

EAST INDIA (ENGINEERS' ESTABLISHMENT, &c.)

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RETURN to an Address of the Honourable The House of Commons,  
dated 27 July 1866;—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 of *India* :”

“ And, of the Names of the SUCCESSFUL CANDIDATES in Order of Merit, their Ages, and the Names of the CIVIL ENGINEERS, if any, to whom any such Candidates have been Articled Pupils ; and the MARKS assigned on each Subject to every Candidate ; and EXAMINATION PAPERS on each Subject (in continuation of Parliamentary Paper, No. 426, of Session 1865).”

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India Office, }  
30 July 1866. }

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,*  
*31 July 1866.*

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## CIVIL ENGINEER EXAMINATIONS.

## NAMES OF EXAMINERS.

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

Major 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. C. Swappe -	22	W. Smith, Esq., C.E., Aberdeen	Not stated.
2. " W. H. P. Sherman.	20	{ J. Sang, Esq., C.E., Kirkaldy; G. May, Esq., C.E., Inverness }	Dollar Institution.
3. " W. F. Male -	20	R. Hodge, Esq., C.E., Plymouth	Dollar Institution.
4. " J. Craig -	21	W. Boulton, Esq., C.E., Scottish N. E. Railway.	Not stated.
5. " R. F. Stein -	22	Messrs. Cotton & Flemyng -	Trinity College, Dublin.
6. " T. Lobb -	23	{ H. G. Rennie, Esq., London; C. P. B. Shelley, Esq., C.E., London - - - - }	Not stated.
7. " M. S. Dooley -	20	S. C. Roberts, Esq., C.E., Galway	Queen's College, Galway.
8. " J. Hannan -	20	John Kennedy, Esq., Cork -	Queen's College, Cork.
9. " H. M. Thompson.	20	J. Price, Esq., C.E., Midland G. W. Railway, Ireland	Trinity College, Dublin.
10. " D. Pringle -	21	C. Jepp, Esq., C.E., Edinburgh	Not stated.

## NUMBER of MARKS assigned to each Candidate.

	Mathematics.	Civil Engineering.	Surveying.	TOTAL.		Mathematics.	Civil Engineering.	Surveying.	TOTAL.
1	257	330	157	744	11	167	325	113	605
2	286	300	151	737	12	191	275	133	599
3	239	330	165	734	13	175	270	120	565
4	283	260	169	712	14	97	320	92	509
5	226	330	128	684	15	116	315	76	507
6	254	275	118	647	16	107	270	108	485
7	219	300	122	641	17	80	305	81	466
8	213	310	110	633	18	70	295	78	443
9	215	295	121	631	19	110	240	87	437
10	218	265	117	600	20	41	255	82	378

PUBLIC WORKS DEPARTMENT—INDIA.

CIVIL ENGINEER ESTABLISHMENT.

EXAMINATION PAPERS for July 1866.

July 1866.

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

1. Find the values of the following:—

$$\frac{2}{15} \text{ of } \text{£.}3. 5 \text{ s.} + \frac{7}{64} \text{ of } \text{£.} 1. 12 \text{ s.} - \frac{5}{8} \text{ of } \frac{1}{2\frac{1}{2}} \text{ of } \text{£.} 1. 15 \text{ s.};$$

$$\cdot 383 \text{ of } \text{£.} 2 + 1\cdot 05625 \text{ of } 6 \text{ s. } 8 \text{ d.} - \cdot 0625 \text{ of a guinea.}$$

2. Simplify the following:—

$$\left(\frac{3}{8} \div \frac{27}{64}\right) + \left(\frac{1}{26} \text{ of } 3\frac{1}{4}\right) + \left(\frac{11\frac{1}{2}}{3} - \frac{1}{17}\right) \div \left(4 - \frac{5}{9}\right);$$

$$\frac{3\cdot 012}{\cdot 006} + \frac{\cdot 03217}{6250} + \frac{\cdot 025075}{1\cdot 003}.$$

3. Find (by Practice) the value of 639 cwt. 3 qrs. 4 lbs. at £. 2. 12 s. 6 d. per cwt.

4. What would be the expense of papering a room, the height being 17 ft. 6 in., length 35 ft. 3 in., and breadth 18 ft., with paper  $\frac{1}{2}$  yd. wide, at 13 $\frac{1}{2}$  d. per yard, there being two doors, each 7 ft. by 4 $\frac{1}{2}$  ft., and four windows, each 8 ft. by 4 ft. 9 in.?

5. A man's estate is worth £. 911. 19 s. 4 $\frac{1}{2}$  d., and he owes A. £. 814, B. £. 1,031. 5 s., and C. £. 586. 13 s. 4 d. How much must each lose?

6. Which is the best investment (supposing both equally secure), Great Indian Peninsular, guaranteed 5 per cent. at 109, or Madras, guaranteed 4 $\frac{1}{2}$  per cent. at 93?

7. Explain, by means of a figure, the changes in the sign and magnitude of the sine and cosine of an arc, as the arc varies from 0° to 360°.

8. Investigate the formula used in the solution of a triangle, the three sides of which are all known; and apply your results to the determination of the angles of the triangle  $ABC$ , where  $AB = 631\cdot 5$ ,  $BC = 679\cdot 5$ ,  $CA = 734$ .

9. A line  $AB$ , 500 yds. long, is measured close by the bank of a river, and,  $C$  being a point in the opposite bank, we find, by observation,  $\angle CAB = 75^\circ 33'$ , and  $\angle CBA = 84^\circ 17'$ ; determine the width of the river at  $C$ .

10. Find the following with the help of Logarithms:—

( $\alpha$ ). The values of  $\frac{3\cdot 78 \times 10000 \times 0\cdot 15}{79\cdot 165 \times 7917\cdot 06}$ ,  $(3\cdot 79451)^{-8}$ ,  $(67^{-5} + 3^8)$ .

( $\beta$ ). The mean proportional to  $\cdot 144\frac{1}{2}$  and  $\cdot 0041\frac{1}{2}$ .

( $\gamma$ ). The log. cosine of  $73^\circ 2' 47''$ .

( $\delta$ ). The angle whose log. tan. is  $9\cdot 9521694$ .

#### 4 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

11. A square court (side being 36 ft.) has in the centre a fountain in a circular basin, whose diameter is 13 ft. What will it cost to pave the court with flags at 1 s. 2 d. per square yard, a flower bed 4 ft. wide being left round the three sides?

12. What will be the cost of 1,000 bell-tents, the post of each being 12 ft. long, and costing 4 d. a foot; the ground diameter of each tent being 11 ft.; canvas costing 2 s. 9 d. per square yard, and the extras and making of each tent costing 7 s. 9 d.?

13. Find the weight of a pair of iron dumb-bells, each consisting of two spheres of  $4\frac{1}{2}$  inches diameter, joined by a cylindrical bar 6 ins. long and 2 ins. diameter, it being known that an iron ball of 4 ins. diameter, weighs 9 lbs.

14. A square reservoir with sides 200 ft. long, has to be constructed with its top 10 ft. above the surface of the ground. How deep must it be excavated in order that the earth thrown out may form round the brick lining an embankment in the form of the frustum of a pyramid, each of whose sides is inclined to the horizontal at an angle of  $30^\circ$ ?

15. How many cubic yards of earth will be required to form an embankment whose side slopes at angle  $45^\circ$  to the horizontal across a narrow valley, the length being 108 ft., and width at top 20 ft.; and the level of the embankment being found at intervals of 6 ft., to be at the following heights above the valley, viz.:

3, 4.2, 4.7, 5, 6.3, 5.1, 6, 6.6, 7, 7.4, 7.2, 6.9, 5, 4.7, 3.1, 2, 1 ft.?

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July 1866.

EUCLID.—Rev. J. Cape.

1. Define the *five* quadrilateral figures mentioned in Euclid. How many kinds of triangles are there in considering the variation both of the *angles* and the *sides*?

2. If two straight lines cut one another, the vertical, or opposite angles shall be equal.

If two straight lines are respectively at right angles to two others which intersect, show that each pair of lines includes the same acute angle.

3. Any two sides of a triangle are together greater than the third.

Prove that the sum of the distances of any points within a triangle from the three angles is greater than half the perimeter of the triangle.

4. The straight lines which join the extremities of two equal and parallel straight lines towards the same parts, are themselves also equal and parallel.

5. Along the sides of a parallelogram taken in order, if we measure  $Aa = Bb = Cc = Dd$ , the figure  $a b c d$  will be a parallelogram.

6. In any right angled triangle, the square which is described on the side subtending the right angle is equal to the squares described upon the sides which contain the right angle. If one of the acute angles of a right angled triangle be double the other, the square on the greater side is three times the square on the other.

7. Enunciate and prove the Proposition in Euclid, Book II., which gives the relation between the sides of an obtuse angled triangle.

8. If

8. If a straight line touch a circle, and from the point of contact a straight line be drawn cutting the circle, the angles which this line makes with the line touching the circle shall be equal to the angles in the alternate segments of the circle.

If two circles touch each other, and parallel diameters be drawn, the straight line joining the opposite extremities of these diameters will pass through the point of contact. (Take the case of external contact.)

9. On a given straight line describe a segment of a circle which shall contain an angle equal to a given rectilineal angle.

Hence describe a triangle of given base, area, and vertical angle.

10. Show how to inscribe an equilateral and equiangular hexagon in a given circle.

If  $ABCDEF$  be a hexagon such that  $AB$  is equal and parallel to  $DE$ , and  $BC$  to  $EF$ , prove that  $CD$  is equal and parallel to  $FA$ . Also that  $AD$ ,  $BE$ ,  $CF$ , all meet in a point bisecting each other.

11. Show that similar triangles are to one another as the squares of their homologous sides.

12. Show that every solid angle having no re-entering angles is contained by plane angles, which together are less than four *right* angles.

July 1866.

ALGEBRA.—Rev. J. Cape.

1. Simplify each of the following expressions:—

$$(a) \frac{bc}{ad} - \frac{1}{2} \left( \frac{a}{b} + \frac{b}{a} \right) \left( \frac{c}{d} + \frac{d}{c} \right) + \frac{1}{2} \left( \frac{a}{b} - \frac{b}{a} \right) \left( \frac{c}{d} - \frac{d}{c} \right) + \frac{ad}{bc};$$

$$(b) \frac{\frac{1}{a} + \frac{1}{b+c}}{\frac{1}{a} - \frac{1}{b+c}} \left\{ 1 + \frac{b^2 + c^2 - a^2}{2bc} \right\};$$

$$(c) \frac{1}{x^2} - \frac{2}{x^2(x+1)^2} + \frac{2}{x^2(x+1)^2(x+2)^2} - \frac{1}{(x+2)^2};$$

2. Extract the square root of  $\frac{9a^3}{4} - 5a^{\frac{5}{2}}b^{\frac{1}{2}} + \frac{179a^2b}{45} - \frac{4a^{\frac{3}{2}}b^{\frac{3}{2}}}{3} + \frac{4ab^2}{25}$ .

3. Show that  $\frac{(x-a)(x-b)}{(c-a)(c-b)} + \frac{(x-b)(x-c)}{(a-b)(a-c)} + \frac{(x-c)(x-a)}{(b-c)(b-a)} = 1$ .

4. Solve the following equations:—

$$(a) \frac{6-5x}{5} - \frac{3(7-2x^2)}{14(x-1)} = \frac{1+3x}{7} - \frac{2x-2\frac{1}{2}}{2} + \frac{1}{35};$$

$$(b) \frac{1}{x} + \frac{1}{a} = \sqrt{\frac{1}{x^2}} + \sqrt{\frac{4}{a^2x^2} + \frac{9}{a^4}};$$

$$(c) \begin{cases} x^{\frac{1}{2}} + y^{\frac{1}{2}} = 4 \\ x^{\frac{3}{2}} + y^{\frac{3}{2}} = 28 \end{cases};$$

$$(d) \begin{cases} x + y + z = \frac{19}{6} \\ x^2 + y^2 + z^2 = \frac{133}{36} \\ x : y :: y : z. \end{cases}$$

6. PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

5. Show that  $\left\{ \frac{2 - \sqrt{3}}{2 + \sqrt{3}} \right\}^{\frac{1}{2}} = \frac{\sqrt{2}}{1 + \sqrt{3}}$ ; and find the square root of  $\sqrt{32} + \sqrt{30}$ .
6. Which is the greater, the ratio of  $a + 2 : \frac{1}{2}a + 4$ ,  
or that of  $a + 4 : \frac{1}{2}a + 5$ ?
7. Find two numbers, the greater of which shall be to the less as their sum is to 84, and as their difference is to 12.
8. The sum of an Arithmetical Series is 280; the first term is 1, and the number of terms is 32. Find the common difference.
9. Sum the following series:
- (a)  $\frac{3}{5} - \frac{14}{10} + \frac{51}{15} + \dots$  to 30 terms.
- (b)  $\frac{1}{5} \sqrt{\frac{3}{2}} \sqrt{\frac{3}{5}} + \sqrt{6} \dots$  to 7 terms.
- (c)  $1 + \frac{1}{2} + \frac{1}{4} + \dots$  to infinity,  
and explain by a figure how the last series can have a finite value.
10. A train has room for 226 passengers, and there are 230 waiting for it. In how many ways can the train be filled?
11. Find the 9th term in the expansion of  $(\frac{1}{2}x + 2y)^{13}$ ; and obtain the first 5 terms of  $\frac{1}{(a^{\frac{1}{2}} - x^{\frac{1}{2}})^7}$ .
12. The difference of the cubes of two consecutive numbers is 169. What are the numbers?
13. In a factory, the profit is 10 per cent. when hand-labour is used, and 20 per cent. when machinery is used. A machine costs 500 *l.* and wears out in 5 years. The owner, by substituting machinery for hand-labour, gains 1,866 *l.* 2 *s.* 7½ *d.* in 5 years, his personal expenses continuing as before 300 *l.* per annum. What capital had he at the beginning of the 5 years?

July 1866.

MECHANICS and HYDROSTATICS.—Rev. J. Cape.

1. Explain fully and accurately the meaning of the following terms in mechanics:—*particle, rigid, force, line of action, equilibrium, moment, resultant, centre of gravity, friction, and coefficient of friction.*
2. Find the magnitude, direction, and point of application of the resultant of two parallel forces acting in the same plane,  
(a) When the forces act in the same direction,  
(b) When they act in opposite directions;  
and hence deduce the condition of equilibrium in the case of a lever resting on a fulcrum.
3. Show from the results obtained in the last question, how the common steelyard is graduated.
4. What are the *three* great requisites in the common balance, and what steps are usually taken to secure them?
5. A body

5. A body weighs 12 lbs. 6 oz. at one end of a false balance, and 14 lbs. 8 oz. at the other. What is its real weight?

6. A bale of cotton in a screw-press exerts a re-action of half a ton in the direction of the axis of the screws. The diameter of the screw is 8 inches, and the thread makes two turns in 3 inches. The power is applied by an arm 8 ft. long, perpendicular to the axis of the screw. The coefficient of friction being 2, find the limits between which the power must lie, in order that the equilibrium may exist.

7. In driving a shaft, a spring is tapped which pours out 2,000,000 gallons every 24 hours. What horse-power must an engine be to keep the water under, the depth of the shaft being 150 fathoms, a gallon containing 277·3 cubic inches?

8. Explain how the power of a stream of water acting on a mill-wheel is estimated, taking the three cases of *undershot*, *breast*, and *overshot* wheels. The mean section of a stream is 5 ft. by 2 ft.; its mean velocity is 35 ft. per minute; there is a fall of 13 ft. in this stream, at which is erected a wheel whose modulus or the ratio of the effective work to the whole power is 0·65. Determine the horse-power of the wheel.

9. Two spheres (7 and 9 inches radius) are connected by a cylindrical rod of the same material, 3 ft. 6 in. long and 2 in. radius. How far is the centre of gravity of the whole from the surface of the smaller sphere?

10. Enunciate the *three laws of motion*; mention any illustrations of them that you can think of; and give reasons why we may feel sure of the correctness of these laws.

11. A body is projected upwards with a velocity of 200 ft. per second. Find where the body will be at the end of 6 seconds, and the velocity and direction of its motion at that time.

12. Explain the uses of the *Fly-wheel*, the *Governor*, and the *Condenser*; and also the plan adopted in modern steam-engines instead of *Watts' Parallel Motion*.

13. Determine the velocities of two balls, *A* (20 lbs.) and *B* (40 lbs.) after impact; *A* moving with a velocity of 100 ft. per second, and overtaking *B* moving with a velocity of 30 ft. per second, their coefficients of elasticity being  $\frac{1}{2}$ .

14. What is meant by the *Centre of Pressure*, and how is it determined? A cubical box is filled with water. Compare the pressures on the horizontal base, and on each of the vertical sides. Where will the resultants of these pressures severally act?

15. When the mercurial column stands at 30 inches, determine in pounds avoirdupois the pressure of the atmosphere on the square inch, the specific gravity of mercury being 13·57.

16. Describe the hydrometer. An eight-gallon pail of London milk is found by means of this instrument to have its specific gravity equal to 1·023, while the specific gravity of pure milk = 1·035. The pail being full, find how much water the milkman must have put into it.

## 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 July 1866.

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

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### DIRECTIONS.

1. You are particularly requested to write legibly, and to answer the questions as concisely as possible.
2. Prefix the number of the question to each answer.
3. Use free-hand sketches or diagrams wherever possible, to illustrate the answer, and it is requested that they may 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; their doing so will disqualify them.
5. Candidates are required to produce *bond fide* finished drawings, with certificate, 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.

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### ON INLAND COMMUNICATIONS.

*(Roads, Tramways, Railways, Canals, River Navigation.)*

The opening up of India by means of roads, tramways, cheaply constructed low-speed railways, canals, and by rendering rivers navigable, is a subject of the first importance.

1. Much attention is now being directed,—with a view to the development of districts where there is little existing traffic, and which would not justify expensive works,—to the construction of cheap low-speed railways or tramways of narrow gauge with steep inclines and sharp curves, in order to save earthwork, masonry, &c. Specify the various points as regards plant, permanent-way, engines, &c., where economy could be effected by adopting a two-foot-six-inch or three-foot gauge, and make an estimate for one mile of permanent-way, adopting your data.

2. Give the particulars of a cheaply constructed narrow-gauge railway in North Wales, originally intended for mineral traffic, but afterwards adapted to passenger and general traffic; give width of gauge, particulars of curves and gradients, &c.

3. Describe the alterations introduced by Mr. Crosse and others in the locomotive engine, specially adapting it for steep gradients and sharp curves, to work lines like the above mentioned.

4. Give particulars of a cheaply constructed low-speed railway recently opened in Norway, at a cost of about 3,000 *l.* per mile, including plant and stations, specific width of gauge, form of rail, sleepers, &c.

5. There are many roads in India which might, at small expense, be converted into tramways, as, for example, the Grand Trunk Road, between Calcutta and Peshawer, nearly 1,500 miles in length; its gradient along the valley of the Ganges



Fig. 1.

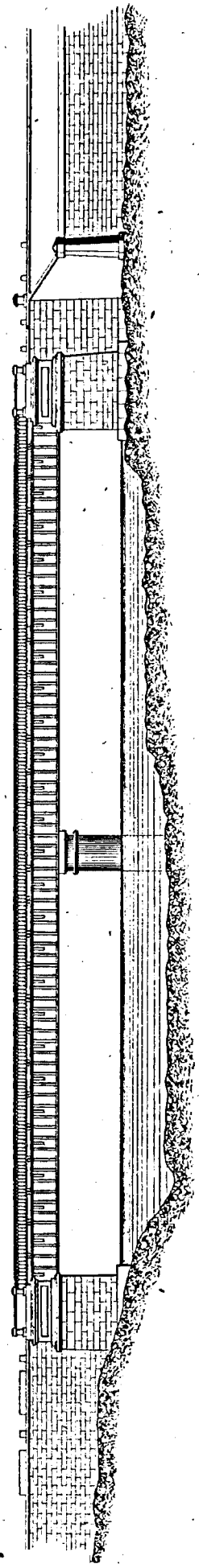
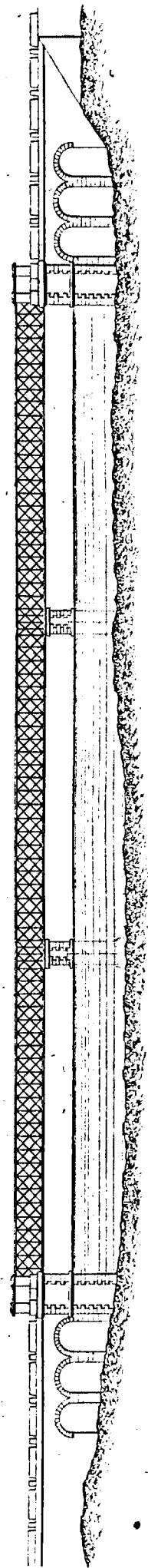


Fig. 2.



Ganges is about one foot per mile, and there are only a few ranges of hills, such as the Dunwa Pass, to be overcome. The mode adopted on the railway over the Mont Cenis for ascending inclines and working sharp curves appears to be most applicable to such cases. Fully describe the means there employed, as also the plans adopted in America, to avoid tunnelling, and save other expenses; and offer any suggestions of your own on the subject.

6. The machinery employed at Mont Cenis. The inventions of Captain Petherick, and the more recent invention of Mr. Lowe, used at the Vartry Waterworks, are calculated to effect great economy in tunneling; describe briefly the nature of these machines.

7. The accompanying design, Fig. 1,\* represents a tubular bridge of two spans, 130 feet each, composed of three "tubular or box" girders, with transverse beams of iron, carrying a timber floor above the main girders sufficiently strong for ordinary traffic; width of roadway, 25 feet. Make free-hand sketches to illustrate the details of such a bridge, figure on dimensions, and thickness of plates, the size and pitch of rivets; and describe the parts where the plates should be increased in thickness, and also the points where it is desirable to increase the strength of top and bottom members. \* See Design opposite.

8. This bridge is supported in the centre on iron cylinders; describe the means usually adopted for forming foundations in this way, and the circumstances under which it is desirable to adopt cylinder rather than masonry piers.

9. Fig. 2\* is a design for a trellis bridge, each span is 105 feet, width of roadway 18 feet. The transverse beams are composed of boiler plate and angle iron. The floor is of timber, the joists running longitudinally, with planking laid transversely. This bridge is intended for ordinary road traffic. Make free-hand sketches to illustrate the details. Describe the parts under compression and extension, and point out where it is desirable to increase the scantlings. \* See Design opposite.

10. Both the above bridges are made as one continuous girder supported at intervals, and not in a series of detached girders. Explain the advantages derived from this mode of construction.

11. Describe what course you would adopt to get these girders into position. When rivetting them together over the piers so as to make one continuous girder, how would you bring the girder to its bearing?

12. Describe the details and make free-hand sketches to illustrate the arrangement necessary to provide for the expansion and contraction of the girders.

13. In making an estimate of the above bridges, state what would be a fair average price per ton for the iron work.

14. Give the names of standard works of reference on the subject of canal and river navigation, and on the improvement of rivers for navigation and other purposes.

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### ON MINING, METALLURGY, MINERALS, QUARRIES, &c.

1. Describe in detail, the appearances which may be expected in exploring a country for coal at the out-crop of a seam. What are the geological formations in which coal is usually found? and describe the nature of the clay and its uses, which generally forms the seat or bed of the coal formation.

2. What minerals and fluxes are usually found in immediate proximity with coal, what is the greatest depth to which coal has been hitherto worked, and what are the circumstances which appear at present to fix a limit as to the depth of the workings?

3. Describe the chemical and other differences between anthracite, bituminous, and cannel coal. State which is the best for the manufacture of iron, and the reasons why, and explain the means employed by Mr. Blackwell and others to smelt iron with anthracite coal. Which is the best coal for the production of gas?

4. Describe the most approved means for the ventilation of coal mines. What is choke-damp, and to what class of mines is it peculiar? How does the safety lamp act in preventing explosions? Explain its principles.

5. What are the best kinds of fuel for the manufacture of iron; to what is the superiority of Swedish iron and steel mainly attributable; and what is the object of the hot blast?

6. Explain and illustrate with free-hand sketches, the following terms used in the mining districts of Cornwall and Devon; adit level, back of a lode, buddling, caunter lode, champion lode, cross course, cross cut, costeaning, dialling, driving, elvan, flookan, fault, halvans, heave, jigging, killas, levels, slide.

7. What is gossan, and what does its presence usually indicate?

8. Describe briefly the different means employed for unwatering mines.

9. Describe briefly the leading features and advantages of the Cornish engine, explain the expansive principle and double cylinder, and state the uses of the plunger pump.

10. What are the economic conditions which enable iron to be manufactured at such a price in Great Britain as to admit of its exportation to India, though iron ore and coal exist largely in that country?

11. Give the names of standard works of reference on mining, and on the manufacture of iron and steel.

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#### ON WATER SUPPLY.

1. Describe briefly the different means employed to supply towns with water, and give illustrative examples. State some of the principal conditions and requirements to be considered and attended to in adopting the gravitation or pumping systems.

2. Describe the principle of the rain gauge. Make free-hand drawing illustration, pointing out peculiarities of the Howard, Glaisher, Negretti, Casella and Calne gauges. State the precautions and conditions necessary to be attended to in fixing gauge, so as to obtain reliable results.

3. Explain the meaning of the terms, impounding, compensating, depositing, and service reservoirs, residuum lodges, collecting and storage grounds.

4. Describe 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 also to render them impervious to water, and describe the difference between the modes 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 Gorbals or Chelsea Waterworks; specify the best materials to employ for the purpose, and explain whether the action is chemical or mechanical.

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

8. Make a free-hand sketch to illustrate the most approved forms for cast-iron water pipes; describe the modes most in use for jointing pipes, pointing out their relative advantages or defects.

9. In preparing a specification for cast-iron pipes, state the conditions necessary to insert as regards the position in which the larger pipes should be cast, and explain the object. 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.

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. Describe the uses of, and illustrate with free-hand sketches, the following: viz., bib cocks, crutch key cocks, spigot and faucet joints, flange joints, stand pipes, reducing pipes, branches and bends, air vessels, scour cocks, hydrants, sluice valves.

12. 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.

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#### IRRIGATION, DRAINAGE, &c.

1. Describe the systems for thorough drainage introduced by the late Mr. Smith, of Deanstone, and by Mr. Josiah Parkes, and specify the relative advantages or defects of the different systems.

2. Make free-hand sectional illustrations of drains, marking on slope depth and other particulars; state the precautions necessary to adopt to prevent drains being choked; and explain the circumstances which would guide you in employing broken stones or tiles, or both, and give sketch of the best form of tiles usually employed.

3. Explain the systems used at Croydon and Edinburgh for applying sewage manure; state the results produced, and the nature of the crops for which this kind of sewage is most suitable.

4. Explain how the mean velocity of rivers is ascertained, and how are rivers gauged?

5. Describe the nature of the soils best adapted and most benefited by irrigation, and the water most suitable for the purpose.

6. How much rain-fall is on an average evaporated and goes to waste; how much absorbed, and how much goes to cultivation? Give the names of the best instruments for measuring the amount of evaporation.

7. What are the monsoon rains, and what are the physical conditions which render irrigation so imperatively necessary in India, Italy, and in tropical climates?

8. State what has been the average cost per acre to irrigate land in Piedmont, Lombardy, and India; and what is the average return on money thus invested, and the increase of produce due to irrigation.

9. Describe the different modes employed to irrigate land. Name the crops most requiring irrigation, specifying which require complete and which partial irrigation, and the length of time and seasons of the year when water is most required.

## 12 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

10. Give the names of important canals of irrigation in India, Lombardy, Spain, and Egypt.

11. Give the names of standard works of reference on the subject of irrigation and drainage.

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*Note.*—The questions used in the present examination are confined principally to those subjects which appeared to be of most practical importance in India. The engineering profession now embraces such a number and variety of subjects that it becomes both necessary and desirable to make a selection, and specially to direct your attention to those branches most likely to be useful in your future field of operations.

Amongst those of paramount importance in India, with a view to the development of the great resources of the country, are:—

1. INLAND COMMUNICATIONS.

2. IRRIGATION AND DRAINAGE.

3. WATER SUPPLY AND SEWERAGE.

4. MINING;—Special attention being directed to the raising of coal and to the manufacture of iron and steel.

5. MAKING CAREFUL, CORRECT, AND TRUSTWORTHY ESTIMATES.—As most of the works upon which the civil engineer is employed (excepting those for sanitary purposes) are of a commercial and economic character, and intended for the development of latent resources, it is of the greatest importance that the utmost economy should be observed in constructing works, so far as consistent with sound and permanent work. The object of the civil engineer, in carrying out works of a reproductive character, should be to produce the greatest possible results as regards the return for capital expended, at the least possible cost, and ornamentation and unnecessary detail should be strictly avoided, remembering, "Tis use alone that sanctifies expense." In a country of such vast extent as India, this becomes a matter of commercial importance.

India possesses great undeveloped mineral resources. Those amongst you who have an opportunity of visiting the mining districts of Cornwall and Devon, the coal fields of South Wales, Northumberland and Durham, and the coal and iron districts of Staffordshire, should not omit doing so; the practical knowledge thus acquired may prove of the greatest importance in after-life. In conclusion, I would direct your attention to the admirable address of Mr. Fowler, President of the Institution of Civil Engineers, as to the DUTIES, KNOWLEDGE, PREPARATION, and TRAINING required by the civil engineer.

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### QUESTIONS ON SURVEYING.

*Morning Paper, 11th July 1866.*

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*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 Gunter's chain, and state for what purpose it is of the prescribed length: to what branch of surveying is it particularly applicable? Also, describe the 100-foot chain and its divisions; how many arrows are attached to each chain, and what is their use?

2. How would you ascertain the distance of a point in the middle of a broad river; 1st, with a chain, 2nd, without anything but a few pickets?

3. Describe the method of using the Prismatic Compass. State how you would survey a road with it. Also, explain the method of finding your station by interpolation, by means of two or more stations already fixed.

4. What are the meanings of the terms Magnetic Meridian and Variation of the Compass? Explain the method of finding the latter in the field, and state how a meridian line can be marked out on the ground, without the aid of any instrument, with sufficient accuracy for common purposes.

5. How

5. How can you ascertain whether a pocket sextant is in adjustment, and why, in trying its adjustment, should the object observed be at least half a mile distant? The arcs of the theodolite and sextant both read to minutes; why is the former the more accurate instrument?

6. How can you ascertain your position on a plan of any ground by the aid of the sextant?

7. How are distances, both vertical and horizontal, found in the field with great facility by means of the pocket sextant and a very simple tangent table of multiple angles? Explain the principle upon which the tangent table of multiple angles is formed.

8. Show, with a diagram, that the angle measured by the sextant is only half of that actually subtended by the objects observed.

9. Describe road traversing with the theodolite: what points should be especially attended to, and in what manner can the work be checked? What is the peculiar character of theodolite traversing, and why may this character not be equally maintained by using the magnetic meridian.

10. Describe the method of measuring a base line by the aid of a chain and theodolite, pointing out the correction necessary for each angle of elevation or depression.

11. Where an object is selected as a trigonometrical point on which the theodolite cannot be set up, the angles taken from its vicinity require "reduction to the centre." Explain how this is done, and illustrate it by a diagram.

12. Explain the principle of the Vernier, and in what manner would you construct a Vernier to read to 15 seconds when the arc is divided into quarter degrees.

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EXAMINATION IN SURVEYING.

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*Afternoon Paper, 11th July 1866.*

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*Note.*—Write your name at the top of the accompanying plan and of each of the papers which 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, and more credit will be given for knowledge of the subject than for minute accuracy of detail in drawing, &c., on which time need not be wasted, though neatness is desirable.

1. Consider the accompanying plan as a tract of country, of which you are required to make a survey. State in what manner you would proceed, and what instruments you would use for the various parts of the work.

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 shown thereon:—

A. Construct and draw a scale at the foot, showing hundreds and thousands of yards, the length of the plan being taken at four miles.

B. Measure a base line on the level top of Shrone Hill. Show, by red ink lines, your system of triangulation therefrom, and let it close on a base of verification, to be measured on Cobduff, about twice the length of your original base.

C. The correct delineation of the Harbour is supposed to be mainly dependent upon careful triangulation; you will be careful, therefore, to avoid admitting any ill-conditioned triangles into this part of the work.

## 14 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

D. The hills in the plan are shaded vertically. Sketch in, on a separate piece of paper, Shrone Hill and the ground in its immediate vicinity, in pen and ink, and on the horizontal system; not with any particular care as to accuracy, but as a specimen of your ability to do such work.

E. Similarly, and for the same reason, sketch in in Indian ink, shading with a brush, and on a slightly larger scale, the hill and adjacent ground to the west of Shrone Hill and south of Barley Lake.

F. Colour in the roads, rivers, lakes, sea, and woods shown on the plan.

G. Compute the area drained by the Maganagan Stream, so far as it is shown on the plan.

H. Hand in a field book of a supposed traverse survey of a portion of the road from Adrigole Harbour; the work to start from the Bridge on the Glogarriff River and to terminate at the Ford on the Maganagan Stream, the measurements to be taken off the scale, and the angles to be taken on the plan with a protractor.

I. Without going through any calculations in detail, explain briefly how you would compute the length of the base of verification proposed to be afterwards measured, as above, on Cobduff.

J. Explain the process you would adopt for sketching in the ground in the field after the necessary previous preliminaries had been completed.

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### QUESTIONS ON LEVELLING AND PRACTICAL SURVEYING.

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*Morning Paper, 14th July 1866.*

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*N.B.*—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.

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1. What is levelling, and to what useful purposes is the art applied? Describe the different modes of levelling, and mention the class of operations to which, in practice, each different method of levelling is most suitable.

2. State the number and the nature of the adjustments required by the common Y spirit level; in what respects does the Dumpy or Gravatt's level differ from the Y level?

3. What are bench marks, and what is their use? Enumerate the different kinds of levelling staves used; state which you prefer, and why?

4. Explain the effect of the curvature of the earth on levelling operations. When is a correction on its account necessary, and what, in general terms, is the amount of such correction? is it an additive or a subtractive quantity? What is the correction for curvature due to the distance of 29,040 feet?

5. What do you understand by "refraction"? Are its effects constant or variable, and to what cause are they attributable? What is the mean correction ordinarily applied on its account to an observed angle? and how, in practice, may the effects of curvature and refraction ordinarily be obviated?

6. What

6. What do you understand by contour lines? How do you trace them upon the ground with a spirit level or theodolite? and for what purposes and with what objects are contoured surveys ordinarily executed?

7. Being directed to survey for and select a new line of road in a comparatively unexplored and little known country, give some description of the way in which you would set about it, the instruments you would use, &c. &c., supposing your instructions required you to send in a project for a road, complete with longitudinal sections, &c.

8. In reconnoitering in unmapped countries, it sometimes happens that the only available check upon your route survey is to find the latitude and longitude of your halting stations: describe simple methods of ascertaining these points.

9. Proceeding up a river in a boat, how would you survey your route as you went along, travelling, of course, only by daylight?

10. Explain how in the field the time may be approximately ascertained by the prismatic compass.

11. Marking out a road in a hilly country, and being limited to a maximum gradient of, say, 1 in 25, how would you proceed to obtain your trial alignments?

12. Marking out a canal in a given direction A B, you find that the alignment, if prolonged, would take you through a village; to avoid this, you change the direction to a line B C, and, between the points A and C, you trace a curve with a radius of four miles: describe the method of doing this in the field, and (without going through the necessary calculations in detail) explain how they are made, when required, the distances A B and B C being measured, and the angle A B C observed.

*On the completion of answers to the above questions, the remainder of the morning sitting will be devoted to the vivâ voce Examination of Candidates in the practical use and adjustment of Instruments.*

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EXAMINATION IN PLOTTING AND PLAN DRAWING.

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*Afternoon Paper, 14th July 1866.*

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

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1. The accompanying lithographed Field Book represents details of a survey as made in the field. The measurements are given in feet. You are required to plot it on a scale of 400 feet to the inch. On this scale the plan will work into the general dimensions of 12 inches by 8 inches. Make the meridian line parallel to the longer side of your paper, and you will find it most convenient to commence work towards the left hand lower corner.

Finish off the plan neatly, colouring in the roads, rivers, houses, woods, &c., showing the traverse lines in red on the plan. Print as a heading the words, "Traverse Survey of Ground plotted by [Name.]"

2. Plot a section from the accompanying Field Book of Levels, and on the section starting from the level of Station 8, draw in a longitudinal section of a proposed line of road, limited to a maximum gradient of 3 feet in 100. The



horizontal scale of the section to be 100 feet to an inch, and the vertical scale 10 feet to an inch. Fill up columns of rise, fall, and reduced level, the datum being assumed at 100 feet below the starting point.

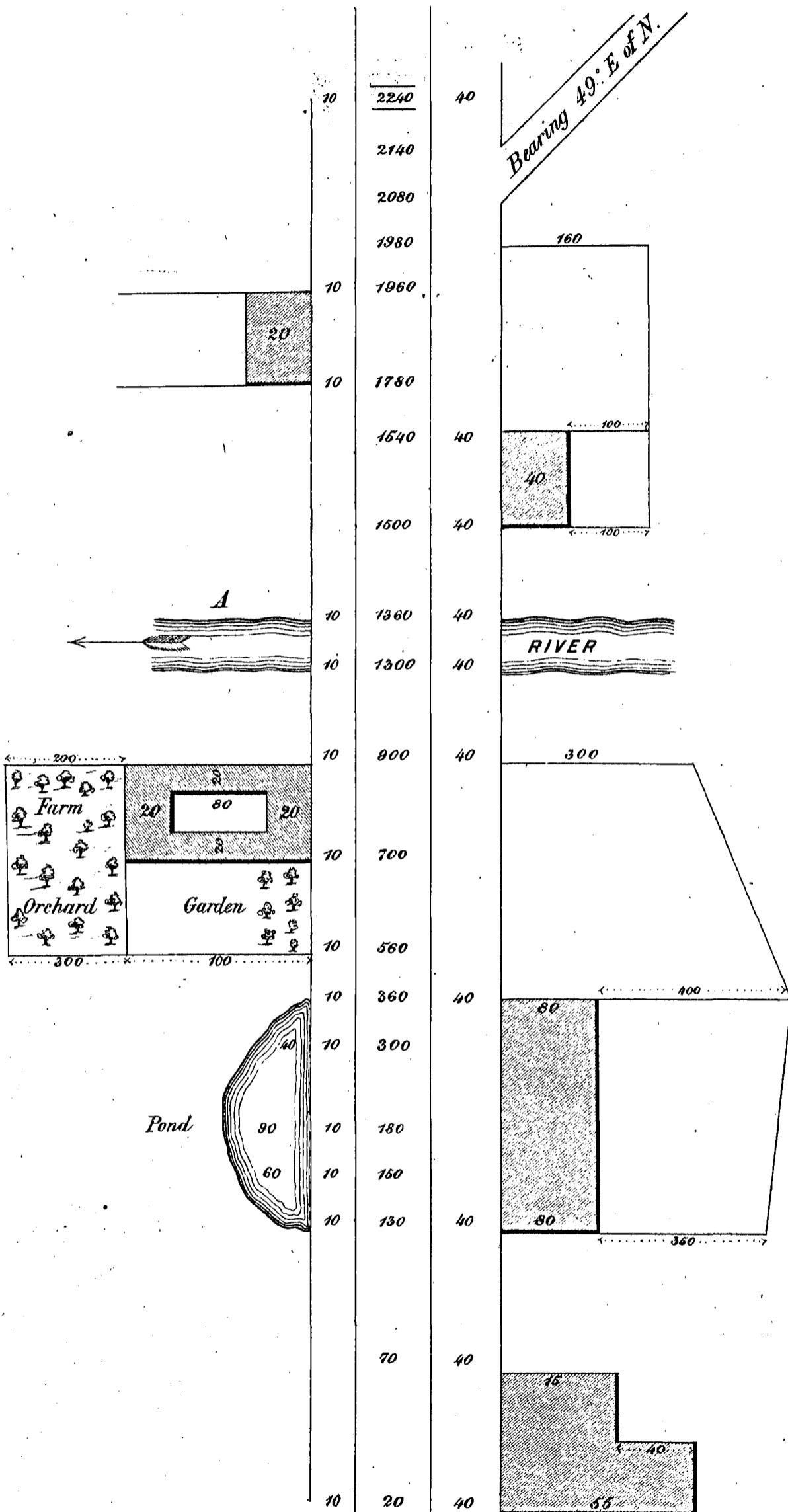
*Field Book of Levels.*

Number of Station.	BACK			Height of Instrument.	FORE			Rise.	Fall.	Reduced Level.
	Bearing.	Distance.	Level.		Level.	Distance.	Bearing.			
	°						°			
1	235	100	3.75	4.95	5.68	120	55			
2	”	150	8.42	5.12	11.78	150	”			
3	”	100	3.89	4.87	6.23	100	”			
4	246	120	7.42	5.09	3.70	150	66			
5	”	40	8.97	4.96	2.48	60	”			
6	”	100	3.72	5.02	6.08	100	”			
7	”	200	2.45	5.06	8.92	200	”			
8	”	160	6.71	4.98	8.02	120	”			
9	”	100	3.57	5.00	7.94	100	”			
10	”	80	8.20	4.97	2.86	120	”			

Plot in the line of proposed road surface in red, and note, below each change of inclination, the rate per 100 feet of gradient adopted, avoiding all unnecessary embanking or excavation beyond what may be rendered absolutely necessary by your prescribed limit of gradient.

3. Draw the ground plan of a building 120 feet long by 30 feet broad, in central block, with two wings projecting in front, 60 feet each, and of the same breadth of 30 feet. Run a 10 feet arcaded verandah, with 6 feet openings and 7 feet rise to the spring of the arch, round the entire building. Proceed to draw an elevation of the same with two stories, the lower story being raised 3 feet off the ground, and 24 feet in height, and the upper 20 feet in height, putting in for effect simple basement and cornice mouldings and stringcourses at the springing of the arches; the building to be flat-roofed, with a parapet wall 3 feet in height. Show on the elevation the effect of the projection of the shadows, the light being supposed to come from the left hand side at an angle of 45 degrees. Scale, 20 feet to an inch. Sky and foreground to be sketched in at discretion.







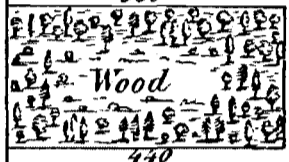
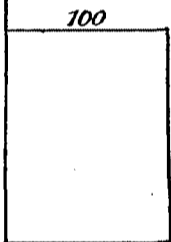


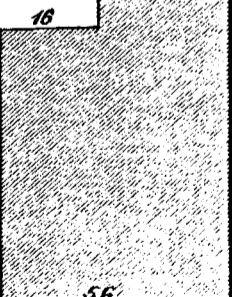
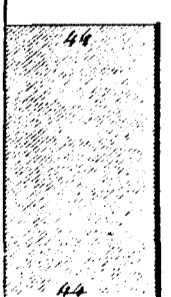

FIELD BOOK.



Start from Cross Roads

on a bearing 20° E of N

RETURN - EAST INDIA (ENGINEERS ESTABLISHMENT &c.)

	20	1480	30	
				<i>RIVER</i>
	20	1480	30	
		1380	30	
	20	1140		
<i>Orchard</i>				
	20	1034	30	
				680
				<i>Wood</i>
				440
	20	976	30	
	20	758	30	
				<i>Bearing 50° E of N.</i>
				<i>ROAD</i>
		744	30	
	20	686	30	
				100
	20	546	30	
				100
	20	480		
		423	30	
				44
	20	364		
				44
				<i>Fore Sight 340° 30'</i>
				<i>Back " 20° "</i>
	10	2240	40	





Closes on			Starting point.	
		<u>2482</u>		
		2080	25	
220	40	1975		
200		1840	26	200
100	30	1660		
	28	1360	42	
150	25	900	45	200
150	25	860	44	250
		720	50	300
	21	480	50	Wood 280
	30	156	40	
		50	30	
				Fore Sight 139° 30' Back " 180° 15'
	30	2050	30	

EAST INDIA  
(ENGINEERS' ESTABLISHMENT, &c.)

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RETURNS 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 (in continuation of Parliamentary Paper, No. 426, of Session 1865).

(*Mr. Adam.*)

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*Ordered, by The House of Commons, to be Printed,  
31 July 1866.*

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[*Price 2s.*]