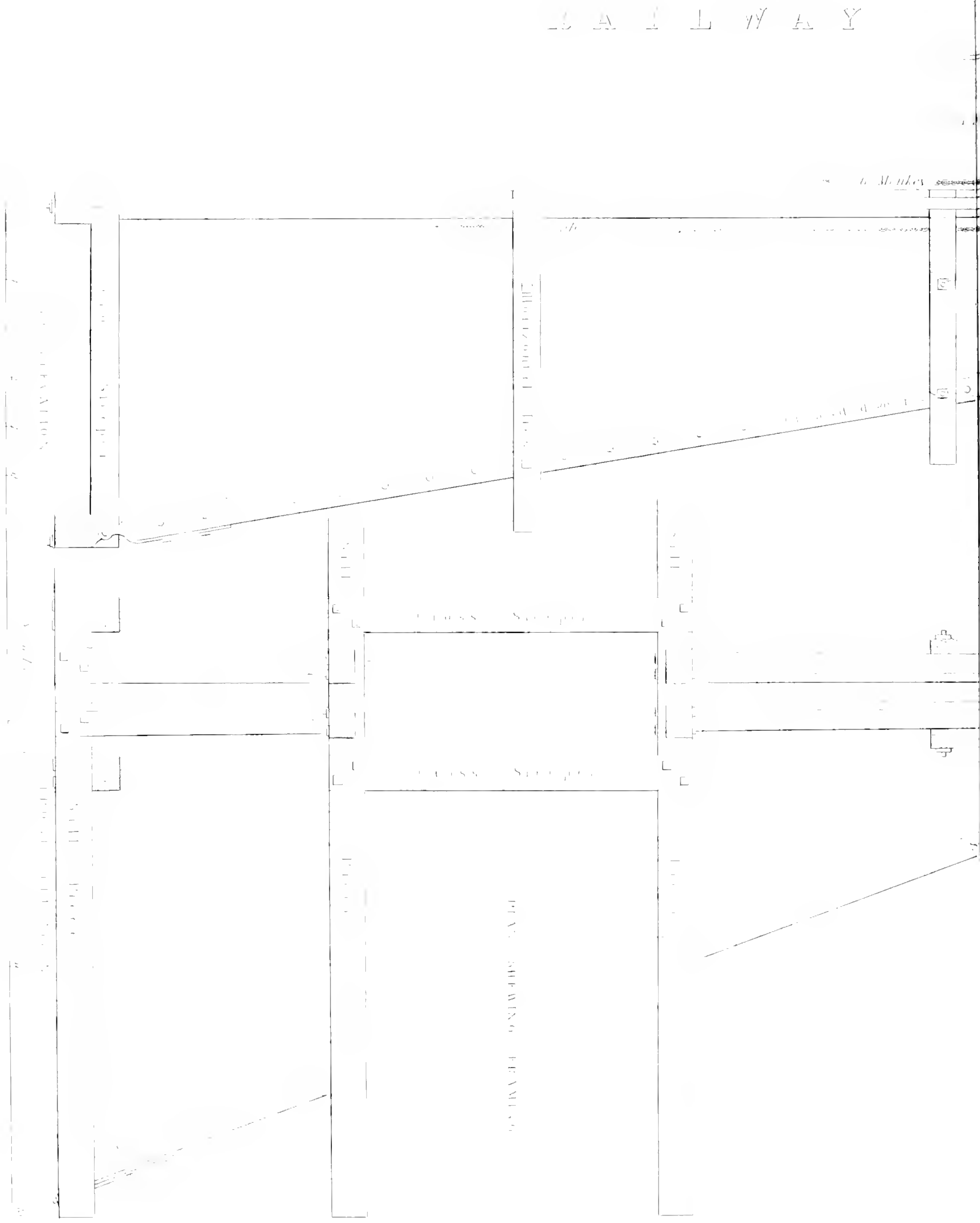


JOHN M'CNEILL ESQ^RE ENGINEER

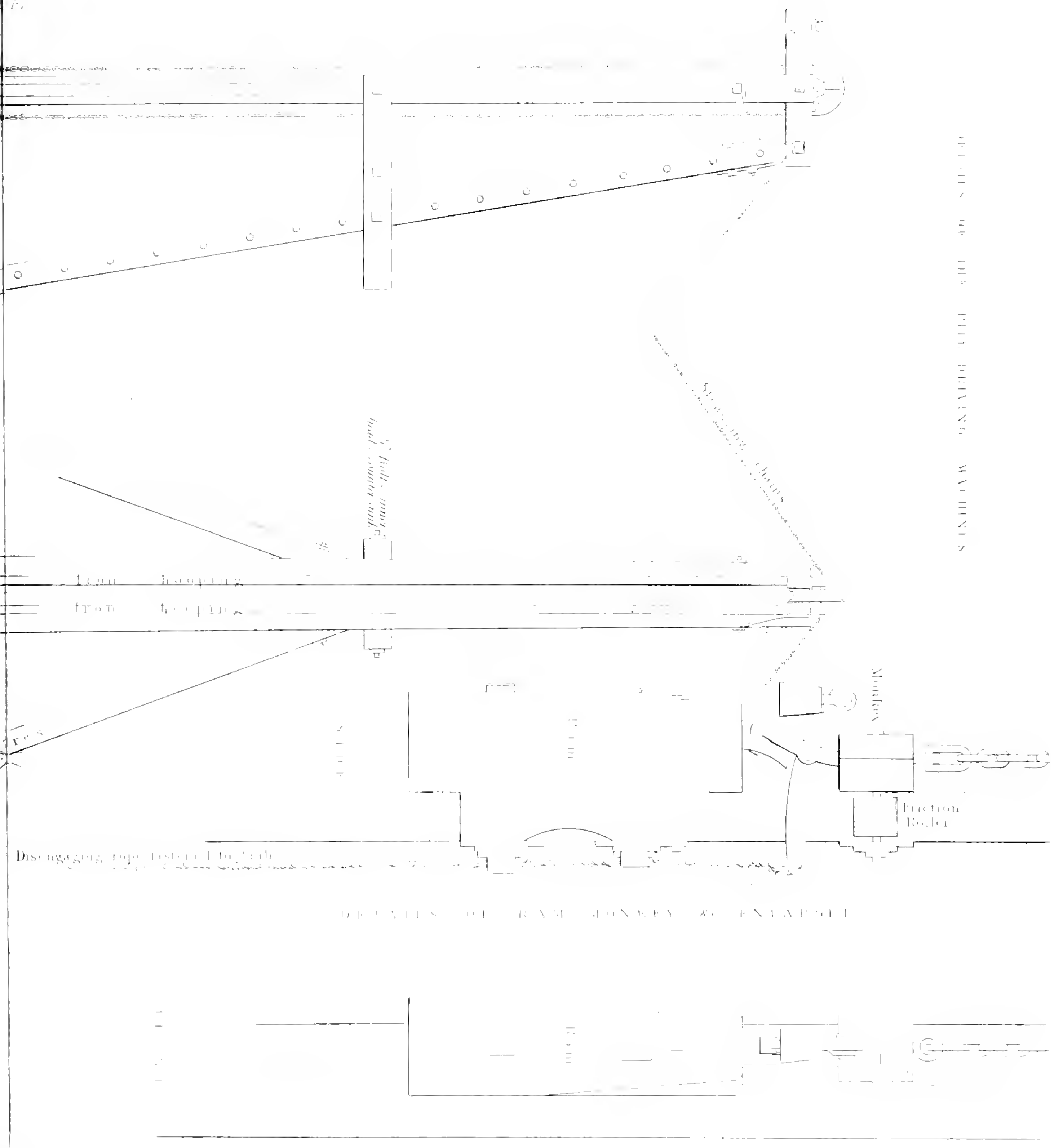
DETAILS OF LOCK Nº 3



C. L. [illegible]


RAILWAY
Monkey
Cross Sleeper
Cross Sleeper
PLAN SHOWING FRAMING

PRACTICE.

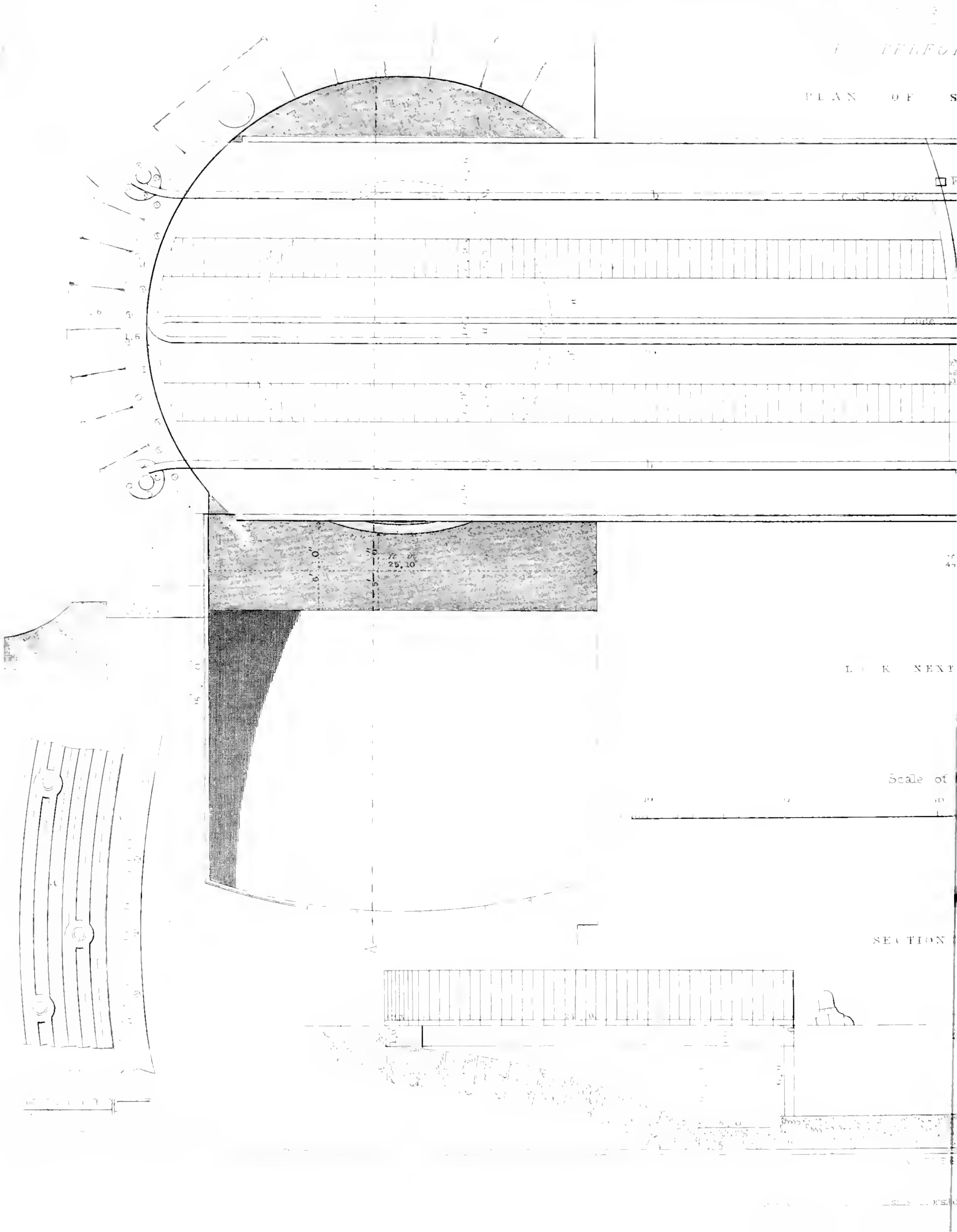


DETAILS OF THE PILE DRIVING MACHINES

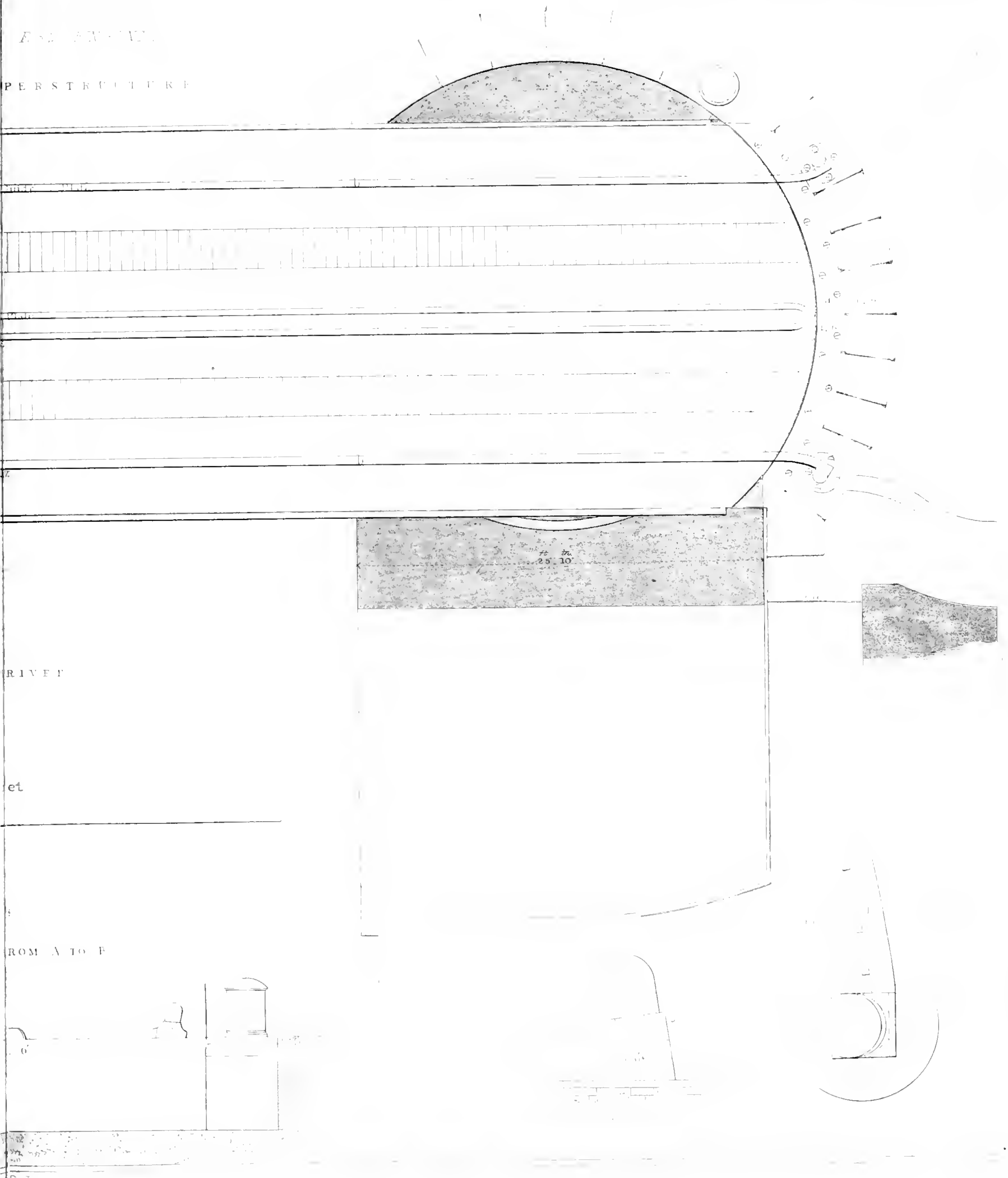
DETAILS OF RAM MONKEY &c ENLARGED

C. E. DIREX

RAILWAY

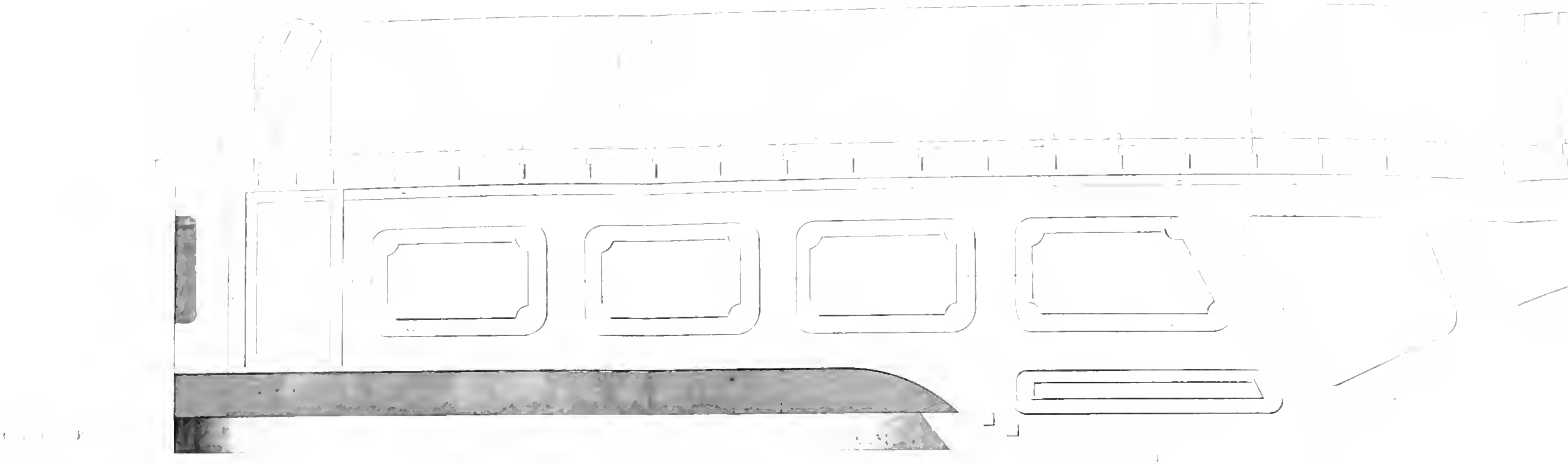


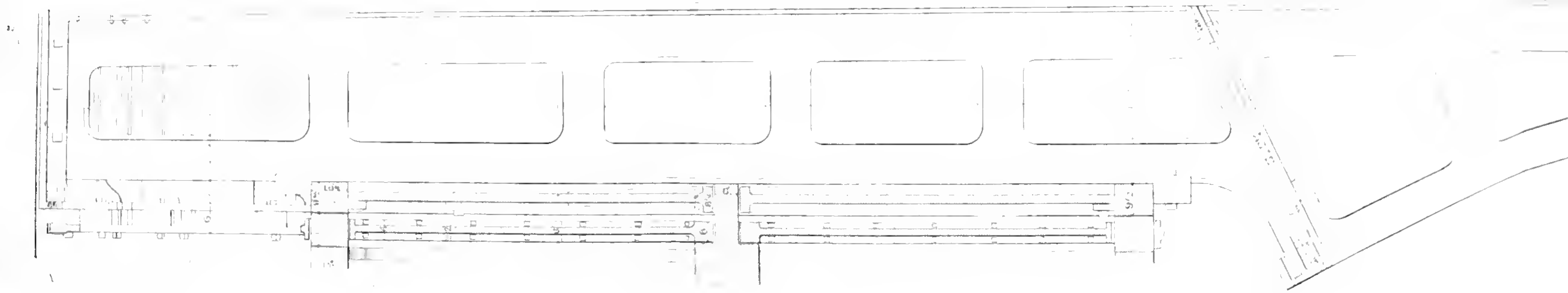
PRACTICE.

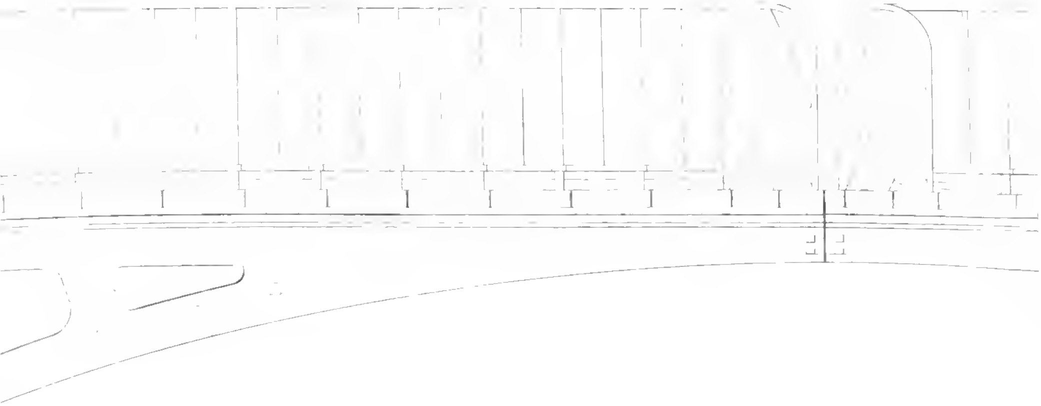


Arts,

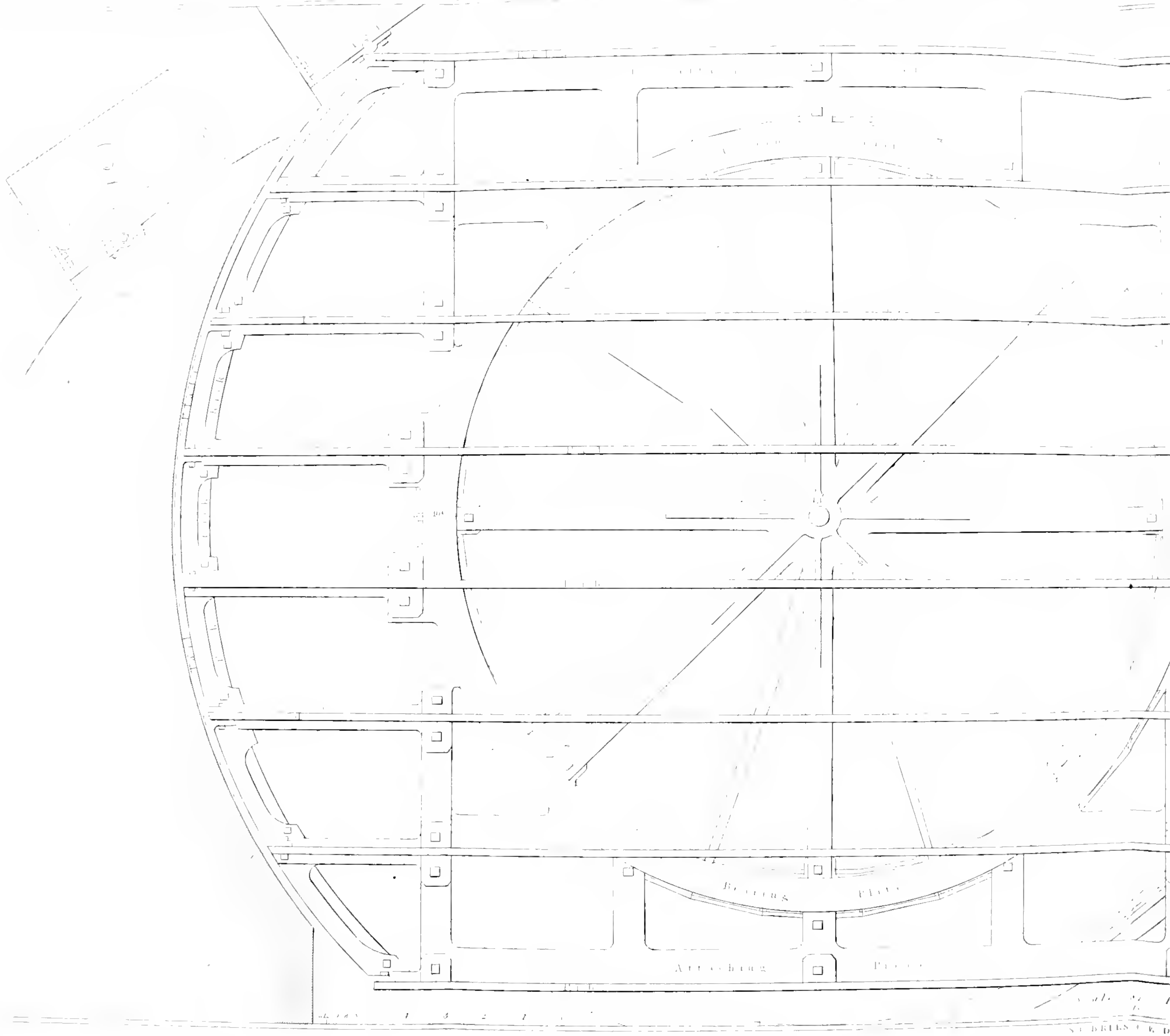
RAILWAY PLACE

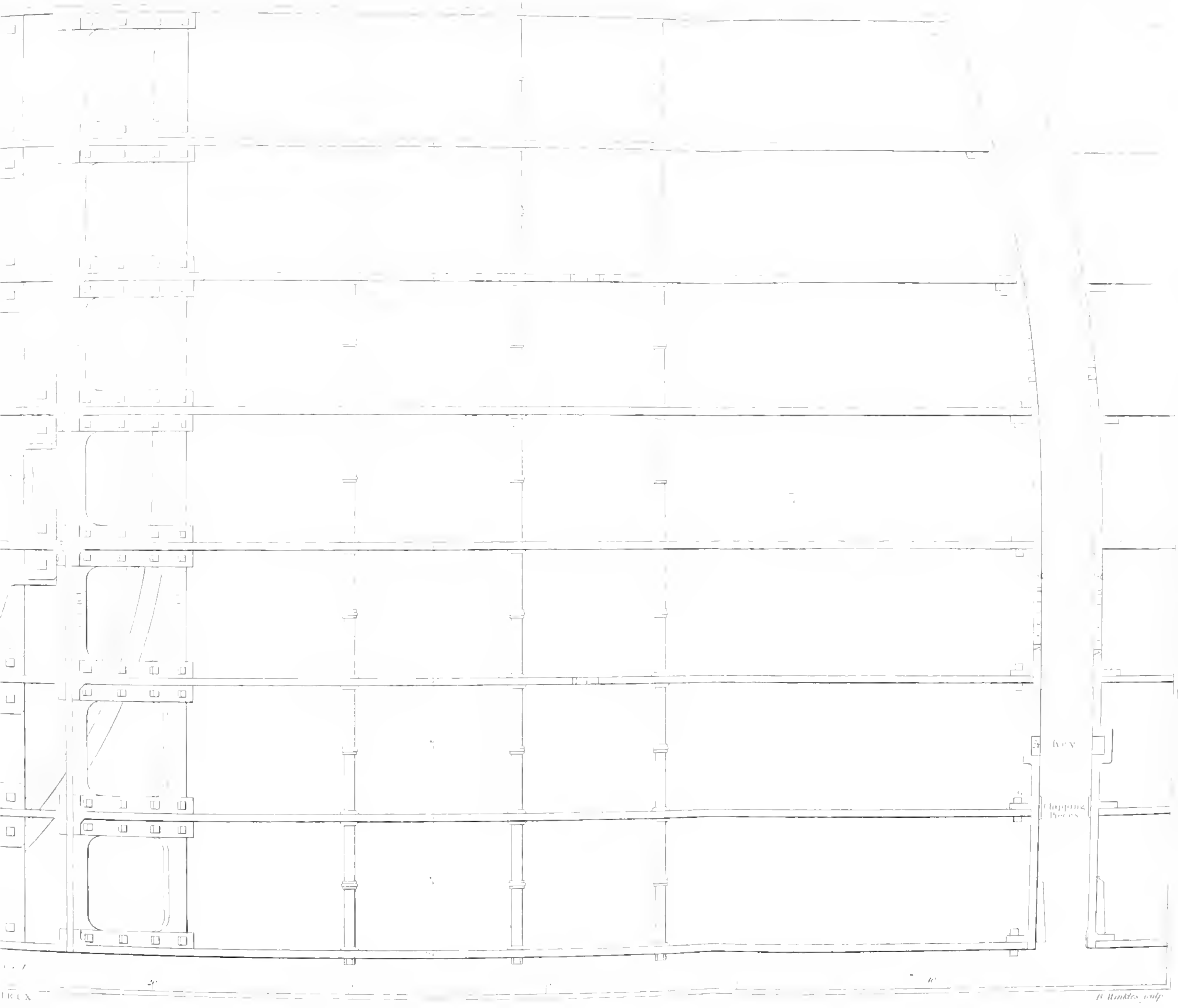






RAILWA





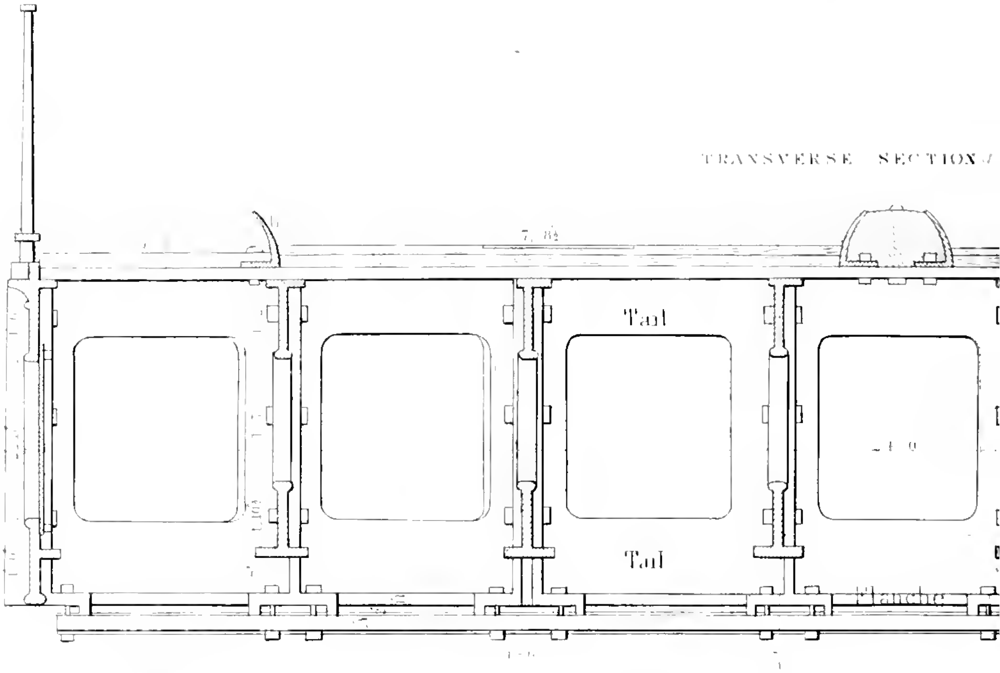
IEUX

B Winkles sculp

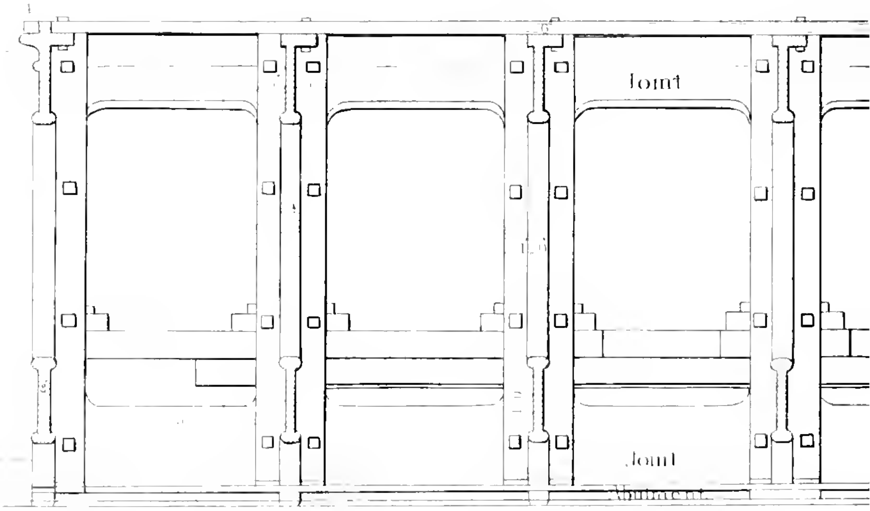
Russel Street near the Museum

RAILWAY.

TRANSVERSE SECTION

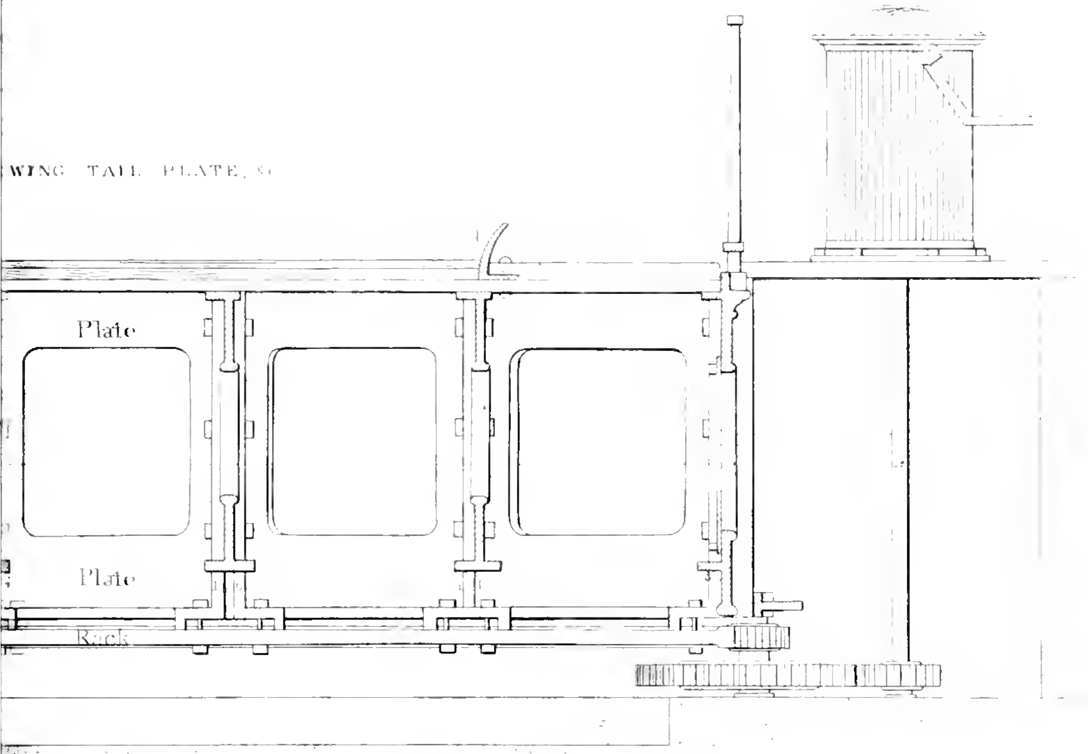


TRANSVERSE SECTION SHE

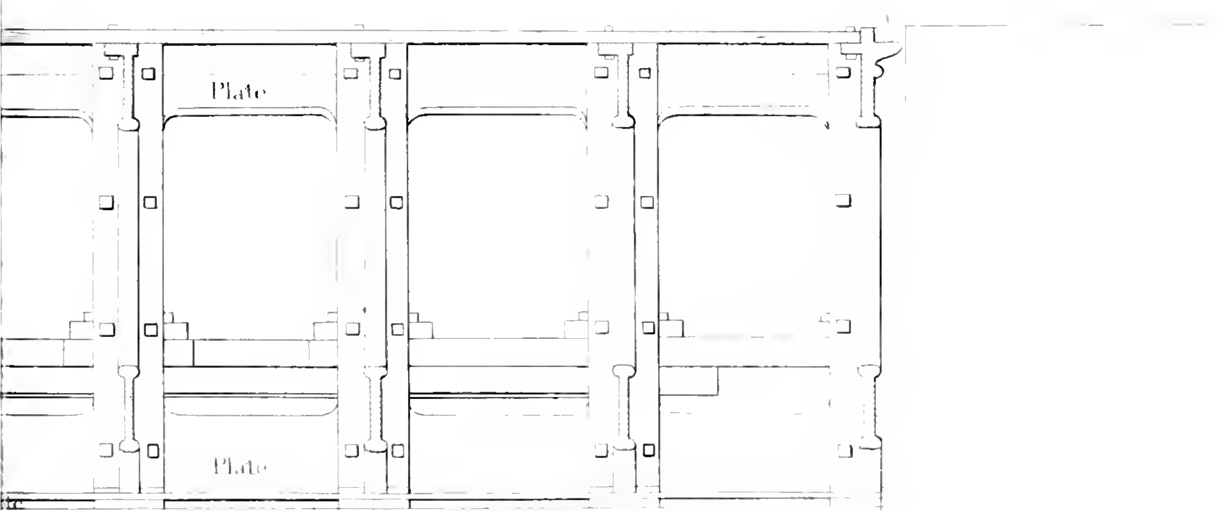


PRACTICE.

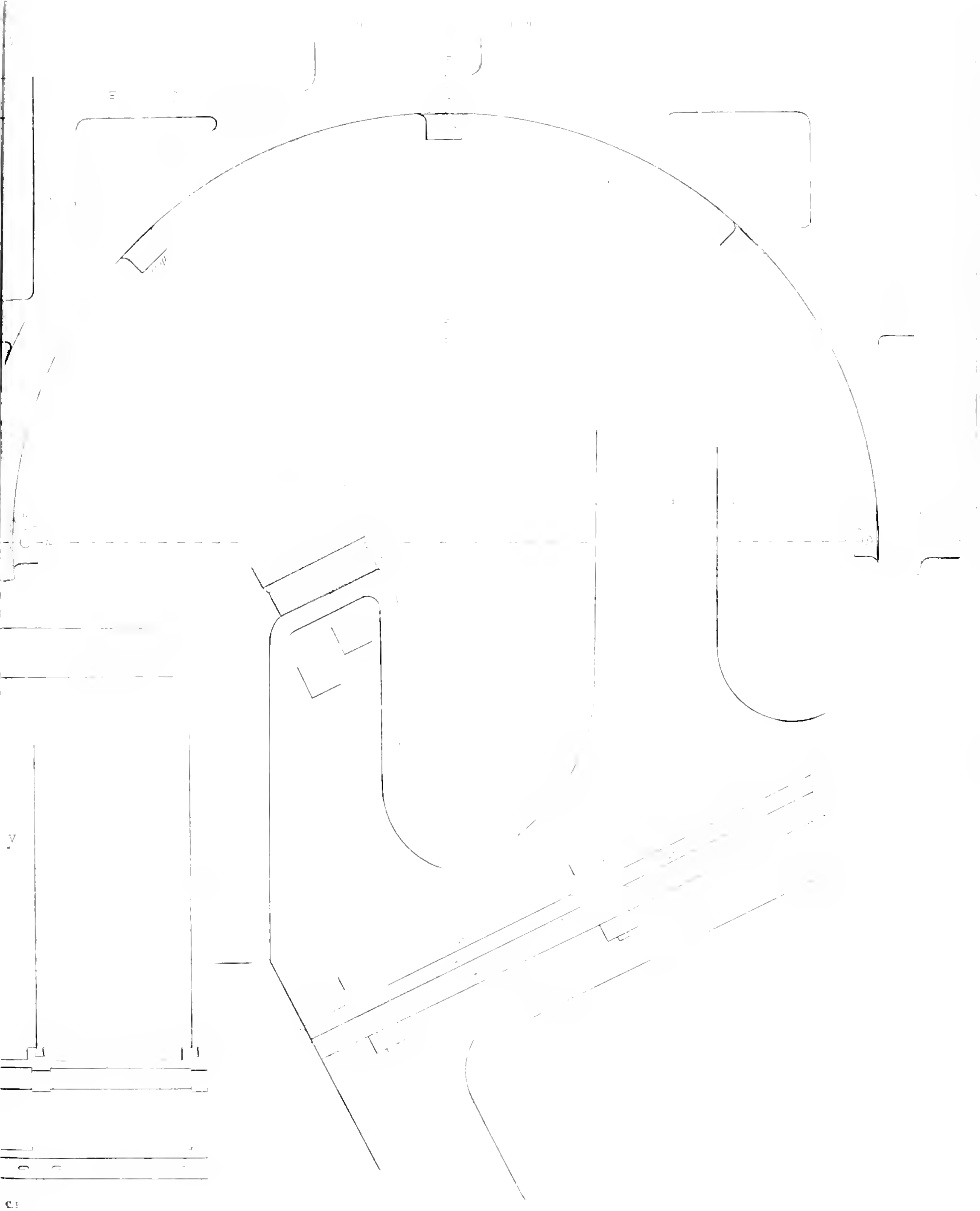
WING TAIL PLATE, &c



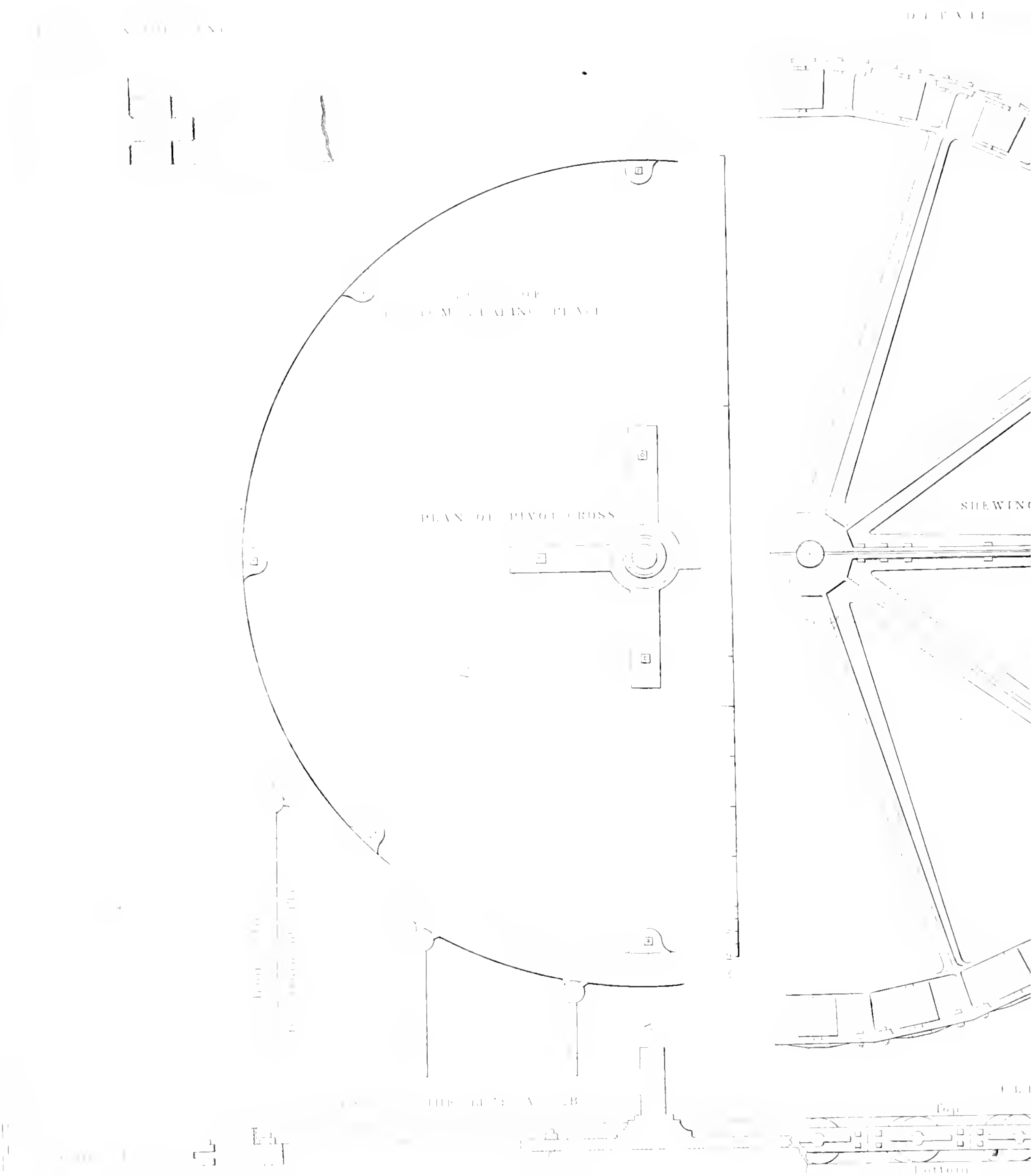
NG JOINT PLATE &c



RAILWAY

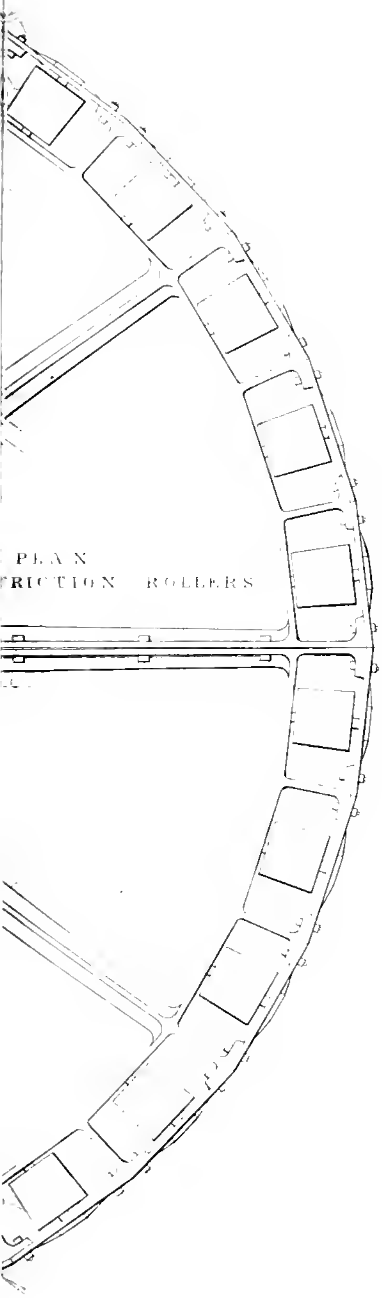


RAILWAY

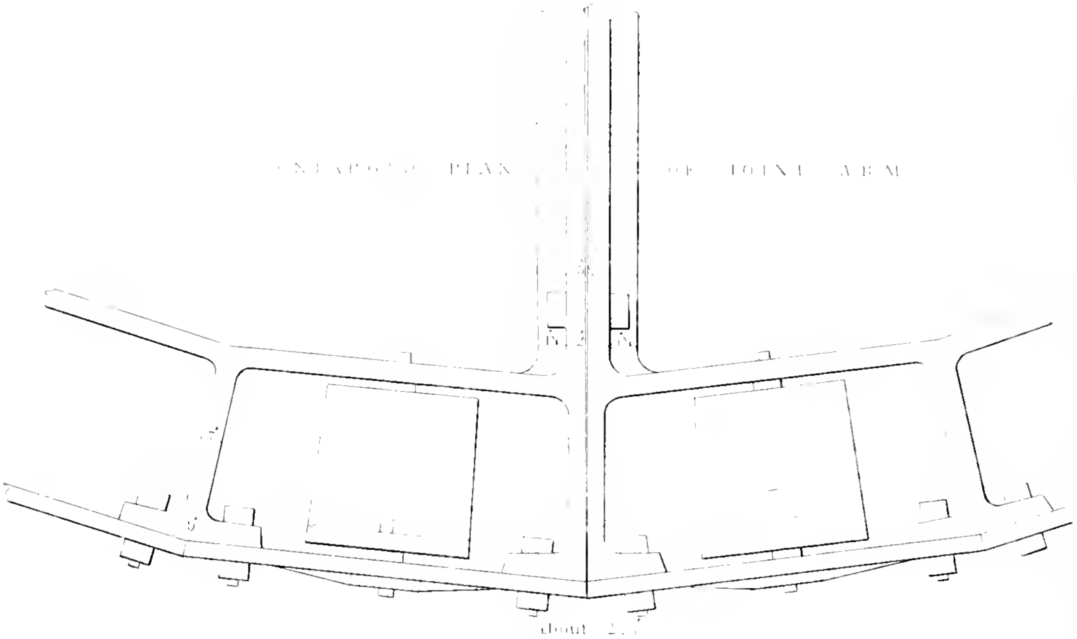


P R A C T I C E

F IRONWORK



PLAN
FRICTION ROLLERS

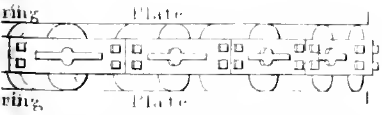


ENLARGED PLAN OF JOINT ARM

ELEVATION

ELEVATION AND SECTION OF A ROLLER

VT PLAN



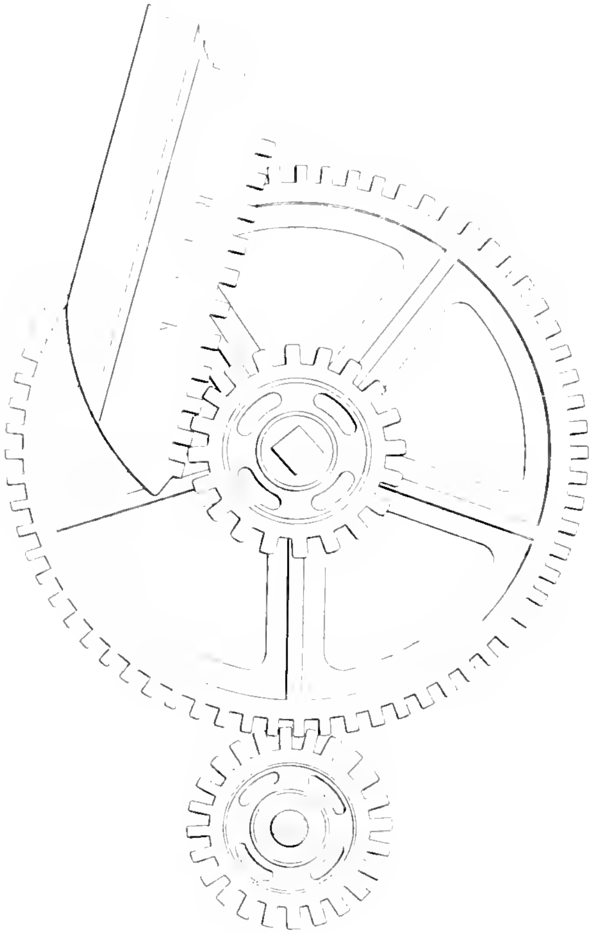
C.E. DIREX
t 100 of Rufsel Street near the Museum

F. Bland

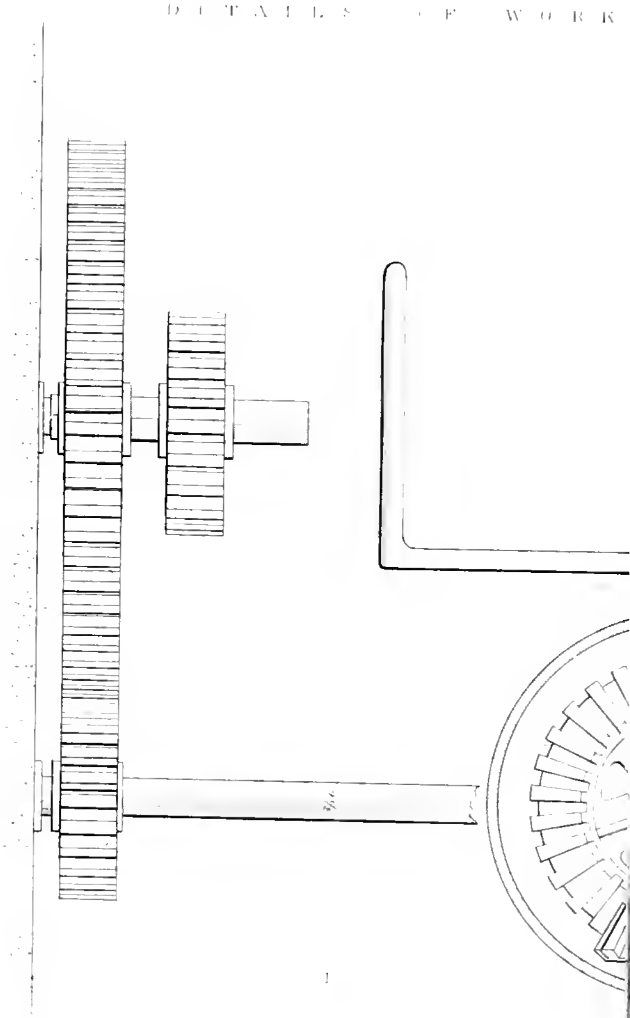
RAILWAY

THOS TELFOR

DETAILS OF WORK



PLAN OF LOWER WHEELS



ELEVATION OF LOWER WHEELS

1

PLAN OF PINION

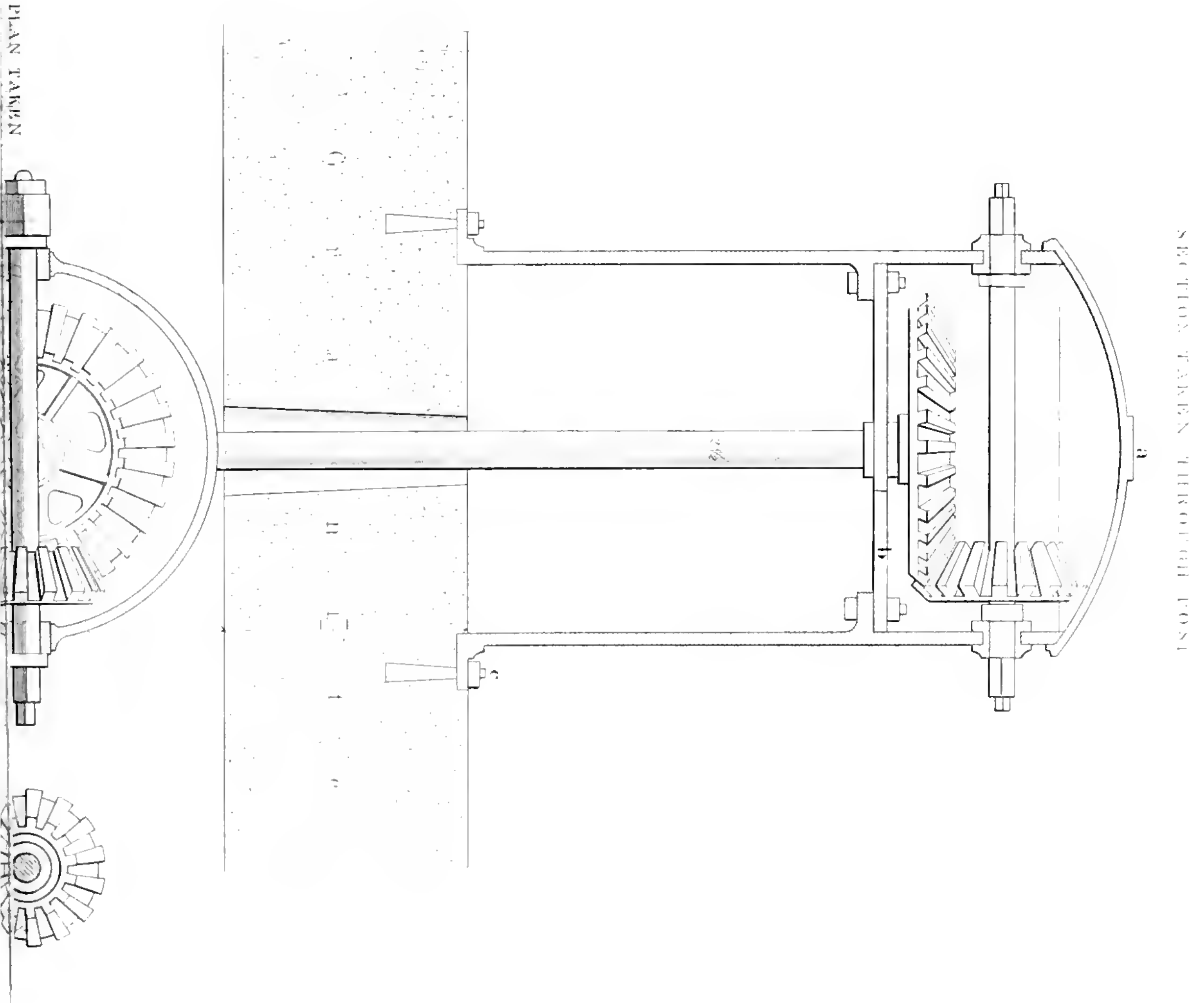
12 9 6 3 0 1 2 3 4

S C BE

John Williams Library of Ar

ESQ^R ENGINEER

G GEAR TO BRIDGE



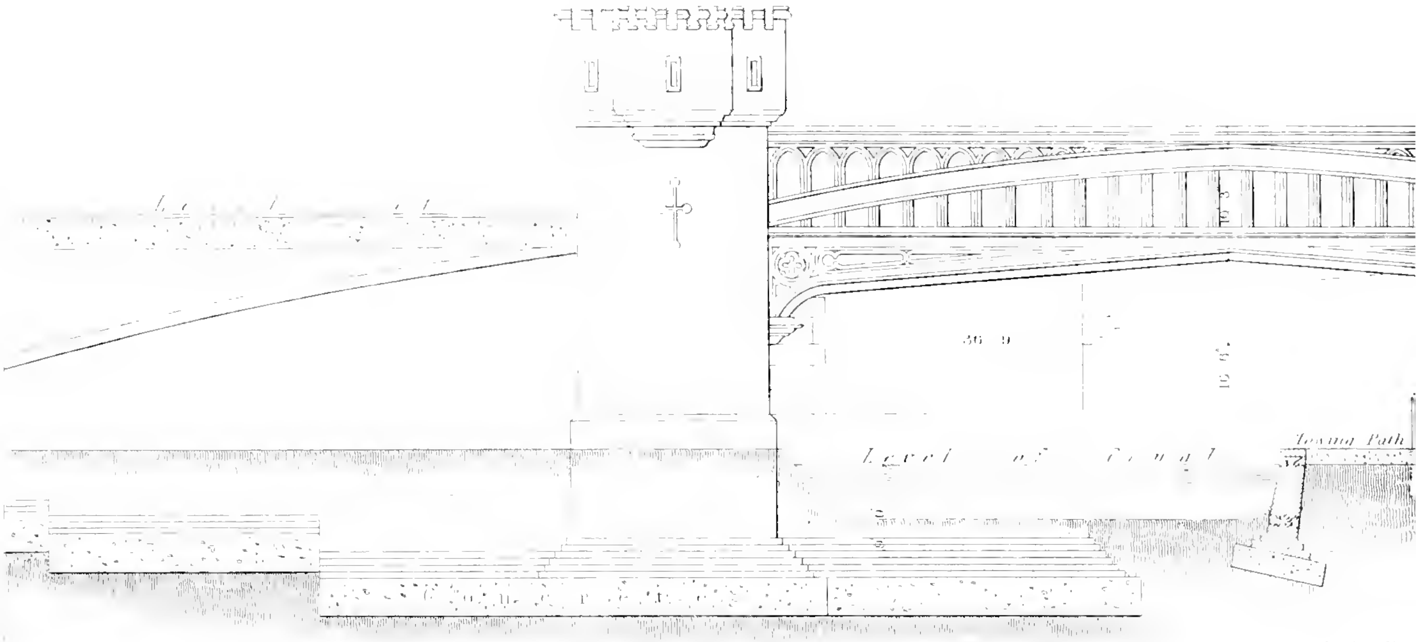
5 6 7 8 9 10 Feet

C E DIREX

26, Great Russell Street, Bl.

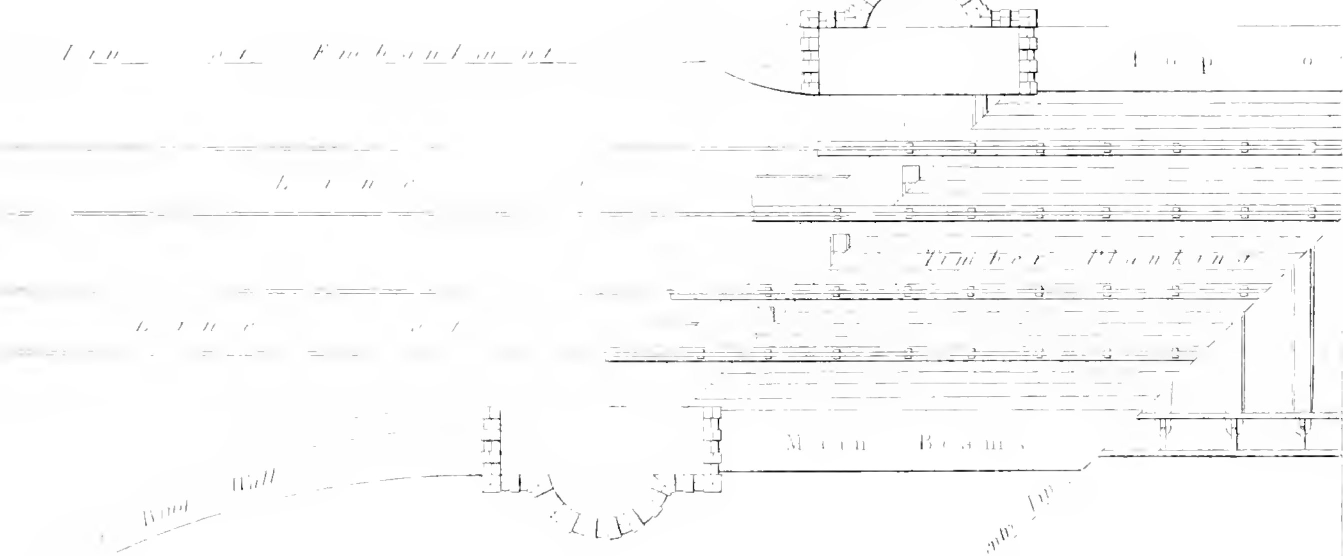
RAILWAY

BRIDGE OVER THE ROCHDAL



E L E

HALF PLAN TAKEN AT THE

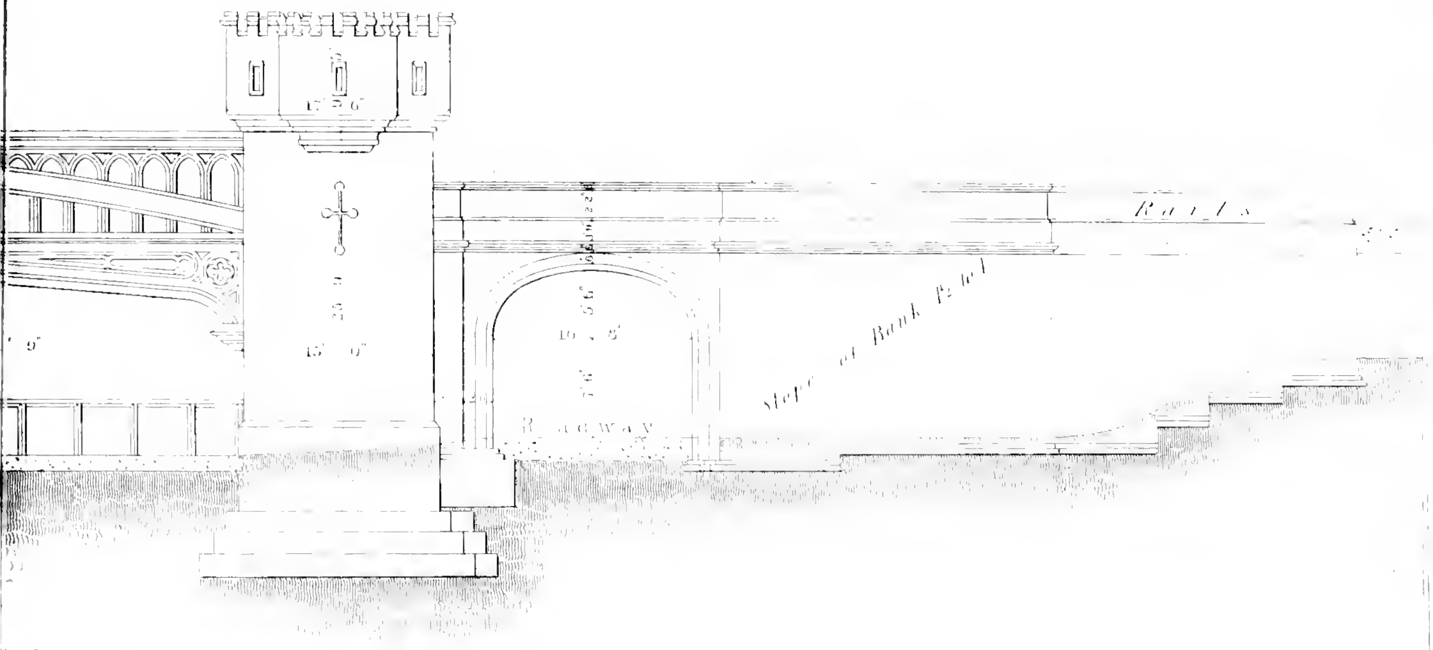


J. Williams, Adams & Son

P R A C T I C E,

2nd ENGINEER

CANAL AT SCOWCROFT

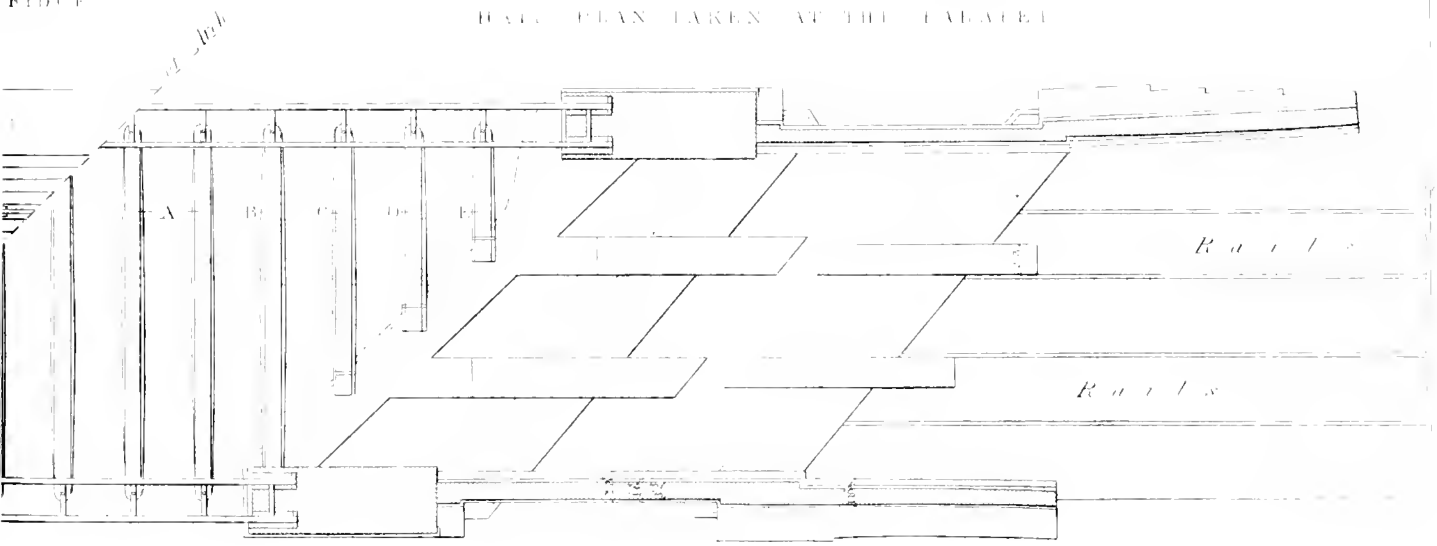


A ... N

Angle of Askew 45°

RIDGE

HALF PLAN TAKEN AT THE PARAPET



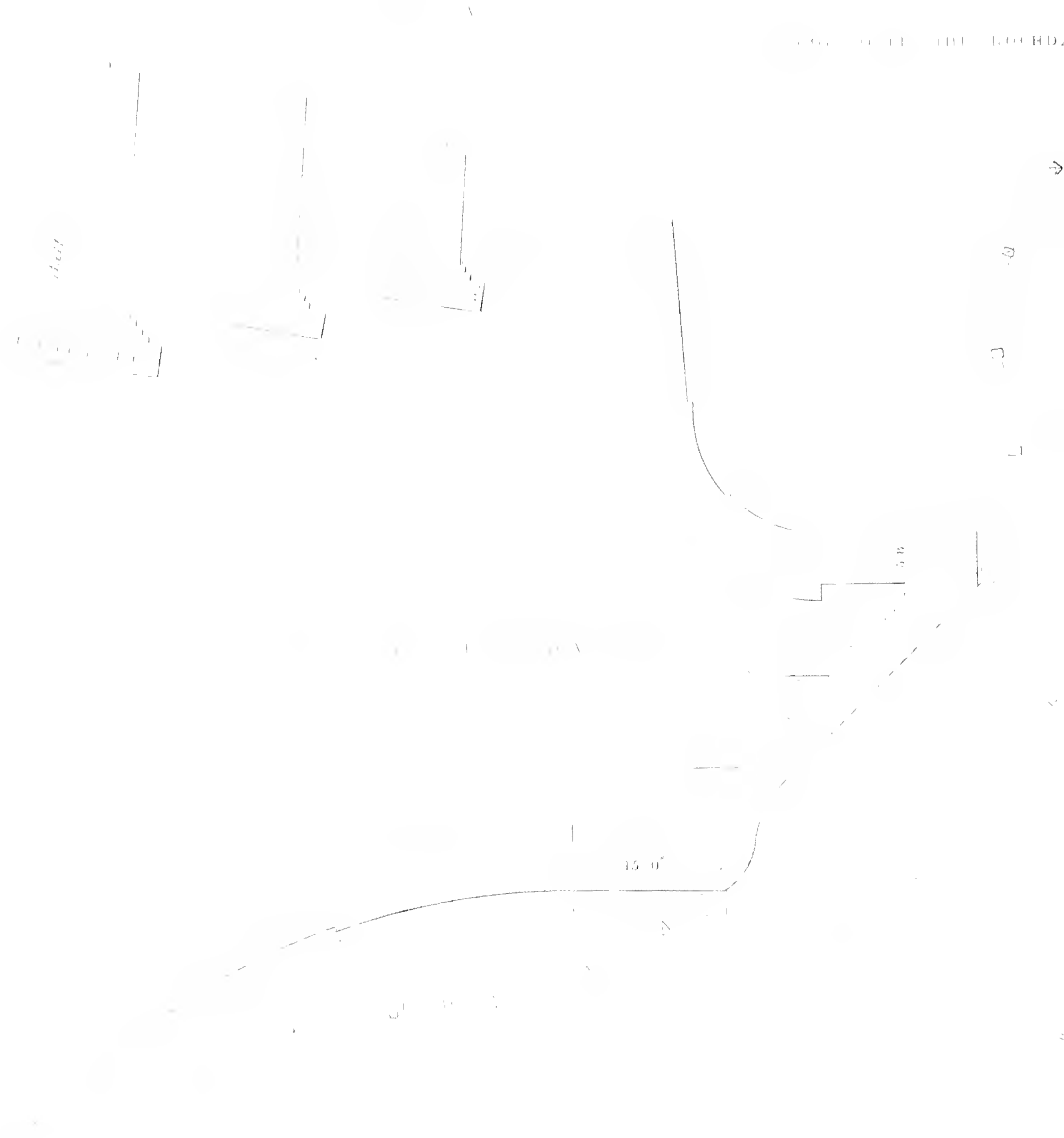
of Feet

60 70 80 90 100 110 120

C E DRIES

106 ... Street near the Museum

R A I L W A Y



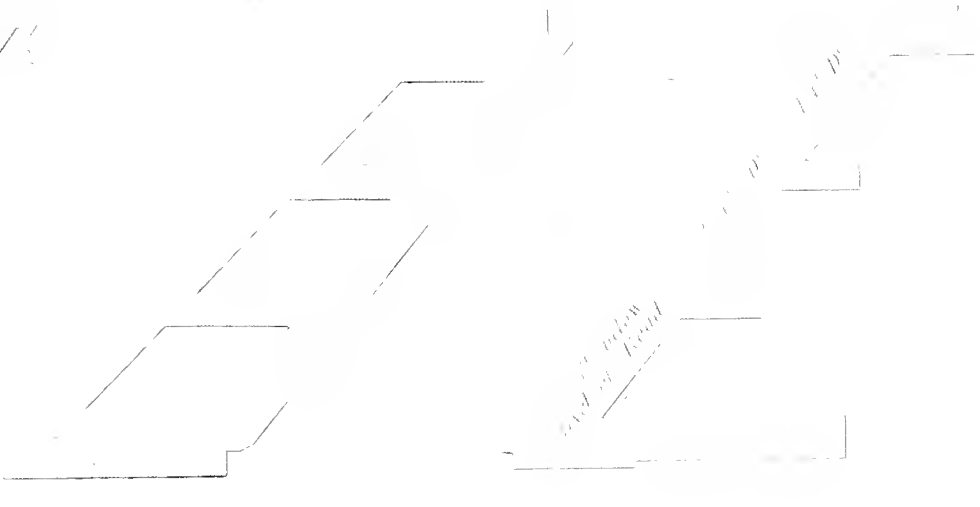
PRACTICE.

CANAL AT [illegible]

SECTION AT D

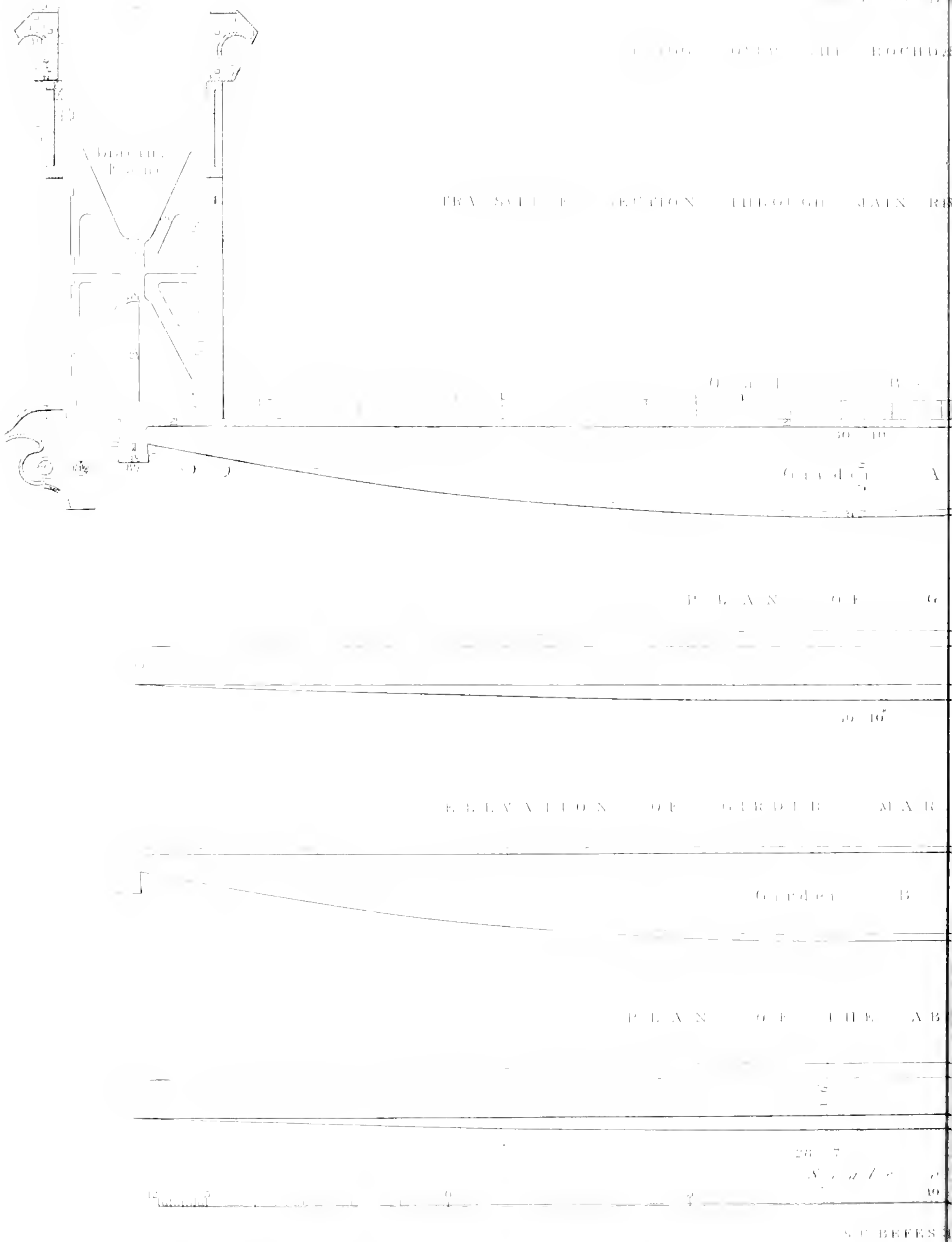
[illegible] ARCHWAY

[illegible] THE SQUARE



RAILWAY

BRIDGE OVER THE ROCHDA



S. C. BREES

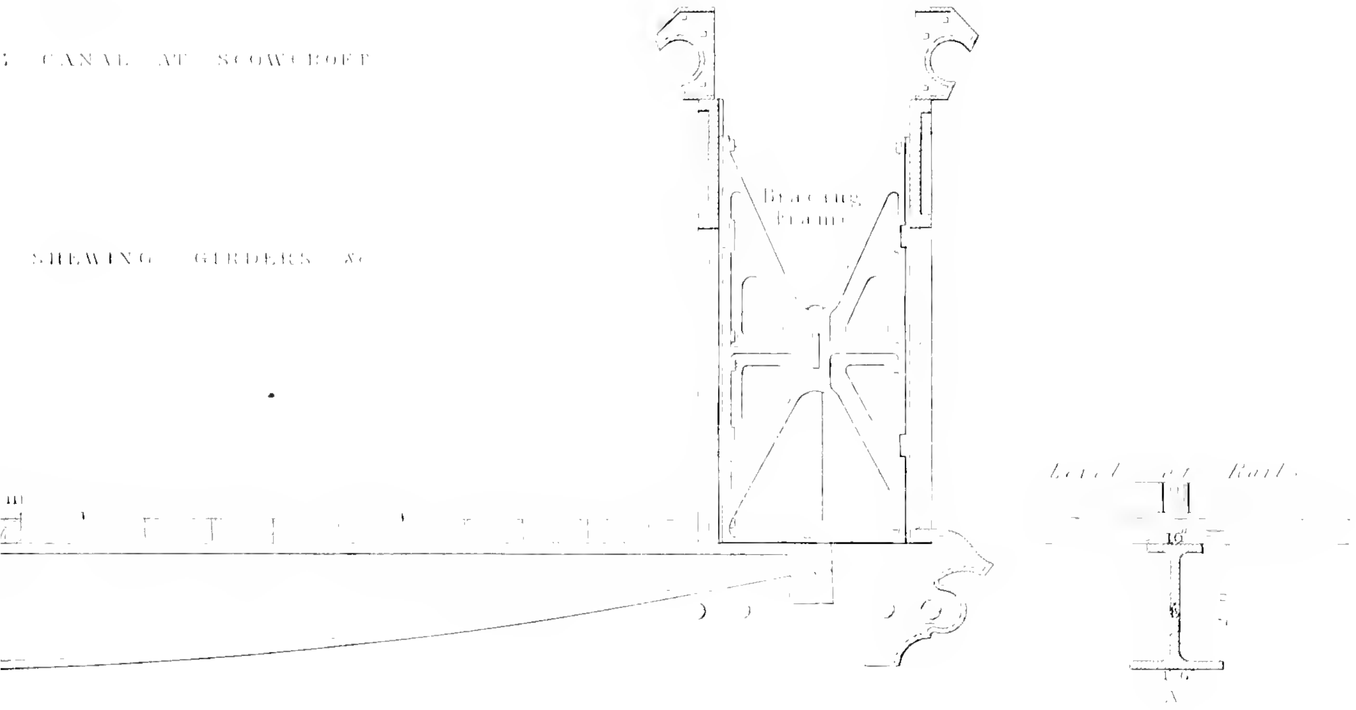
J. I. Brees del.

John Williams Library of Science &

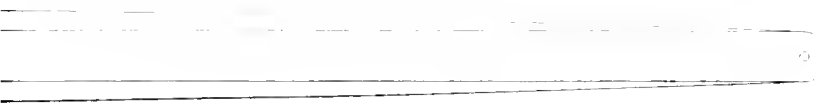
PRACTICE.

CANAL AT SCOWCROFT

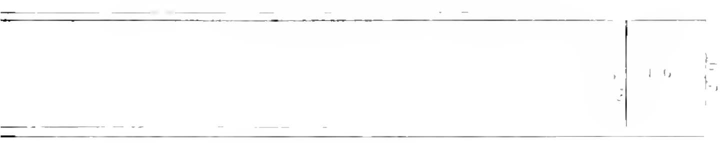
SHEWING GIRDERS &c



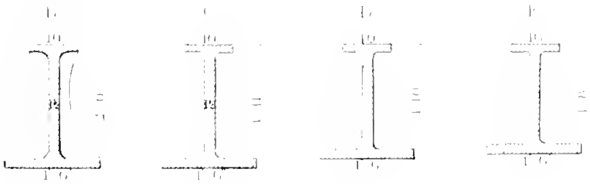
R D E R



E D B O PLAN



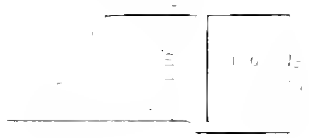
SECTIONS OF GIRDERS MARKED ON PLAN



V E

ELEVATION OF THE ENDS OF GIRDERS

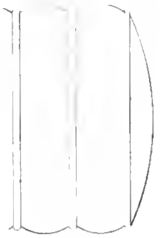
C D A E



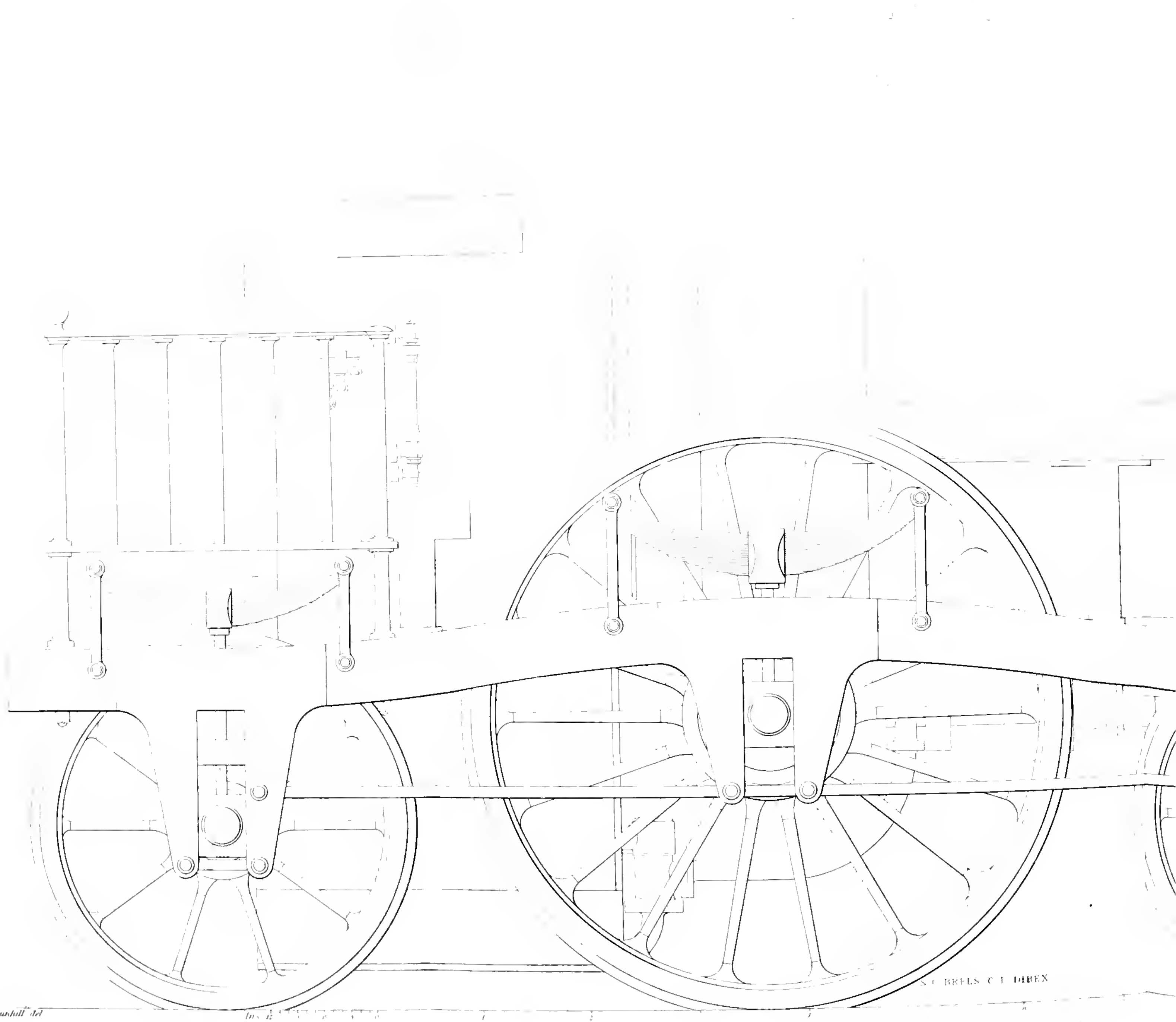
Feet

DIREX

00 6' Russel Street near the Museum.



AILWAY PLAT



S C BREES C E DIREX

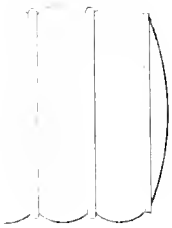
T Dunhill del

Ins 12

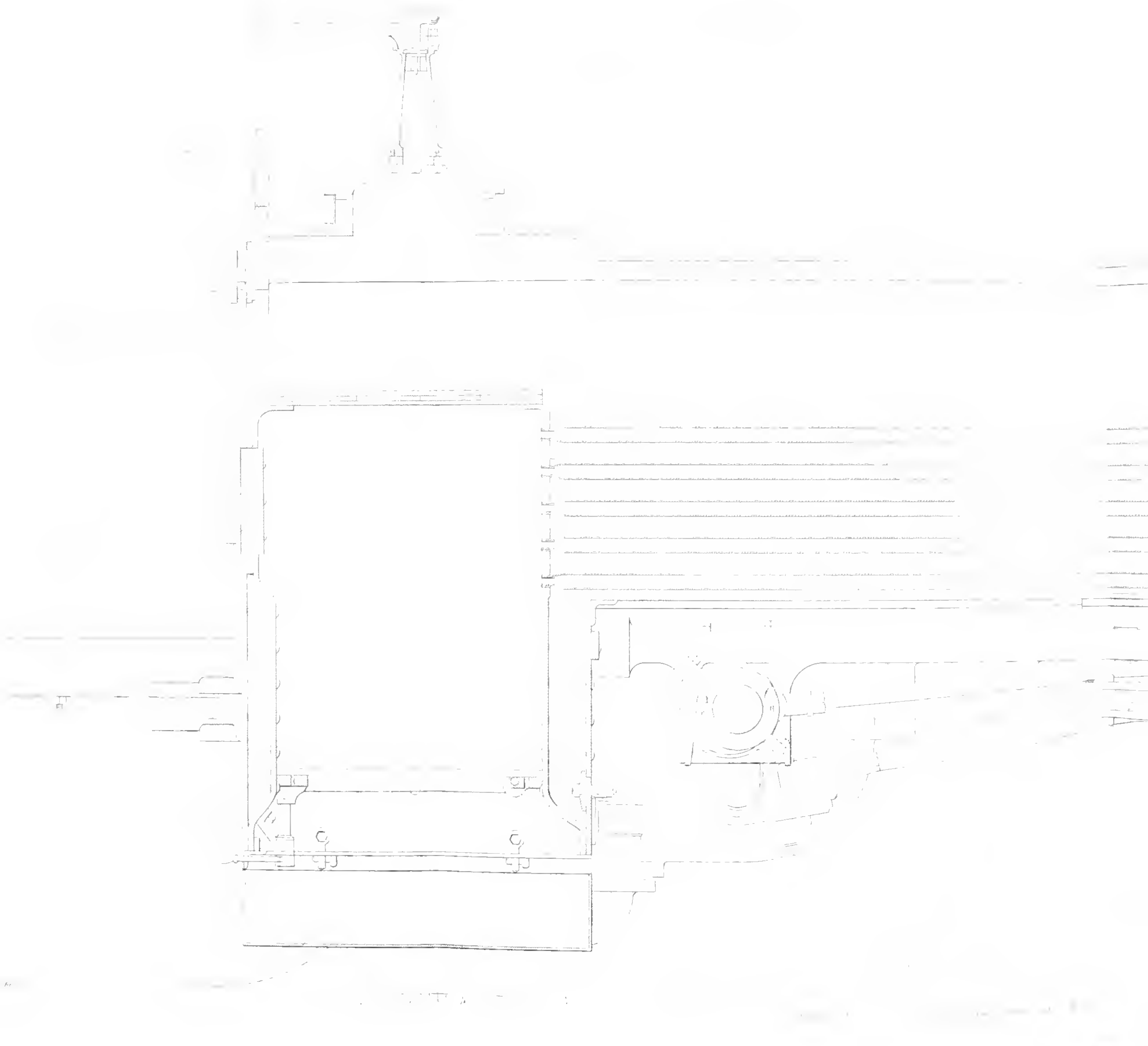
John Williams Library of Science & Art 106 Gt Russel Street near the Museum

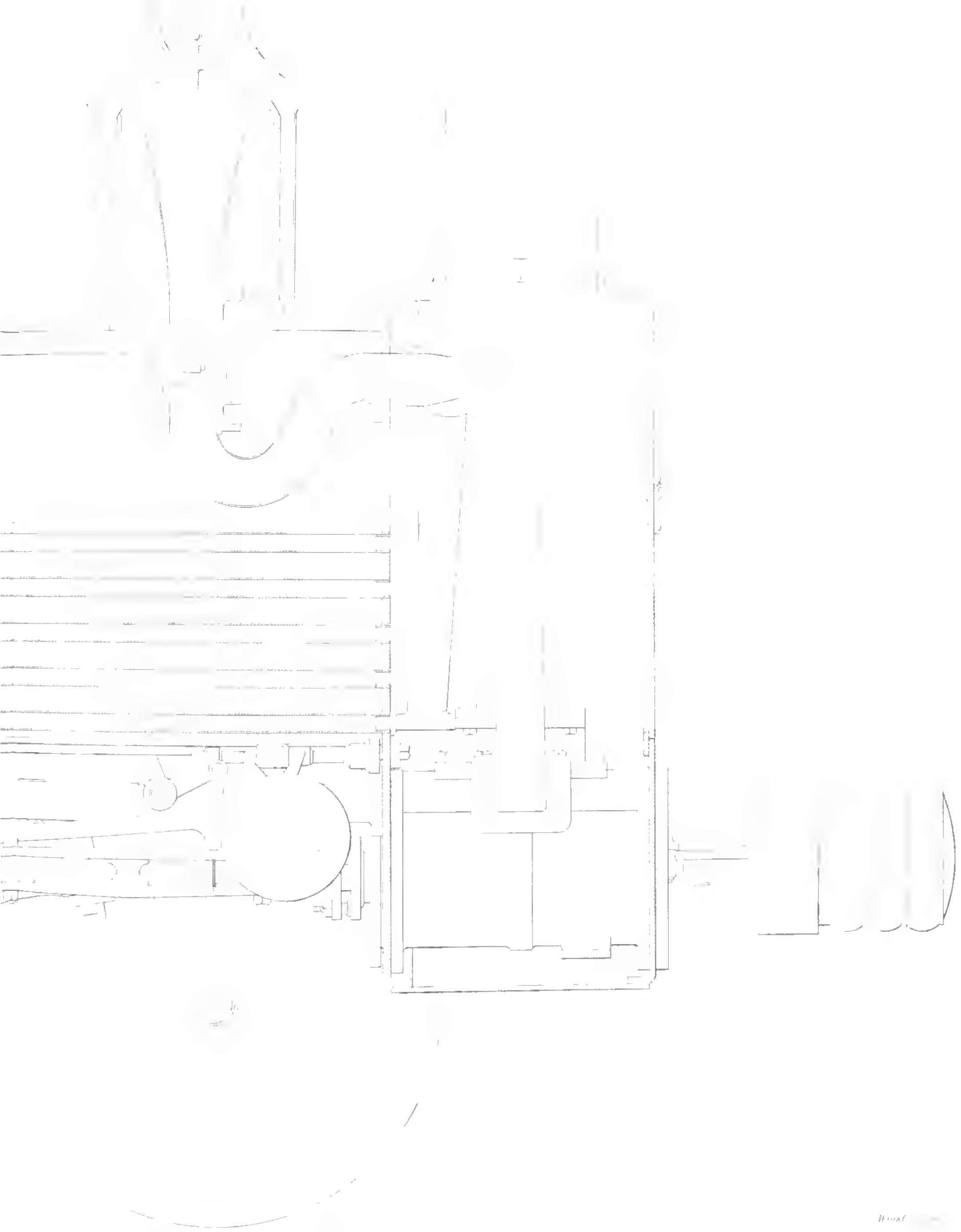
ICE

H. Winkl

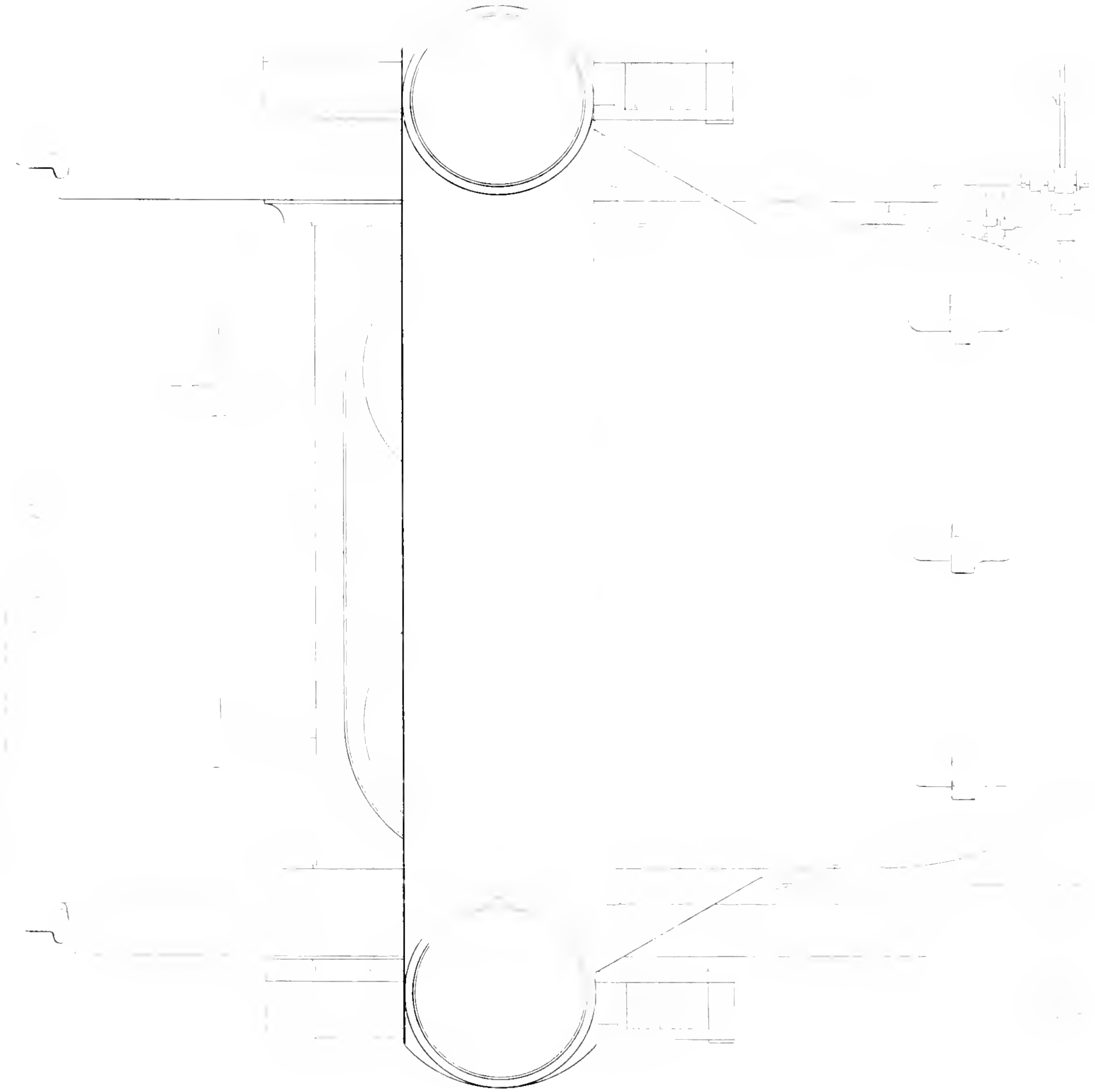


RAILWAY PR

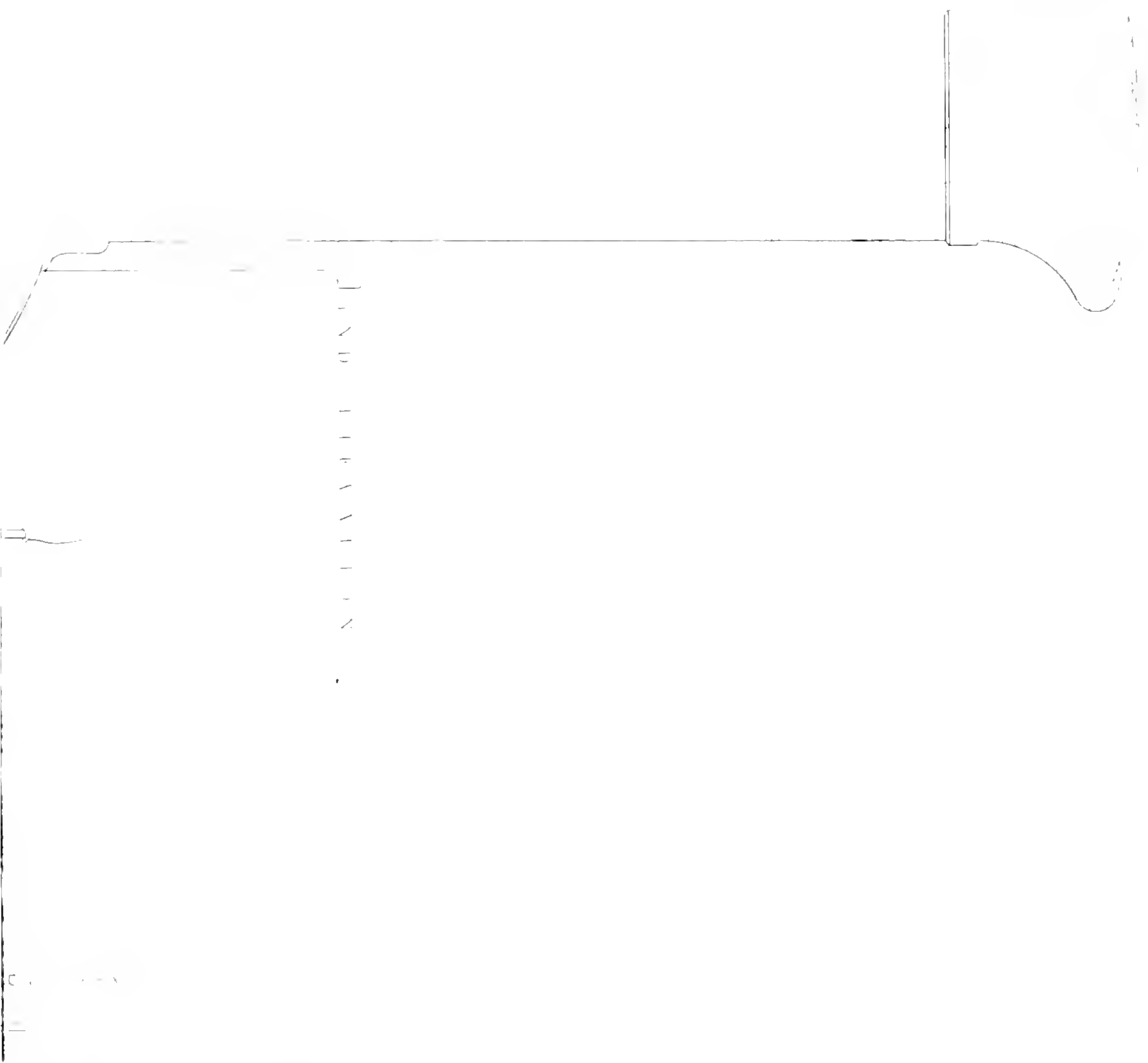



Hunt

RAILWAY



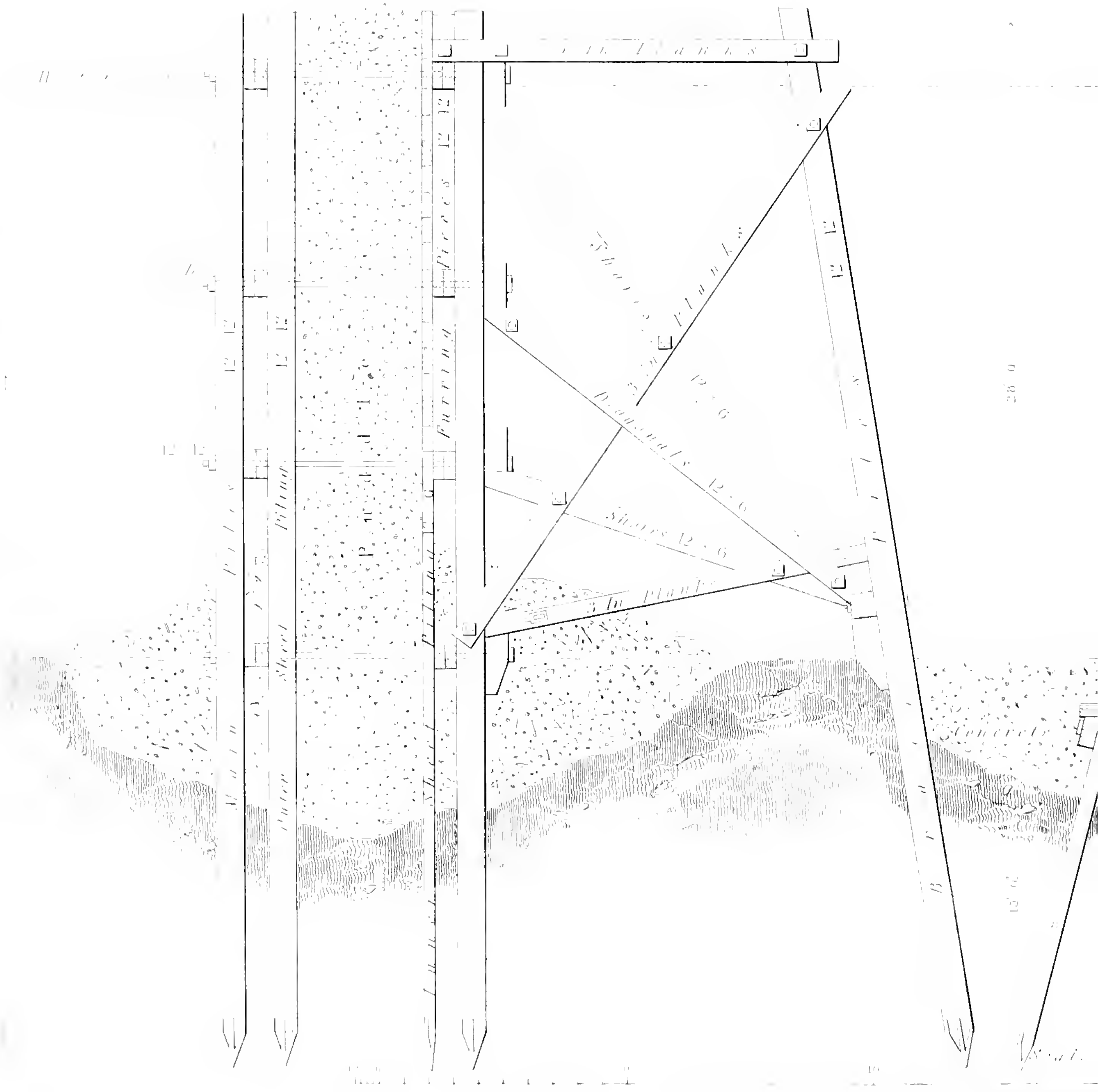
PRACTICE



[illegible]

QUAY

SECTION SHEWING



S C BR

John Williams Library of Science &

PLATE

WALL.

OFFER DAM WALL.

Bottom length of Pitching 30 feet

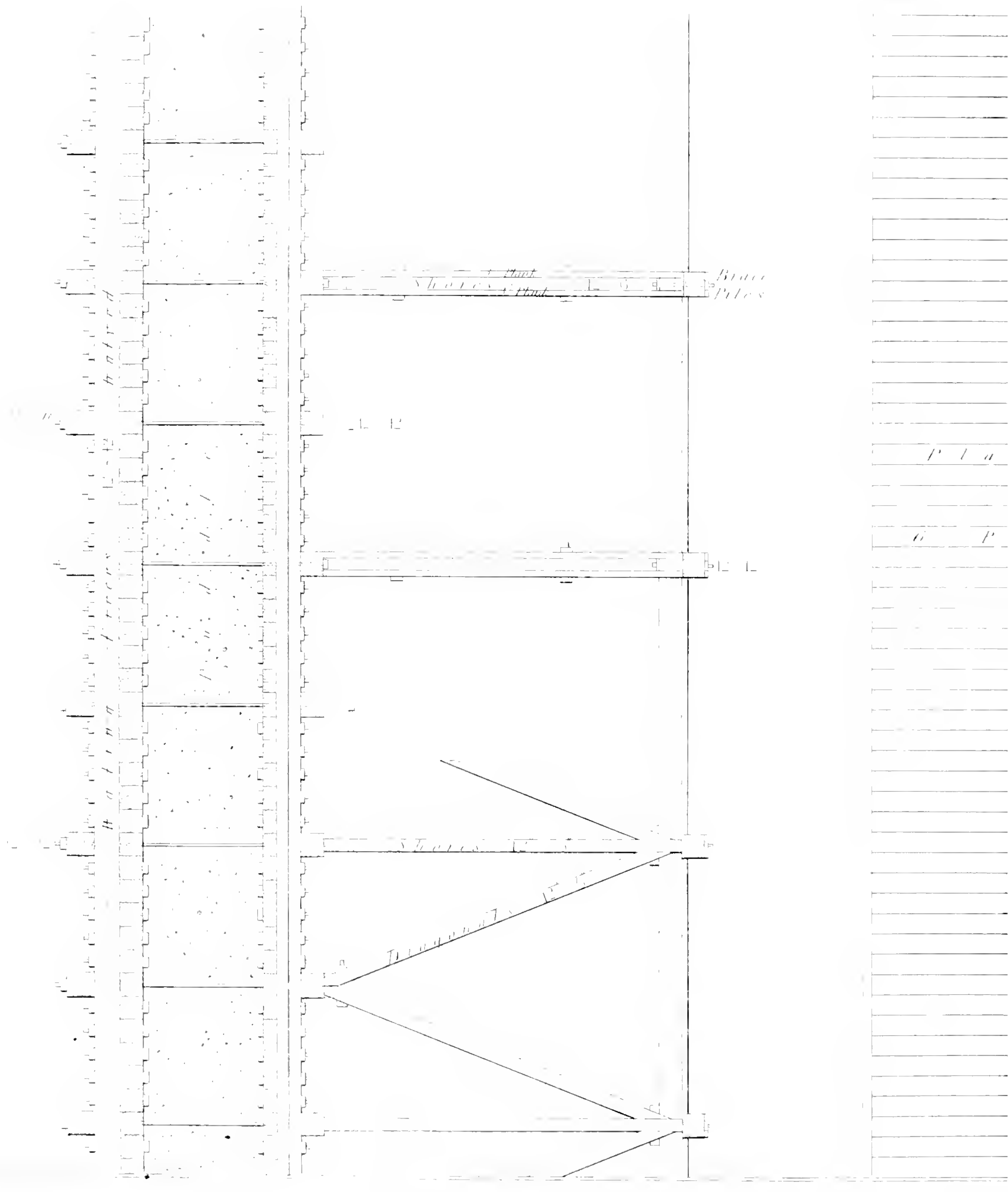
C. E. DIREN
406 Oxford Street near the Museum

Weeks sculp

RAILWAY

JOHN MACNEI

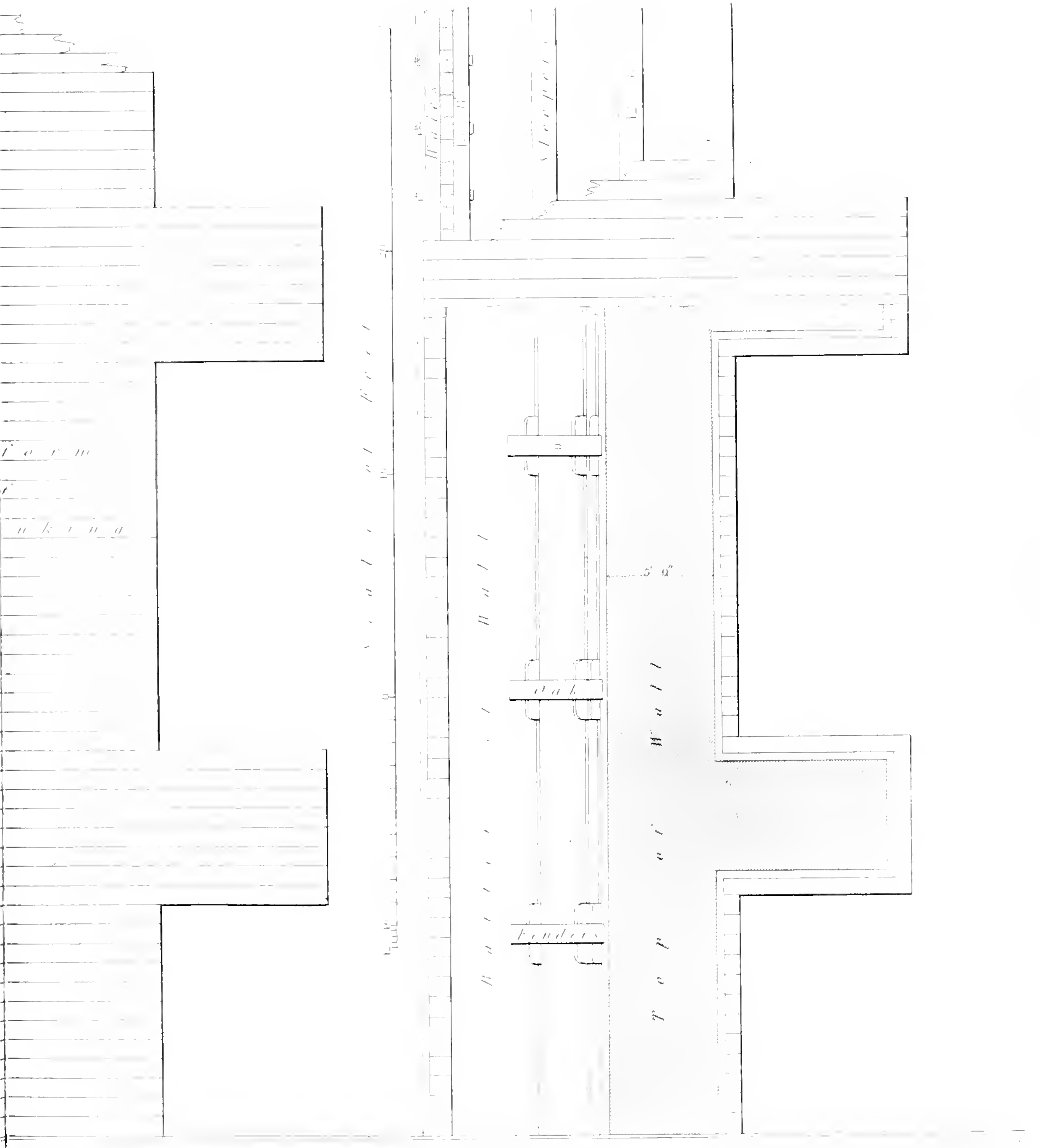
QUAY



PRACTICE.

ESQ^R ENGINEER.

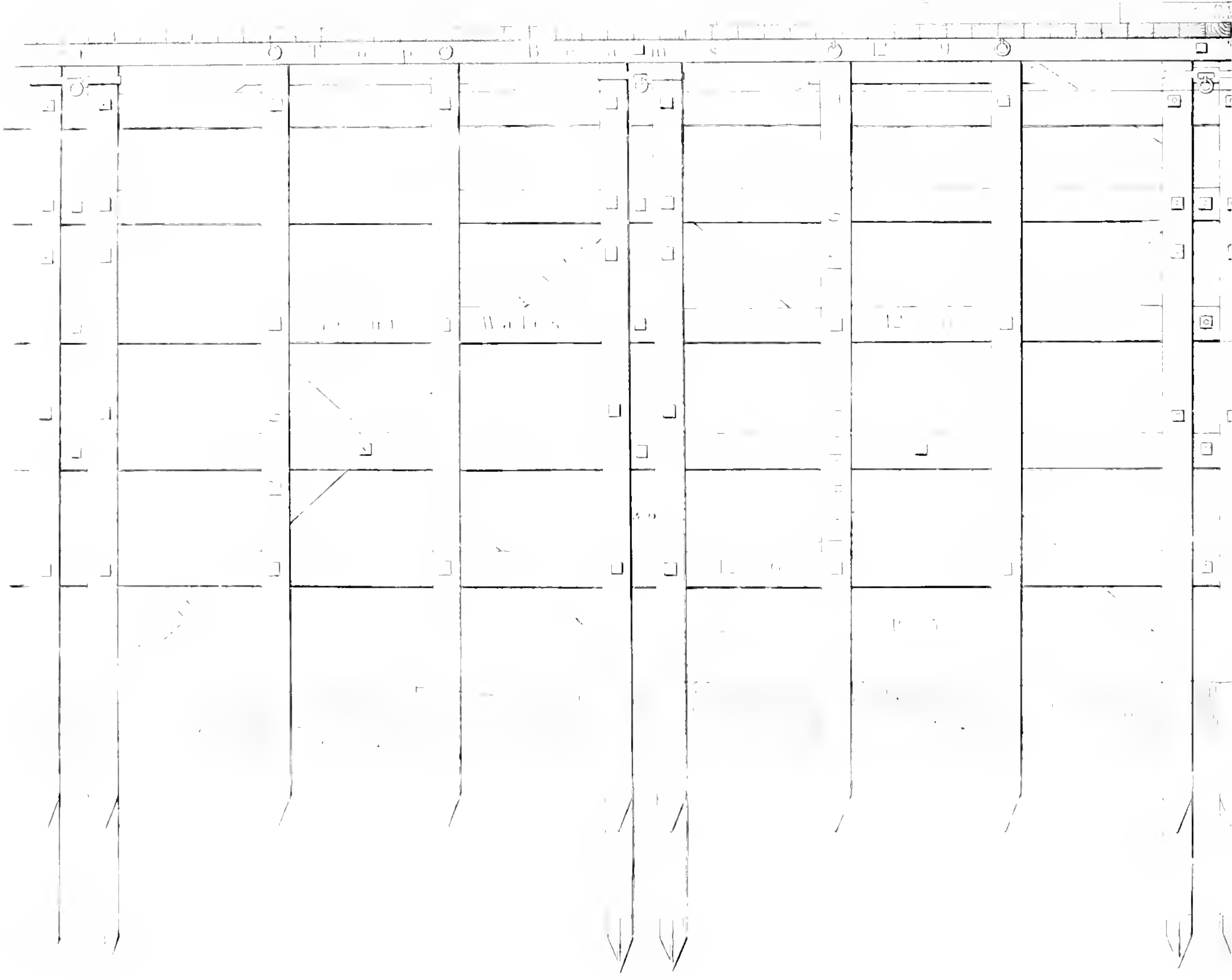
WALL



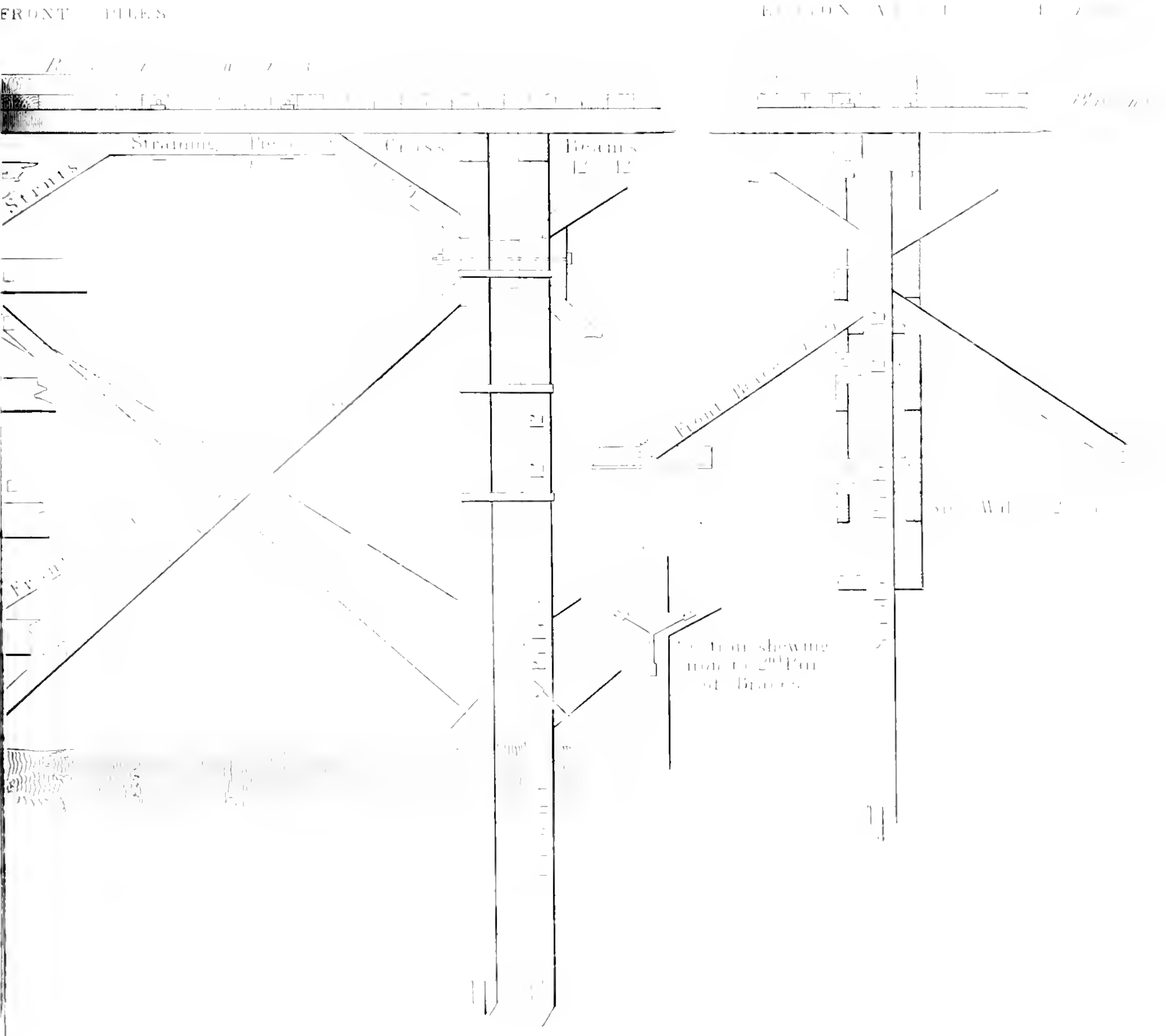
C. F. CHEFFIN

RAILWAY

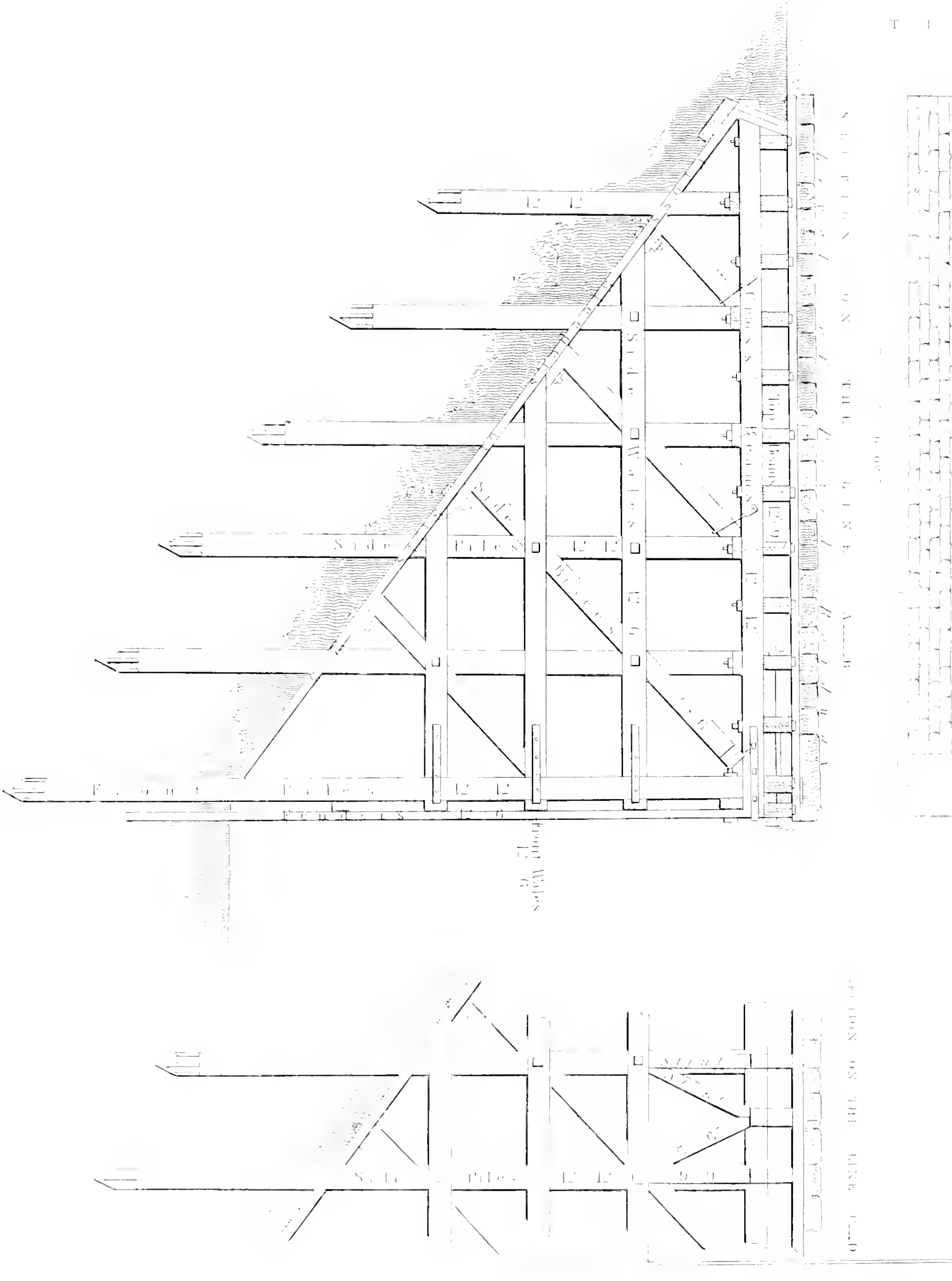
ELEVATION AND SECTION [illegible] THE [illegible] O



PRACTICE.


FRONT PILES
SECTION AT
Straining Piece
Cross
Beams
12 12
Struts
Front Brace
Pile
Section shewing notch for 2nd Pair of Braces

R A I L W A Y

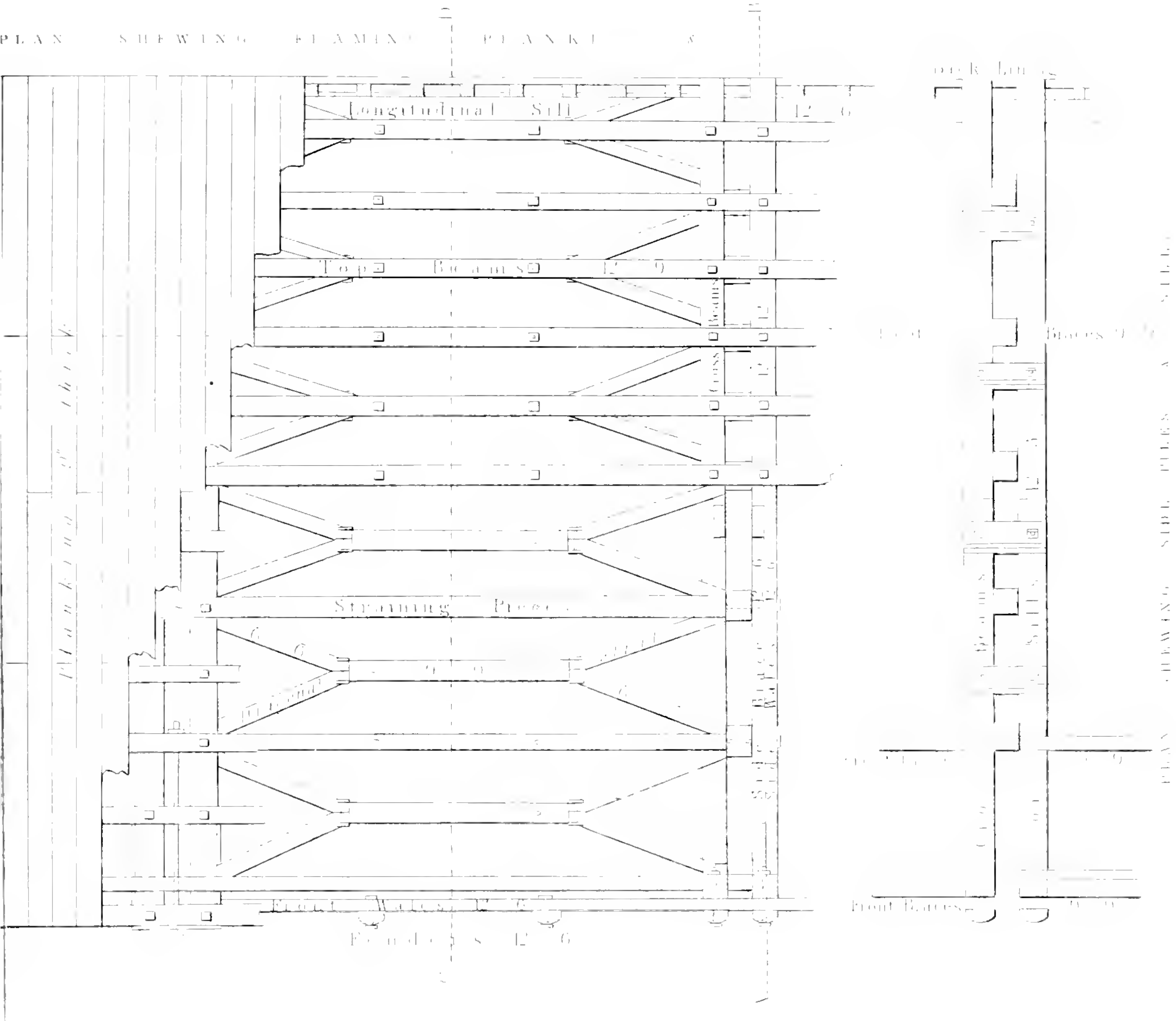


Jn. Williams Engraver

PRACTICE

BER PIER

PLAN SHEWING FRAMING PLANKING

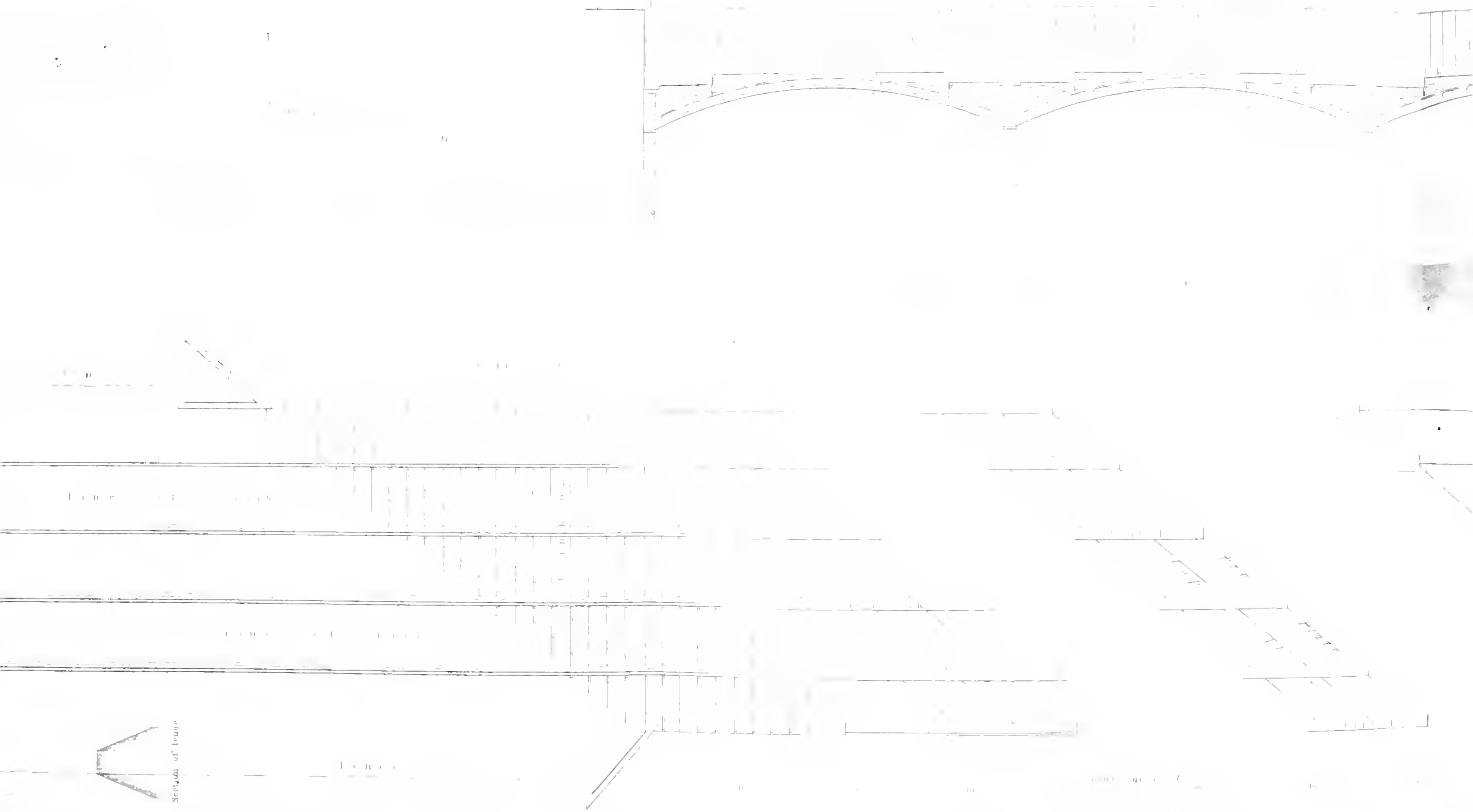


No 12 Russell Street near the Museum

LATE 54

[illegible] sculp

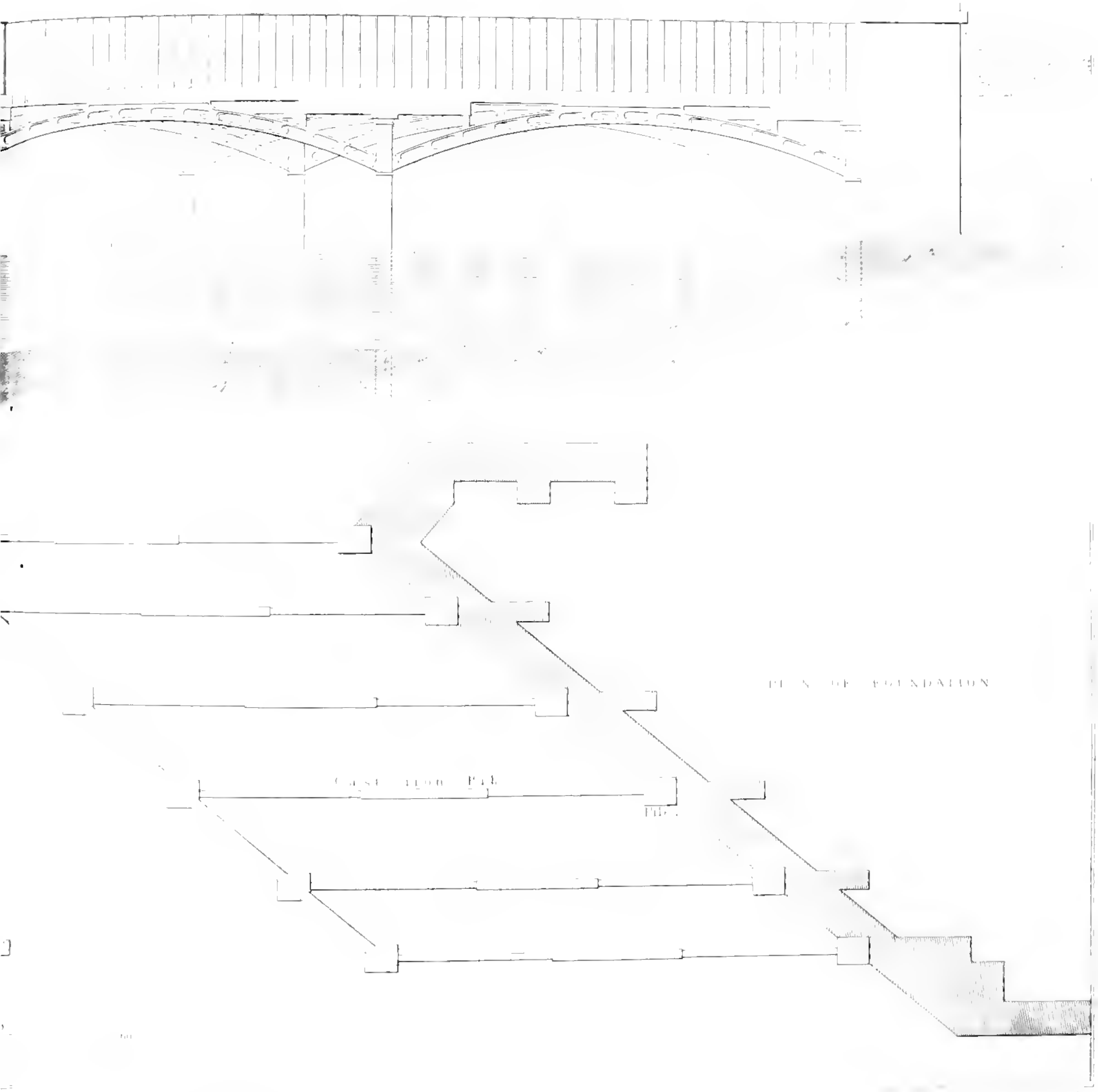
RAILWAY PRACTICE



T. Dunhill, del.
Designed by T.J. Woodhouse, M.I.C.E.

John Williams, Library of Science & Art, 106, Gt Russell Street near the Museum

C E



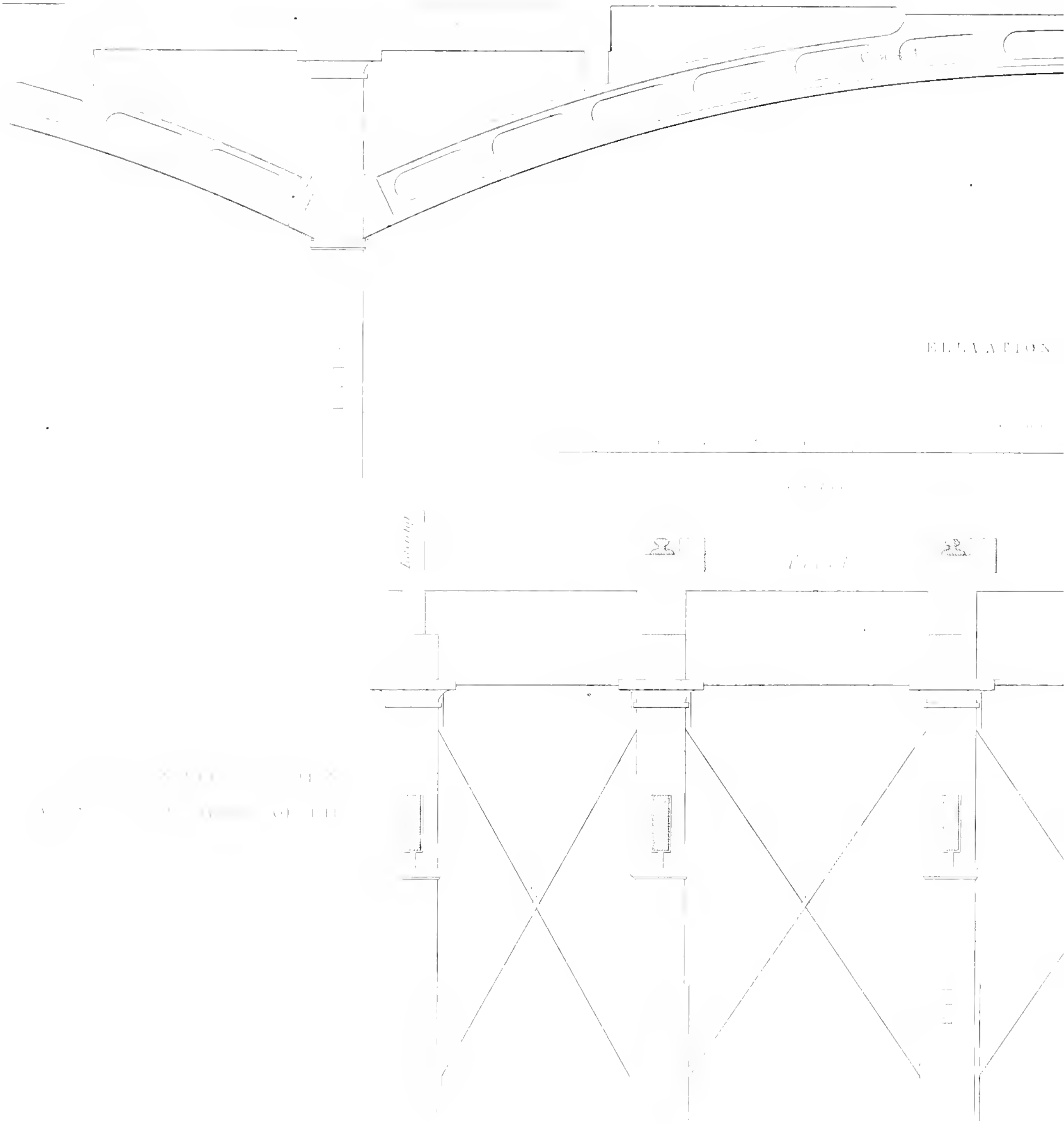
B.R.Davies sculp

RAILWAY

BRIDGE OVER THE R

DETAILS O

Timber

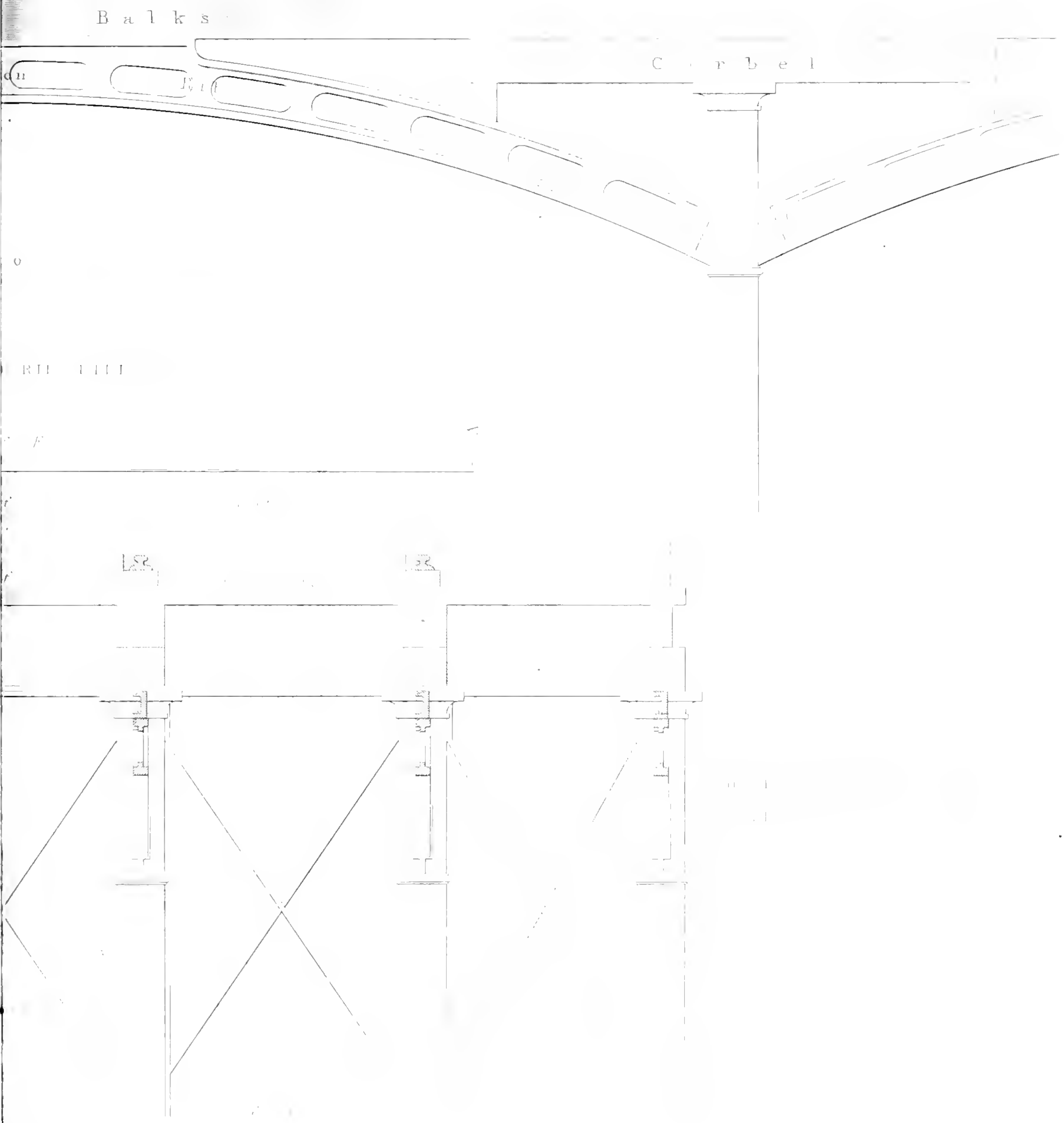


P R A C T I C E.

ESQ. ENGINEER

R ROAD NEAR STAMFORD.

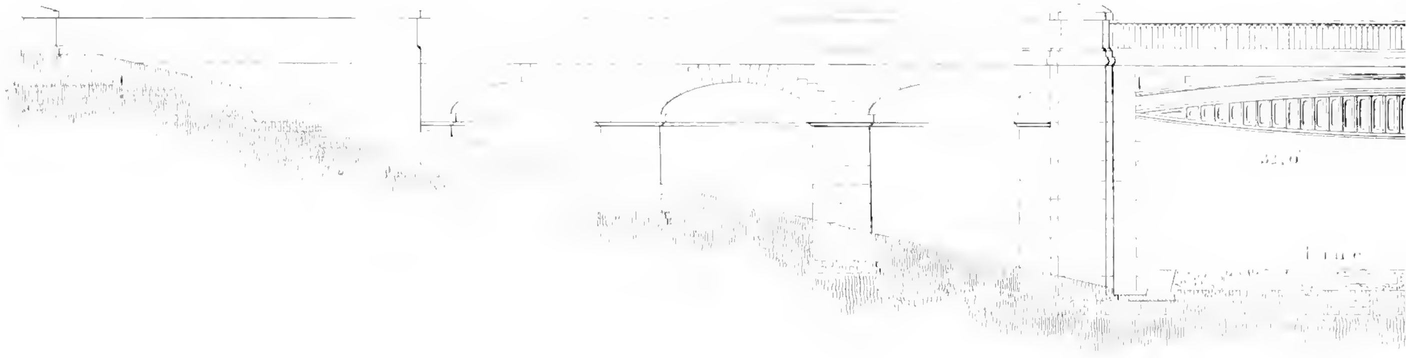
ONSTRUCTION.



RAILWAY

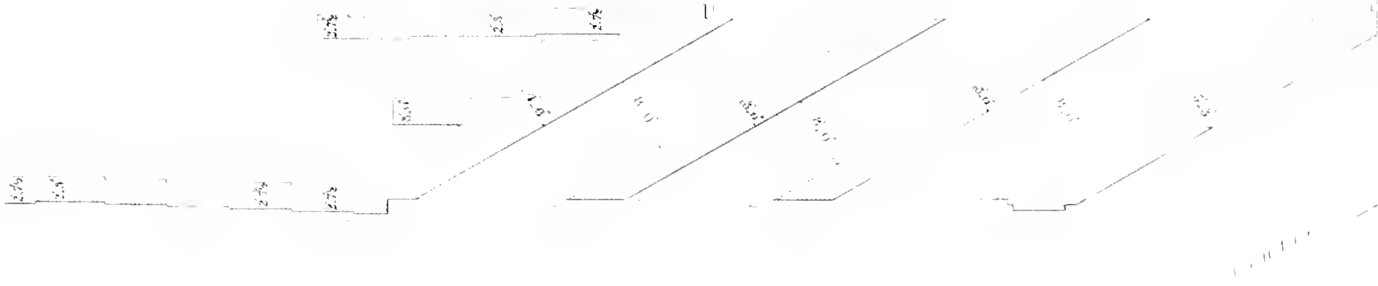
BRIDGE [illegible] ROAD FROM

ELEV



Angle of

HALF PLAN TAKEN AT FOUNDATIONS



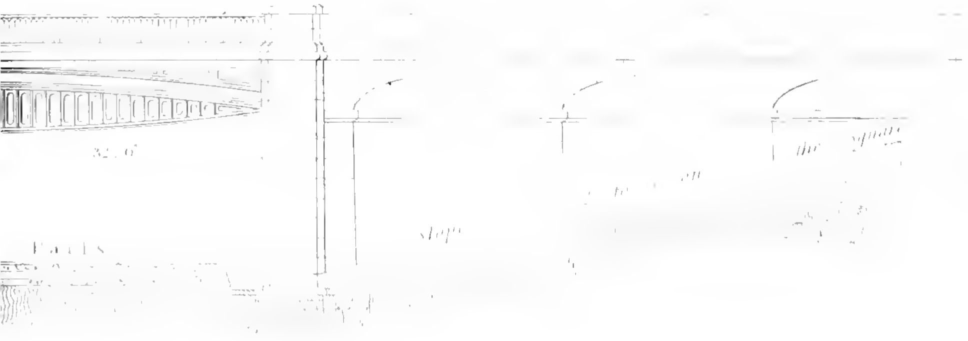
Scale

BREE

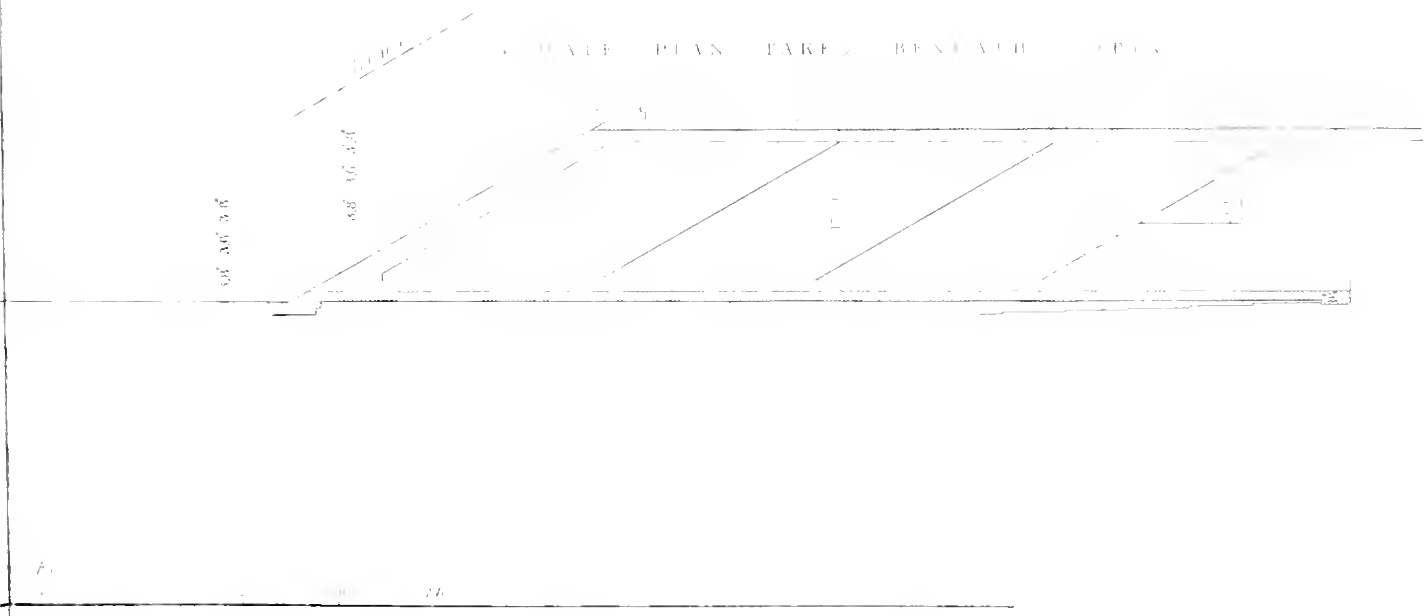
William [illegible]

PRACTICE.

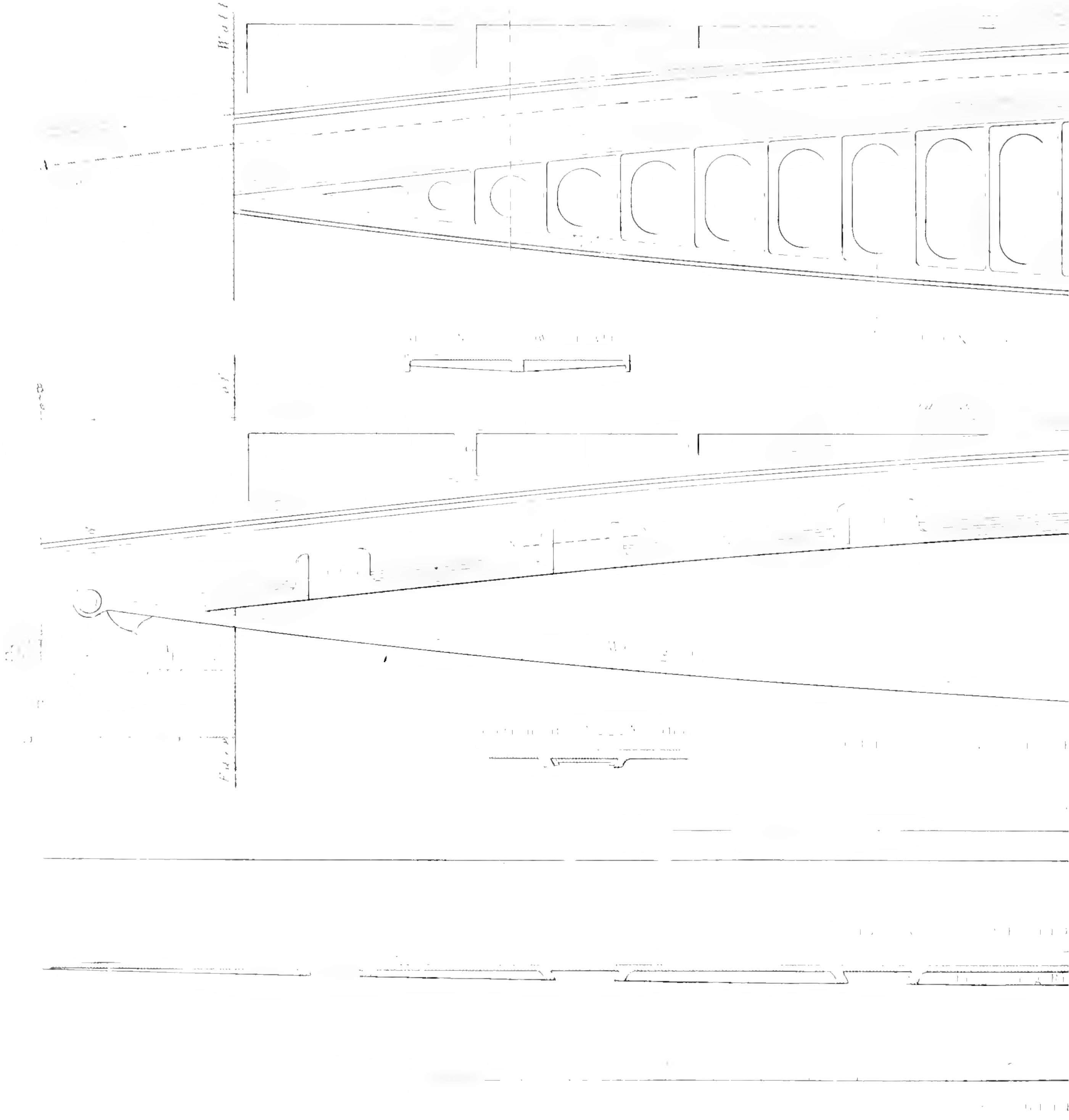
BANBURY TO LUTTERWORTH



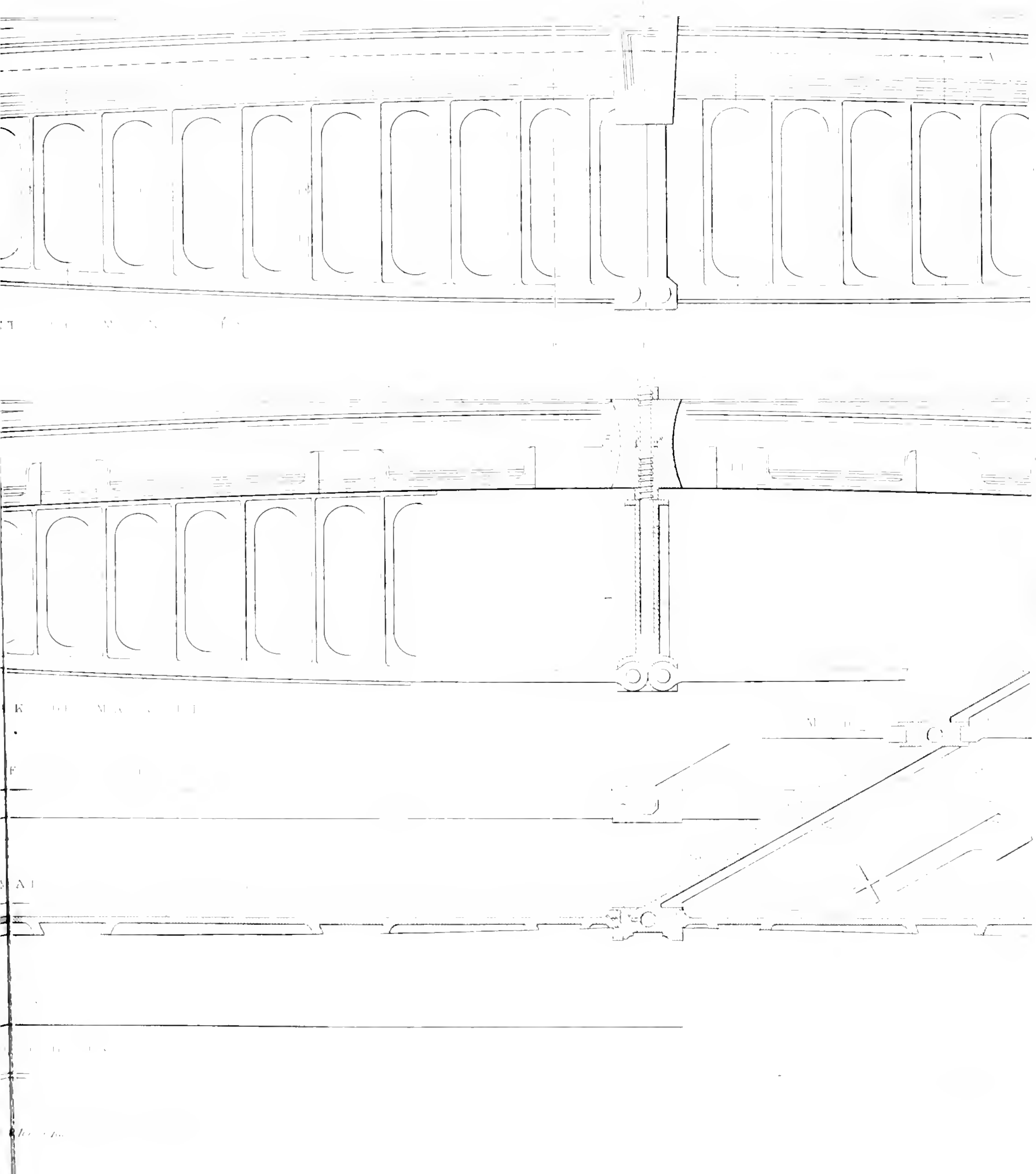
HALF PLAN TAKEN BENEATH



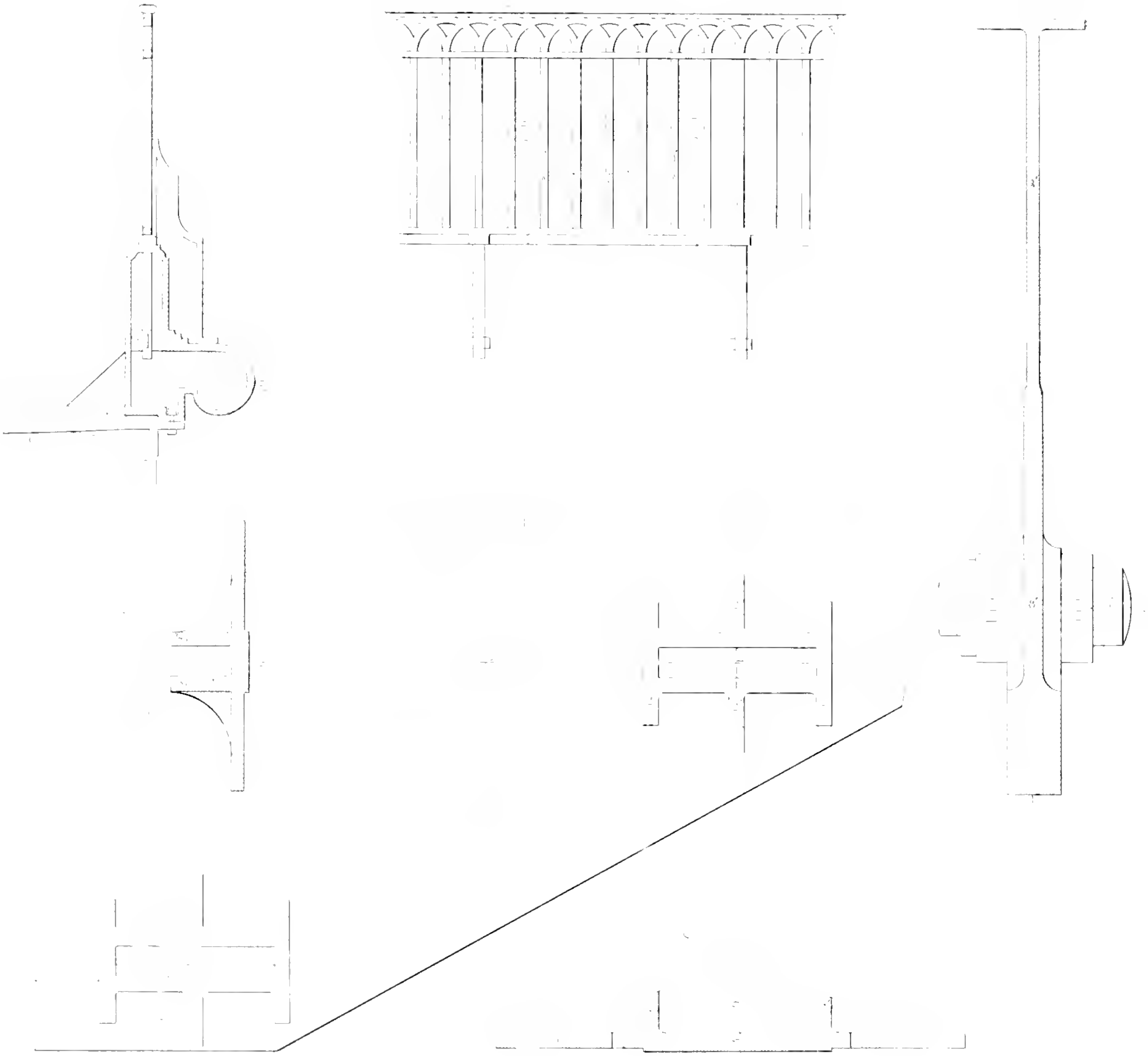
RAILWAY



PRACTICE.



R A I L W A Y

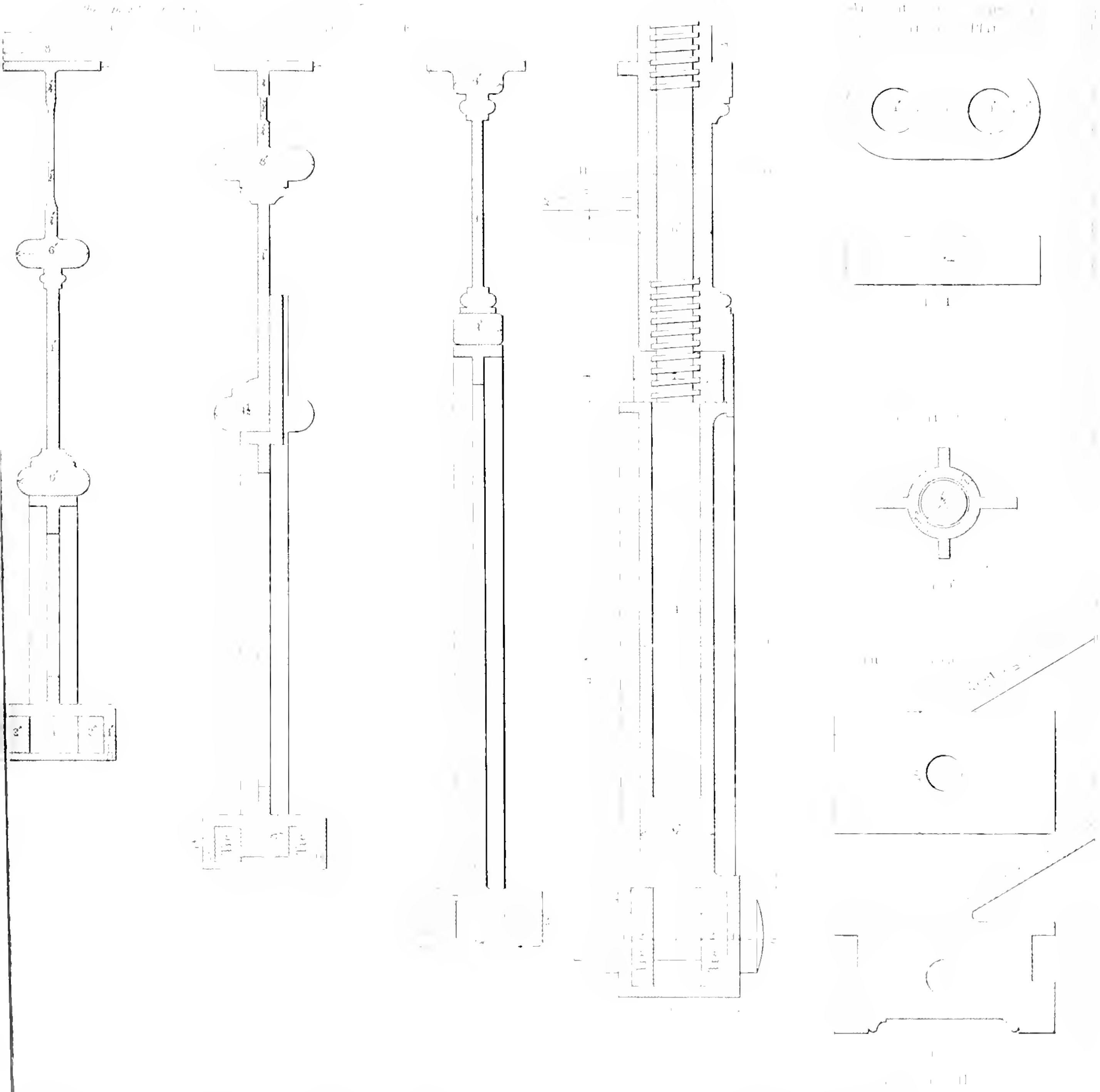


PRACTICE.

№

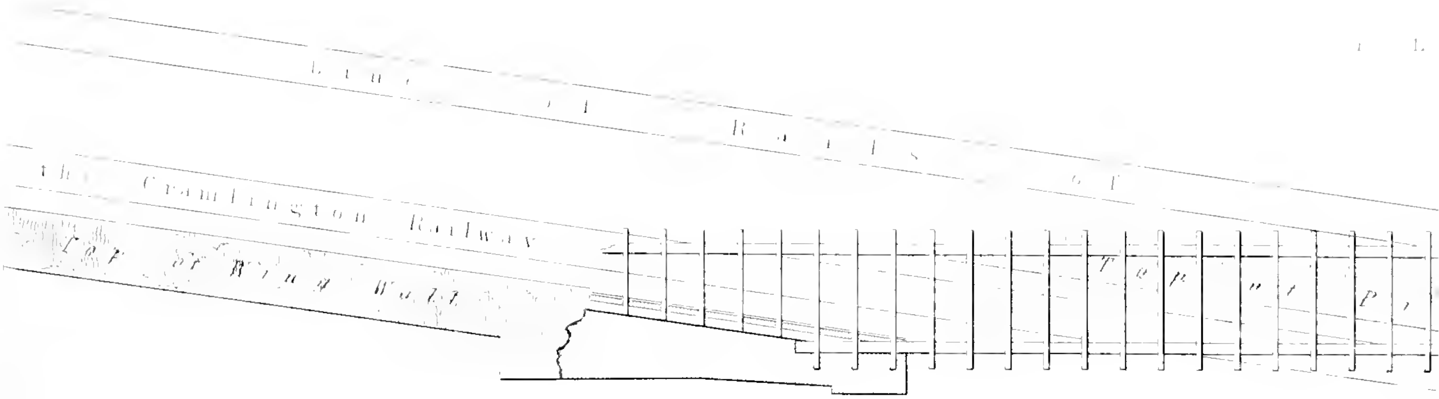
2A

IRONWORK

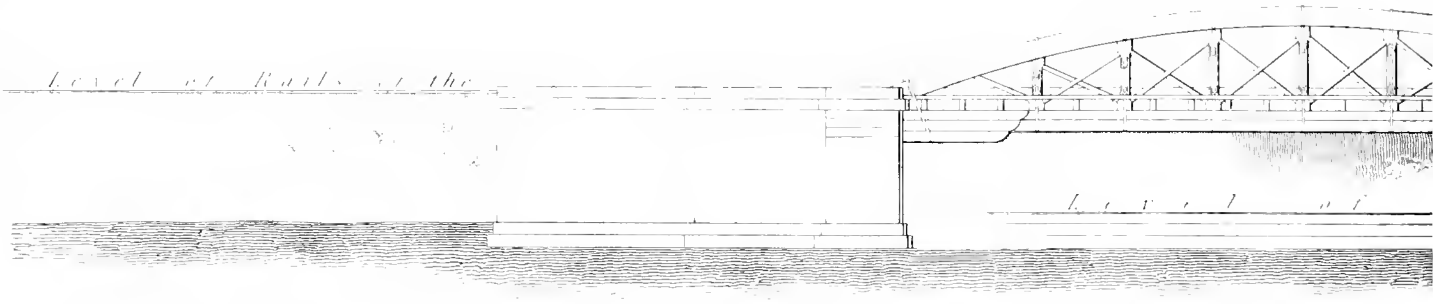


RAILWAY

BRIDGE OVER THE



SOUTH WEST



Scale

S. C. BRE

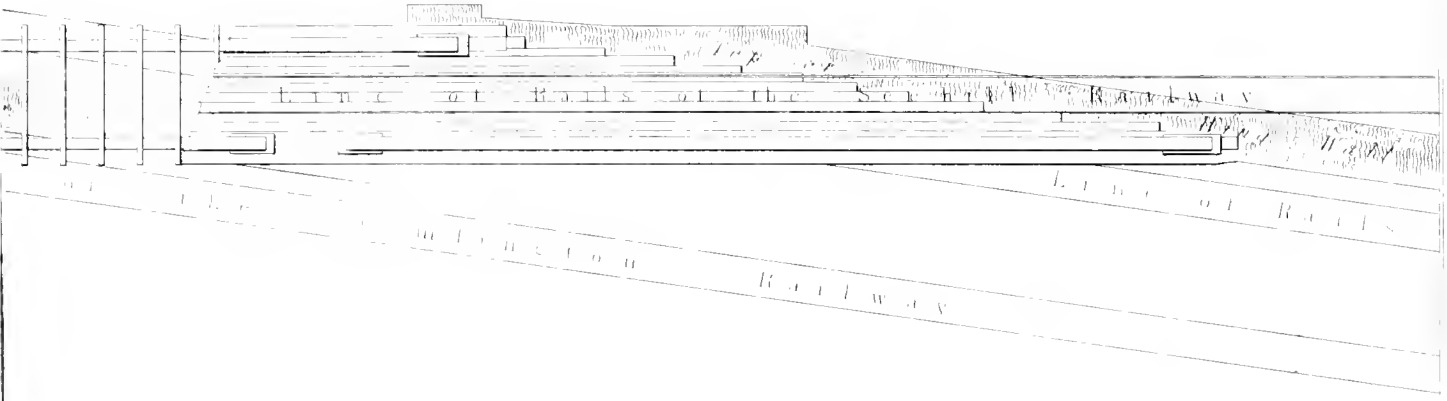
John Williams Library of Science

PRACTICE.

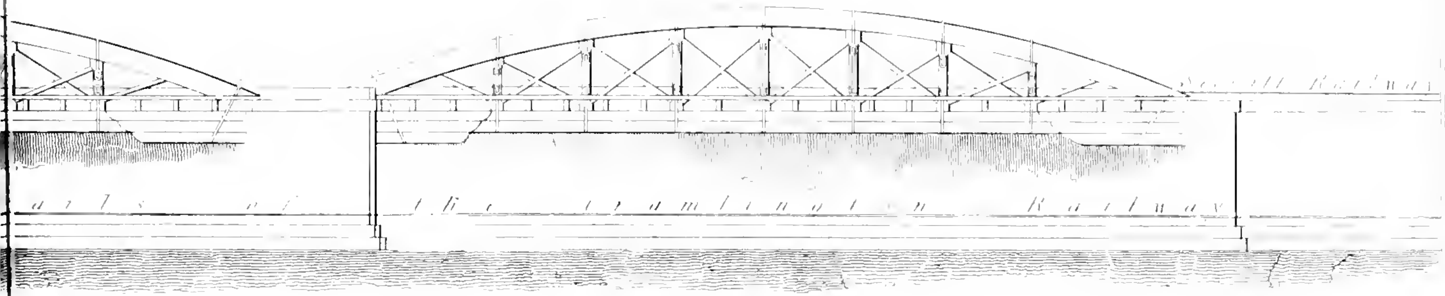
PLATE 9

RAMLINGTON RAILWAY

N



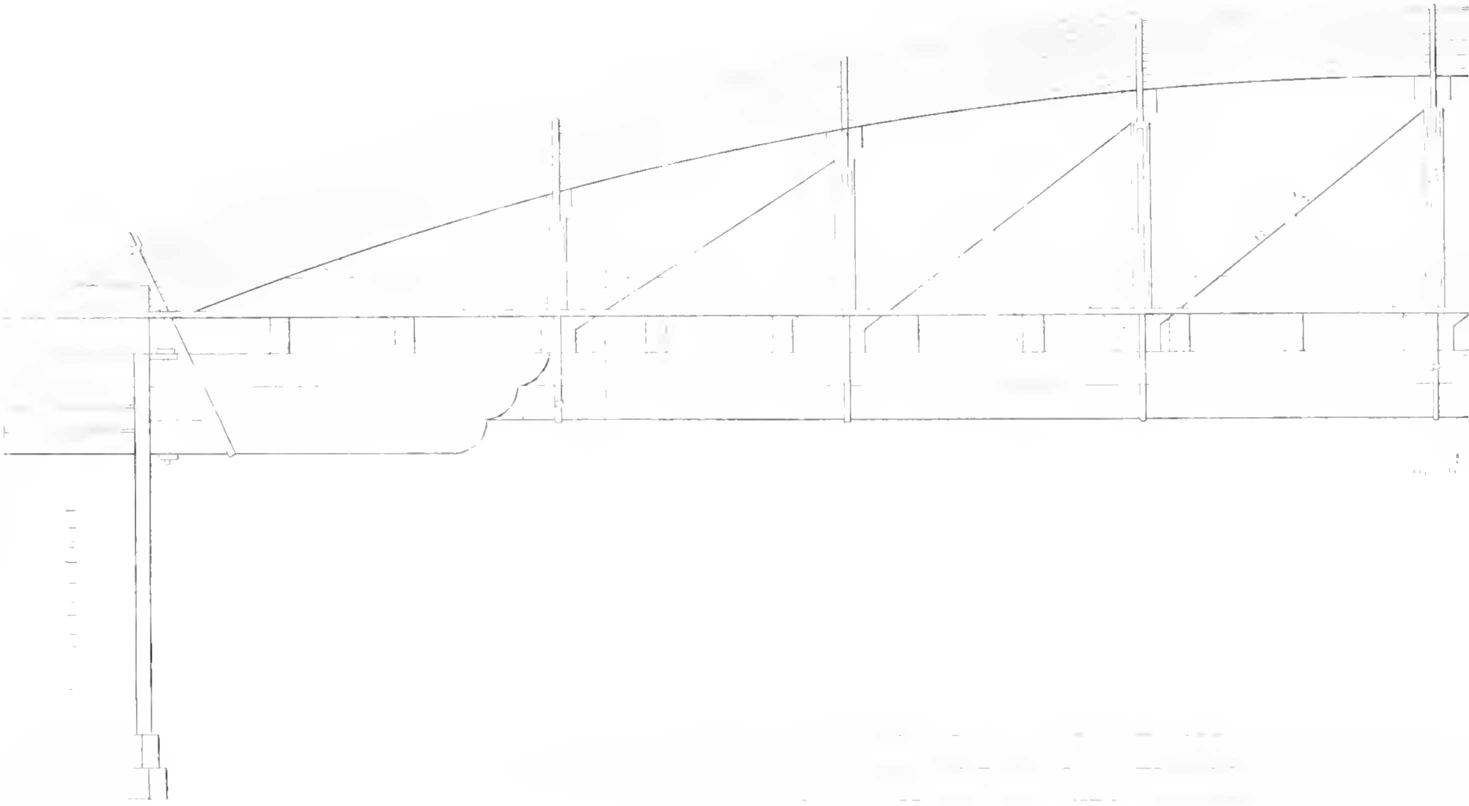
ELEVATION

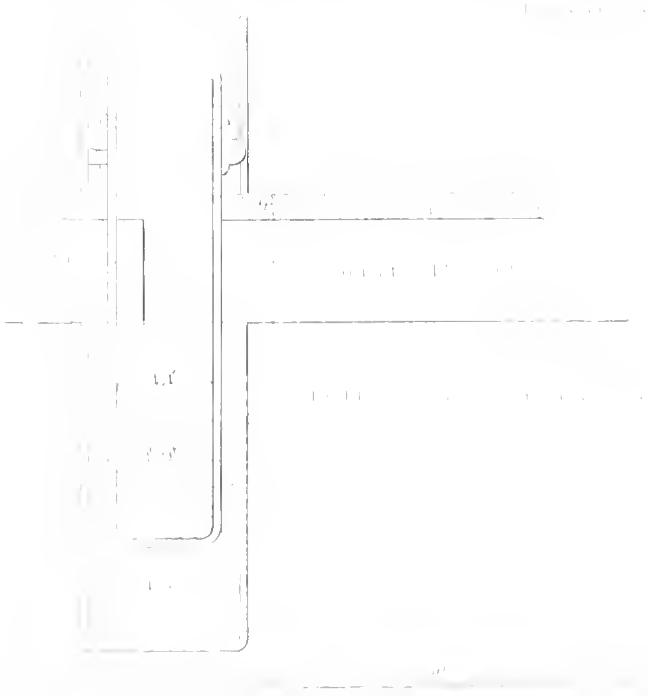


F

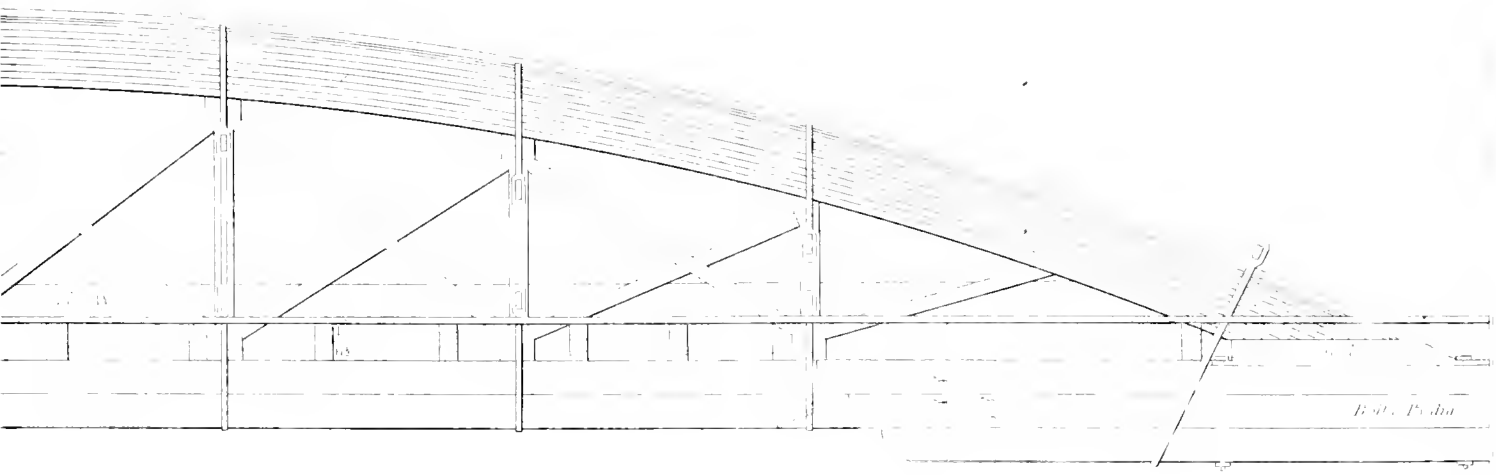
E DIREN

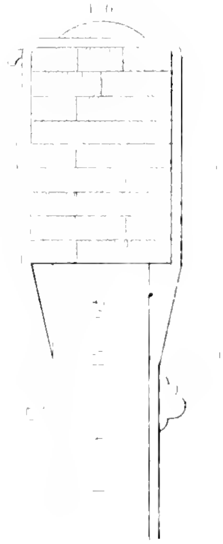
at Russell Street near the Museum





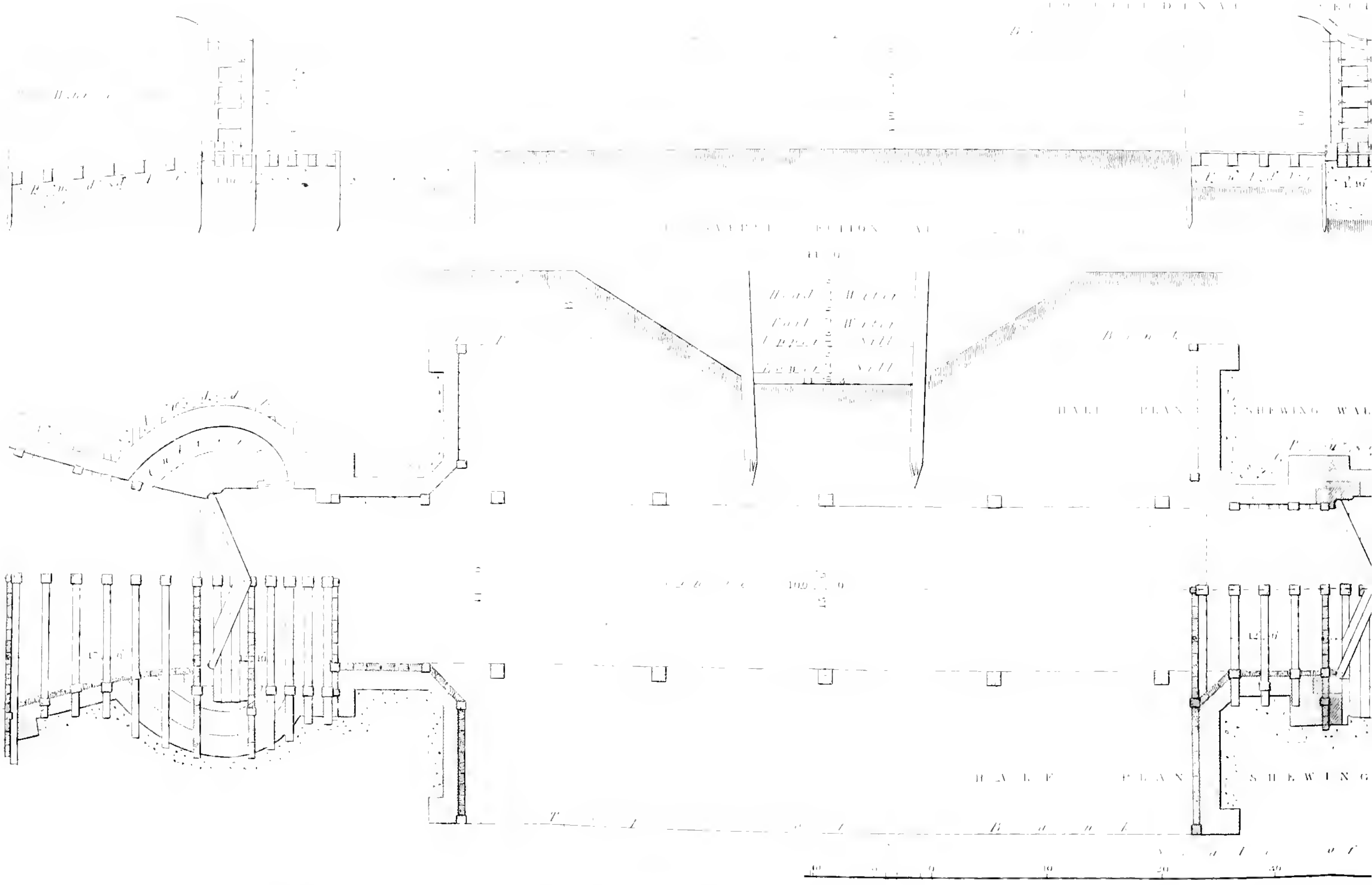
PRACTICE.





Feet

AILWAY

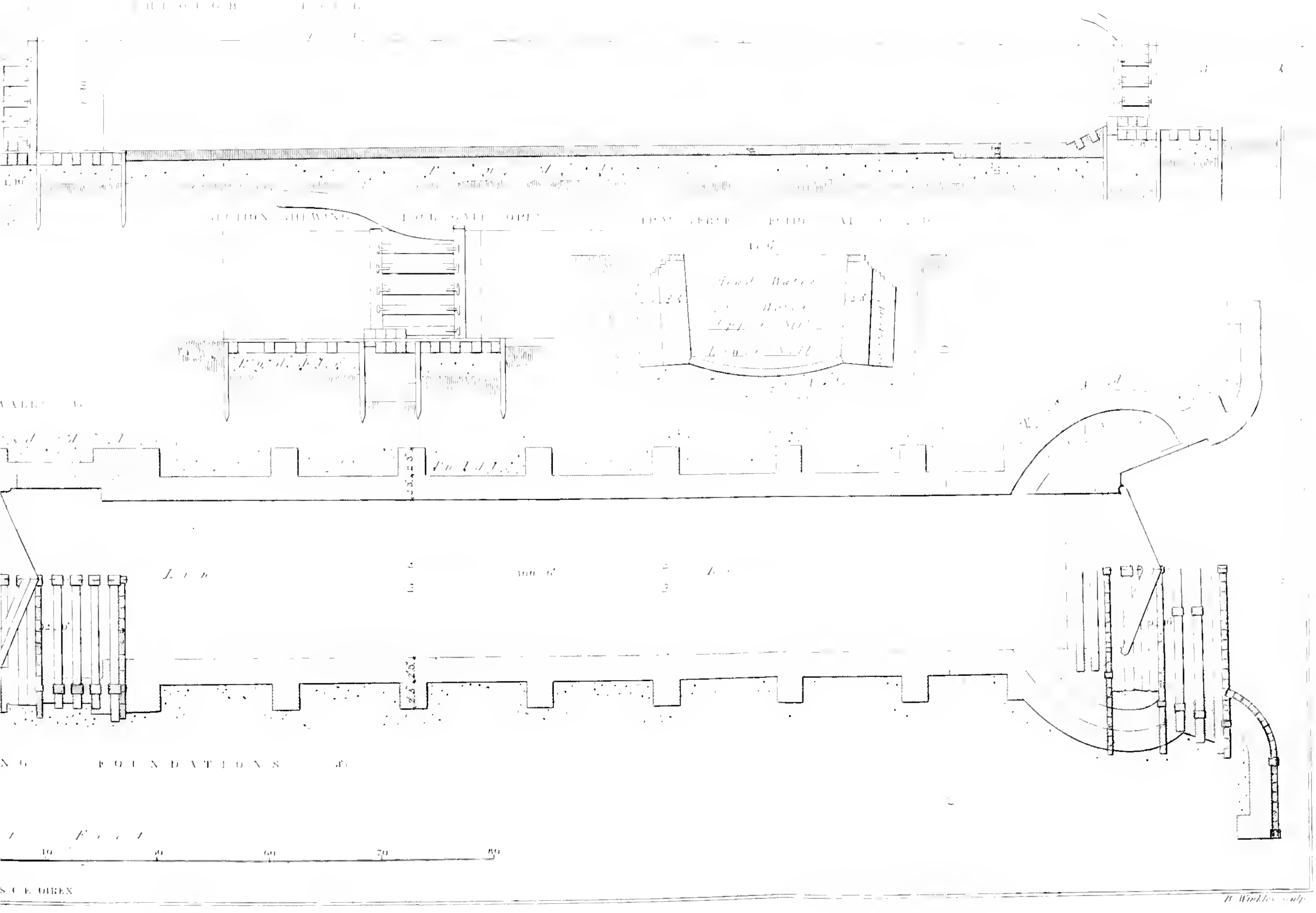


Randall Del

S C BREES C.E.

John Williams Library of Science & Art, 106

PRACTIC



S C E. OBREN

B. Winkles sculp

Russel Street near the Museum