

EAST INDIA (ENGINEERS' ESTABLISHMENT, &c.)

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RETURN to an Address of the Honourable The House of Commons,  
dated 20 March 1868;—for,

- “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. 25, of the present Session).”

India Office, }  
March 1868. }

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W. T. THORNTON,  
Secretary, Public Works Department.

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(*Mr. Adam.*)

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*Ordered, by The House of Commons, to be Printed,*  
*28 April 1868.*

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CIVIL ENGINEER EXAMINATIONS.

NAMES OF EXAMINERS.

Rev. Jonathan Cape, A.M., F.R.S.  
 Captain George 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. R. W. Everett-Green.	20	F. W. Shields, c. e., Westminster; Tiverdale Iron Company; C. P. B. Shelley, c. e., Westminster.	Not stated.
2. „ H. Lyon -	20	W. Humber, c. e., London -	Not stated.
3. „ J. N. Grainger	21	H. M's. Steam Engine Factory, Dockyard, Portsmouth.	Not stated.
4. „ F. Brickwell -	23	Ordish & Le Feuvre, c. e., Westminster; W. Perry, c. e., Beas; C. P. B. Shelley, c. e., Westminster.	Not stated.
5. „ E. Le Lievre -	23	Sir C. Fox & Sons, c. e., London	Not stated.
6. „ W. Eckstein -	21	Clayton & Co., m. e., London; W. Parsey, c. e., Westminster.	King's College, London.
7. „ S. F. Cox -	20	Stothert & Peti, m. e., Bath -	Not stated.
8. „ C. F. MacIvor	22	J. Price, c. e., M. G. W. Railways of Ireland.	Trinity College, Dublin.
9. „ J. W. Johnson	23	Ravenhill & Hodgson, m. e., London; C. P. B. Shelley, c. e., Westminster.	College, Cheltenham.
10 „ *C. Dunscombe	21	J. Price, c. e., M. G. W. Railways of Ireland.	Trinity College, Dublin.
11. „ A. H. Tyndall -	23	J. Price, c. e., M. G. W. Railways of Ireland.	Trinity College, Dublin.
12. „ R. Ewing -	21	Stewart & Menzies, c. e., Edinburgh.	Dollar Institution.
13. „ R. Wallnutt -	23	H. P. Ribton, c. e., Kingstown; J. Lynan, c. e., Ballinasloe.	Not stated.
14. „ J. W. Martin -	20	J. Ramsden, m. e., Cork - -	Queen's College, Cork.
15. „ D. F. Martin -	23	K. H. Roche, c. e., Cork - -	Queen's College, Cork.
16. „ J. M. Bell -	19	E. Sang & Son, c. & m. e., Edinburgh; G. Hunter, c. e., Westminster.	Not stated.

\* Mr. Dunscombe did not accept an appointment.

NUMBER of MARKS which were assigned on each Subject to every Candidate.

No.	Number of Marks allotted in			TOTAL.	No.	Number of Marks allotted in			TOTAL.
	Mathematics.	Civil Engineering.	Surveying and Levelling.			Mathematics.	Civil Engineering.	Surveying and Levelling.	
1	274	335	157	766	12	239	265	107	611
2	269	330	131	730	13	200	300	110	610
3	337	260	121	718	14	205	285	116	606
4	254	335	125	714	15	234	265	106	605
5	224	335	145	704	16	210	293	101	604
6	229	330	105	664	17	218	250	72	540
7	214	335	106	655	18	156	285	86	527
8	256	295	102	653	19	170	245	86	501
9	226	285	121	632	20	129	290	80	499
10	254	245	125	624	21	133	255	99	487
11	274	245	100	619	22	77	240	108	425

PUBLIC WORKS DEPARTMENT—INDIA.

CIVIL ENGINEER ESTABLISHMENT.

EXAMINATION PAPERS for December 1867.

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

1. Reduce  $\frac{\frac{120}{119} - \frac{1}{239}}{1 + \frac{1}{239}}$  of  $\frac{120}{119}$  +  $\frac{1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4}}{1 + \frac{1}{2} - \frac{1}{3} - \frac{1}{4}}$  to its lowest terms;

and also express the result as a decimal.

2. Find the value of  $\frac{2}{7}$  of 15 l. +  $3\frac{3}{7}$  of 1 l. +  $\frac{1}{3}$  of  $\frac{2}{7}$  of  $\frac{3}{7}$  of 1 l. +  $\frac{2}{3}$  of  $\frac{2}{7}$  of 1 s.

3. Divide 1121·4 by ·534; also, 411·3519 by 58·7645.

4. Two steam ploughs are tried at an Agricultural Show; one finishes 6 acres, 2 roods, 30 perches in 7 hours 50 minutes; the other, 6 acres, 1 rood, 26 perches in 7 hours 20 minutes. Which is the best plough as regards speed?

5. What principal will amount to 739 l. 1 s. 8 $\frac{1}{2}$  d. in 1 year 11 months, at 4 $\frac{1}{2}$  per cent. per annum Simple Interest?

6. Cotton is bought in Bombay at 9 d. per lb.; the freight home is 38 s. per ton; it is sold here at 1 s. 2 d. per lb. What profit per cent. is made by the transaction?

7. Draw a figure illustrating the meanings of the terms *sine*, *cosine*, *tangent*, *cotangent*, *secant*, and *cosecant*. Also, it being given that the sine of an arc is ·25, determine the numerical values of the other *five* above-mentioned functions of the same arc.

8. Determine the following quantities by means of Logarithms:—

(a) the values of  $\frac{\sqrt[3]{\cdot 0382972}}{1 + \sqrt{2\cdot 18}}$ , and  $\frac{23\cdot 01 \times 468\cdot 13 \times \cdot 0624}{368\cdot 5 \sqrt{\cdot 82608}}$ .

(β) the mean proportional to 42·681 and 2·6089.

(γ) the angle whose secant is 9·3347620, from a Table of log. secants.

(δ) the natural cosine of 73° 2' 45".

9. Compute to 5 places of decimals the value of  $\sqrt{\frac{1 - \sin A}{1 + \sin A}}$ , when  $A = 32^\circ 5' 20''$ , from a Table of natural sines.

10. Solve the triangle  $ABC$ , it being given that  $AB = 17\cdot 24$ ,  $AC = 23\cdot 42$ .  $\angle A = 36^\circ 15'$ .

11. Explain how we may find the width of a river (which we cannot cross) by means of a measuring tape only.

12. Two objects,  $A$  and  $B$ , are due S. E. of my first station. I travel 6 miles in a direction  $30^\circ$  West of South, and I find then that  $A$  is due East of me, while  $B$  bears  $15^\circ$  South of East. Find the distance of  $A$  from  $B$ , and show that my two positions are equidistant from  $B$ .

4 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

13. A mug, 4 inches in diameter, and 5 inches high, is 3 quarters full of water. Through what angle may the mug be tilted, without spilling any of the water?

Work the same for a hemispherical bowl of 6 inches radius, having 4 inches depth of water in it.

14. Find the weight of an iron roller 6 feet 6 inches long, 2 feet 4 inches in diameter, and 2 inches thick, iron weighing 464 lbs. per cubic foot.

15. What will be the cost of painting the outside of a rectangular goods' shed, with tarred-felt roof, the shed being 90 feet long, 32 feet broad, 22 feet high at the eaves, and 38 feet to the ridge of the roof, painting costing 3*d.* per square foot, and tarring 3*d.* per square yard?

16. How much earth must be excavated to form a dock 300 feet long, 25 feet deep, the sides sloping uniformly with a top and bottom breadth of 60 and 50 feet respectively, and the ends being vertical; and how many gallons of water will the dock hold when filled within 8 feet of the top? (One gallon contains 277·3 cubic inches.)

17. A tank is to be built at a station, 14 feet long, 8 feet wide, and 5 feet deep. What weight will its supports have to carry when it is full, the weight of the tank itself being 4 tons 3 cwt., and the water being supposed to weigh 1,000 ounces the cubic foot?

18. How many bricks are required to build a wall a brick and a half thick, 9 feet high, and 150 yards long? And what will it cost at 5*l.* a standard rod?

December 1867.

ALGEBRA.—Rev. J. Cape.

1. Simplify the following expressions:—

$$\frac{2}{a-b} + \frac{2}{b-c} + \frac{2}{c-a} + \frac{(a-b)^2 + (b-c)^2 + (c-a)^2}{(a-b)(b-c)(c-a)} \dots\dots (a)$$

$$\left\{ \frac{1}{3} + \frac{2x}{3(1-x)} \right\} \cdot \left\{ \frac{3}{4} - \frac{3x}{2(1+x)} \right\} \dots\dots (b)$$

$$\frac{a^3 - b^3}{a^3 + b^3} \cdot \frac{a+b}{a-b} \cdot \left\{ \frac{a^2 - ab + b^2}{a^2 + ab + b^2} \right\}^2 \dots\dots (c)$$

2. Find the least common multiple of  $x^3 + x^2y + xy^2 + y^3$ ,  $x^3 + y^3$ , and  $x^3 - x^2y + xy^2 - y^3$ .

3. Solve the following equations:—

$$\frac{x-5a}{4a} - \frac{x-3a}{9} = \frac{a}{18} \dots\dots (a)$$

$$(x^2 - 2)^2 = 2x^3 - 5x \dots\dots (b)$$

$$\left. \begin{aligned} \frac{x^3}{y} - \frac{y^3}{x} &= \frac{65}{6} \\ \frac{x}{y} - \frac{y}{x} &= \frac{5}{6} \end{aligned} \right\} \dots\dots (c)$$

$$\left. \begin{aligned} \frac{1}{2}x + \frac{1}{3}y + z &= 19 \\ \frac{1}{2}x + y - \frac{1}{4}z &= 16 \\ x - \frac{1}{3}y - \frac{1}{4}z &= 14 \end{aligned} \right\} \dots\dots (d)$$

4. Shew that  $\sqrt{4 + 3\sqrt{-20}} + \sqrt{4 - 3\sqrt{-20}} = 6$ ; also, that

$$\frac{7 + \sqrt{-3}}{2 - \sqrt{-3}} + \frac{8 + 3\sqrt{-3}}{2 + \sqrt{-3}} - \frac{4(2 - \sqrt{-3})}{1 - \sqrt{-3}} = \frac{1}{2}$$

5. If

5. If  $(a + b + c + d)(a - b - c + d) = (a - b + c - d)(a + b - c - d)$ , show that  $a : b :: c : d$ .

Also, if  $a : b :: b : c$ ,  
show that  $a + b : b + c :: a^2(b - c) : b^2(a - b)$ .

6. Find the sum of ten terms of the series  $13 + 11\frac{1}{2} + 10 + \dots$  beginning at the *fifth*; also, find the *thirtieth* term.

7. The sum of 1,200 *l.* was to be divided among 4 persons, whose shares are in Geometrical Progression; and the difference between the greatest and least was to the difference between the means as 13:3. What were their respective shares?

8. A semaphore has *four* fixed lamps, with sliding shades to cover them, the lamps being red, green, blue, and white respectively. How many different signals may be made with it?

9. Expand  $(1 - 4x)^{-1}$  and  $(1 - 4x)^{-2}$  each to 5 terms; and then show by actual multiplication that the former series, when squared, becomes the same as the second.

10. There are two casks, one containing 136 gallons of wine, the other 200 gallons of water; 86 gallons are drawn off from each cask, mixed together, and the casks again filled up with the mixture. After this operation has been repeated, find how much wine there is in each cask.

11. A general sends away 800 men to guard a ford, and  $\frac{2}{5}$  of the remainder of his troop on a reconnaissance, and he finds he has only  $\frac{5}{17}$  of his original force left with him; of how many men did his original force consist?

12. A man of war, with a crew of 350 men, sails with just enough water to last the computed length of her voyage. After 30 days scurvy breaks out, and carries off 6 men a day till she reaches her port, which she does 3 weeks later than had been expected. Her water just lasts out the voyage. How long was it?

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December 1867.

EUCLID.—Rev. *J. Cape.*

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

Given the base, an angle adjacent to the base, and the difference of the other two sides; construct the triangle.

2. If two triangles have two angles of the one equal to two angles of the other, each to each; and one side equal to one side, viz. either the side adjacent to the equal angles, or the sides opposite to the equal angles in each; then shall the other sides be equal, each to each; and also the third angle of the one to the third angle of the other. *Take the first case, when the side is adjacent to the equal angles.*

If two exterior angles of a triangle be bisected, and from the point of intersection of the bisecting lines a line be drawn to the opposite angle of the triangle, it will bisect that angle.

3. To draw a straight line through a given point parallel to a given straight line.

One of the diagonals of a parallelogram being given, and the angle which it makes with one of the sides, complete the parallelogram so that the other diagonal may be parallel to a given right line.

6 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

4. In any right angled triangle, the square which is described upon the side subtending the right angle, is equal to the squares described upon the sides which contain the right angle.

If in the figure given in Euclid— $GH$ ,  $KE$ , and  $FD$  be drawn, thus joining the exterior angular points of the three squares; show that each of the three triangles thus formed equals the given triangle  $ABC$ .

5. In obtuse angled triangles, if a perpendicular be drawn from either of the acute angles to the opposite side produced, the square of the side subtending the obtuse angle is greater than the squares of the sides containing the obtuse angle, by twice the rectangle contained by the side upon which, when produced, the perpendicular falls, and the straight line intercepted between the perpendicular and the obtuse angle.

6. In equal circles equal arcs are subtended by equal straight lines.

$AB$ ,  $AC$  are equal arcs of a circle; prove that the chord  $BC$  is parallel the tangent at  $A$ .

7. If a straight line touch a circle, and from the point of contact a straight line be drawn cutting the circle, the angles made by this line with the line which touches the circle, are equal to the angles in the alternate segments of the circle.

If two circles touch each other, any two lines passing through their point of contact will cut off arcs whose chords are parallel.

8. To describe a circle about a given square.

9. If a straight line be drawn parallel to one of the sides of a triangle, it will cut the other sides, or the other sides produced, proportionally; and if the sides, or the sides produced, be cut proportionally, the straight line which joins the points of section, will be parallel to the remaining side of the triangle.

$A$ ,  $B$ ,  $C$ ,  $D$  are four points in a straight line taken in order. Through  $A$  and  $C$  draw any two parallel lines  $AM$ ,  $CN$ ; and through  $B$  and  $D$  draw any two parallel lines  $BM$ ,  $DN$ , meeting the former in  $M$  and  $N$ . Join  $MN$ , and produce it to meet the line  $ABCD$  in  $O$ . Prove that the rectangle contained by  $OA$  and  $OD$  is equal to that contained by  $OB$  and  $OC$ .

10. If two straight lines be cut by parallel planes, they shall be cut in the same ratio.

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December 1867.

MECHANICS and HYDROSTATICS.—Rev. *J. Cape*.

1. Enunciate the theorem called the "Parallelogram of Forces." Mention any way by which the truth of it may be practically illustrated.

If 15 lbs. is the resultant of two forces, with the directions of which it makes angles of  $30^\circ$  and  $45^\circ$  respectively, what are the magnitudes of the component forces?

2. Two weights of 60 and 70 lbs. balance on a straight lever without weight. If 8 lbs. be added to the 60 lbs. the fulcrum must be shifted through the space of 15 inches to restore the equilibrium. Find the length of the lever.

3. A uniform heavy rod 16 feet long, has the last 7 feet bent at right angles to the first 9 feet. If it be hung freely from each end in turn, show how it will hang in each case.

4. A uniform beam 10 feet long is placed in a smooth hemispherical bowl of 4 feet radius. Determine the position in which the beam will rest.

5. What

5. What is meant by the "*Funicular Polygon*?" Show how the condition of equilibrium in it is determined. Also, explain briefly how this Theorem may be applied practically, to determine the required form of an arch in any particular case.

The extremities of a cord four feet in length are fixed at two points *A* and *B*, three feet apart in the same horizontal line. Three equal weights are suspended from this cord at equal distances of one foot from each other, and also from the extremities *A* and *B*. Show how the tension of each portion of the cord may be determined, and also the angle which it makes with the horizon.

6. Enunciate the Theory of Mechanical Friction, and explain the experiment by which the truth of it is usually illustrated.

A ladder 25 feet long, weighing 60 lbs., leans against a wall, the Coefficient of Friction between the ladder and the pavement being .6, and between the ladder and the wall being .5. If the ladder makes an angle of 60° with the ground, how high may a man weighing 140 lbs. ascend before it begins to slip?

7. The mean section of a stream is 12 feet by 18 inches, and its mean velocity is 35 feet per minute, and there is a fall on the stream of 16 feet. How much water per minute may be pumped up to a reservoir 300 feet above the bottom of the fall, by means of a wheel whose modulus is .75?

8. The shaft of a mine is 600 fathoms deep. How long would a 20 H.P. engine be in bringing up a basket containing one ton of coal?

9. Explain clearly the meaning of the term "*Centrifugal Force*," and describe by means of a figure, the part it plays in the action of Appold's Centrifugal Pump.

10. Prove the formulæ

$$s = \frac{1}{2}ft^2, \quad v^2 = 2fs.$$

A man drops a stone from the monument (202 feet high). With what velocity, and in what time, will it strike the ground?

11. How many miles an hour can a 60 H.P. engine draw a train of 76 tons up an incline of 1 in 250, the retarding force due to friction being 8 lbs. per ton.

12. Explain the constructions of the "*Gridiron Pendulum*," and the "*Mercurial Pendulum*;" and give the reason which renders such improvement in the common Pendulum necessary.

13. The specific gravity of cast-iron being 7.197, what will be the weight of 10 feet of iron pipe of 4 inches bore, the metal being 1¼ inches thick?

14. A rectangular self-acting sluice gate (8 feet by 6 feet) has its longer sides horizontal. Find the pressure on the gate when the water has risen 12 feet above the top of the gate.

15. Give the construction of the Thermometer. In Reaumur's the freezing point is at 0°, and the boiling point at 80°. In Fahrenheit's they are at 32° and 212° respectively. What would Reaumur's register when Fahrenheit's stands at 120°?

## 8 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

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 December 1867.

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*George Preston White, C.E., Examiner.*

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*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 certificate, respecting which there will be a *vivâ voce* examination.
6. Write on both sides of the paper, leaving a margin of about an inch.

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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 articed, 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.

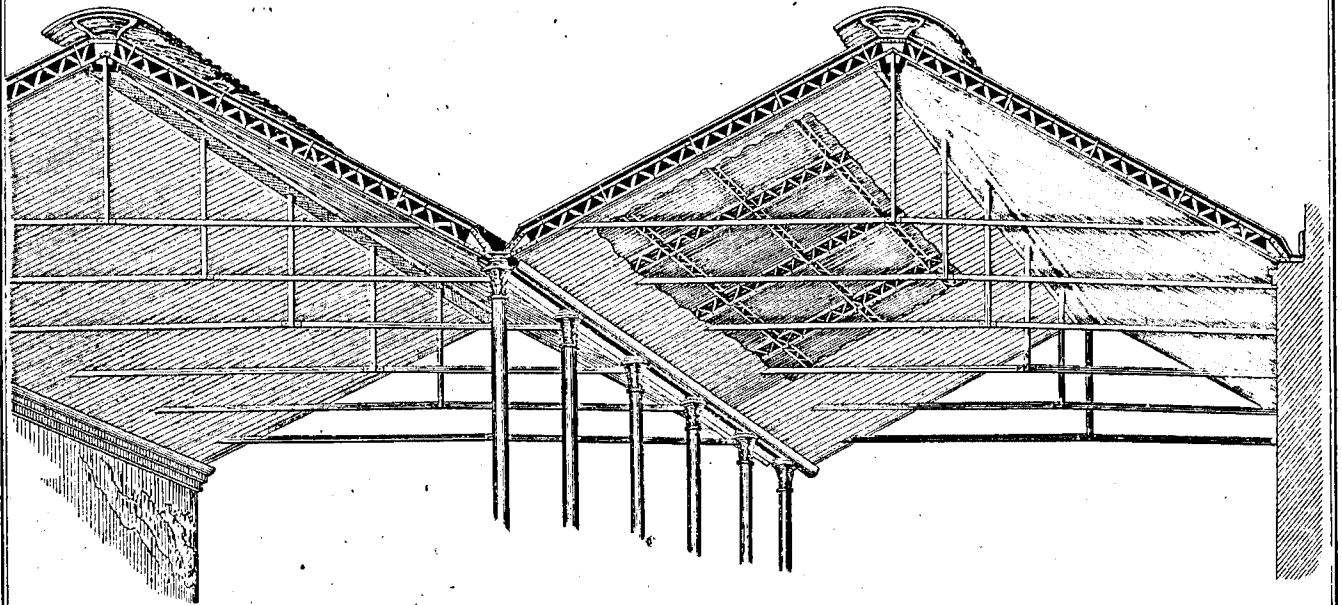
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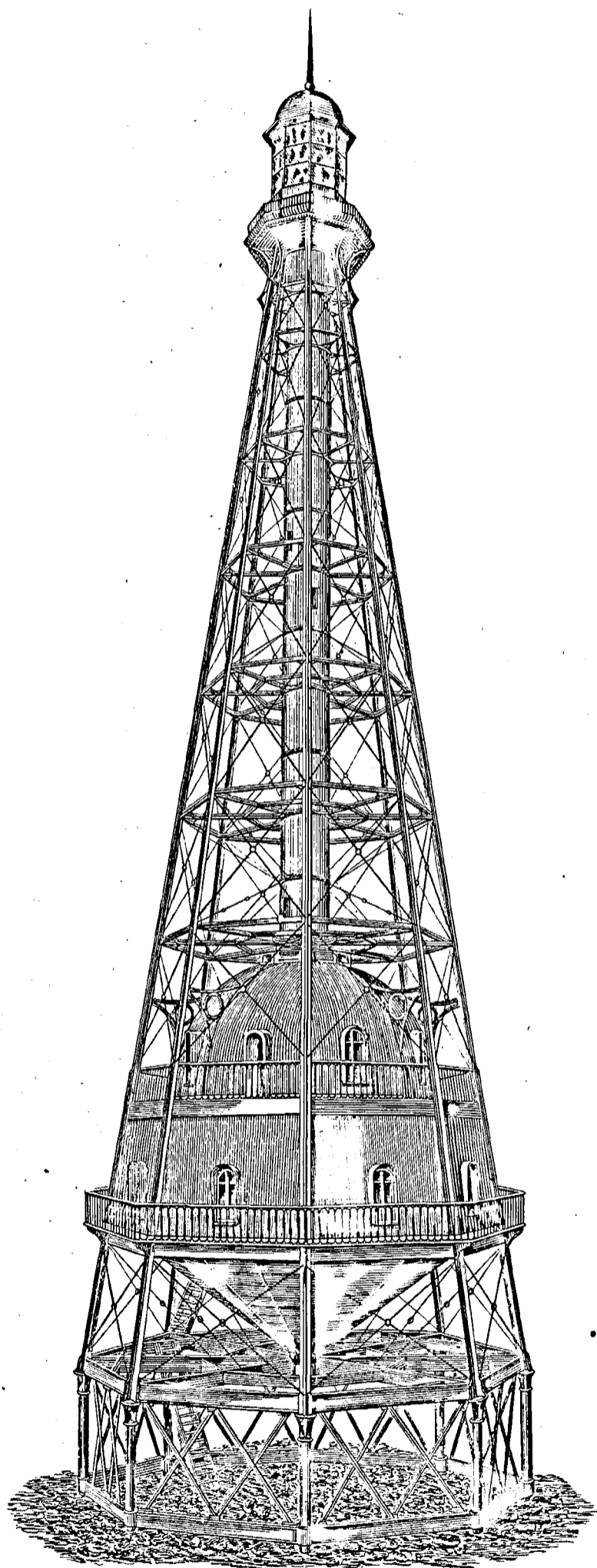
### ON ARCHITECTURE, BUILDING MATERIALS, AND CONSTRUCTION.

1. DESCRIBE briefly the characteristic differences of the Doric, Ionic, and Corinthian orders of architecture, make free-hand sketches of their capitals and columns, and name some well-known examples, both ancient and modern, of each order.
2. Describe the leading features of what is commonly called Gothic architecture; but more correctly, Christian. Point out in what it mainly differs from Classic architecture.
3. Considerable constructive skill, combined with æsthetic feeling, is displayed in Gothic architecture. Give some examples.
4. Make a free-hand sketch of the pointed roof, and point out the combination of science and beauty in its arrangement.
5. Make a free-hand sketch of the ground plan of a cathedral, and name and describe the different parts. What is the difference between the Greek and Roman cross?
6. Explain the meaning, and describe with free-hand sketches, the following terms used in architecture, viz., Entablature, Fluting, Frieze, Intercolumniation, Metope, Pedestal, Pediment, Pilaster, Porch, Portico, Soffit.
7. Describe the nature of Ransome's patent concrete stone, and state under what circumstances, and for what parts of a building, it is most economical and desirable to employ it. Explain some of the means employed for the preservation of stone.
8. Describe the characteristic qualities of good bricks under the following heads, viz., as regards shape, sound when struck, appearance presented when broken, their absorption of water as compared to their weight, and the crushing load required per square inch.
9. Describe with free-hand sketches the different bonds used in brickwork, and explain the uses and application of hoop iron.
10. What is the best time for felling trees? Explain what changes timber undergoes in the process of seasoning, what is its *rationale*, what is the time required, and describe some of the most approved methods of preserving timber, and explain their chemical action.

11. Steel







11. Steel is becoming much employed instead of iron. What are the comparative advantages as regards cost, durability, and strength, for bridges and rails? and state the reasons why its substitution would be most advantageous in India.

12. The employment of good lime and cement is a matter of the greatest importance in construction; describe how you would mix mortar, the proportions you would use; specify the limes which are hydraulic, and what tests you would employ, and name some of the best authorities on the subject.

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### ON LIGHTHOUSES and CONSTRUCTIONS in IRON.

THE accompanying drawing\* represents the Buda Iron Lighthouse, designed by his Excellency Don Lucio del Vallé, for the Spanish Government, and erected at the mouth of the Ebro, the ironwork being manufactured, and the details of construction designed and carried out by Mr. J. H. Porter, at Birmingham. The height of the structure, from the pile caps to the platform of the gallery at the summit, is 150 feet, giving a height from the mean level of the Mediterranean to the centre of the light, of about 169 feet. The total weight of iron employed above the piles is about 200 tons. The structure is supported on nine wrought-iron screw piles in a sandy foundation.

\* See Drawing opposite.

1. Make free-hand sketches of the section you would consider best for the eight principal ascending supports, and sketch details of the connection of these with the horizontal stiffening frames.

2. The central column contains an iron staircase. Sketch your ideas of the best mode of constructing this, and explain how the weight is distributed upon the external supports.

3. Specify some of the conditions under which the "screw pile" is superior to other supports for foundations.

4. What load per square foot of its surface would a cast-iron screw fixed upon a wrought-iron pile safely sustain in a firm sand?

5. What sized screws would you recommend for the nine piles upon which this structure is supported? Would you prefer a wrought or a cast-iron pile? Describe the effects of sea water on iron.

6. Give an approximate estimate of the cost of manufacturing a lighthouse of this description, not including the lantern and light, and specify the parts of this structure you would make of wrought and of cast-iron.

7. In designing a structure of this character, a very important element for consideration is the force of the wind during a cyclone. Give the result of the experiments of Smeaton and others on this subject. State at how many pounds per square foot you would estimate it, and how you would ascertain the amount of area exposed to it in this case.

8. Give the names of some important examples of lighthouses of iron and stone; their comparative height; and the names of standard works of reference on lighthouse construction.

9. Sketch, in detail, what you consider the best means and apparatus for screwing down the piles in dry land and under water.

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### ON IRON ROOFS.

The accompanying design\* represents an iron roof, of 40 feet span, manufactured in England, and erected at Calcutta. As a protection against heat, the roof is double, with an outer and inner covering of galvanised corrugated iron, with a space of 12 inches between. The principals, in order to interfere as little as possible with the inner covering, are formed of lattice work, 10 inches in depth, and sufficiently rigid to dispense with the ordinary "trussing" of struts and ties. The tie-bar consists of a flat iron, supported in

\* See Design opposite.

the centre by a lighter bar suspended from a connecting plate at the centre. The gutters are made very large, to provide against tropical rains. For ventilation, there is an opening of 17 inches at the top of the roof, and suspended beneath a plate of perforated zinc; a small raised roof, with projecting eaves, protects the opening from rain. The inner covering stops short at the end of the rafter at foot, to assist ventilation; a moulding below conceals this from view, and also serves as a gutter for any condensed moisture.

1. Make an approximate estimate of the cost of such a roof per "square" of 100 superficial feet, together with a specification. Make detailed sketches of the various parts of the roof, with dimensions figured on, and show mode of fastening the corrugated iron plates to principals, &c.

2. State what protection you would recommend to preserve the corrugated iron, and what wire gauge you would adopt.

3. The columns, 11 feet in height, were necessary as supports for the shafting to drive machinery. Had they not been thus required, which would be preferable and least costly,—a roof of two spans of 40 feet, or one span of 80 feet?

4. Having regard to the heat of the climate, the heavy rain-fall at certain seasons, the great force of the hurricanes, and the necessity for good ventilation for a large number of people, would the single or double span be preferable, apart from the question of cost? and give your reasons.

5. What do you estimate as the maximum pressure of the wind per square foot, on the surface of the roof? Explain what tests you would subject the roof to before its erection.

6. Make a free-hand sketch for a curved roof of 40 feet span. Sketch the kind of principals and purlins you would adopt, and state at what distance apart you would place them, and the pitch of corrugation and gauge you would specify for the covering, and what overlap at the joints.

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#### ON IRRIGATION, DRAINAGE, WATER SUPPLY, &c.

1. A great desideratum in irrigation is a module which will give a uniform discharge of water in small channels issuing from a large canal, of which the depth or head of water is constantly varying. Can you suggest any simple machine for effecting this?

2. The bed of a canal is 50 feet wide, the depth of water 5 feet, the side slopes 1 to 1, the slope of bed 1 in 4,000; required the mean velocity and discharge in cubic feet per second.

3. Will the velocity in the above example be too great for a soil of firm gravel; and is it desirable to give a canal simply intended for irrigation as high a velocity as possible, consistent with safety?

4. The canal in question (No. 2) has to be carried over a country of which the general slope is 1 in 2,000. How will this be effected? Give a free-hand sketch of the section of any masonry works that may be required to keep the level of the water nearly the same as that of the country.

5. A canal, of discharge 25 cubic feet, and velocity 30 inches per second, has to be carried by a masonry syphon under the sandy bed of a torrent, which crosses the canal at a level of 15 feet below it. Give a sketch of the syphon you would build.

6. In the last question, what would be the diameter, and what the thickness, of a wrought-iron pipe to be used for the syphon instead of masonry?

7. Make free-hand sketch, and describe the different means employed for jointing gas and water pipes, point out their comparative merits or defects, and explain the advantages of the bored and turned joints manufactured by Messrs. D. Y. Stewart & Co., of Glasgow, over the old systems.

8. Describe

8. Describe the different means employed to filter water, explain the chemical action of Spencer's "Magnetic Carbide," and the modes of ascertaining the comparative softness and purity of water for domestic and manufacturing purposes by the soap and other tests.

9. State what are the chief requirements in water for town supplies.

10. Describe the pumping system of supply, give illustrative examples, and point out cases of combined supply where both gravitation and pumping are resorted to.

11. Explain shortly the system of supply from wells, and define what is called an Artesian well, and the best geological water-bearing strata.

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### ON PHYSICAL MAPS, &c.

There are many subjects which can be better illustrated by the aid of physical maps than in any other way. If required to report on the agricultural, mineral, and other capabilities and resources of a district, and the best means of developing them by opening up communications, and by works of irrigation, &c., describe how you would illustrate your report by the aid of physical maps, and mark on the accompanying map, by colours and otherwise, the following features:—

1. The geological and mineralogical features of the district, as, for example, the stratified and unstratified rocks, coal fields, iron, lead, copper, tin, and other mineral productions, building stone, lime, &c.

2. Physical map indicating the river systems, mountain ranges, marking on natural drainage of the country, watershed, &c.

3. Hydrographic chart of the ocean, with soundings indicating direction of the currents, prevailing winds, trade routes, imports and exports, &c., from different harbours.

4. Meteorological map, marking on ranges of temperature, rainfall, &c.

5. Botanical map, showing geographical position of food-producing and other useful plants, as rice, corn, maize, sugar, tobacco, indigo, cotton, flax, opium, and forest timber.

6. Public works map, showing roads, tramways, railways, canals of navigation and irrigation, works of drainage.

7. Map showing comparative density of population.

8. Traffic map, showing amount and direction of passenger, goods, and merchandize traffic.

9. Military map, showing forts, military stations, disposition of troops, electric telegraph stations, &c.

10. Describe the characteristics and topographical references usually employed in the Ordnance and other surveys to denote the following, viz.—boundaries of counties, parishes, baronies and townlands; also, the marks used to denote lime-kilns, brickfields, collieries, bridges, forts, gravel-pits, waste or uncultivated land, trigonometrical points, weirs or dams, canal locks, wells, quarries, coal, iron, copper, lead and tin.

*Note.*—Physical maps are capable of being applied to many other subjects not hitherto used, and may be most usefully employed to illustrate reports. I therefore wish particularly to direct your attention to this interesting subject.

## 12 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

The following Remarks of the President of the Institution of CIVIL ENGINEERS are deserving of your most careful attention and study:—

The rapid growth of communities has developed the necessity of provision being made for a more abundant supply of pure water, and for a more complete system of sewerage than is now generally possessed by our towns and cities. Some of these works are already being carried out, or seriously contemplated, on a scale of almost startling, but not unnecessary, magnitude.

It is plain, that in every department of civil engineering the wants of commerce and society are pressing more and more urgently upon the resources of our profession. We have ship canals, but the Suez Canal throws them all into the shade. We have long tunnels through our English mountains, but we have now to penetrate the Alps. We have large bridges, but larger are required. We have noble ports, but they are choked with trade, and new accommodation of an improved kind is called for. We have steam ferries across rivers, estuaries, and straits, and rapid ocean steamers, but higher speed and better accommodation are demanded. We have large warehouses with convenient mechanical appliances, but larger warehouses and better mechanical appliances have become a necessity. We have many thousands of miles of telegraphic communication, but nothing short of its universal extension will suffice.

In the solution of these problems, thus rapidly indicated, and in others which could be easily adduced, we may rest perfectly satisfied that the difficulties they present are not to be overcome by a stroke of genius or by a sudden happy thought, but they must be worked out patiently by the combination of true engineering principles, ripe experience, and sound judgment.

Having thus called your attention to the peculiar position of our profession in consequence of its rapid growth, and pointed out some of the problems which await an early solution, I shall now attempt to describe the nature of the functions of the modern CIVIL ENGINEER; and consider how the coming generation can be best prepared for its inevitable work.

Although we know from history that men have existed from the earliest times who have been distinguished by great mechanical capacity, remarkable skill in working materials, profound science, and constructive knowledge, yet it is only during the present century that civil engineering can be considered to have become a distinct and recognised profession. Now, however, it has assumed the position of an *art* of the highest order. Perhaps we may without arrogance be entitled to claim for it the title of a true *science*.

Many attempts have been made to define and describe a civil engineer in a few general words, but all such attempts have been more or less unsatisfactory. Still, though it is difficult, if not impossible, to describe an engineer by a short definition, it is not so difficult to enumerate and describe the nature of the works he is required to design and execute, and the professional duties he is called upon to perform.

He has to design and prepare drawings, specifications, and estimates, and to superintend the carrying out of works which may be thus enumerated:—

1. Railways, roads, canals, rivers, and all modes of inland communication.
2. Water supply, gas works, sewerage, and all other works relating to the health and convenience of towns and cities.
3. The reclamation, drainage, and irrigation of large tracts of country.
4. Harbours of refuge and of commerce, docks, piers, and other branches of hydraulic engineering.
5. Works connected with large mines, quarries, ironworks, and other branches of mineral engineering.
6. Works on a large scale connected with steam-engines, with machinery, ship-building, and mechanical engineering.

This list, which might be almost indefinitely extended, involves a vast variety of work, and must appear almost appalling to a young engineer. Yet it greatly concerns his future success that he should as far as possible be prepared to undertake any or all of the works embraced in the list.

I believe the personal history of most of us would show that circumstances have led us in a widely different direction, in the exercise of our profession, from that which we originally contemplated, and that the success of many men may be distinctly traced to their ability to avail themselves of unforeseen opportunities to advance in some new direction.

The civil engineer must therefore be prepared for the various classes of constructive works thus enumerated; but in addition to this professional preparation, it is of the first importance, as affecting his true position, and the confidence which ought to be reposed in him, that he should also have a correct appreciation of the objects of each work contemplated, as well as their true value, so that sound advice may be given as to the best means of attaining them; and he must be prepared, if necessary, to advise his employers that the objects which are sought are not commercially worth the cost of the means which would secure them. It is not the business of an engineer to build a fine bridge, or to construct a magnificent engineering work, for the purpose of displaying his professional attainments, but, whatever the temptation may be, his duty is to accomplish the end and aim of his employers by such works and such means as are, on the whole, the best and most economically adapted for the purpose.

The first question which will present itself to an engineer with respect to any proposed work, will be the selection of his material; and as this question is so vital to the accomplishment of a satisfactory result, I propose to treat it in a preliminary and special manner. I wish to impress upon every young engineer a due sense of its importance, because probably a greater number of mistakes have been made by the use of a wrong material, than from any other cause.

In the case of stone work, it is essential that the mode of construction shall have reference to the character of the stone; and this requires much of the knowledge of the geologist, the stonemason, and the quarryman, so that the engineer may know how best to work and set the stone, and what are the peculiarities of the quarry as to its sound or unsound beds; and, in addition, he should have sufficient chemical knowledge to detect any unfitness in the conditions of use to which he proposes to subject the stone.

Let us always bear in mind, in connection with this subject, the example of Sir Christopher Wren, engineer as well as architect, who himself selected the quarries, and sometimes even the blocks of which his structures were composed.

Of bricks I must be content with saying, that the power of detecting the good from the bad, the suitable from the unsuitable, must be acquired by the combined assistance of reading, experiment, and practice.

A knowledge of lime, and the art of making the best practicable mortar from each description of building lime, is almost of equal importance to that required for selecting the stone, brick, and building materials themselves, but it is somewhat remarkable, that the art of preparing mortar in a proper manner is not so general as it deserves to be; and to secure good mortar is a matter of continual anxiety to the engineer.

Mortar for engineering works is ordinarily made from cement (chiefly Portland cement); or from hydraulic lime, such as lias; or from ordinary lime, such as grey or chalk lime.

Cement is chiefly used in combination with sand in various proportions, according to the nature of the work to be executed, and it is not only necessary to possess the requisite knowledge and experience for determining the proper proportions of cement and sand for each individual case, but it is desirable to have the means of determining by direct and repeated experiment the strength and quality of the cement which it is intended to use.

In the case of hydraulic lime, such as lias, the same general knowledge of the proper proportion of sand to be used is also requisite, but, from the great variation in the character of lias lime, and the different proportions of silica and alumina in combination with the lime itself, it is essential to obtain a careful chemical analysis, in order to avoid the great disappointment and bad consequences which may result from ignorance of the various qualities.

Of ordinary limes, it is only necessary here to say that they are of almost infinite variety as to quality and constituent parts, and must each be dealt with accordingly, and the engineer can scarcely take too much trouble to inform himself of the exact nature of each lime he has to use, and the best mode of using it.

Modern science, and the convenient manner in which steam-power can now be applied, have given to the modern engineer the means of obtaining better mortar from the same materials than was possible before the general introduction of steam.

The heavy rollers and iron pan worked by steam-power are now almost universally used for grinding and mixing lime and sand for works of magnitude: they produce, with properly proportioned ingredients, a mortar so good in quality, and so equal in the time and power of setting, that the engineer can calculate with certainty upon the conditions under which his designs will be carried out: and when he has become thoroughly acquainted with the quality and power of good mortar, and acquired confidence in its use, he will feel himself justified in its adoption in cases where our predecessors, and even some modern engineers, would have hardly ventured to employ it in the place of the more costly Portland cement.

When iron is intended to be used in structures, it is essential to know under what circumstances cast iron is best for the purpose, or when wrought iron should be employed, and also when steel must be resorted to. The profession has probably been assisted to a greater extent by the experiments and writing of its members, and of distinguished men of science, in the material of iron, than on any other subject; but these valuable investigations and experiments must be supplemented by the practical knowledge which can only be acquired by attentively studying the peculiarities of material and manufacture.

Cast iron or pig iron re-melted and run into moulds is largely used by engineers for columns and other parts requiring great power of resisting compressive strains; and, as its price per ton is generally about one-half of that of wrought iron, it becomes a matter of economic importance to adopt it in all cases where it can be safely and properly used, but it is of the most varied quality and strength, and the greatest attention of the engineer is required to secure the proper kind.

Wrought iron is perhaps less varied in its quality than cast iron, and for many purposes of engineering it is the safer metal to adopt, from its greater power of resisting tensile strains, and less liability to sudden fractures; but it must be remembered that wrought iron is sometimes pure and of high quality, sometimes very impure and of the commonest quality, and even with the same degree of purity it may be soft and fibrous, or hard and crystalline; therefore it is obvious that the young engineer should acquire a sound knowledge of its nature both chemically and practically, so as to enable him to obtain the quality he desires, and to know when he has secured it.

It would be easy to enlarge upon this interesting question of wrought iron, but it may suffice to instance armour-plates and rails, as cases where the best quality is required, but the quality, though best, must be different in kind; for armour-plates the iron can scarcely be too soft and fibrous, whilst for rails it can scarcely be too hard and crystalline, provided it is not so brittle as to be liable to fracture by use. Again, in some iron, such as the "best Yorkshire," the quality appears to improve with every additional operation in the manufacture, whilst the ordinary Welsh iron is almost destroyed by repeated manipulation. All these, and many other matters connected with iron, should therefore be known thoroughly and practically to the engineer.

In order to illustrate the necessity of the systematic study of the peculiarities of the metals called iron and steel, let me refer to the experiments of Mr. Eaton Hodgkinson, which first demonstrated that the average resistance of cast iron to crushing was more than six times its tenacity, whilst the resistance of wrought iron to crushing was only four-fifths of its tenacity, and it will be remembered that the mathematical investigations he founded upon these experiments first established, on a satisfactory and reliable basis, the degree and ratio of tensile and crushing force in cast and wrought iron.

With respect to steel, it must be admitted, that before we can safely adopt it to any considerable extent for purposes of construction, it will be necessary to have a similar series of experiments and investigations specially made, but so promising a metal will amply repay all the trouble that may be bestowed upon it.

Of timber a thorough knowledge should be acquired, as no material is otherwise more likely to deceive and to disappoint the engineer. Not only is great difference found in trees of the same general description, such as the numerous varieties of the pine, but the same kind of pine is a different quality of wood in different countries, and even in different soils and climate in the same country; and again the same tree is entirely changed by being "bled," or having its sap withdrawn. The oaks of America, England, and the Continent, are entirely different in their character, and oaks also differ in quality from each other in the same country, and so with numerous other woods used by the engineer. The strength, durability, and peculiarity of different kinds of timber, and the true value of artificially preserving them, should also be known and understood.

I have selected these examples for the purpose of illustrating this important fact, that before an engineer can even commence the designs of his works he must have previously obtained a large amount of preliminary information regarding the nature of all the materials employed upon engineering works, so as to enable him to select for his intended structures those materials which will be on the whole most suitable, having reference to efficiency, durability, and economy.

I will now proceed to the question of the kind and degree of knowledge which is required to enable a young engineer to proceed to the actual design of a public work of importance, such as a railway with its stone, brick, and iron structures, its earthworks, and its all-important permanent way, a railway station, a station roof, docks and their appliances, waterworks, breakwaters, or a Great Eastern steam-ship.

Although it has become the practice in modern times for many civil engineers to be employed chiefly, or almost entirely, in some one branch of the profession, I desire to repeat my conviction that it is most important that the early preparation and subsequent study should be as extensive as possible, and should embrace every branch of professional practice, not only for the purpose of securing to a young engineer more numerous opportunities for his advancement, but also because sound knowledge and experience in all branches of engineering will greatly add to his efficiency and value in any special branch, in the same manner that a medical man will be more reliable in his practice on the eye and ear if he possesses a sound practical and theoretical knowledge of every part of the human frame.

The professional knowledge required by the *railway engineer* commences with surveying of all kinds, the use of the theodolite, the aneroid barometer, the level, the sextant, &c., and includes the surveys for preliminary and parliamentary purposes; and also working surveys of minute accuracy, on a large scale, from which engineering works may be set out with precision upon the ground.

The railway engineer must understand thoroughly the nature of earthworks of every kind, and the proper angles or slopes to be adopted for cuttings and embankments.

He must have the qualifications requisite to enable him to design bridges, viaducts, tunnels, and all other incidental works and buildings in the best and most economical manner.

He must have a knowledge of the training of rivers, and of the effect of floods and drainage, in order that he may make accurate provision for the due discharge of water without wasting money on works unnecessarily large, or to avoid the risk of damage arising from making them insufficient.

He must be familiar with the various characters of permanent way, the best description of rail, sleeper, fastenings, and ballast, and with the different descriptions of switches, crossings, turntables, signals, and telegraphs.

The railway engineer should not be destitute of some knowledge of architecture, and such a taste for those graceful outlines and simple appropriate details which should always characterize the works of an engineer, so as to be able to avoid, on the one hand, the unnatural ornamentation which seems to have no connexion with the structure, and, on the other hand, a disregard of either form, outline, or proportion.

But all such knowledge may fail if there be not a constant supervision and control over the quality of all the materials and workmanship employed upon the railway. And it is not too much to say that without the practical knowledge which is obtainable only by the actual performance of the duties of resident engineer, it is hopeless to expect that any engineer can be competent to undertake the responsibility of important works, or be fit to have large sums of money entrusted to him for expenditure. It is in the capacity of resident engineer that all previous preparation, both scholastic and professional, and all theoretical acquirements, become utilized and rendered of practical value, and it is only after much experience on different works of varied character, dimensions, and materials, and the acquisition of the power of discriminating between good and bad materials and workmanship, that a young student of engineering can claim to take rank as a "Civil Engineer."

The *waterworks and drainage engineer* must possess many of the qualifications of the railway and dock engineer, and especially those which concern earthwork and masonry; he must also be familiar with the means of obtaining information on the subject of rainfall in different localities, the methods of correctly gauging streams of every kind; the proportions of the rainfall available for his purposes, after estimating for evaporation and waste, and the extent of the provision to be made for periods of dry weather, or for compensation to mill-owners and other interested parties.

He must be conversant with the proper mode of executing the works of reservoirs, conduits, weirs, tunnels, and aqueducts.

He must understand, by the aid of the chemist and his own experience, the nature of the impurities in water, and the best mode of diminishing them, whether mechanically, by subsidence and filtration, or otherwise.

To the waterworks engineer we must look for the solution of one of the great problems which the rapid increase of population is now forcing upon us, viz., a comprehensive system of conservancy of the flood waters of mountainous localities for the use of large cities and towns and densely populated districts. We are completely outgrowing our present arrangements for water supply in the great majority of instances; and the convenience, comfort, and health of the public demand that such works when required shall be no longer postponed.

The waterworks engineer must also be competent to design and superintend works of sewerage, as well as of water supply, for large and small towns and localities; and his familiarity with waterworks will naturally aid him in this, as the problems for the discharge and pressure of fluids are identical in both cases.

It is no longer a matter of doubt that deodorisation or purification is quite practicable in every locality, and therefore no sewage should ever be permitted to be discharged into existing streams without this purification, or it should be carried out to the sea, and there discharged, as is now proposed for the north side of London.

The *mechanical engineer* deals with the most varied and numerous subjects of all the branches of engineering. They require that he should thoroughly understand the means of producing mechanical power, and of applying it to all the infinite variety of purposes for which it is now demanded. To this end he should be master of the laws of motion and rest, of power and speed, of heat and cold, of liquids and gases.

He must be familiar with the strength of materials under every variety of strain, the proper proportions of parts, and the friction of surfaces.

He must apply existing tools, and contrive new ones, for his work, and know how to direct power in the raising of weights, or for driving all fixed machinery, or in producing locomotion on land or water.

On railways he is responsible for the vast number of objects required in the machinery for erecting and repairing shops for the engines and carriages, for the pumping and other fixed engines, and especially for the locomotive engine itself, and for rolling and fixed plant generally.

In connection with docks he is required to design the machinery for opening and closing the dock gates, working sluices, emptying graving docks, or for working the cranes on the quays, or in the sheds and warehouses.

The mechanical engineer generally also executes the designs of the gas engineer, even when he does not originate the work which is entrusted to him; and in this branch considerable chemical knowledge must be added to his mechanical qualifications.

For waterworks he designs and executes pumping engines, sluices, valves, stopcocks.

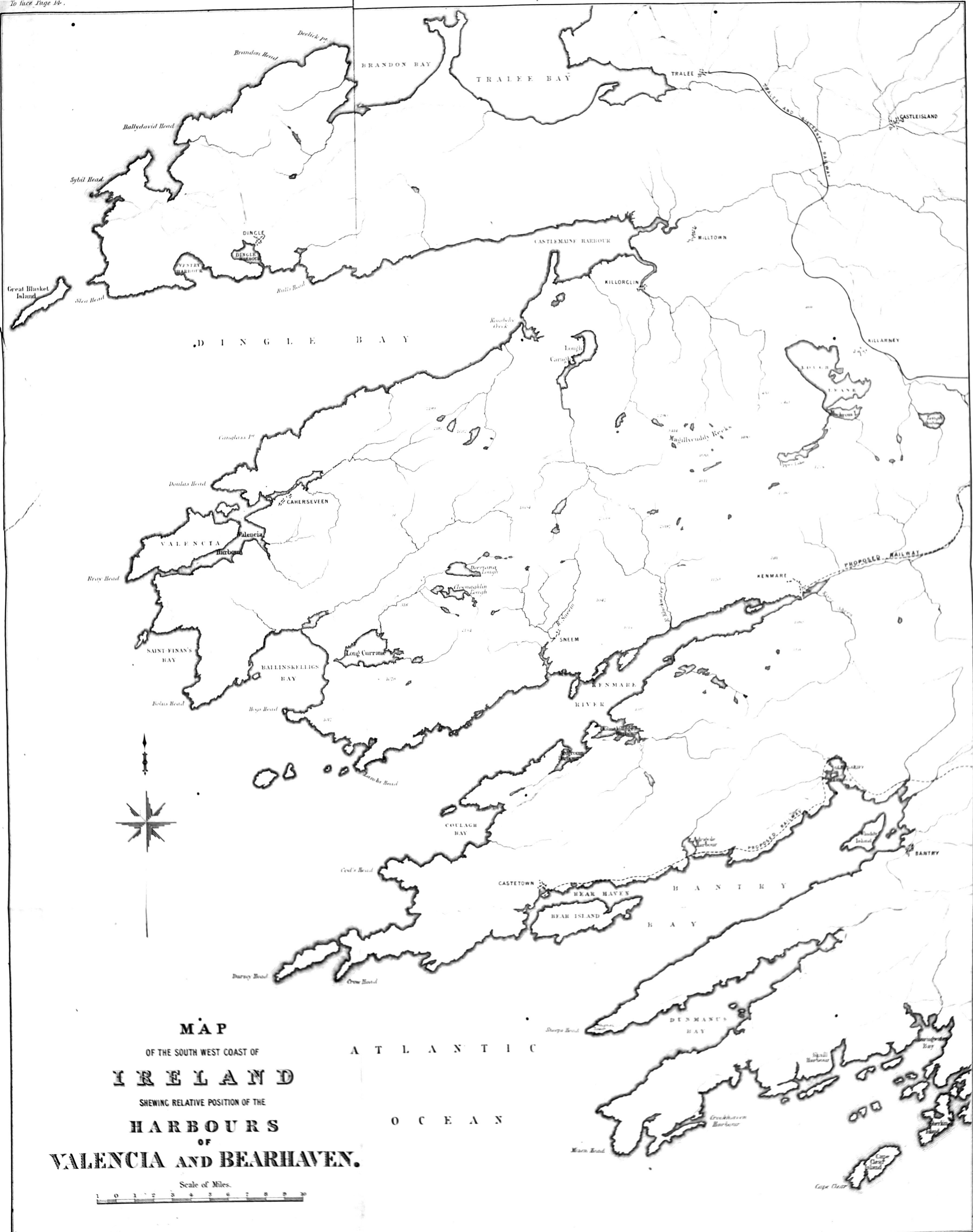
In the case of mines he supplies designs of the engines for pumping, drawing, winding, or ventilating; for locomotives above and below ground, as well as for the various mechanical appliances required in collieries, mines, and ironworks.

The *mining engineer* must possess much of the knowledge of the railway and the mechanical engineer, and he must add to that general knowledge much special knowledge of his own. He must know how to sink shafts to the minerals if they require to be extracted from beneath the surface (which is usually the case), and how to divert or pump out the water he meets with, either in the shafts or the workings.

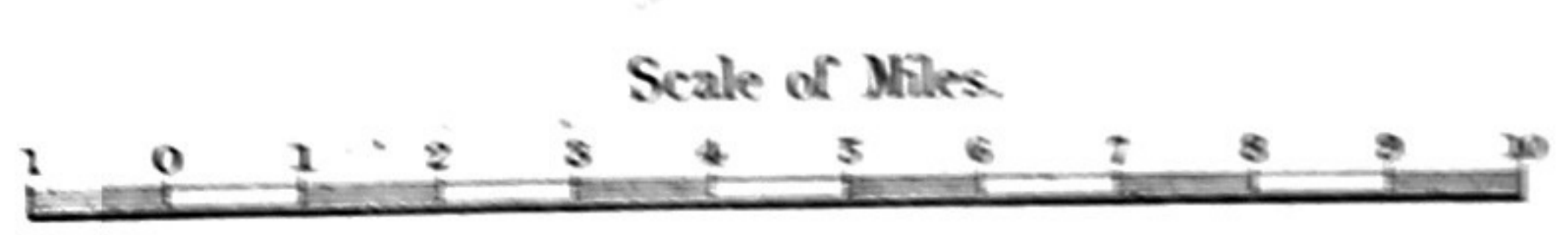
He must know how to excavate and bring to the surface minerals, whether they be coal, copper, tin, lead, or iron, and to do this he must construct subterranean railways, provide means of ventilation by fans or furnaces, supply power to lift the extracted mineral to the surface; and when brought there, he must understand the further requisite work, as the coal will probably require screening, or washing, or manufacturing into coke, and the ore will require crushing, washing, or smelting, or possibly all three operations.

In all these cases, and many others, such as the collection of surface ironstone and other minerals, by railways and locomotive engines, and the working of lifts and inclined planes, the mining engineer has most important functions to perform, and has special machinery to adapt or invent; and, relying on his judgment and skill alone, the investment of large sums of money for the development of the mineral wealth of this country is annually made.





**MAP**  
 OF THE SOUTH WEST COAST OF  
**IRELAND**  
 SHEWING RELATIVE POSITION OF THE  
**HARBOURS**  
 OF  
**VALENCIA AND BEARHAVEN.**



QUESTIONS ON SURVEYING.

December 1867.—Morning Paper.

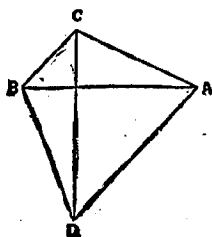
Examiner—Captain G. NEWMARCH, R. E.

*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; their doing so will disqualify them. Questions remaining unanswered at the close of the sitting cannot be taken up again afterwards.

1. Describe the course of instruction in surveying you have undergone. What surveys 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. Describe briefly the method of conducting a trigonometrical survey, and the principal points to be attended to, in the order of their importance, to ensure a correct result.
3. Explain what is meant by a "base of verification." Give a brief account of the method of measuring a base line with which you are best acquainted.
4. Illustrate by a diagram and work out the formula for reducing a base measured on an elevated plan to its true value at the level of the sea.
5. Describe the chains used in surveying, why they are of the prescribed lengths, and how the exact standard length is ensured where great accuracy is required.
6. In chaining a line you come across a wide stream; how would you continue the measurement, and determine the breadth of the stream, and the position of a shoal or fixed point in mid-stream?
7. What element of error renders heights obtained by means of vertical angles extremely uncertain?
8. In observing vertical angles, why should the telescope be reversed in its Y's in making the second observation?
9. How would you ascertain the variation of the compass with only a pocket compass, the latitude being known? 2nd, in any other way you are acquainted with.
10. How are the cross hairs in a theodolite fixed, and how would you replace them if broken?
11. How is the theodolite superior to the sextant in measuring the angle between two places of different elevation?
12. Explain the method of finding your place in a survey by "interpolation," the principal stations being fixed: 1st, by taking the magnetic bearings of two fixed points; 2nd, by observing the angles formed between three fixed points, all on the same side of the observer.
13. Give a form of field book for entering the measurements of a base line, and the angles to the principal stations.

16 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

14. In the fig.  $ABCD$  the base  $AB$  is measured and found to be 5365.001 feet; the following angles are also measured:



At A,  $\angle BAC = 30^\circ 47'$       At B,  $\angle CBA = 45^\circ 14' 50''$   
 $\angle CAD = 104^\circ 56' 40''$        $\angle CBD = 98^\circ 58'$   
 At C,  $\angle BCD = 59^\circ 12' 44''$       At D,  $\angle BDC = 21^\circ 49' 16''$   
 $\angle ACD = 44^\circ 45' 26''$        $\angle CDA = 30^\circ 17' 54''$

From these data find the lengths of  $CD$ ,  $AD$ ,  $BD$ ,  $AC$ ,  $BC$ , in feet, and draw the figure correctly to the scale of 6 inches to a mile.

EXAMINATION IN SURVEYING.

Afternoon Paper.—December 1867.

*Note.*—Write your name at the top of the accompanying plan, and of each of the papers you hand in in reply to the following questions. Candidates must not communicate with or assist each other. Work on this paper must close at the termination of the sitting.

1. Consider the accompanying map as a tract of country of which you are required to make a trigonometrical survey on a scale of six inches to the mile. Show how you would proceed, and state what instruments you would use in the different portions of the work.

The plan may be drawn over in any way you think proper in illustration of your procedure, the proposed base line being represented by a thick red line and the triangulation by thin red lines.

2. Enlarge the plan on a separate piece of paper to the scale of four inches to the mile, or as much of it as will come on your paper, measuring from the lower right-hand corner of the map both ways; and show the roads, buildings, and features of the country. (Great accuracy in filling in the details is not expected, as the time is limited.)

3. Draw the scale at the foot on the diagonal principle, showing tens, fifties, hundreds, and thousands of yards.

4. Shade-in the hills on the enlarged plan with Indian ink, on the horizontal system, as accurately and neatly as the limited time at your disposal will admit of. (You should aim rather at giving a good general idea of the country, than at following exactly each undulation of the ground.)

5. Colour-in the roads, streams, buildings, and sea, on the enlarged plan.

6. Compile from the enlarged plan a field-book of a supposed transverse survey with compass and chain of the road from Emlaghmore Bridge round by the National School, and back by Emlaghmore House to the place of starting. Take the measurements and angles from the plan.

7. Calculate the area of the land enclosed by these roads.

*Note.*—On the completion of answers to the above questions, the remainder of the afternoon sitting will be devoted to the *viva voce* examination of the candidates in the practical use and adjustment of instruments.

QUESTIONS ON LEVELLING AND PRACTICAL SURVEYING.

December 1867.—Morning Paper.

*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 communicate with nor assist each other. Questions remaining unanswered at the close of the sitting cannot be taken up again afterwards.

1. State the different instruments used in levelling, and the class of operations to which each method of levelling is suitable.

2. What

2. What is the advantage of setting up a level at equal distances from the forward and back staves ?

3. Describe the operation of running contour lines, and state the objects for which a contoured survey is required.

4. In taking a round of vertical angles, why is it desirable to level the telescope by the attached level, and read the index error before taking each angle ?

5. Explain the manner of making trial sections for a proposed line of road. What do you consider the maximum gradient for a cart-road and for a mule-road ?

6. State how you would survey a river above and below a proposed crossing, and calculate the water-way required.

7. Give the form of field-book you have been accustomed to use when levelling, and fill it in with a few imaginary readings briefly explaining the operation.

8. Assuming the mean diameter of the earth to be 7,916 miles, show that the effect of curvature at 1 mile distance is 8·004 inches, or nearly the square of the distance in chains divided by 800.

9. Describe the mode of making a special survey for the exact measurement of areas, and give a description of the computing scale for ascertaining mechanically the contents of enclosures.

10. Explain the different methods of laying down a railway curve on the ground, 1st, by measurements and offsets; 2nd, by angles taken simultaneously from two theodolites placed at the opposite ends of the curve.

11. Let P be the centre of a station, S a satellite station at 20 feet distance, from which the angles P S A, P S B are observed, and found to be P S A = 80°, and P S B = 210°. Given also P A = 2,500 feet, and P B = 3,000 feet. Find the value of the angle A P B.

12. Explain how you would obtain a rough section of a piece of undulating ground without a levelling instrument.

13. Show how the latitude of a place is found by a meridian altitude of the sun, and find it in the following case:—The meridian altitude of sun's lower limb was 43° 18', the observer being north of the sun; assume the sun's semi-diameter at 16', refraction at 1', and the sun's declination at 22° 26' N.

14. Describe the mountain barometer and its application, and give a formula for ascertaining heights by the barometer, applying it in the following case:—At the summit of Snowdon the barometer read 26·409, the detached thermometer 46°, the attached thermometer 50°. On Carnarvon quay the readings were 30·091, 60°, and 60°, respectively. Find the difference in height between the two stations.

## EXAMINATION IN PLOTTING AND PLAN DRAWING.

December 1867.—Afternoon Paper.

*Note.*—Write your name at the top of every paper you hand in. Candidates must not communicate with or assist each other. Work on this paper must close at the termination of the sitting.

1. Plot a section from the accompanying Field Book of Levels. The horizontal scale of the section to be 400 feet to the inch; the vertical scale to be 40 feet to the inch. Fill up columns of rise, fall, and reduced level, the datum being assumed at the sea level.

*Field Book of Levels.*

No. of Station.	Distances in Feet.	Back Sight.	Fore Sight.	Rise.	Fall.	Reduced Level.	Remarks.
Commenced at bench-mark, 171.61 above sea level.							
1	197	3.92	6.19				
2	217	.17	10.90				
3	276	2.51	7.91				
4	347	2.74	11.16				
5	396	.20	7.76				
6	427	.80	7.24				
7	524	3.74	4.18				
8	527	3.22	5.45				
9	326	3.95	10.48				
10	238	4.07	2.06				
11	250	5.55	3.45				
12	414	5.30	2.21				
13	401	10.25	3.77				
14	164	7.08	2.03				
15	233	3.26	7.80				
16	227	2.68	3.55				
17	154	9.02	2.68				
18	257	7.09	1.11				
19	300	10.83	1.18				
20	297	9.69	.74				
21	392	9.25	3.62				

2. On this section plot in a proposed line of road, no slope to exceed 1 in 40; cuttings and embankments to balance each other as nearly as possible, the cross section being assumed horizontal throughout; road 30 feet wide.

3. Draw a plan, front elevation, and cross section of an Inspection Bungalow, containing two main rooms, each about 22 feet by 18 feet, with dressing rooms attached, about 11 feet wide, and a bath room not less than 10 feet square. The building to be completed by an arcaded verandah, nowhere less than 8 feet wide; the plinth to be  $2\frac{1}{2}$  feet high, and the main rooms not less than 20 feet to the underside of beam. All other details at your discretion. Scale for plan and section, 8 feet to the inch.

4. Draw the same building in isometrical perspective.

*Note.*—On the completion of answers to the above questions, the remainder of the afternoon sitting will be devoted to the *vivâ voce* 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.

EAST INDIA  
(ENGINEERS' ESTABLISHMENT, &c.)

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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. 25, of Session 1867-8).

(*Mr. Adam.*)

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*Ordered, by The House of Commons, to be Printed,*  
*28 April 1868.*

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[*Price 2 s.*]

EAST INDIA (ENGINEERS' ESTABLISHMENT).

RETURN to an Address of the Honourable The House of Commons,  
dated 30 July 1869;—*for*,

“ RETURNS of the Names of the 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, and their Places of Education :”

“ And, of the MARKS which were assigned on each Subject to every Candidate (in continuation of Parliamentary Paper, No. 234, of Session 1867-8).”

India Office, }  
August 1869. }

W. T. THORNTON,  
Secretary, Public Works Department.

(*Mr. Adam.*)

Ordered, by The House of Commons, to be Printed,  
7 August 1869.

## CIVIL ENGINEER EXAMINATION.—JULY 11

## NAMES OF EXAMINERS.

Rev. Jonathan Cape, A. M., F. R. S.

Colonel H. Yule, R. E.

George Preston White, Esq., C. E.

## SUCCESSFUL CANDIDATES in Order of Merit.

No.	NAME.	AGE.	Engineer to whom Articled, or under whom Served.	Place of Education.
1	J. C. Pottinger - -	21	Royal Engineers, Chatham; C. P. B. Shelley, C. E., Westminster.	Royal Military Academy, Woolwich.
2	D. G. Ottley - -	22	Midland Railway Locomotive Works; C. P. B. Shelley, C. E., Westminster.	Not stated.
3	E. J. Moore - -	20	J. W. Wilson, C. E., London; C. P. B. Shelley, C. E., Westminster.	Brighton College; King's College, London.
4	F. E. Robertson - -	21	E. Wragge, C. E., Westminster - - - -	London University; Stroud School of Art.
5	R. N. Unkles - -	22	P. R. Roddy, C. E., Cork; W. B. Taylor, C. E., Barmouth.	Queen's College, Cork.
6	W. Lynam - -	21	J. Lynam, C. E., Ballinasloe - - - -	Queen's College, Galway.
7	W. H. Nightingale - -	19	S. U. Roberts, C. E., Galway - - - -	Queen's College, Galway.
8	H. Groves - -	19	J. Fogerty, C. E., Westminster; J. F. Blair, C. E., Glasgow.	Not stated.
9	G. H. Bayly - -	22	Messrs. Cotton & Flemyng, C. E., Dublin; J. L. Worrall, C. E., Tipperary.	Trinity College, Dublin.
10	J. Barron - -	23	A. J. Adie, C. E., Edinburgh; Messrs. E. & E. Sang, C. E., Edinburgh.	Not stated.
11	J. T. Brown - -	21	H. H. Fulton, C. E., Westminster - - - -	University College, London.
12	A. R. Becher - -	21	J. W. Wilson, C. E., London - - - -	Not stated.
13	H. Richard - -	23	J. M'Landsborough, C. E., Bradford - - - -	Queen's College, Dublin.
14	J. R. Hatherly - -	22	R. M. Ordish, C. E., Westminster; C. P. B. Shelley, C. E., Westminster.	Not stated.
15	G. J. Turner - -	20	J. Willet, C. E., Aberdeen - - - -	Gymnasium, Old Aberdeen.
16	C. T. Burke - -	22	J. Benson, C. E., Cork - - - -	Queen's College, Cork.
17	J. D. Grant - -	19	T. O. Donaldson, M. E., Newcastle - - - -	Dollar Institution.
18	A. Davidson - -	22	R. P. Brereton, C. E., Westminster - - - -	Ecole Speciale de Lausanne.
19	W. C. Hughes - -	17	J. Hughes, C. E., Westminster - - - -	King's College, London.
20	E. K. Reinold - -	23	M. Samuelson, M. E., Hull - - - -	Not stated.
21	W. Hughes - -	20	S. U. Roberts, C. E., Galway - - - -	Queen's College, Galway.
22	J. L. Tickell* - -	22	Sir C. Fox & Sons, C. E., Westminster - - - -	Not stated.

\* Mr. Tickell did not accept his appointment.

## NUMBER OF MARKS which were assigned on each Subject.

No.	Number of Marks allotted in			TOTAL.	No.	Number of Marks allotted in			TOTAL.
	Mathematics.	Civil Engineering.	Surveying.			Mathematics.	Civil Engineering.	Surveying.	
1	400	265	162	827	12	288	275	100	663
2	319	315	153	787	13	233	310	115	658
3	345	310	125	780	14	222	280	138	640
4	270	315	161	746	15	206	290	108	604
5	280	263	158	701	16	223	280	100	603
6	262	270	162	694	17	206	285	111	602
7	276	295	122	693	18	230	270	101	601
8	230	295	156	681	19	327	300	86	713
9	284	280	115	679	20	264	300	88	652
10	244	295	134	673	21	286	265	95	646
11	242	310	115	667	22	240	315	78	633

Note.—The Number of Marks obtained by Unsuccessful Candidates was not reported by the Examiners on this occasion.



## CIVIL ENGINEER EXAMINATION.—DECEMBER 1868.

## NAMES OF EXAMINERS.

Rev. Alfred Wrigley, M. A.

Major George Chesney, R. E.

George Preston White, Esq., C. E.

## SUCCESSFUL CANDIDATES in Order of Merit.

No.	NAME.	AGE.	Engineer to whom Articled, or under whom Served.	Place of Education.
1	G. J. Perram - -	21	W. H. Barlow, c. E., Westminster - - -	King's College, London.
2	J. E. Gore - -	23	Midland Great Western Railway of Ireland	Trinity College, Dublin.
3	H. G. McKinney -	22	S. U. Roberts, c. E., Galway - - -	Queen's College, Belfast; Queen's College, Galway.
4	G. J. Burke - -	23	J. P. Romaine, c. E., Cork - - -	Queen's College, Cork.
5	J. S. Carey - -	22	J. F. Blair, c. E., Westminster - - -	College, Cheltenham.
	H. D. Pearsall - -	23	Messrs. Simpson & Co., London - - -	Not stated.
7	J. L. Tickell - -	23	Sir C. Fox & Sons, c. E., London - - -	Not stated.
8	T. L. Tanner - -	23	T. O. Donaldson, c. E., Newcastle; J. T. Naylor, c. E., Newcastle.	King's College, London.
9	F. R. Upcott - -	21	J. M. Martin, c. E., Exeter - - -	King's College, London.
10	J. H. Apjohn - -	23	Great Southern and Western Railway of Ireland	Trinity College, Dublin.
11	W. H. King - -	21	W. Humber, c. E., Westminster; London, Brighton, and South Coast Railway.	Not stated.
12	W. Harvey - -	22	T. M. Johnson, c. E., Westminster; C. P. B. Shelley, c. E., Westminster.	King's College, London.
13	W. Connan - -	21	W. Smith, c. E., Aberdeen - - -	Not stated.
	R. T. Smith - -	22	E. Wilson, c. E., Westminster - - -	Not stated.
	J. Young - -	23	D. H. Halkett, c. E., Alyth, N. B. - - -	Glasgow University.
16	J. G. Single - -	22	W. Watson, c. E., New Zealand - - -	Not stated.
17	G. White - -	23	J. Price, c. E., Midland Great Western Railway of Ireland.	Trinity College, Dublin.
18	P. T. S. Large - -	20	O. C. Edwards, c. E., Cork - - -	Queen's College, Cork.
19	J. C. Larminie - -	22	J. Price, c. E., Midland Great Western Railway of Ireland.	Kingstown School; Trinity College, Dublin.
20	M. Potter - -	23	G. Russell, c. E., Auckland; T. M. Gregan, c. E., Limerick.	Queen's College, Galway.

CIVIL ENGINEER EXAMINATION.—December 1868—*continued.*

NUMBER of MARKS which were assigned on each Subject. c

No.	Number of Marks allotted in			TOTAL.	No.	Number of Marks allotted in		
	Mathematics.	Civil Engineering.	Surveying.			Mathematics.	Civil Engineering.	Surveying.
1	331	305	147	783	23	143	266	106
2	279	312	152	743	24	250	305	57
3	327	276	134	737	25	169	292	145
4	285	296	150	731	26	180	302	122
5	279	302	144	725	27	191	261	147
6	272	306	147	725	28	208	298	85
7	246	307	171	724	29	160	278	135
8	270	304	144	718	30	143	315	92
9	260	280	176	716	31	160	293	93
10	291	314	100	705	32	222	200	120
11	260	294	148	702	33	101	316	110
12	209	324	138	671	34	152	288	59
13	218	318	134	670	35	129	269	100
14	204	320	146	670	36	170	249	70
15	271	295	104	670	37	99	299	84
16	200	303	143	651	38	119	254	65
17	237	301	110	648	39	154	205	76
18	208	308	130	646	40	20	310	53
19	205	305	133	643	41	111	209	42
20	230	268	119	617	42	74	258	27
21	316	270	49	635	43	69	230	30
22	183	291	154	628				

## CIVIL ENGINEER EXAMINATION.—JULY 1869.

## NAMES OF EXAMINERS.

Rev. Alfred Wrigley, M.A.

Lieutenant J. R. Westmorland, R.E.

George Preston White, Esq., C.E.

## SUCCESSFUL CANDIDATES in Order of Merit.

No.	NAME.	AGE.	Engineer to whom Articled, or under whom Served.	Place of Educ.
1	F. L. Brown - - -	23	F. Fox, c. e., Bristol; C. P. B. Shelley, c. e., Westminster.	King's College, I
2	L. Heath - - -	21	G. Berkley, c. e., Westminster - - - -	King's College, I
3	R. B. Buckley - - -	21	I. D'A. Samuda, m. e., Poplar; Armstrong, Kershaw, & Marshall, c. e., London.	Not stated.
4	P. D. Alexander - - -	21	McTaggart Covan, c. e., Glasgow - - - -	Dollar Institution
5	D. McMordie - - -	23	H. Smyth, c. e., Downpatrick - - - -	Queen's College,
6	A. B. Phelan - - -	21	J. L. Worrall, c. e., Tipperary - - - -	Trinity College,
7	W. Atkins - - -	22	J. Price, c. e., Midland Great Western Railway of Ireland.	Trinity College,
8	J. H. Thornhill - - -	19	Sir J. Benson, c. e., Cork - - - -	Queen's College,
9	C. G. Warren - - -	23	B. Latham, c. e., Westminster - - - -	Not stated.
10	W. G. Bligh - - -	23	R. J. Hood, c. e., Westminster; W. H. Dorman, c. e., Westminster.	Not stated.

CIVIL ENGINEER EXAMINATION.—July 1869—*continued.*

Successful Candidates in Order of Merit—*continued.*

No.	NAME.	AGE.	Engineer to whom Articled, or under whom Served.	Place of Education.
11	W. H. Wells - -	21	J. W. Ward, c. E., Westminster - - -	Eton College.
12	J. O. Lawder - -	21	J. Barton, c. E., Dundalk - - - - -	Not stated.
13	C. J. Lockwood - -	23	E. T. Bellhouse & Co., M. E., Manchester - -	Not stated.
14	C. Thomson - -	23	C. J. Mackintosh, c. E., Westminster - -	Not stated.
15	W. B. Christie - -	21	Forman & McCall, c. E., Glasgow - - -	Dollar Institution.
16	J. M. Campion - -	21	H. Bolden, c. E., Westminster; A. R. Binnie, c. E., Westminster; C. P. B. Shelley, c. E., Westminster.	Doveton College, Calcutta.
17	A. Morton - - -	22	Avonside Engine Company; G. L. Fuller, c. E., Westminster.	Not stated.
18	J. F. Birkenshaw -	21	M. Kirtley, Midland Railway, Derby - -	Not stated.
19	W. Good - - -	22	Sir J. Benson, c. E., Cork - - - - -	Queen's College, Cork.
20	T. J. P. Jeffery - -	21	Keyham Factory, Devonport; Her Majesty's Royal Navy.	Not stated.

NUMBER of MARKS which were assigned on each Subject.

No.	Number of Marks allotted in			TOTAL.	No.	Number of Marks allotted in			TOTAL.
	Mathematics.	Civil Engineering	Surveying.			Mathematics.	Civil Engineering.	Surveying.	
1	256	328	158	742	26	169	285	105	559
2	279	337	119	735	27	123	315	120	558
3	284	275	172	731	28	212	230	108	550
4	369	245	108	722	29	219	210	118	547
5	309	295	114	718	30	254	170	120	544
6	266	328	109	703	31	116	335	84	535
7	282	305	102	689	32	188	225	120	533
8	280	275	134	689	33	163	265	67	495
9	200	334	143	677	34	154	210	121	485
10	228	325	121	674	35	96	290	97	483
11	211	338	120	669	36	89	245	117	451
12	229	328	108	665	37	84	295	70	449
13	200	330	134	664	38	124	220	102	446
14	221	330	108	659	39	109	275	39	423
15	270	265	116	651	40	65	270	73	408
16	211	295	143	649	41	90	230	81	401
17	204	325	111	640	42	79	240	76	395
18	200	320	119	639	43	43	305	42	390
19	239	280	119	638	44	79	245	62	386
20	221	285	110	616	45	133	165	74	372
21	198	270	113	581	46	58	235	52	345
22	189	260	117	566	47	119	135	77	331
23	127	332	106	565	48	99	155	58	312
24	151	285	127	563	49	41	165	64	270
25	163	336	64	563	50	78	140	46	264

CIVIL ENGINEER EXAMINATION.—December 1868—*continued.*

## NUMBER of MARKS which were assigned on each Subject.

No.	Number of Marks allotted in			TOTAL.	No.	Number of Marks allotted in			TOTAL.
	Mathematics.	Civil Engineering.	Surveying.			Mathematics.	Civil Engineering.	Surveying.	
1	331	305	147	783	23	143	266	106	615
2	279	312	152	743	24	250	305	57	612
3	327	276	131	737	25	169	292	145	606
4	285	296	150	731	26	180	302	122	604
5	279	302	144	725	27	191	261	147	599
6	272	306	147	725	28	208	298	85	591
7	246	307	171	724	29	160	278	135	573
8	270	304	144	718	30	143	315	92	550
9	260	280	176	716	31	160	293	93	546
10	291	314	100	705	32	222	200	120	542
11	260	294	148	702	33	101	316	110	527
12	209	324	138	671	34	152	288	59	499
13	218	318	134	670	35	129	269	100	498
14	204	320	146	670	36	170	249	70	489
15	271	295	104	670	37	99	299	84	482
16	200	303	143	651	38	119	254	65	438
17	237	301	110	648	39	154	205	76	435
18	208	303	130	646	40	20	310	53	383
19	205	305	133	643	41	111	209	42	362
20	230	268	119	617	42	74	253	27	359
21	316	270	49	635	43	69	230	30	329
22	183	291	154	628					

## CIVIL ENGINEER EXAMINATION.—JULY 1869.

## NAMES OF EXAMINERS.

Rev. Alfred Wrigley, M.A.  
 Lieutenant J. R. Westmorland, R.E.  
 George Preston White, Esq., C.E.

## SUCCESSFUL CANDIDATES in Order of Merit

No.	NAME.	AGE.	Engineer to whom Articled, or under whom Served.	Place of Education.
1	F. L. Brown - -	23	F. Fox, c. e., Bristol; C. P. B. Shelley, c. e., Westminster.	King's College, London.
2	L. Heath - - -	21	G. Berkley, c. e., Westminster - - - -	King's College, London.
3	R. B. Buckley - -	21	I. D'A. Samuda, M. E., Poplar; Armstrong, Kershaw, & Marshall, c. e., London.	Not stated.
4	P. D. Alexander - -	21	McTaggart Covan, c. e., Glasgow - - - -	Dollar Institution.
5	D. McMordie - - -	23	H. Smyth, c. e., Downpatrick - - - -	Queen's College, Belfast
6	A. B. Phelan - - -	21	J. L. Worrall, c. e., Tipperary - - - -	Trinity College, Dublin.
7	W. Atkins - - -	22	J. Price, c. e., Midland Great Western Railway of Ireland.	Trinity College, Dublin.
8	J. H. Thornhill - -	19	Sir J. Benson, c. e., Cork - - - -	Queen's College, Cork.
9	C. G. Warren - - -	23	B. Latham, c. e., Westminster - - - -	Not stated.
10	W. G. Bligh - - -	23	R. J. Hood, c. e., Westminster; W. H. Dorman, c. e., Westminster.	Not stated.

ADMISSION TO THE ENGINEERS' ESTABLISHMENT, &c. IN INDIA.

CIVIL ENGINEER EXAMINATION.—July 1869—continued.

Successful Candidates in Order of Merit—continued.

No.	NAME.	AGE.	Engineer to whom Articled, or under whom Served.	Place of Education.
11	W. H. Wells - -	21	J. W. Ward, c. e., Westminster - - -	Eton College.
12	J. O. Lawder - -	21	J. Barton, c. e., Dundalk - - - - -	Not stated.
13	C. J. Lockwood - -	23	E. T. Bellhouse & Co., m. e., Manchester - -	Not stated.
14	C. Thomson - - -	23	C. J. Mackintosh, c. e., Westminster - - -	Not stated.
15	W. B. Christie - -	21	Forman & McCall, c. e., Glasgow - - - -	Dollar Institution.
16	J. M. Champion - -	21	H. Bolden, c. e., Westminster; A. R. Binnie, c. e., Westminster; C. P. B. Shelley, c. e., Westminster.	Doveton College, Calcutta.
17	A. Morton - - -	22	Avonside Engine Company; G. L. Fuller, c. e., Westminster.	Not stated.
18	J. F. Birkenshaw -	21	M. Kirtley, Midland Railway, Derby - - -	Not stated.
19	W. Good - - - -	22	Sir J. Benson, c. e., Cork - - - - -	Queen's College, Cork.
20	T. J. P. Jeffery - -	21	Keyham Factory, Devonport; Her Majesty's Royal Navy.	Not stated.

NUMBER OF MARKS which were assigned on each Subject.

No.	Number of Marks allotted in			TOTAL.	No.	Number of Marks allotted in			TOTAL.
	Mathematics.	Civil Engineering	Surveying.			Mathematics.	Civil Engineering.	Surveying.	
1	256	328	158	742	26	169	285	105	559
2	279	337	119	735	27	123	315	120	558
3	284	275	172	731	28	212	230	108	550
4	369	245	108	722	29	219	210	118	547
5	309	295	114	718	30	254	170	120	544
6	266	328	109	703	31	116	335	84	535
7	282	305	102	689	32	188	225	120	533
8	280	275	134	689	33	163	265	67	495
9	200	334	143	677	34	154	210	121	485
10	228	325	121	674	35	96	290	97	483
11	211	338	120	669	36	89	245	117	451
12	229	328	108	665	37	84	295	70	449
13	200	330	134	664	38	124	220	102	446
14	221	330	108	659	39	109	275	39	423
15	270	265	116	651	40	65	270	73	408
16	211	295	143	649	41	90	230	81	401
17	204	325	111	640	42	79	240	76	395
18	200	320	119	639	43	43	305	42	390
19	239	280	119	638	44	79	245	62	386
20	221	285	110	616	45	133	165	74	372
21	198	270	113	581	46	58	235	52	345
22	189	260	117	566	47	119	135	77	331
23	127	332	106	565	48	99	155	58	312
24	151	285	127	563	49	41	165	64	270
25	163	336	64	563	50	78	140	46	264

RETURNS of the Names of the 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, and their Places of Destination; and, of the MARKS which were assigned on each Subject to every CANDIDATE (in continuation of Parliamentary Paper, No. 234, of Session 1867-8).

(*Mr. Adam.*)

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*Ordered, by The House of Commons, to be Printed,  
7 August 1869.*

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