

EAST INDIA (ENGINEERS' ESTABLISHMENT, &c.)

RETURN to an Address of the Honourable The House of Commons,
dated 30 July 1867;—for,

“RETURN of the Names of the EXAMINERS appointed to examine the CANDIDATES who presented themselves, since last Return, for Admission to the ENGINEERS' ESTABLISHMENT and PUBLIC WORKS DEPARTMENT of India:”

“And, of the Names of the SUCCESSFUL CANDIDATES in Order of Merit, their Ages, Place of Education, the Names of the CIVIL ENGINEERS, if any, to whom such Candidates have been Articled Pupils; the MARKS assigned to every Candidate on each Subject; and the EXAMINATION PAPERS on each Subject (in continuation of Parliamentary Paper, No. 454, of Session 1866).”

India Office, }
1 August 1867. }

CLEMENTS R. MARKHAM,
Assistant Secretary, Public Works Department.

CIVIL ENGINEER EXAMINATIONS.

NAMES OF EXAMINERS.

Rev. Jonathan Cape, A.M., F.R.S.
Lieut. Col. C. D. Newmarch, R.E.
George Preston White, Esq., C.E.

SUCCESSFUL CANDIDATES in order of Merit.

NAME.	AGE.	Engineer to whom Articled, or under whom Served.	Place of Education.
1. Mr. P. Maitland -	23	J. S. Peirce, c. e., Westminster.	King's College, London.
2. „ T. Higham -	19	W. Martley, m. e., London, and T. J. Hay, c. e., Westminster.	King's College, London.
3. „ H. Joll - -	22	R. P. Brereton, c. e., Westminster.	Not stated.
4. „ E. W. Oates -	21	C. L. Light, c. e., London -	Rev. J. Back, Hauwell.
5. „ J. F. Mackenzie	19	J. Mackenzie, c. & m. e.; G. Bertram, m. e.; Edinburgh.	Dollar Institution.
6. „ W. B. Bromley	21	Peto & Betts, c. e.; G. Berkeley, c. e.; Westminster.	King's College, London.
7. „ J. Stewart -	22	J. Stewart, c. e., Edinburgh -	Not stated.
8. „ T. E. Ivens -	22	J. Rennie, c. e., London -	Madras College, St. Andrew's.
9. „ J. S. Beresford	22	Roderick Gray, c. e., Enniskillen.	Queen's College, Belfast.
10. „ A. Grant -	18	H. H. Maclure, c. e., Glasgow	Dollar Institution.
11. „ T. Beatty -	22	R. Young, c. e., Belfast -	Queen's College, Belfast.
12. „ J. Heinig -	21	Sir C. Fox & Sons, c. e., London.	King's College, London.

2 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

SUCCESSFUL CANDIDATES in order of Merit—*continued.*

NAME.	AGE.	Engineer to whom Articled, or under whom Served.	Place of Education.
13. Mr. E. G. Davies -	18	J. N. Butler, C. E., Dunmow -	Dollar Institution.
14. " W. G. Strype -	20	T. Grendon & Co., M. E., Drog- heda.	Not stated.
15. " F. W. Stevens -	20	C. E. Davis, C. E., Bath -	Bath School of Art.
16. " A. W. De Crettes	21	J. C. Burne, C. E., Dublin -	Not stated.
17. " D. Wallace -	19	J. Sang, C. E., Kirkaldy -	Madras College, St. An- drew's.
18. " R. Ring -	20	J. L. Howell, C. E., London -	Queen's College, Cork.
19. " D. Noyes -	20	G. W. Hemans, C. E., West- minster.	Not stated.
20. " H. B. Parry -	21	Jenkin & Trathan, C. E., Lis- keard.	Not stated.
21. " R. W. Norris -	21	G. W. Hemans, C. E., West- minster.	Not stated.
22. " G. D. Wybrow	22	Parr, Curtis & Madelay, M. E., Manchester.	College, Chester.
23. " C. J. Peters -	19	J. C. Craven, M. E., Brighton	Madras College, St. An- drew's.
24. " D. Rutherford -	23	J. Bell, C. E., N. B. Railway, Ireland.	Dollar Institution.
25. " J. Tate -	18	A. Tate, C. E., Belfast.	Queen's College, Belfast.

NUMBER of MARKS assigned to each Candidate.

	Mathematics.	Civil Engineering.	Surveying.	TOTAL.		Mathematics.	Civil Engineering.	Surveying.	TOTAL.
1	298	335	150	783	22	200	325	100	625
2	276	330	173	779	23	213	265	132	610
3	230	335	180	745	24	205	285	110	600
4	250	335	155	740	25	215	235	150	600
5	280	295	164	739	26	170	260	176	606
6	235	335	163	733	27	128	335	140	603
7	219	330	174	723	28	146	330	122	598
8	233	325	160	718	29	122	330	128	580
9	239	325	150	714	30	216	235	127	578
10	205	295	193	693	31	248	220	104	572
11	201	330	152	683	32	151	320	100	571
12	205	330	144	679	33	203	255	104	562
13	204	320	145	669	34	211	225	115	551
14	201	320	140	661	35	202	245	100	547
15	202	330	128	660	36	138	285	110	533
16	200	320	138	658	37	207	230	68	505
17	261	240	144	645	38	178	230	63	471
18	235	255	150	640	39	130	275	50	455
19	223	300	116	639	40	82	235	100	417
20	200	325	104	629	41	90	240	68	398
21	201	315	110	626	42	68	235	54	357

PUBLIC WORKS DEPARTMENT—INDIA.

CIVIL ENGINEER ESTABLISHMENT.

EXAMINATION PAPERS FOR APPOINTMENTS FOR JULY 1867.

EXAMINATION PAPERS for Competitive Examination of Candidates for Appointments in the Engineer Establishment of the Department of Public Works in India, held at the India Office, London, in July 1867.

George Preston White, C. E., Examiner.

Candidates are particularly requested to attend to the following Directions :

1. Prefix the number of the question to each answer.
 2. Write legibly, and answer the questions as concisely as possible.
 3. Use free-hand sketches or diagrams wherever possible, to illustrate the answer, which must be carefully executed, in order to show the Candidate's proficiency in this style of drawing.
 4. Candidates must not, during the Examination, refer to any Book or MS., nor communicate with each other.
 5. Candidates are required to produce *bond fide* finished drawings, with certificates, respecting which there will be a *viva voce* examination.
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Describe the course of education you have undergone, name the Engineer to whom you have been a pupil, the number of years articulated, the nature of the works on which you have been engaged, and state in what branch of the profession you have had most practical experience.

ON WATER SUPPLY, RESERVOIRS, DAMS, &c.

1. Describe briefly the different means employed to supply towns with water, and give illustrative examples.
2. Describe the gravitation and pumping systems, pointing out their comparative advantages, and state the principal conditions and requirements to be considered and attended to in adopting either system.
3. Describe briefly what are impounding, compensating, depositing, storage and service reservoirs, residuum lodges, and collecting grounds,
4. Describe the geological formations which are the best water-bearing strata, and explain why the flow of water is generally more regular through the chalk than through the clay formation.
5. In constructing dams for impounding water, specify the precautions which should be adopted for security, and to render them impervious to water; and specify the difference between the forms of construction employed in this country and France.
6. Describe some of the most approved means for forming filter beds, as for example at the Lambeth, York, Chelsea, and other Waterworks, as first introduced by Mr. Simpson, C. E.; specify the best materials to employ for the purpose, and explain whether the action is chemical or mechanical, and what head of water is necessary.

4 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

7. If employed to supply a town with water, state some of the principal conditions which would guide you as to the mode of supply; how you would ascertain the probable amount of supply, the quality of the water, and the number of gallons per day, on the average, it would be desirable to provide for per head of population.

8. Make a free-hand sketch to illustrate the most approved forms for cast-iron water pipes; describe the different means used for jointing pipes, pointing out the advantages or defects of each system. What are turned and bored joints, and specify when they are particularly applicable?

9. In preparing a specification for cast-iron pipes, explain why it is desirable that large pipes should be cast perpendicularly with the faucet end downwards. Also as to the nature of the material which should be employed to cast them in, the quality of the metal, and the mixtures most approved; and describe how the pipes should be tested to ascertain their strength and freedom from laps, air holes, or other imperfections.

ON PUMPING ENGINES, &c.

10. To how many atmospheres of pressure would it be desirable to test water pipes, as compared with the head of water to which they would be actually subjected in practice? And when under pressure what further test is then desirable?

11. Illustrate with free-hand sketches and describe the uses of the following; viz., bib cocks, crutch key cocks, spiggot and faucet joints, flange joints, stand pipes, reducing pipes, branches and bends, air vessels, scour cocks, hydrants, sluice valves.

12. Calculate the number of gallons of water which a pipe 30 inches diameter is capable of delivering in 24 hours, with a fall of 20 feet per mile.

13. Describe briefly the different kinds of pumps and other contrivances for raising water; give a free-hand sketch of a bucket and plunger pump, with its suction and delivery valves, and state under what circumstances centrifugal pumps are most applicable.

14. Describe the mode of ascertaining the power of pumping engines required in any given case, supposing the quantity of water to be delivered per hour, size and length of main, and difference of level between the water in pump well and top of stand pipe or service reservoir, be given.

15. The following is a practical application of the foregoing question:— It is required to construct pumping machinery, consisting of two engines, two pumps, and two boilers, capable together of forcing 50,000 gallons of water per hour through 3,600 yards of 12-inch main, and into a reservoir 370 feet above level of water supply. How would you determine the dimensions of the principal parts of the machinery?

16. Calculate head due to friction in preceding question.

17. Having ascertained head due to friction, which, if unable to give the formula for, assume at 36 feet, making a total lift of 406 feet, calculate the net horse power required, taking a horse power at 33,000 lbs. raised 1 foot high per minute.

18. Having ascertained the net horse power, and added thereto 20 per cent. to obtain the indicated horse power, what would be the diameter of cylinder required, supposing 40 lbs. of steam in boiler, and an expansion, say at half-stroke, assuming 30 lbs. mean average pressure per square inch of piston during stroke, length of stroke being 3 feet, and number of revolutions 30 per minute?

19. Supposing a bucket and plunger pump to be used, with stroke of 30 inches, and 30 strokes per minute, calculate diameter of bucket or pump barrel for delivering each 25,000 gallons per hour, bearing in mind that there are 277 cubic inches to a gallon.

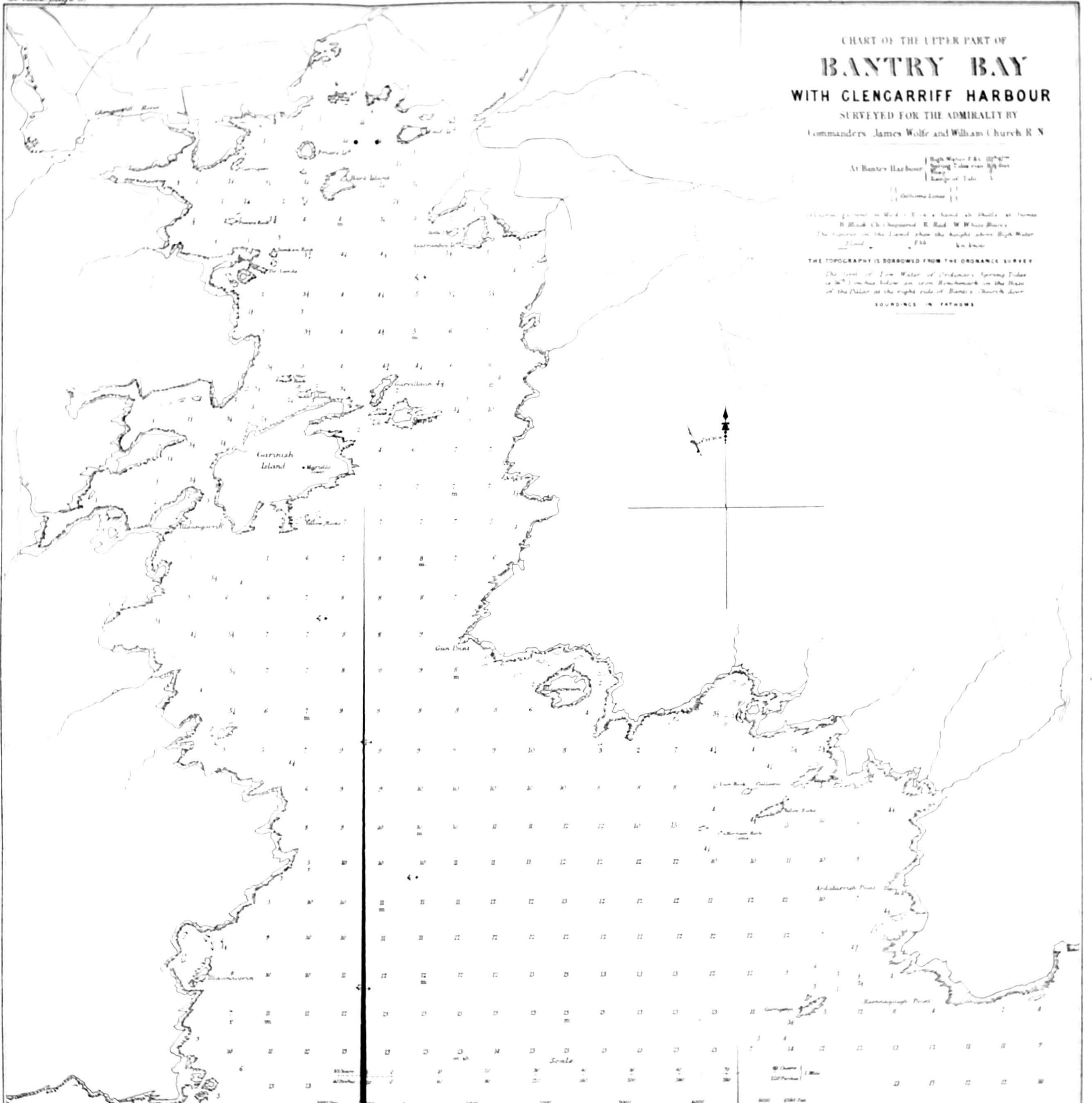
20. Assuming

CHART OF THE UPPER PART OF
BANTRY BAY
 WITH GLENCARRIFF HARBOUR
 SURVEYED FOR THE ADMIRALTY BY
 Commanders James Wolfe and William Church R N

At Bantry Harbour { High Water of Sea 107° 45'
 Spring Tides rise 1/2 ft less
 Range of Tide 1
 { Difference of Time 1

Colour given in Map - E in a Sand at Shells at James
 B Black Ch. Chopped R Red W White Shells
 The numbers on the Land show the height above High Water
 Flood 100 1/2 ft less

THE TOPOGRAPHY IS BORROWED FROM THE ORDNANCE SURVEY
 The level of Low Water of Ordinary Spring Tides
 is 10 1/2 inches below an iron Benchmark on the Base
 of the Pillar at the right side of Bantry Church door
 SOUNDINGS IN FATHOMS



Scale

Chart
 1 Mile
 1/2 Mile

20. Assuming that at the pressure of 40 lbs. in boiler the relative volume of steam to water is at 640 to 1, calculate the number of cubic feet of water consumed per hour in each boiler.

21. Assuming that 22 square feet of heating surface of boiler is required for evaporating a cubic foot of water, and that a single flued Cornish boiler, shell 6 feet diameter, with flue 3 feet 6 inches diameter, be supplied for each engine, calculate the length of boiler required.

22. Make free-hand sketches and describe the rain gauge and hygrometer, and explain their uses for engineering purposes.

23. Describe the wrought-iron tube employed by Mr. Simpson, c. e., for the Bristol Waterworks, for continuing the aqueduct across the Combe or Ravine; explain the arrangements to provide for expansion and contraction, and also to prevent leakage at the points of junction with the stone aqueduct.

24. Give the names of standard works of reference on the subject of water supply, and name, as examples, some of the principal works which have been executed in this country and abroad for the supply of cities with water.

ON HARBOURS, DOCKS, GROINS, &c.

The accompanying plan represents a harbour, possessing considerable natural advantages, but requiring certain engineering works to render it suitable for the purposes of commerce and navigation.

1. If professionally employed to make a report on this harbour as to its capabilities, and as to the works necessary to render it suitable for a naval station and harbour of refuge, state how you would proceed to make the necessary surveys, take soundings and reduce them to a common datum, ascertain the nature of the bottom, and whether affording good anchorage, and also the direction of the prevailing currents, &c.

2. It will be seen that several rivers flow into the harbour; describe how you would gauge them, ascertain the volume of water discharged, the drainage area, and the amount of solid matter either held for a time in solution or finally deposited.

3. There is a tendency to silt up at the head of the harbour; explain the usual cause of this, and how you would avail yourself of back-water or tidal-water to counteract this deposition, and describe the means adopted for this purpose by Smeaton at Ramsgate, or any other well-known example.

4. Should it appear on investigation that in particular states of the wind or tide additional shelter is required in the outer harbour, mark on chart the position where you would recommend a breakwater to effect this object; give a cross section of it, showing sea slope or face, and specify how you would make the foundations, and the character of the masonry you would recommend for the purpose. Explain the nature of "pierre perdue" foundations.

5. Specify the character of the lime you would employ for the submarine portion of the work; and in the event of not being able to obtain, conveniently, natural hydraulic lime, explain how artificial hydraulic lime could be produced according to the experiments of Sir Charles Pasley and M. Vicat; describe the chemical difference between ordinary and hydraulic lime. In what time should good hydraulic lime set and harden?

6. If found necessary to remove some of the rocks in the harbour, dangerous to the navigation, describe the different means employed for the purpose, and if too large to be dealt with in this way, make a free-hand sketch of a simple form of beacon. If required to lay down permanent moorings, describe the Mitchell and mushroom anchor, and other forms in use.

6 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

7. One of the first requirements will be the formation of docks, quays, and landing stages. Mark on accompanying map where you would place them, showing position of locks and entrance gates.

8. It frequently occurs, as along the south-east coast of England, that there is a movement of shingle, sand, or other material, which deposits itself at the entrance of harbours, and proves most detrimental; describe some of the means employed to arrest this, and explain the use of wave traps and beaching basins, and give some examples.

9. It will also be necessary to establish lighthouses and beacons. Mark on the map the position you would place them in; state the chief conditions which would guide you as to the height of lighthouse, and the nature of the lights you would employ, whether fixed, revolving, coloured, or with flashes at intervals.

10. If a landing stage should be required, give a free-hand sketch of a simple form of one, and describe those at Liverpool, or any other well-known or important examples.

11. Having laid out the breakwater and other works included in the foregoing questions, point out what you consider will be the probable effect (if any) in altering the existing conditions of the harbour as to the currents and the deposition of mud and silt, or other material, &c., &c.

12. The Railway Commissioners recommended in their report that a railway should be carried over Garinish Island and across the harbour at the narrow entrance by a viaduct, where there is 60 feet of water. Point out the engineering difficulties and disadvantages of such a line, and mark on map where you consider the best route for a railway, making the embankment subservient for docks and other purposes.

13. Give the names of standard works of reference and reports on the subject of harbour engineering, and the names of some of the engineers who have specially distinguished themselves in this most important branch of the profession.

ON LIGHTHOUSES, PIERS, AND MISCELLANEOUS SUBJECTS.

* See Design opposite.
No. 1.

1. The accompanying design* represents a simple form of lighthouse, 60 feet in height, suitable in cases where building materials are deficient, skilled labour expensive or not obtainable, or where there is a difficulty in forming foundations. It is intended to erect this structure on a sand bank, and found it on Mitchell's screw piles. Describe how you would get the piles into position, what depth it would be desirable to go to in sand or alluvial deposit, the size of pile, and diameter of screw. Make free-hand sketches of the piles, screw, braces, &c., showing the means of securing the work together. Give an approximate estimate of the cost of such a structure, exclusive of lantern, and name some successful examples of structures of this character which have been erected either in this country or abroad.

† See Design opposite.
No. 2.

2. The accompanying design† represents a simple form of iron pier with T-head, suitable in cases where there is a difficulty in obtaining a good foundation for structures of the ordinary character, or where suitable building materials or skilled labour cannot easily be obtained. Make free-hand sketches to illustrate the details of the work. Describe the form and material of the screw, the mode of manufacturing solid iron piles, the means of getting them into position, what batter it would be desirable to give, and the mode of bracing together the beams, girders and other parts of the work.

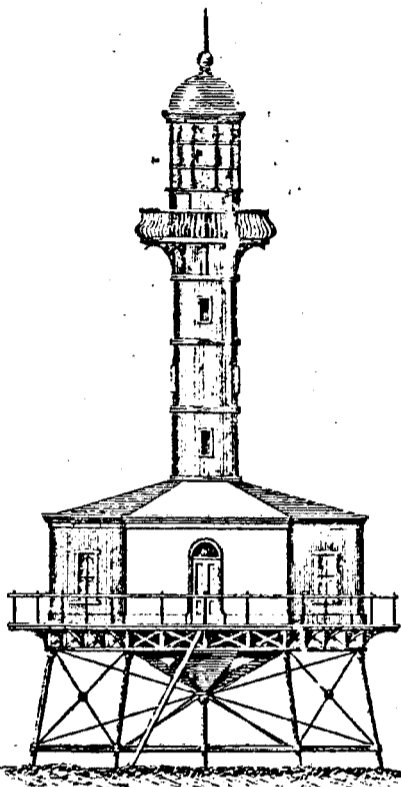
3. What are the comparative advantages of the hollow cast-iron pile and the solid wrought-iron pile? Explain the mode usually adopted for getting the former into position.

4. Give the names of any important examples of structures of this kind which have been erected either in this country or in India.

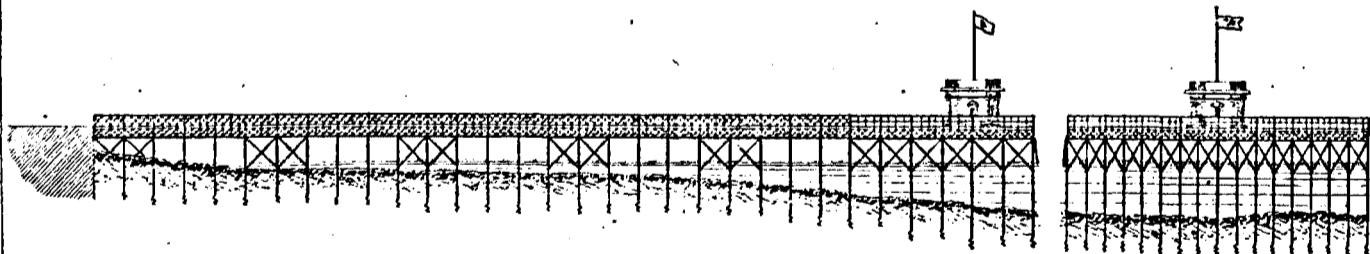
5. Describe

Plate page 6.

Nº 1.



Nº 2.



5. Describe the effect of sea-water on iron, and specify what steps should be taken as a prevention to injury.

6. Describe and make free-hand sketches of the following forms of wrought-iron girders: the trellis, the warren, the tubular, and the Brunel girder. Specify which form would be most desirable for India, taking into consideration expense of carriage, facility of erection, or where skilled labour was either expensive or difficult to obtain, and describe which of the above forms require staging to get them into position, and what forms can, under certain conditions, be erected without staging.

7. Describe and make free-hand illustrations of some of the most approved modes for scarfing and trussing timber.

8. Name the different kinds of stone employed in building under the following heads, viz., siliceous, argillaceous, calcareous, stratified and unstratified.

9. Describe with free-hand illustration, the means adopted in the main sewers for the drainage of London, to provide for storm-water, and to prevent sewers from blowing up.

10. Describe and make free-hand illustration of the weirs employed at the Manchester Waterworks to separate the storm and turbid water from that suited for the town supply.

11. Illustrate with free-hand sketches, and give the meaning of the following terms: facing point, falling point, blind siding, back shunt, chock block; and state what are the objections to facing points.

12. Photography, for the purpose of making "Photographic Reports," to illustrate the progress of works, copying drawings, &c., is most valuable for engineering purposes, especially in India; attention is therefore directed to the subject. State if you are able to use photography for this purpose.

Note.—On the present occasion I have specially directed attention to the subject of water supply and harbour engineering, two of the most important, but at the same time difficult branches of the profession, and which are yearly becoming more necessary in India, only a few of the principal cities being at present supplied with water; much, therefore, remains to be done in this way. Whilst, as regards harbour engineering, a wide field presents itself, as India, considering her extensive seaboard, is very deficient in natural harbours. I would, therefore, suggest these subjects as being deserving of especial attention.

The President of the Institution of Civil Engineers, in his recent admirable address, has truly remarked, that "The dock and harbour engineer requires the general, and much of the special knowledge of the railway engineer, such as that which belongs to railways and tramways, and warehouses for goods; and to this he must add a vast amount of other special knowledge not required by the railway engineer.

"For example, he must understand the laws which govern the ebb and flow of the tides, the rise and fall, and time of high and low water; and he must have a knowledge of marine surveying, or the best means of ascertaining the set and speed of currents, and their tendency to increase depth of water by scour, or to diminish it by silting; he must also know, in the case of docks, what kind and extent of entrance accommodation to provide, whether the general plan should comprise only a simple lock, or be combined with a half-tide basin; whether single or double gates should be used; and whether it would be necessary to have a tidal basin or a recessed space, or both.

"The nature of the trade to be accommodated in the proposed docks must also be carefully ascertained, in order to provide a proper proportion of quay space and water space, and proper width of quays, warehouses for bonding or for goods to be deposited, sheds for temporary protection, entrance for barges into warehouses from the docks, graving-docks and workshops, with mechanical appliances for gates, sluices, and pumping; and for shipping or discharging minerals or goods.

"He may have to deal with solid foundation, and enjoy a facility of procuring suitable materials for construction, as at Liverpool; or he may have the bad foundations of Hull, and other places; where alluvial silt of great depth has accumulated. It may be that good sound stone is too costly for the mass of his work, and that he must resort to brickwork, or rubble stonework, or concrete, or to a combination of all three; but in determining such questions, it is impossible that anything but previous experience and habits of careful investigation will enable an engineer to arrive at the best decision. For it is not enough that his work should be solid, permanent, and safe, but it should be rendered so at the smallest possible cost.

"The dock and harbour engineer is also required to report upon, and to construct, harbours of refuge, piers, landing stages, lighthouses, forts, canals, and their appliances, river improvements and many other hydraulic works; and in short, of this branch of engineering it may be truly said, that questions are continually arising which require special study and mechanical invention to a greater extent than in almost any other branch of the profession."

8 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

July 1867.

EUCLID.—Rev. J. Cape.

1. Define the terms *superficies*, *circle*, *scalene triangle*, and *parallelogram*; and state what is meant by a straight line being at right angles to another straight line.

2. If two angles of a triangle be equal to one another, the sides also which subtend or are opposite to the equal angles, shall be equal to one another.

In a triangle, if the lines bisecting the angles at the base be equal, the triangle is isosceles, and the angle contained by the bisecting lines, is equal to an external angle at the base of the triangle.

3. To bisect a given finite straight line, that is, to divide it into two equal parts.

Shew how to trisect—(1) a right angle; (2) one-fourth of a right angle.

4. The opposite sides and angles of parallelograms are equal to one another, and the diameter bisects them, that is, divides them into two equal parts.

If in the diagonal of a parallelogram any two points be taken equi-distant from its extremities, and joined with the opposite angles, a figure will be formed which is a parallelogram.

5. If the square described upon one of the sides of a triangle, be equal to the squares described upon the other two sides of it; the angle contained by these two sides is a right angle.

If from the vertex of a plane triangle a perpendicular is let fall on the base, or the base produced, the difference of the squares on the sides is equal to the difference of the squares on the segments of the base.

6. The angle at the centre of a circle is double of the angle at the circumference upon the same base, that is, upon the same part of the circumference.

7. In a circle, the angle in a semicircle is a right angle; but the angle in a segment greater than a semicircle, is less than a right angle; and the angle in a segment less than a semicircle, is greater than a right angle.

8. To describe an isosceles triangle, having each of the angles at the base double of the third angle.

Let ABD be the isosceles triangle, A the vertex, C the point in which AB is divided. If in the base BD , DE be taken equal to BC , prove—(1) that the rectangle contained by BE and BD is equal to the square on DE ; (2) that CE is parallel to AD .

9. The sides about the equal angles of equiangular triangles are proportionals; and those which are opposite to the equal angles are homologous sides, that is, are the antecedents or consequents of the ratios.

An angle ACB of a triangle is bisected by the line CD , which cuts the base AB in D . If E be a point in AB produced such that EC is equal to ED , prove that BE , DE , AE are in continued proportion.

10. If two straight lines meeting one another be parallel to two others that meet one another, and are not in the same plane with the first two, the first two and the other two shall contain equal angles.

July 1867.

ALGEBRA.—Rev. J. Cape.

1. Reduce to their simplest forms :—

$$\frac{x^3 + 3ax^2 + 3a^2x + a^3}{x^6 - 3a^2x^4 + 3a^4x^2 - a^6} \dots\dots\dots (1)$$

$$\frac{x^4 - xy(x^2 + y^2) + y^4}{x^4 - xy(3x^2 - 4xy + 3y^2) + y^4} \dots\dots\dots (2)$$

$$\frac{\sqrt[3]{a^4} + \sqrt[3]{a^2b^2} + \sqrt[3]{a^3b}}{\sqrt[3]{a^4} + \sqrt[3]{a^2b^2} + \sqrt[3]{b^4}} \dots\dots\dots (3)$$

2. Shew that $\frac{a^2 - (b - c)^2}{(a + c)^2 - b^2} + \frac{b^2 - (c - a)^2}{(a + b)^2 - c^2} + \frac{c^2 - (a - b)^2}{(b + c)^2 - a^2} = 1$.

Also that $(x + y + z)^3 - (x^3 + y^3 + z^3) = 3(x + y)(x + z)(y + z)$.

3. Solve the following equations :—

$$\frac{2x + 25}{13} + \frac{30 - x}{8} = \frac{10x - 327}{19} \dots\dots\dots (1)$$

$$(x - 3)(x - 2) + (x - 3)(x - 1) + (x - 2)(x - 1) = 2 \dots\dots\dots (2)$$

$$\left. \begin{aligned} (ax + by)^2 + (xy - bx)^2 &= 2 \left(\frac{a}{b} + \frac{b}{a} \right)^2 \\ \frac{x}{a} + \frac{y}{b} &= 2 \frac{a^2 + b^2}{a^2 - b^2} \end{aligned} \right\} \dots\dots\dots (3)$$

$$x(x + 1) + 3\sqrt{2x^2 + 6x + 5} = 25 - 2x \dots\dots\dots (4)$$

$$xyz = 231, \quad xyw = 420, \quad xzw = 660, \quad yzw = 1540 \dots\dots\dots (5)$$

4. Extract the square root of $\frac{1051}{25}x^2 - \frac{6}{5}x - \frac{14}{5}x^3 + 9 + 49x^4$; also, of $41 - 12\sqrt{5}$; and simplify $\frac{\sqrt{18a^2b^3} + \sqrt{50a^3b^5}}{\sqrt{8ab^3} + \sqrt{2a^3b - 8a^2b^2 + 8ab^3}}$.

5. If $a : b :: c : d$,

shew that $\frac{4a + 5b}{3a - 7b} = \frac{4c + 5d}{3c - 7d}$

6. Find the series in Arithmetical Progression in which the 5th and 9th terms are 11 and 9 respectively.

7. Sum the following series :

$$\frac{5}{7} + \frac{2}{9} - \frac{17}{63} + \dots\dots\dots \text{to 99 terms} \dots\dots\dots (1)$$

$$\frac{1}{5} - \frac{2}{15} + \frac{4}{45} + \dots\dots\dots \text{to 7 terms} \dots\dots\dots (2)$$

$$\frac{1}{3} + \frac{3}{9} + \frac{5}{27} + \dots\dots\dots \text{to infinity} \dots\dots\dots (3)$$

8. Find the middle term of $(a^{\frac{1}{2}} + b^{\frac{1}{2}})^{10}$, and the two middle terms of $(a^3 - 3a^2b)^{13}$; also, expand $\frac{3a}{(ax - x^2)^{\frac{1}{2}}}$ to five terms.

9. A rectangular area of 8 acres, 480 yards, has a perimeter of 840 yards. Find its length and breadth.

10. Goods are marked for a sale at a price which gives a profit of n per cent. on the selling price, and $(n + 50)$ per cent. on the cost price. Find n .

11. A man has 4 hours at his disposal. How far may he ride in a coach travelling 10 miles an hour, so that he may be able to walk back in time, his rate of walking being 4 miles an hour ?

12. The rent of a farm is paid in a certain fixed number of quarters of wheat and barley. When wheat is at 55*s.* and barley at 33*s.* per quarter, the portions of rent by wheat and barley are equal; but when wheat is at 65*s.* and barley at 41*s.* per quarter, the rent is increased by 7*l.* What is the corn-rent ?

July 1867.

MECHANICS and HYDROSTATICS.—Rev. J. Cape.

1. If two forces acting on a point are represented in magnitude and direction by two straight lines, prove that their resultant is represented in magnitude and direction by the diagonal of the parallelogram of which those two lines are the sides.

Two forces, represented by 7 and 9 acting on a point, are inclined to one another at an angle of 60°. Find the magnitude of their resultant.

2. A boy weighing 96 pounds sits on a gate 4 feet from the post on which the gate hangs by hinges, one 3 feet above the other. Find the additional horizontal pressure which he causes on the hinges.

3. On a uniform straight lever weighing 7 lbs., and 7 feet in length, weights of 1, 2, 3, 4, 5, 6 lbs. are hung at distances 1, 2, 3, 4, 5, 6 feet respectively from the extremity. Find the position of the fulcrum on which the lever will balance.

4. Find the relation that the power bears to the weight in the following machines :

(1.) The system of pulleys in which the same rope passes round all the pulleys, the weight of the pulleys being neglected.

(2.) The wedge without friction.

(3.) The inclined plane with friction, the power being inclined at an angle α to the inclined plane.

5. A weight of 500 pounds is placed on an inclined plane, the angle of inclination being 45°, and the coefficient of friction being $\frac{1}{\sqrt{3}}$. Find the least force which will keep the weight from sliding down the plane, and the least force which will draw it up the plane.

6. A line is drawn parallel to the base of a triangle, and cutting off a triangular piece, the area of which is $\frac{1}{4}$ of the area of the whole triangle. Find the position of the centre of gravity of the remaining trapezium.

7. What is meant by the Mechanical terms—*Work, Unit of Work, Friction, Modulus, Horse Power* ?

8. A train weighs 75 tons, and the friction is 7 pounds per ton. What horse-power must an engine be to draw it up an incline of 1 in 250, at a uniform rate of 24 miles an hour ?

9. A shaft, 12 feet in diameter, is to be sunk 130 fathoms through chalk, S. G. 2.315). How long will a two-horse-power engine take to raise the earth excavated, being kept at work nine hours a day ?

10. When a body is moving under the influence of a uniform accelerating force, show that $s = \frac{1}{2}ft^2$.

Ex.—The Monument is 210 feet high; how long would a stone take in falling from the top to the ground ?

11. Explain

11. Explain how the heights of mountains and depths of mines may be calculated by means of the pendulum.

Ex.—If a pendulum, when carried to the top of a mountain, loses in 24 hours twice as much as it does in the same time when taken to the bottom of a mine close by, show that the height of the mountain is the same as the depth of the mine.

12. With what velocity, and at what elevation, must a stone be thrown to hit the ground at a distance of 375 yards in 11 seconds, the resistance of the air not being taken into consideration?

13. Describe the Hydraulic Ram, and state the defects and advantages attending its use.

14. What weight will an empty 96-gallon cask support in water, the weight of the cask being 52 pounds, and 8 cubic feet of wood being used in making it

15. What must at least be the size, in cubic feet, of an inflated balloon, that it may be able to rise in the air when inflated with gas, whose specific gravity, compared with air, is .09, the weight of a cubic inch of air being .3 grains, and the balloon, car, and contents weighing 750 pounds?

July 1867.

ARITHMETIC, TRIGONOMETRY, and MENSURATION.—Rev. J. Cape.

1. Reduce $\frac{\frac{2}{3} - \frac{2}{9} + \frac{52}{81}}{\frac{4}{5} - \frac{16}{25} + \frac{24}{125}}$ to a simple fraction, and then to a decimal.

2. Which is the cheapest, a coat that costs £. 3. 16 s. and will last nine months, or one that costs £. 2. 5 s. and will only last seven months? How much will a man save in 7 years 14 weeks, by regularly wearing the cheaper one?

3. Find the square root of .007, and also of $\frac{.00125}{.72}$, to four places of decimals.

4. Divide the weekly wages £. 104. 8 s. among 100 labourers, 5 foremen, and 1 superintendent; the superintendent having thrice as much as each foreman, and a foreman twice as much as a labourer.

5. A man who owes £. 1,373. 6 s. 8 d., settles his bill by paying £. 1,308. 2 s. What rate of discount is allowed him?

6. A man bought Brighton Railway shares some years back at 119. He is now obliged to sell some, and can only realise 63. What is his loss per cent. on the stock sold?

7. Find the numerical values of $\sin 45^\circ$, $\cos 30^\circ$, $\tan 18^\circ$, $\cot 75^\circ$, by geometrical construction, without using any tables.

8. Determine an expression for the sine of any angle of a triangle in terms of the sides of the triangle, and hence deduce a convenient expression for the area of a triangle.

Ex.—The three sides of a triangle are 450, 500, 570 feet; find its area, and greatest angle.

12 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

9. What is the height of an inaccessible object which has an angle of elevation $30^{\circ} 16'$ at A , and after retreating directly from the object to B , a distance of 325 yards, the angle of elevation is diminished to $22^{\circ} 13' 10''$?

10. A man observes that the angle of elevation of a tower on the opposite side of a river is 60° , and of another tower of the same height half a mile lower down the stream, the angle of elevation is 45° . Also the angle subtended by the feet of the two towers, is 120° . Find the breadth of the stream, and the height of each tower.

11. Find the following by the help of Logarithms:—

(1.) The values of $\frac{\sqrt{43.725}}{\sqrt[3]{5.962}}$, $\frac{(24.76)^{\frac{2}{7}}}{(.0045)^{\frac{3}{2}}}$

(2.) A fourth proportional to $(41.06)^{\frac{1}{3}}$, $(.00056)^{\frac{2}{3}}$, $(120)^{\frac{3}{5}}$.

(3.) The natural sine of $43^{\circ} 25' 37''$ from a table of logarithmic sines.

(4.) The angle whose logarithmic cosine is 9.3472693.

12. What is the weight of a 13-inch shell, its thickness being two inches, a solid shot of four inches diameter weighing nine pounds?

13. How much earth must be excavated in laying a mile of 18-inch drain pipes, the lower side of the pipes being four feet below the surface; and how much earth will have to be carted away, supposing the earth returned to be so rammed as to occupy the same space after the disturbance as before?

14. A cylindrical boiler with hemispherical ends, being 17 feet long and 5 feet in diameter, how many gallons of water will it hold, the water not rising higher than within 18 inches of the horizontal top?

15. Required the number of gallons a cask holds, the length of which is 40 inches, while the girths at the two ends are 70 inches, at the middle 101.2 inches, and at 10 inches distance from each end 90 inches, the thickness of the cask being everywhere uniformly half an inch.

16. A canal has to be cut 100 feet long, the bottom being 12 feet wide throughout, and the sides being inclined at an angle of 45° to the horizon. The depths at successive distances of 10 feet are—

5, 5.4, 5.7, 6.1, 6.7, 7, 7.9, 7.2, 6.8, 6.1, 5.4 feet.

How much earth must be removed?

QUESTIONS ON SURVEYING.

Morning Paper, July 1867.

Examiner—Lieut. Colonel C. D. NEWMARCH, R. E.

Note.—You are particularly requested to write legibly, and to answer the questions as concisely as possible. Prefix the number of the question to each answer, and write your name at the top of each of your papers. Candidates must not, during the examination, refer to any book or MS., nor communicate with each other. Questions remaining unanswered at the close of the sitting cannot be taken up again afterwards.

1. Describe the course of instruction in surveying which you have undergone. What survey or levelling operations have you been employed upon? Produce any finished drawings or survey plans, *bonâ fide* of your own execution, with certificate, stating whether plotted from your own surveys or otherwise.

2. The Gunter's chain is 66 feet long—why? What is the length of a link of the Gunter's chain in yards, in feet, and in inches?

3. A survey

3. A survey being plotted and laid down to a scale of 6 inches to 1 statute mile, what proportion does that plan bear, both lineally and superficially, to the actual size of the ground ?

4. Describe the mode of using a plane table, and state under what circumstances you would employ it.

5. What is the use of a triangulation, and in what manner is it carried out ? Illustrate, by a diagram, how, when the measured base is unavoidably short, the sides of the principal triangles may be made rapidly to increase, without admitting any ill-conditioned triangles.

6. Describe the process of taking a round of horizontal angles with the theodolite, supposing it to be in correct adjustment, giving the reason for using two Verniers, and for making 60° and 120° zero points. Point out the particular advantages or disadvantages of a tower, a spire, or a tree, as trigonometrical stations.

7. Suppose that P is the centre of a station where it is not possible to place the theodolite, S a satellite at 20 feet distance, A and B other stations from which P has been observed, $63^\circ 30'$ and $92^\circ 15'$ the angles P S A and P S B respectively, and P A, P B, 5,000 and 6,000 feet approximately ascertained, what will be the true value of the angle A P B ?

8. Explain the principle upon which inaccessible heights and distances are measured in the field by the aid of the pocket sextant, as illustrated in the following examples:—

(1.) In order to obtain the breadth A B of a river, I set off the angle A B C a right angle, and from C, 50 yards from B, I found A C B $26^\circ 34'$; on B C produced I found another station D 100 yards from C, where A C B was $7^\circ 8'$; the scale of tangents corresponding to these angles gave the numbers 2 and 8 respectively; find the distance A B.

(2.) From a point A on a horizontal plane the angle of elevation of a hill was $7^\circ 8'$; upon approaching it 1,000 feet the angle was $14^\circ 2'$. The tangents corresponding to these angles are 8 and 4 respectively taken from the divisor tables. Find the height of the hill above the horizontal plain.

9. Find, by construction, the relative position of a point X, when $A X B = 19^\circ$, $B X C = 25^\circ$, $A B C = 160^\circ$, A B = 800 feet, B C = 1,100 feet, and state the distances A X and C X.

10. The measured distance between A and B was found to be 956 links; the reciprocal angles of elevation and depression were $2^\circ 4'$ and $2^\circ 7'$; the horizontal readings + 2' and + 3'. The chain was 66.21 feet in length. Required, the horizontal and vertical distances in feet between A and B.

EXAMINATION IN SURVEYING.

Afternoon Paper, July 1867.

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1. Accompanying is a traverse survey of a plot of ground near Shooter's Hill. All the angles, bearings, and measurements are recorded on the plan. From the data thus given compile a "Field Book," in the form and manner in which such observations are usually recorded when surveying in the field. The object of this question is to test your ability to keep a Field Book, so far as that can be tested otherwise than in the field. You will therefore regard the

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EXAMINATION IN SURVEYING.

Afternoon Paper, July 1867.

Examiner—Lieut. Colonel C. D. NEWMARCH, R. E.

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plan as a piece of country, on the survey of which you are supposed to be engaged, and proceed to book your observations accordingly, just as you would do if actually in the field.

2. The accompanying lithographed map represents the Lakes of Killarney, and portions of the counties of Kerry and Cork in their vicinity. You are requested to consider this as a tract of country on the survey of which you are proposed to be employed, more especially with reference to the selection of the proposed new line of railway to Kenmare.

State in what manner you would proceed to execute such a survey, first, with reference to the production of such a map as you now see; and further, with reference to the more detailed surveys necessary for the selection and demarcation of the proposed new line of railroad.

The accuracy of the survey is supposed to be checked by the positions of the principal points being determined trigonometrically. You will, accordingly, select your own base line and suitable trigonometrical stations.

The plan may be drawn over in any way that you think proper in illustration of your proposed mode of procedure; and the following points should be attended to:—

A. Show, by a thick red line, the position of the proposed base; and, by thin red lines, the proposed system of triangulation.

B. Compute, as accurately as the scale will admit, the length of the proposed new line of railway.

C. Colour in the road, rivers, lakes, sea, &c., shown on the plan, finishing off the map neatly.

D. Compute the area of water embraced by the larger lake or Lough Leane.

E. Sketch in, on a separate piece of paper, and on an enlarged scale, the group of hills in the vicinity of Mangerton Mountain. This should be done as a free-hand sketch, and may be executed either with the pen or the brush, and is merely required in illustration of your capability of doing such work.

F. Explain how, in practice, you would obtain the delineation of such hills, contouring being supposed, in this instance, to be considered as an unnecessarily expensive process; detail the process of sketching in ground in the field, and state what are the necessary previous preliminary checks upon the work.

Note.—A portion of the afternoon sitting will be devoted to the Examination of some of the Candidates in the Practical Use and Adjustment of Instruments.

QUESTIONS ON LEVELLING AND PRACTICAL SURVEYING.

Morning Paper, July 1867.

Examiner—Lieut. Colonel C. D. NEWMARCH, R. E.

Note.—You are particularly requested to write legibly, and to answer the questions concisely; prefix the number of the question to each answer, and write your name at the top of each of your papers. Candidates must not communicate with or assist each other.

1. When are two points on the surface of the earth said to be on the same level? What instruments are used in levelling?

2. What is the effect of the curvature of the earth on the apparent place of any object? Prove that two-thirds of the square of the distance, in miles, is the amount in feet, of the correction for curvature.

3. What do you understand by refraction, and how do you explain the law in optics on which the effect of refraction depends? How do you ascertain the amount

amount of refraction at any time when the atmosphere is in an abnormal condition?

4. Suppose that in running a section line up a very flat slope, the levelling staves are placed as far apart as will allow of distinct vision, what will be the result on the height, omitting curvature and refraction?

5. At a horizontal distance of 8,000 yards, the vertical angle observed with a theodolite, 5 feet high to the top of a tower, was $2^{\circ} 6'$. The tower was 150 feet high, and the observer's position 260 feet above the sea level. What was the height of the foot of the tower above the sea, curvature and refraction being taken as usual?

6. How do you trace contour lines upon the ground with a spirit level or theodolite, when required to be marked out with great accuracy? At what vertical distance apart may contour lines most usefully be applied, according to the scale of the plan, the nature of the country, and the purpose for which they are required?

7. Explain the mode of ascertaining the longitude of any point by the occultation of Jupiter's satellites, or by a lunar observation.

8. The apparent time, by observation at A, was 11 a.m. A chronometer, 10 minutes fast for Greenwich, showed 8 hours 20 minutes a.m. The equation of time was 16 minutes, mean time being before apparent time. Find the longitude of A.

9. Explain the meaning of the term circum-meridian altitudes, and show how such observations are applied to finding the latitude.

10. A star's zenith distance was 68° on the meridian, its north declination 60° ; the observer south of the star, but north of the equator, and the allowance for refraction $1'$. Find the latitude.

11. In order to lay down a magnetic meridian line upon a plan, what observations are necessary to be taken upon the ground, and how is it laid down? How can you, at certain times, by means of the sun's amplitude, ascertain the variation of the compass?

12. Explain how you would ascertain the height of a hill by means of boiling water, in the absence of any table of values.

13. Describe the different methods of marking out curves on the ground, when the radii are supposed to be of considerable length, as in the case of canals, &c.

EXAMINATION IN PLOTTING AND PLAN DRAWING.

Afternoon Paper, July 1867.

Examiner—Lieut. Colonel C. D. NEWMARCH, R. E.

Note.—Write your name at the top of every paper which you hand in. Candidates must not communicate with or assist each other.

1. Accompanying is a lithographed Field Book, comprising the details of the traverse survey of a road in the vicinity of the Great Northern Railway. The measurements are given in feet. You are required to plot it on a scale of two chains to an inch. On this scale the plan will work into the general dimensions of 18 inches by 12 inches. It will be as well to commence your plot towards the upper right hand corner of the paper.

Finish off the plan neatly, colouring in the roads, houses, &c., and showing the traverse lines in red on the plan. Put in the meridian line from the compass observation taken at the first station. Print as a heading the words,

“Traverse Survey of the Road through Andover, near the Great Northern Railway, plotted by [Name].”

2. The following Field Book exhibits a line of levels taken for the construction of an embankment to protect low land against inundation. The crest of the embankment is to be raised four feet above the highest known rise of the flood waters; its exterior slope to be two to one, and interior slope one to one; the breadth of the embankment at top to be 10 feet.

You are required to plot a longitudinal section, showing thereon the proposed level of the embankment, as also the flood level. Also to plot a transverse section of the embankment at its highest point. The horizontal scale of the sections to be 100 feet to an inch, and the vertical scale 10 feet to an inch.

The height to which the embankment will require to be raised to be marked on the section at every 50 feet.

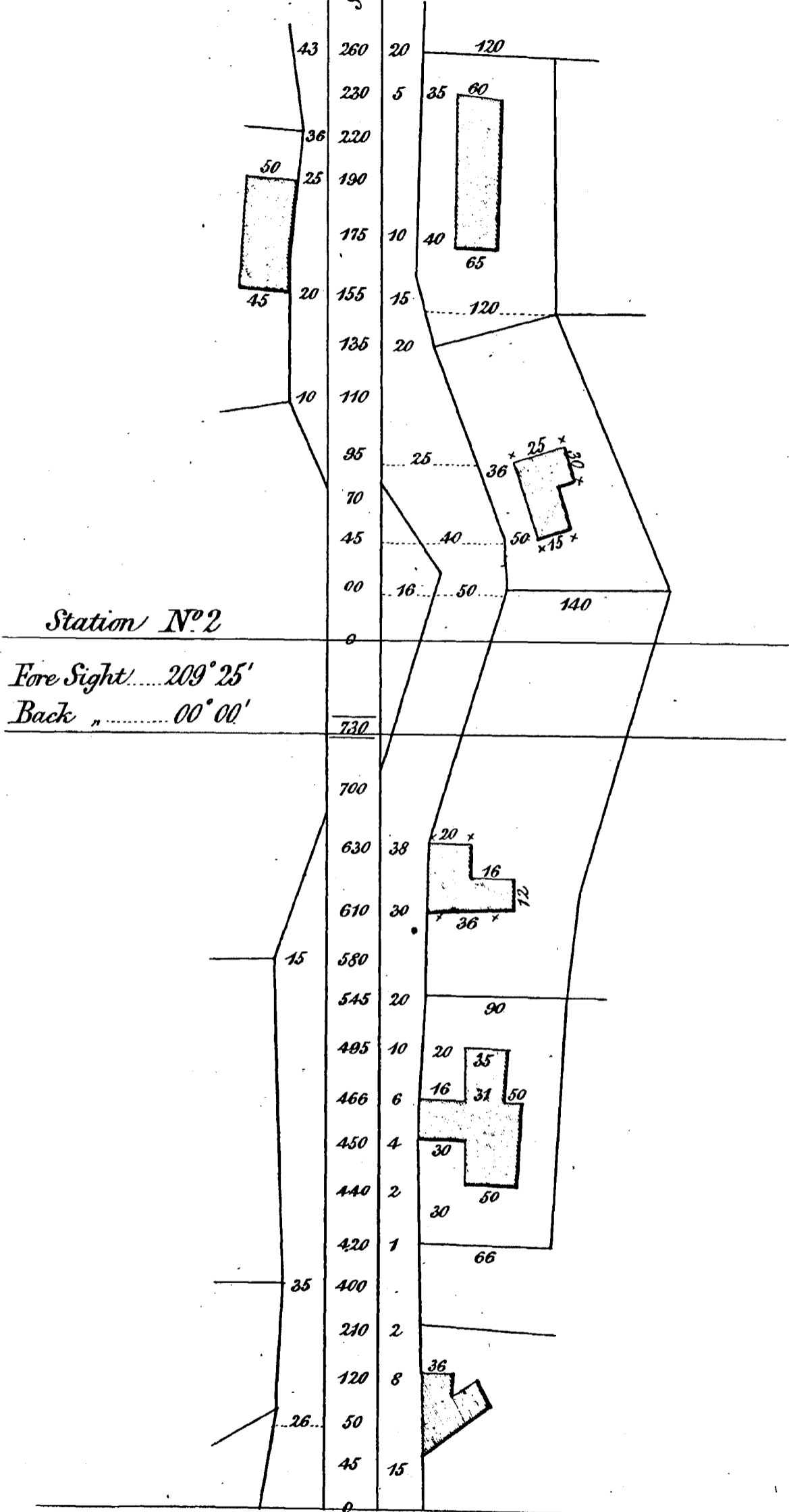
Field Book of Levels.

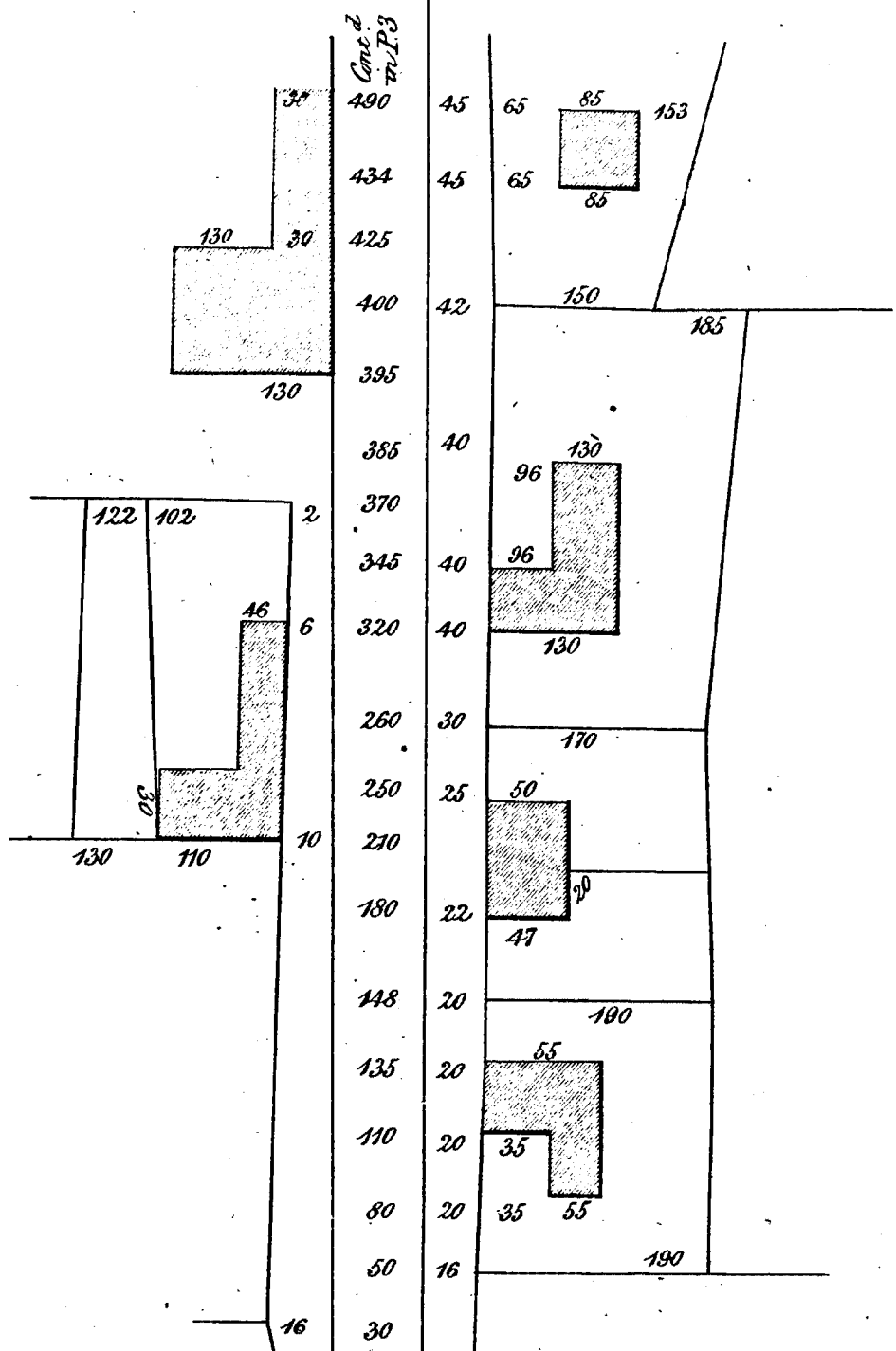
Number of Station.	BACK			Height of Instrument.	FORE			Rise.	Fall.
	Bearing.	Distance.	Level.		Level.	Distance.	Bearing.		
1	35	50	2·01	5·01	7·47 * 1·46	50	215	—	5·46
2	”	50	1·57	4·97	6·12	50	”	—	4·55
3	”	50	5·08	4·98	6·01	50	”	—	·93
4	”	50	4·02	5·02	4·99	50	”	—	·97
5	”	50	7·21	5·00	4·57	50	”	2·64	—
6	”	50	3·68	4·97	6·98	50	”	—	3·30
7	”	50	5·62	4·96	7·01	50	”	—	1·39
8	”	50	2·78	5·01	6·99	50	”	—	4·21
9	”	50	6·12	4·99	2·29	50	”	3·83	—
10	”	50	8·10	4·98	3·99	50	”	4·11	—
11	”	50	6·49	4·98	3·42	50	”	3·07	—
12	”	50	8·97	5·02	2·11	50	”	6·86	—

* Reading of flood level at this point.

Note.—A portion of the afternoon sitting will be devoted to the Examination, in the practical use and adjustment of instruments, of such of the candidates as there may not have been time so to examine on the previous day.

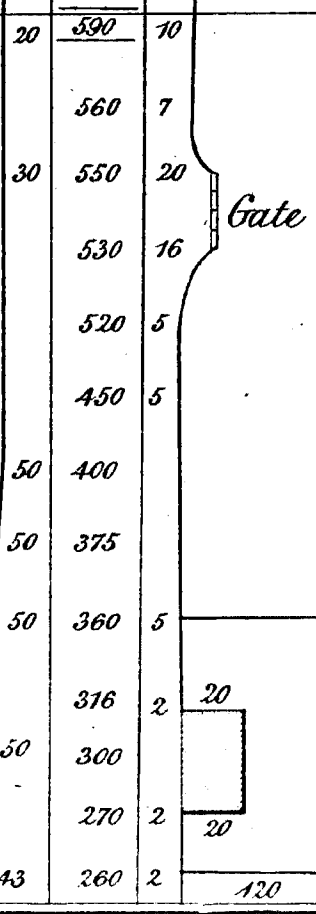
See P. 2





Station N°3

Fore Sight 221° 30' . . .
 Back " 209° 25'



Gate

Station N^o 4.

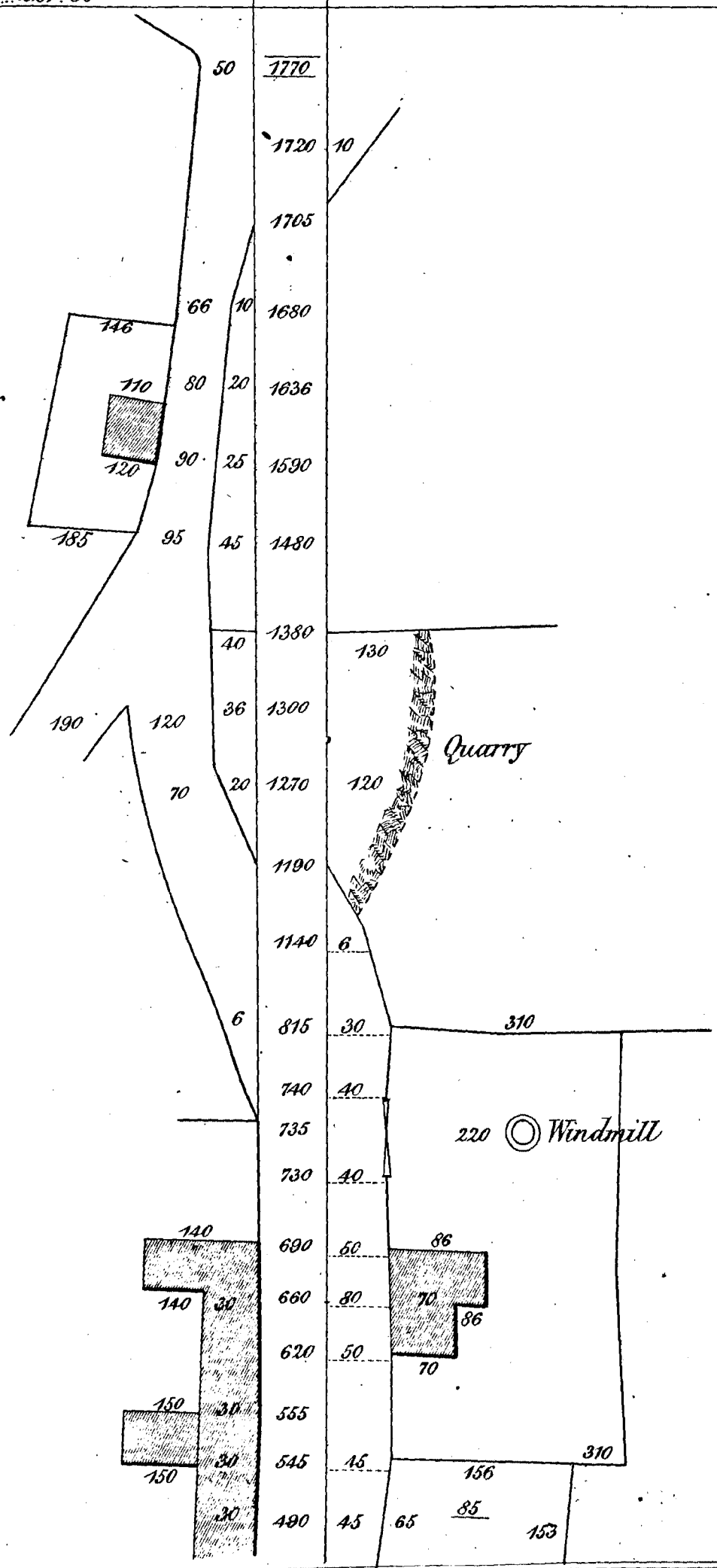
Fore Sight.....151° 20'
Back 221° 30'

Toll Bar

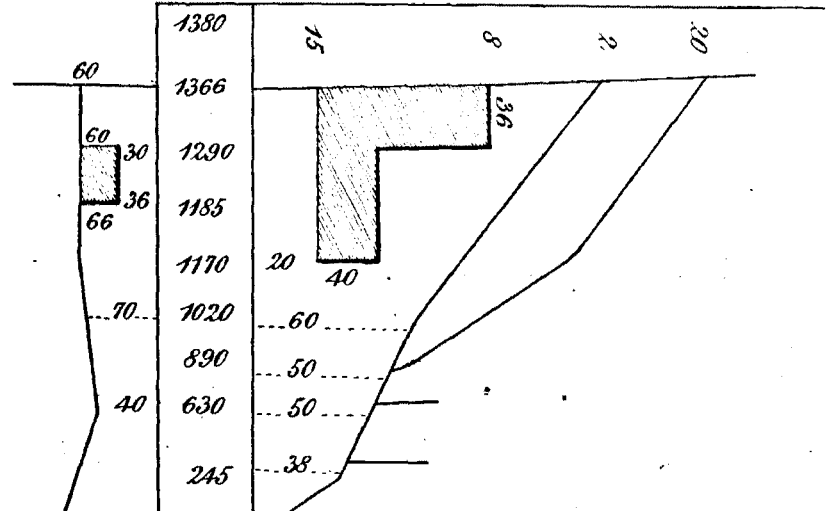
Quarry

220 © Windmill

Cont. of
in P.A.

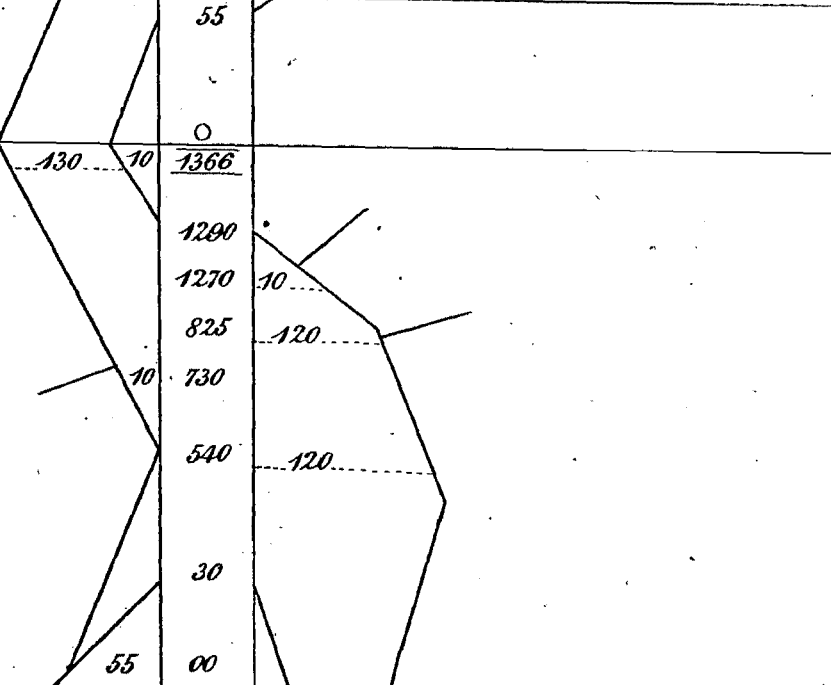


45 120 210 545



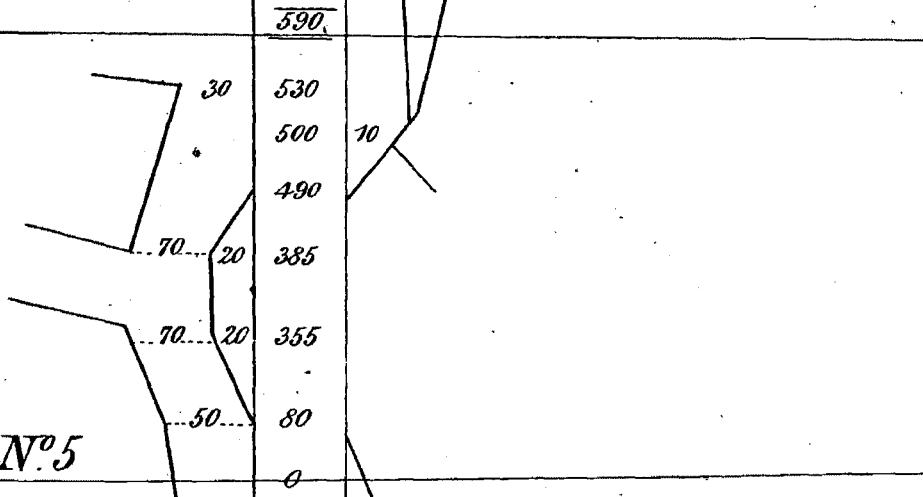
Station N°7

Fore Sight... 229° 00'
Back "..... 258° 30'



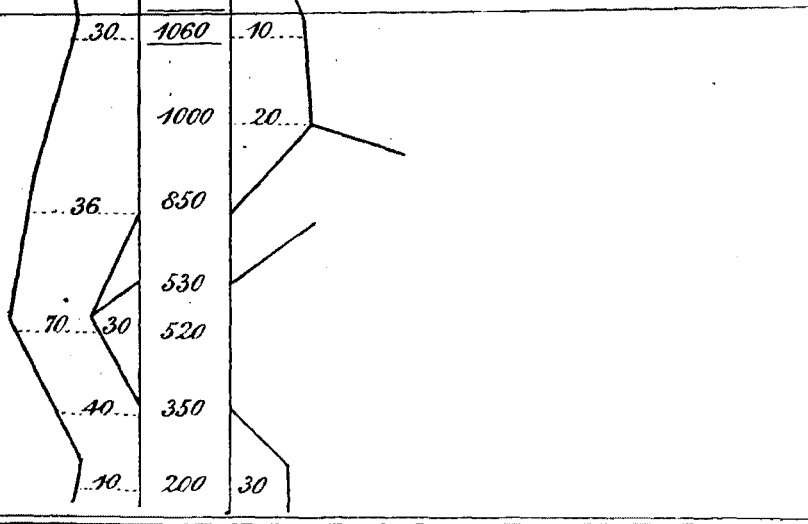
Station N°6.

Fore Sight... 258° 30'
Back "..... 316° 00'



Station N°5

Fore Sight... 316° 00'
Back "..... 151° 20'



EAST INDIA
(ENGINEERS' ESTABLISHMENT, &c.)

RETURN of the Names of EXAMINERS appointed to examine the CANDIDATES who presented themselves, since the last Return, for Admission to the ENGINEERS' ESTABLISHMENT and PUBLIC WORKS DEPARTMENT in *India*; of the Names of the SUCCESSFUL CANDIDATES in Order of Merit; of the MARKS which were assigned on each Subject to every CANDIDATE; and, of the EXAMINATION PAPERS of each SUBJECT; &c. (in continuation of Parliamentary Paper, No. 454, of Session 1866).

(*Mr. Adam.*)

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