

EAST INDIA (PUBLIC WORKS DEPARTMENT).

RETURN to an Address of the Honourable The House of Commons,
dated 16 July 1863;—for,

“ RETURNS specifying the Names of the EXAMINERS appointed to examine the CANDIDATES who presented themselves since last Return, for Admission to the ENGINEER'S ESTABLISHMENT and PUBLIC WORKS DEPARTMENT of *India* :”

“ Of the Names of the SUCCESSFUL CANDIDATES in Order of Merit, their respective Ages, Places of Education, and the Names of the CIVIL ENGINEERS to whom any of such Candidates have been Articled Pupils :”

“ And, of the MARKS assigned on each Subject to every Candidate ; and of the EXAMINATION PAPERS on each Subject (in continuation of Parliamentary Paper, No. 76, of Session 1863).”

India Office, }
17 July 1863. }

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

(*Mr. Adam.*)

Ordered, by The House of Commons, to be Printed,
21 July 1863.

2 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

CIVIL ENGINEER EXAMINATIONS.

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.

NAME.	AGE.	Place of Education.	Engineer to whom Articled, or under whom Served.
1. Mr. R. Gordon -	22	Not stated - - -	{ J. Woore, Liverpool. G. Forrester & Co., Liverpool. A. McLennan, Liverpool.
2. " A. F. Watson -	22	Glasgow University -	{ D. Smith, Glasgow. Wylie & Peddie, Edinburgh.
3. " A. N. Nimmo -	18	Dollar Institution - -	R. Thornton, Edinburgh.
4. " A. Izat - - -	19	Dollar Institution - -	J. Bell, North British Railway.
5. " S. D. Alexander	20	Queen's College, Galway	J. Wright, Westminster.
6. " G. Potheary -	21	Not stated - - - -	W. Humber, Westminster.
7. " C. Blair - - -	19	Dollar Institution - -	W. Robertson, Glasgow.
8. " W. C. Rennie -	19	{ Glasgow University Dollar Institution - - }	Bell & Miller, Glasgow.
9. " F. M. Avern -	18	King's College, London -	C. P. B. Shelley, Westminster.
10. " W. Scott - - -	22	Queen's College, Galway	A. Gahan, Omagh.

NUMBER OF MARKS assigned to each Candidate.

	Mathematics.	Civil Engineering.	Surveying and Levelling.	TOTAL.		Mathematics.	Civil Engineering.	Surveying and Levelling.	TOTAL.
1	366	320	103	789	14	256	270	74	600
2	256	335	147	738	15	252	283	65	600
3	382	260	93	735	16	207	295	85	587
4	371	265	75	711	17	286	235	54	575
5	242	330	137	709	18	203	275	79	557
6	275	300	108	683	19	176	305	61	542
7	283	315	82	680	20	176	270	67	513
8	323	290	63	676	21	131	285	66	482
9	224	335	99	658	22	110	270	58	468
10	272	275	96	643	23	212	190	56	458
11	343	245	49	637	24	80	270	72	422
12	218	310	94	622	25	84	190	26	300
13	312	230	69	611	26	52	235	1	288

PUBLIC WORKS DEPARTMENT—INDIA.

CIVIL ENGINEER ESTABLISHMENT.

EXAMINATION PAPERS for June 1863.

2 June 1863.

EUCLID.—Rev. J. Cape.

1. DEFINE *scalene triangle, acute angled triangle, rhombus, segment of a circle, and similar segments.*

2. Upon the same base, and on the same side of it, there cannot be two triangles that have their sides, which are terminated in one extremity of the base, equal to one another, and likewise those which are terminated in the other extremity.

3. If two triangles have two sides of the one equal to two sides of the other, each to each, but the angle contained by the two sides of one of them greater than the angle contained by the two sides equal to them of the other; the base of that which has the greater angle shall be greater than the base of the other.

4. Through a given point, to draw a straight line which shall make equal angles with two given straight lines.

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 without the triangle between the perpendicular and the obtuse angle.

If the obtuse angle C be a third part of four right angles, then

$$AB^2 = AC^2 + BC^2 + AC \times BC.$$

6. If two circles touch each other externally, the straight line which joins their centres shall pass through the point of contact.

7. If a straight line touches 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 which are in the alternate segments of the circle.

If two circles touch each other externally, and through the point of contact any two straight lines be drawn meeting both the circumferences, the chords of the two intercepted arcs will be parallel.

8. To inscribe an equilateral and equiangular hexagon in a given circle.

Compare the sides of an equilateral triangle, and an equilateral hexagon inscribed in a circle.

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

10. In right angled triangles, the rectilinear figure described upon the side opposite to the right angle, is equal to the similar and similarly described figures upon the sides containing the right angle.

11. If the four sides of a trapezium be bisected, the lines joining the points of bisection shall form a parallelogram, whose area equals half the area of the trapezium.

4 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

12. If two straight lines meeting one another be parallel to two other straight lines which meet one another, but are not in the same plane with the first two; the plane which passes through these is parallel to the plane passing through the others.

2 June 1863.

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

1. FIND the value of $\left[\frac{3\frac{1}{2}}{7} + \frac{2}{10\frac{1}{2}} - \frac{5}{18} \text{ of } \frac{4}{7} \right] \times 1\frac{1}{2}$.
2. Divide 234·375 by ·0375; and also ·0375 by 234·375.
3. What are the vulgar fractions which can be reduced to *finite* decimals; and what are those which produce *recurring* decimals? Find the vulgar fraction equivalent to the recurring decimal ·1272727.
4. Find the value of ·75 of a guinea + $\frac{3}{8}$ of 5 s. + 0·6 of 7 s. 6 d. - $\frac{1}{2}$ of 2 d.
5. If 11 cwt. can be carried 15 miles for a sovereign, how far can 23 cwt. 14 lbs. be carried for 9 l. 5 s.?
6. What is the difference between discount and interest? Required the *true* discount on a bill of 612 l. 15 s. due 6 months hence, at 4½ per cent. per annum.
7. Define *complement* of an arc, *sine*, *cotangent*, and *secant* of an arc.
8. In any plane triangle, the sides are to one another as the sines of the opposite angles.
9. Find from the tables the following quantities:—
 - (a.) Logarithm of 123·456.
 - (β.) Number corresponding to logarithm 3·456789, to six places of significant figures.
 - (γ.) Log sine of 123° 34' 50".
 - (δ.) Log cotangent of 55° 40' 40".
 - (ε.) Arc to log cosine 9·345678, to the nearest second.
10. In the triangle *ABC* whose sides are *AB* = 2569·2 links, *AC* = 4900·4 links, and *BC* = 5024·6 links: to find the angle *A* to the nearest second.
11. Explain the ambiguous case in plane triangles. When may the ambiguity be removed?
12. Wishing to know the height of a tower on the top of a hill, I took the angle of elevation of the top of the tower 51°, and of its bottom 40°; then measuring on a horizontal plane in a line directly from my first station to the distance of 250 feet further, I found the angle of elevation of the top of the tower to be 33° 45'. Required the height of the tower.
13. Find the area of the triangle given in the 10th Question, in acres, roods, and perches.
14. Find the area of the segment of a circle whose chord is 150 feet, and the arc contains 112° 30'.
15. The perambulator is so made as to turn twice in the length of 1 pole; required its diameter.
16. Find the whole superficies and the solid content of the frustum of a square pyramid, each side of the greater end being 20 feet, and each side of the lesser end 8 feet; also the perpendicular height being 8 feet.
17. What

17. What quantity of canvas is necessary for a conical tent, whose perpendicular height is 8 feet, and the diameter at the bottom 13 feet?

18. Required the number of cubic yards in an embankment, the transverse sections perpendicular to the axis being trapezoids, whose dimensions were as follows:

Horizontal lines at top, 22; 21·9; 21·6; 21·6; 21·8; 21·6; 22 feet.

Ditto - - bottom, 46; 46·9; 47·6; 50·2; 52·4; 55·2; 62 „

Perpendicular heights, 6; 6·3; 6·7; 7·2; 7·8; 8·4; 10 „

Also the common distance between two transverse sections was 50 feet.

4 June 1863.

ALGEBRA.—Rev. J. Cape.

1. Divide $x^4 - \frac{19}{6}x^2y^2 + \frac{1}{3}xy^3 + \frac{1}{6}y^4$ by $x^2 + 2xy + \frac{1}{3}y^2$.

2. Find the values of the following expressions:

$$(a). \frac{1}{2(x-1)} - \frac{1}{2(x+1)} - \frac{1}{x^2}$$

$$(b). \frac{x+y}{y} - \frac{x}{x+y} - \frac{x^2 - x^2y}{x^2y - y^3}$$

$$(c). \frac{a+c}{(a-b)(x-a)} - \frac{b+c}{(a-b)(x-b)}$$

3. Solve the equations:

$$(a). x - \frac{x-2}{3} = 5\frac{1}{2} - \frac{10+x}{5} + \frac{x}{4}$$

$$(b). \sqrt{5x+10} = \sqrt{5x} + 2.$$

4. From a certain sum I took away a third part, and put in its stead £.50. Again, from the sum thus augmented I took away one-fourth, and put in its stead £.70; I then found that I had £.120. What was the original sum?

5. Solve the simultaneous equations:

$$(a). \frac{4x+5y}{40} = x-y; \text{ and } \frac{2x-y}{3} + 2y = 20.$$

$$(b). 3x-4y+5z = 24; 5x-2z = 1; \text{ and } 7x+6y-4z = 23.$$

6. A and B engage together in play. In the first game A wins as much as he had, and 4s. more, and finds he has twice as much as B. In the second game, B wins half as much as he had at first, and 1s. more, and then it appears he has three times as much as A. What sum had each at first?

7. Solve the equations:

$$(a). \frac{8}{x-3} - \frac{10}{x+5} = 3.$$

$$(b). x^2 + xy + y^2 = 84; \text{ and } x + \sqrt{xy} + y = 14.$$

8. A vintner sold 7 dozen of sherry and 12 dozen of claret for £.50. He sold three dozen more of sherry for £.10 than he did of claret for £.6. Required the price of each.

9. If 4 quantities, a, b, c, d be proportionals, they are also proportionals by composition, and division; that is,

$$a + b : a - b :: c + d : c - d.$$

10. The distance between two towns is 159 miles. The first day a person travels from one town towards the other 16 miles, the second day 15½, the third day 15, and so on. In what time will the journey be performed?

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11. If a be the first term, r the common ratio, the number of terms, and s the sum of a series in Geometrical progression: prove that

$$s = a \frac{r^n - 1}{r - 1}.$$

Sum the series $1 - \frac{1}{2} + \frac{1}{4} - \frac{1}{8} + \&c.$, to infinity.

12. Find the values of

(α) $\sqrt{243} - \sqrt{27} + \sqrt{75}.$

(β) $ab \times \left[a\sqrt{a + \sqrt{c}} \right] \times \left[b\sqrt{a - \sqrt{c}} \right].$

(γ) The cube of $2\sqrt{a} + 3\sqrt[3]{x}$

13. How many different numbers can be made out of two 2's, three 3's, and four 4's, supposing all the figures to be in every number.

14. Raise $2a^2 - \sqrt{x}$ to the 6th power by the binomial theorem.

4 June 1863.

MECHANICS AND HYDROSTATICS.—Rev. J. Cape.

1. Explain what is meant by the *parallelogram of forces*. And supposing the proposition already demonstrated as to the *direction* of the resultant; prove that it is also true as to its *magnitude*.

2. If any number of forces in the same plane acting on a point be represented in magnitude and direction by the sides of a polygon taken in order, they will be in equilibrium.

3. Four forces in the same plane, and represented by the numbers 10, 20, 30, 40 taken in order, act on a point. The directions of the first and third are at right angles to each other; and so are the directions of the second and fourth; and the second is inclined at an angle of 60° to the first. Find the magnitude and direction of the resultant.

4. A weight W is supported by two strings, which passing over two fixed pullies A, B not in the same horizontal line, have two weights P, Q at their other extremities; find the position of W , when at rest.

5. From a given rectangle of uniform thickness, to draw from one of its angles a line cutting off a triangle, so that the remaining trapezoid when suspended by the obtuse angle may hang with its parallel sides horizontal.

6. What are the requisites of a good balance? Investigate an expression which will show how these requisites may be obtained.

7. When a body is sustained upon an inclined plane, the power : the weight :: $\sin \alpha$: $\cos \epsilon$; α being the inclination of the plane to the horizon, and ϵ the angle which the string makes with the plane.

8. Prove that the principle of *virtual velocities* is true in the case of the inclined plane, the string being parallel to the plane.

9. To determine the horizontal thrust on the tie beam AD of the roof $ABCD$; of which the rafters AB, CD are equal, and BC is horizontal.

10. To determine the transverse strain of any beam fixed horizontally in a wall, when a weight is suspended at its extremity, the weight of the beam being neglected, and every particle at the instant of fracture exerting an equal force of cohesion.

Hence, on this hypothesis, show that a joist laid on its narrow edge b , is stronger than when laid on its flat side d , in the proportion of d to b .

11. Define

ADMISSION TO ENGINEER'S ESTABLISHMENT, &c. (INDIA). 7

11. Define *mass*, *weight*, *velocity*, and *momentum*; and prove that in the direct impact of two bodies, the momentum gained by one body, is equal to the momentum lost by the other.

12. *A* and *B* are perfectly elastic, and *A* with a velocity of 20 feet per second, strikes *B* at rest; find their velocities after impact—1st, when $A = B$; 2nd, when $A = 4B$; and 3d, when $A = \frac{1}{4}B$.

13. If a body be moved from a state of rest by a constant accelerating force, the space described from the beginning of the motion is as the square of the time.

Find the velocity acquired in 10 seconds, when a body falls from rest; and also the space described in the last second.

14. If a clock loses 30 seconds in 12 hours, how much must the pendulum be shortened to make it keep true time?

15. Explain *labouring force*, *unit of work*, *horse-power*, and *vis viva*. And prove that when any pressure acts upon a body, the labouring force is proportional to the vis viva which would be generated by this pressure acting through the same space.

How much labouring force is necessary to raise 85,000 gallons of water from a mine whose depth is 80 fathoms?

16. Prove that the surface of every fluid at rest is horizontal; and if there be two fluids of different densities in the same vessel which do not mix, their common surface also will be horizontal.

17. Find the centre of pressure of any plane surface.

In a rectangle placed vertically in water, having the upper side coinciding with the surface of the fluid, prove that the centre of pressure is at two-thirds of the depth of the lower side from the surface.

18. Explain the methods of determining the specific gravities of different bodies, whether solid, liquid, or gaseous.

A piece of copper weighs 62 grains in air, and 55 grains in water; required its specific gravity.

19. The density and elastic force of any gas at a temperature of 32° being given; to find the elastic force for any other temperature and density.

20. Explain the construction of the *common pump*, the *lifting pump*, and the *forcing pump*. What is the use of the air vessel?

EXAMINATIONS for CIVIL ENGINEER ESTABLISHMENT, INDIA. 1863.

Examiner—Colonel *H. Yule*.

All dimensions in these questions and surveys are in feet, if not otherwise specified.

5 June.

LAND SURVEYING AND PLOTTING.

1. (See Fig. 1.) A B C D E F G is in a regular field:

a. Detail how you would make an accurate plan of it;

1st. With chain only.

2d. With chain and compass.

b. Reduce the figure geometrically so that its area can be computed at a single calculation.

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2. In measuring with the chain only, you find your line intersected by an inundated pond, which your chain cannot span :

a. Show how you will continue your measurement across the water without wetting yourself.

b. Determine for your field-book the offset position of an obelisk standing in the water to the left of your line.

3. Plot the field book of the fragment of (chain and compass) survey shown in Fig 2. Scale 200 feet to an inch.

TRIGONOMETRICAL SURVEYING.

4. One of your triangulation points in a survey may be a church spire. When you come to observe from that station you cannot place your instrument on the spire, but you can place it (say) on the tower at its base. Detail the process of correction for the observation thus made.

5. It is a rule in accurate trigonometrical survey that no important triangle should have any angle less than 30° , or greater than 90° . Why? Illustrate your reply by a diagram.

6. Explain the principle of the Vernier.

7. Fig. 3. represents the plot of a small survey, for which the base A B was 2,000 feet in length ; the scale being 500 feet to an inch.

a. On this base construct, to the best of your judgment, a triangulation, which shall fix at least *ten* points in the survey exclusive of A and B. Set down the details of the process of calculating all triangles necessary for the accurate determination of these points, so that nothing would remain to be done but to fill in the proper figures. No actual figures need be entered.

b. Explain how you would proceed, after triangulation, to fill in the details of the survey, by traverse with theodolite and chain ; and complete as much as time will allow of actual field book, from which the survey might be plotted.

8 June 1863.

LEVELLING.

8. *a.* Explain the corrections theoretically applicable to any operation of levelling. *b.* Do these corrections operate in the same direction? *c.* Is it necessary to apply these corrections in ordinary observations with the spirit level for sections of ground, and why is it necessary or unnecessary?

9. In the absence of a regular levelling instrument what means would you make use of to obtain an approximate section of ground?

10. What arrangement is best as to the relative distance of your levelling instrument from the back-staff and fore-staff when you can choose? and why?

11. You are directed to select a line of road in a mountainous and uncleared region. Give some description of the way you would set about it, mentioning the instruments you would use.

12. I wish to ascertain if it is practicable to drain a stagnant pond A, by a long culvert into a river B, from which it is separated by undulating ground. The direct line is much built upon, and I follow the open ground. The following is my field-book. Plot the levels on a horizontal scale of 200 feet to an inch, and vertical scale of 10 feet to an inch. What will be the length and slope of the culvert if made in a straight line to the river? Fill up columns of rise, fall, and reduced level.

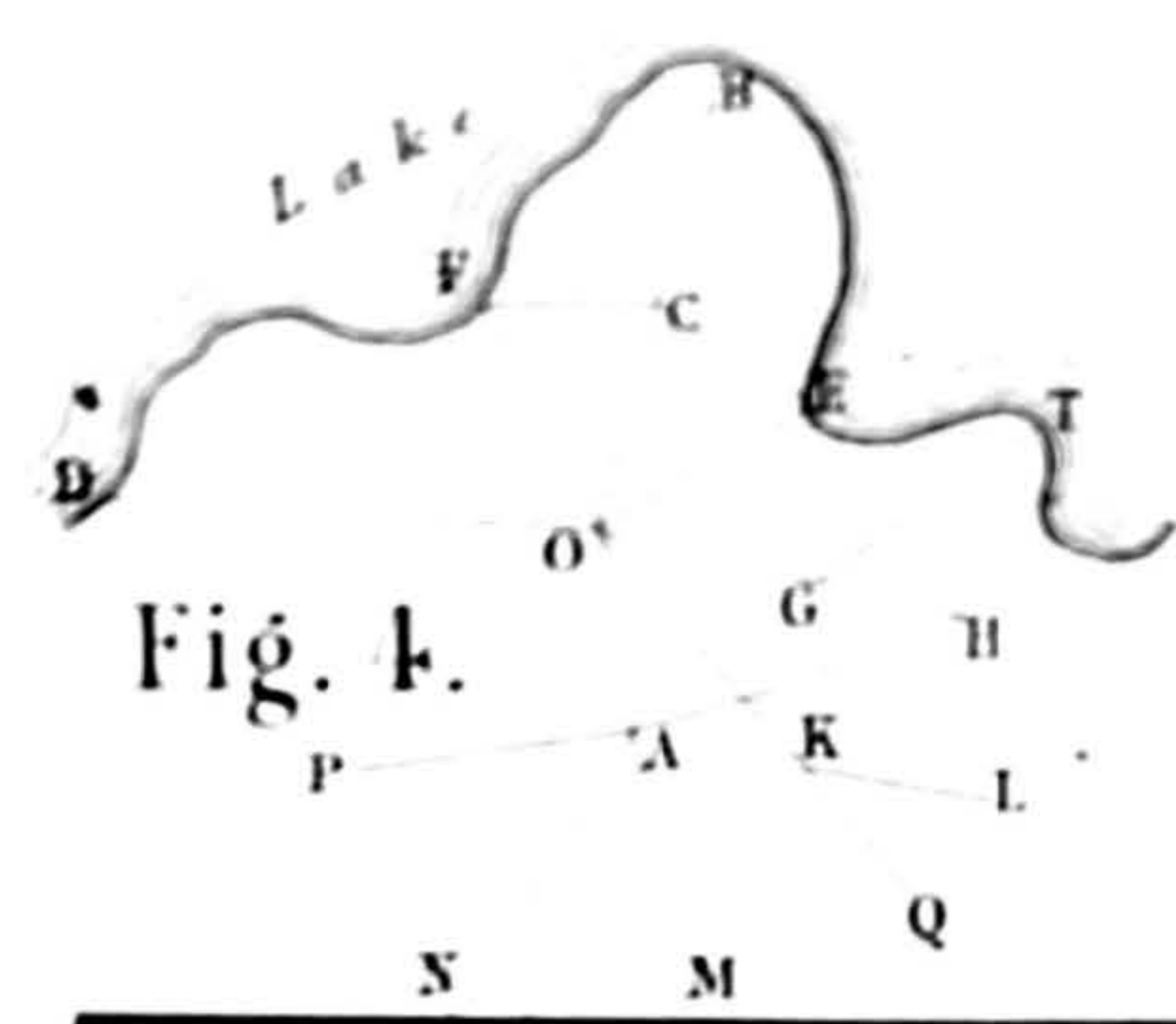


Fig. 4.

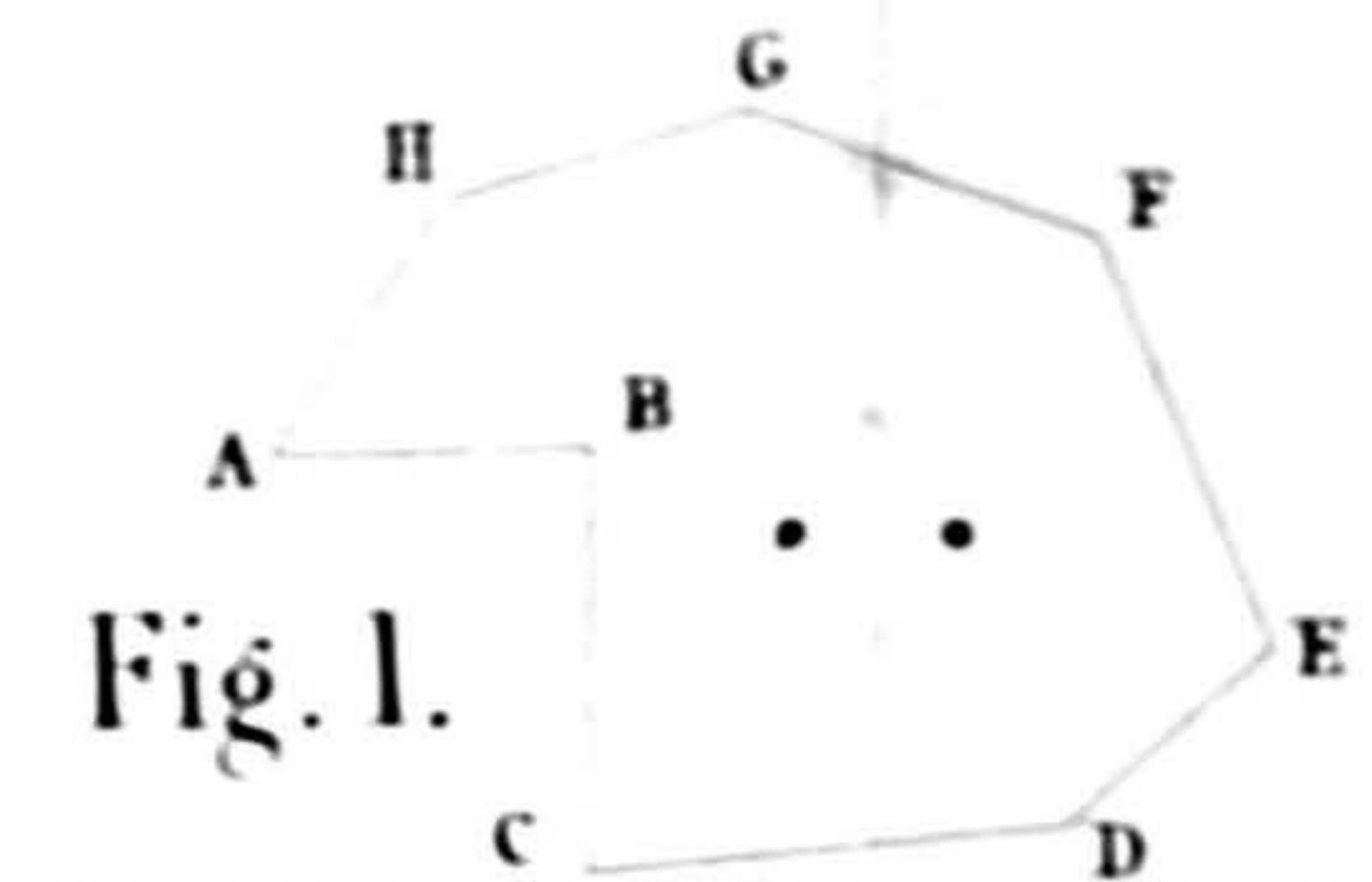
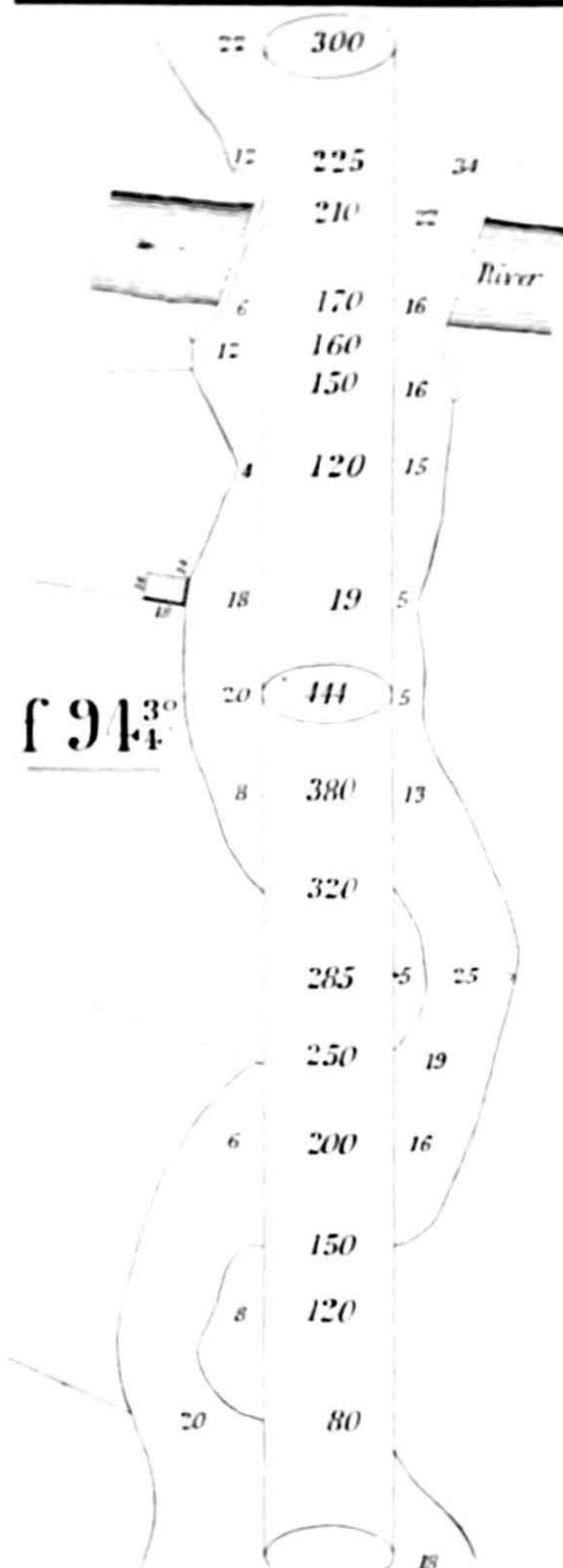
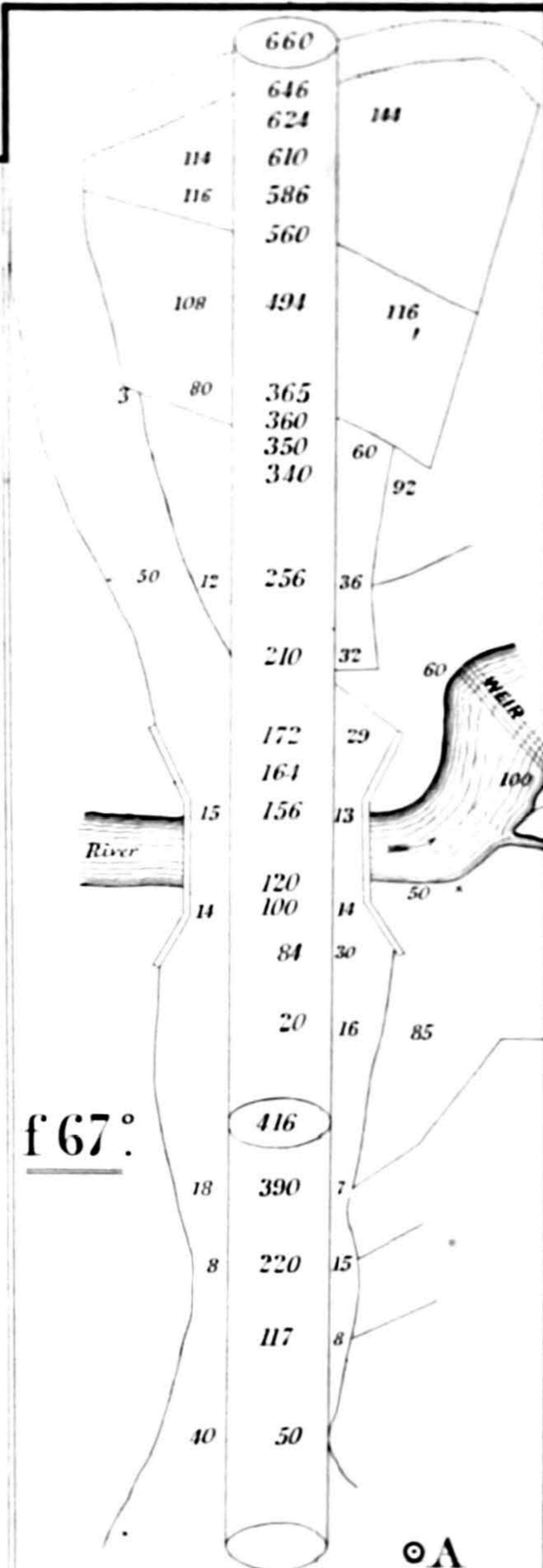


Fig. 1.



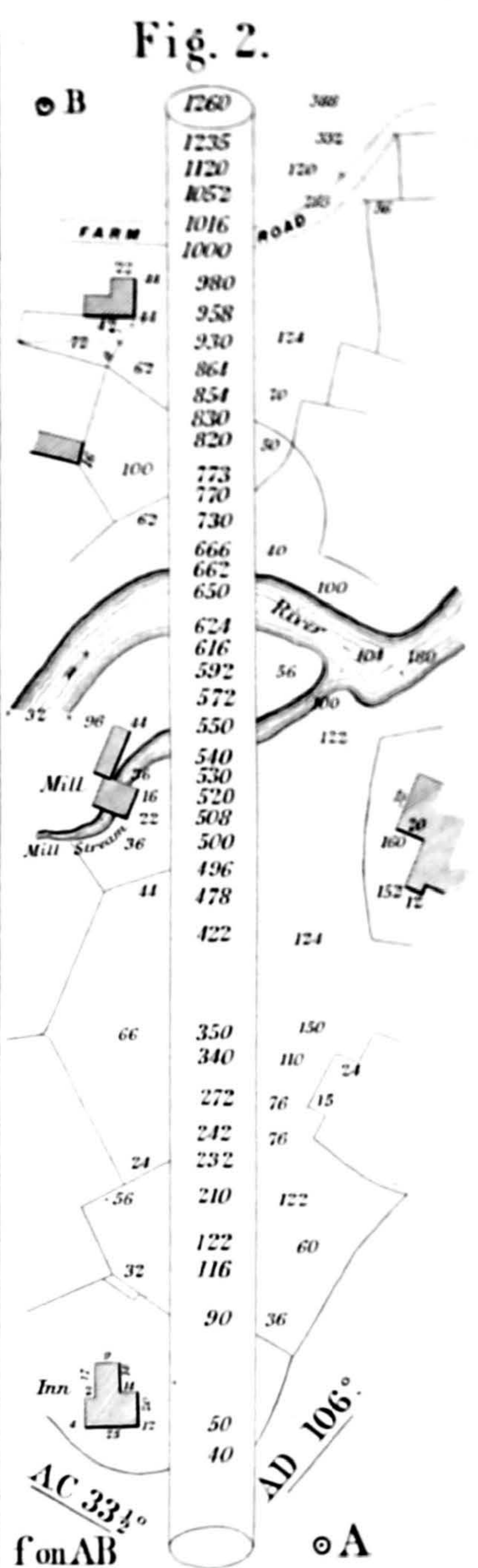
f 94³/₄

Return to $\odot A$ and proceed on AD



f 67^o

Return to $\odot A$ and proceed on AC



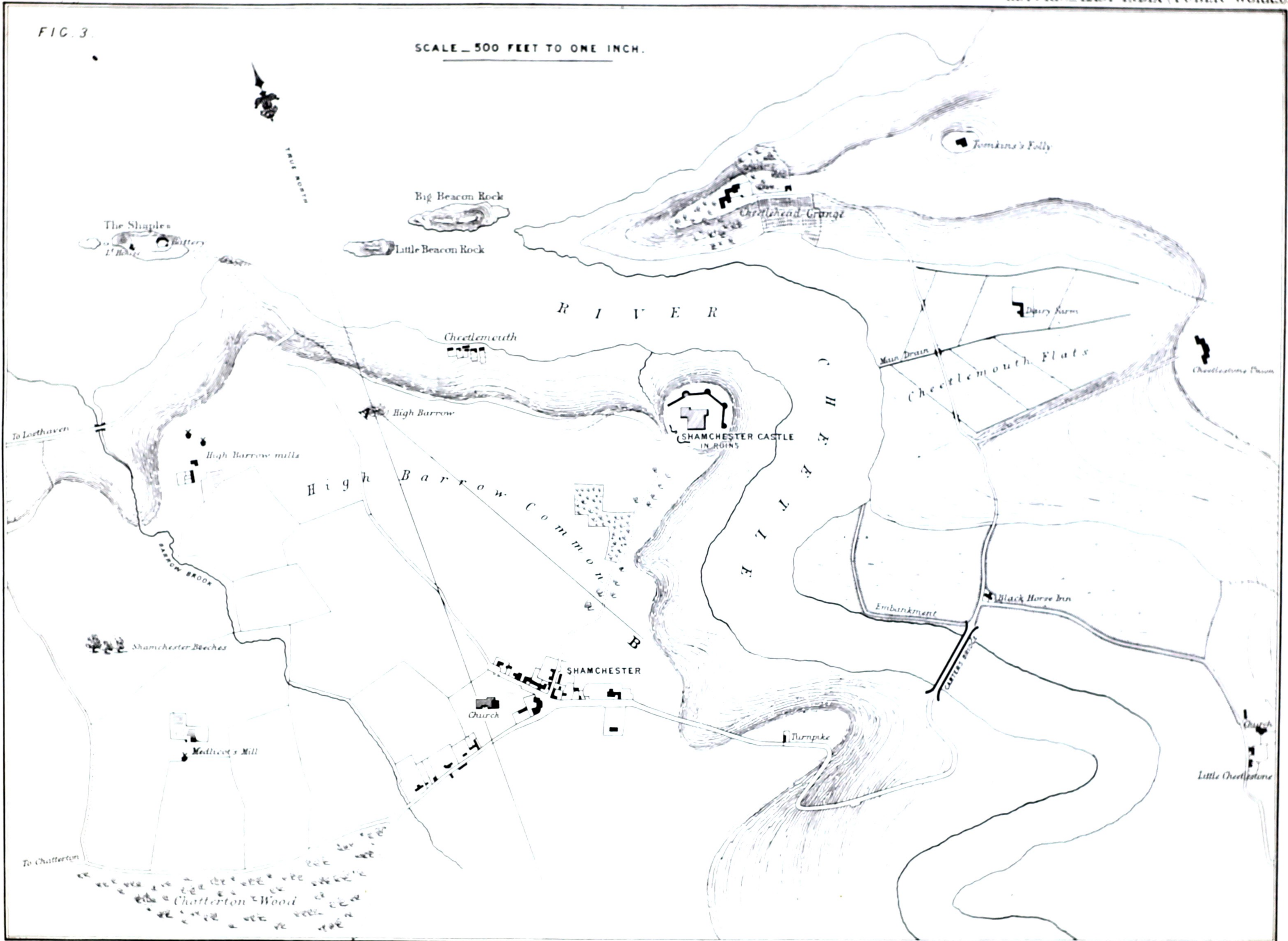
f on AB 74¹/₄

Mag North bearing 0^o

Commence at Station A on cross-roads in front of Inn.

FIG. 3.

SCALE - 500 FEET TO ONE INCH.



To face page 8.

Rough Sketches Not to Scale See Question N^o 15.

FIG. 5.
Elevation

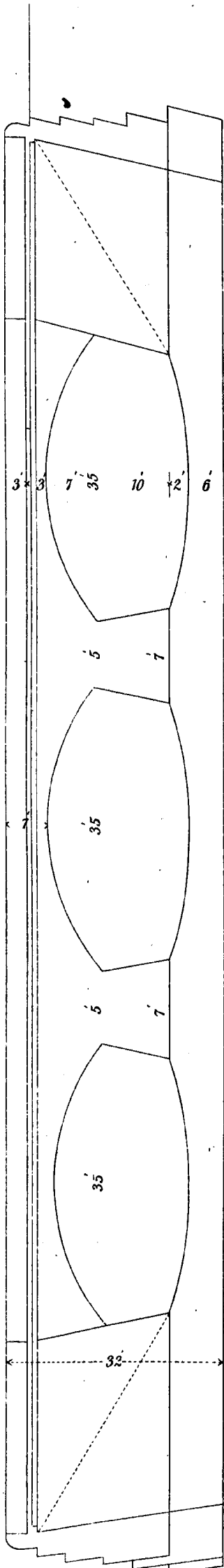


FIG. 8.
Section of Abutments

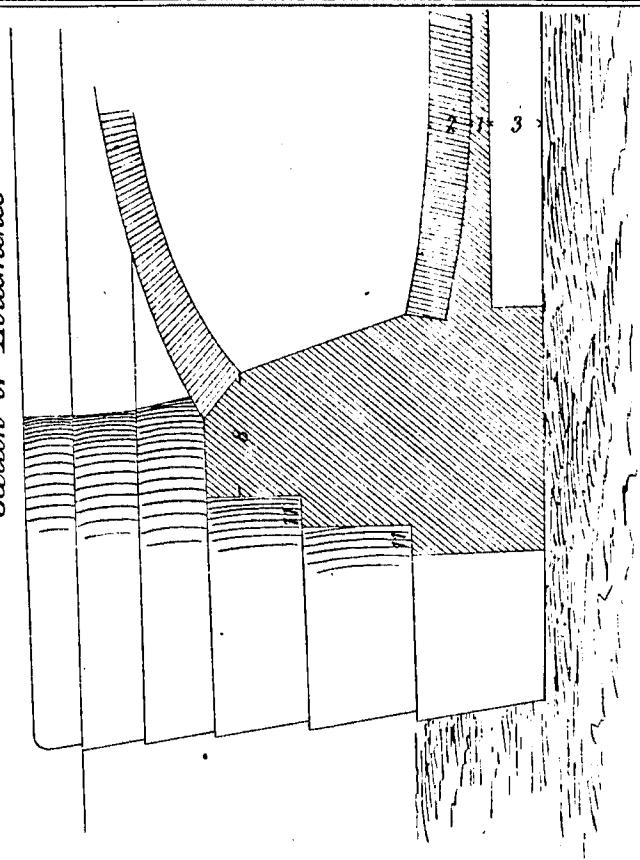


FIG. 7.
Plan of Wing

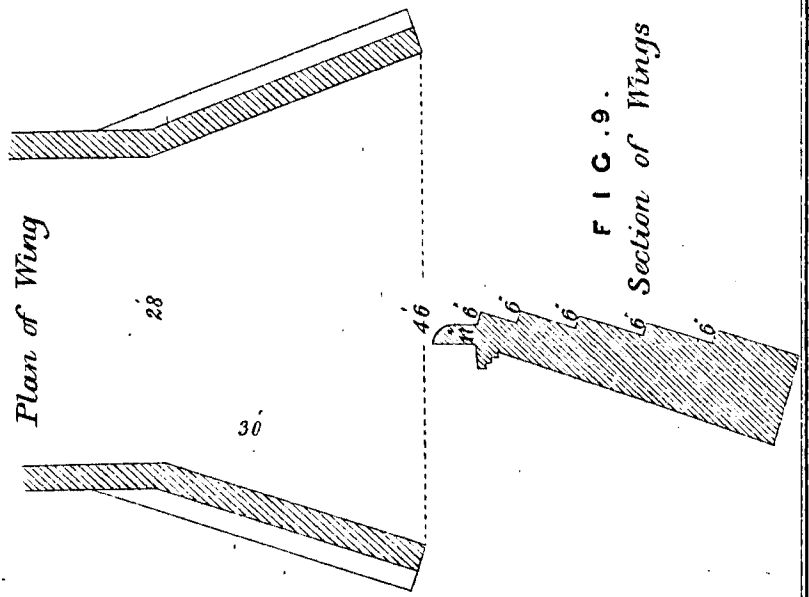


FIG. 9.
Section of Wings

FIG. 6.
Section

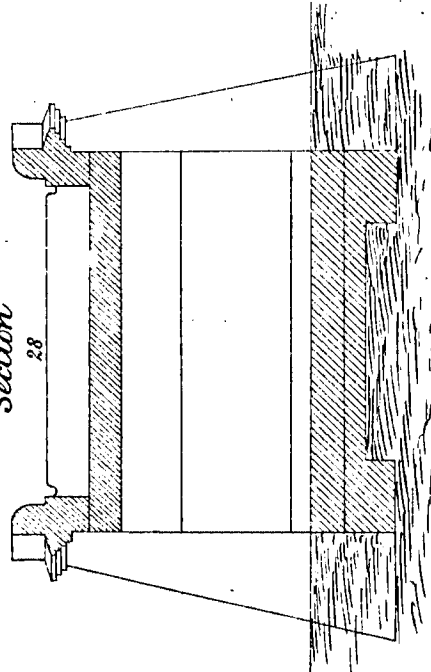
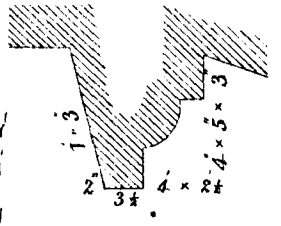


FIG. 10.
Cornice



FIELD BOOK OF LEVELS.

No. of Station.	BACK.			Instrument.	FORE.			Rise.	Fall.	Reduced Level.	REMARKS.
	Bearing.	Distance.	Level.		Level.	Distance.	Bearing.				
1	272°	120	10.25	4.95	4.05	120	92°				<i>Datum assumed 50 feet below level of pond.</i> No. 1 Back is at water-level of pond. Pole in deepest part of pond bears from No. 1 300°, and is 400 feet distant. Greatest depth 8 feet. No. 7 Fore is at highest ordinary level of river.
2	286°	120	6.46	-	5.19	60	84½°				
3	307°	60	4.02	5.65	7.10	120	127°				
4	307°	100	7.73	5.38	10.46	100	180½°				
5	0½°	120	4.20	5.02	7.63	50	205°				
6	8½°	50	6.89	4.96	5.25	120	214°				
7	34°	62	2.44	-	11.56	62	214°				

13. The following notes of bearings and measurements have been taken, in order to lay down the contours of a piece of rising ground. *a.* Lay down the plan of contours in ink, on a scale of 200 feet to an inch, and shade in the form of the hill with pencil, over these contours. *b.* Also draw a section on the line B O, O M.

[Note.—The contours are at vertical intervals of 10 feet. The contours, commencing from above, are marked (a), (b), (c), &c. See Diagram, fig. 4.]

BEARINGS.	Distances at which Contours are intersected.					REMARKS.
	(a)	(b)	(c)	(d)	(e)	
From highest point O, O B bears 11½°, and intersects contours at -	48	114	240	375	555	At 795 strikes lake 7.5 feet below (e). At 336 strikes lake.
" " O E " 60° " -	42	108	159	189	222	
" " O H " 108° " -	66	186	231	255	273	
" " O Q " 125° " -	72	318	372	423	477	
" " O M " 164½° " -	87	228	288	330	354	
" " O D " 276° " -	48	108	231	345	483	
" " O F " 325° " -	33	63	120	159	192	At 267 strikes lake.
From A, a point on O M, 144 feet from O - A P " 265° " -	-	72	141	198	228	
" " A N " 207° " -	-	135	255	387	447	
" " A H " - " -	-	132	159	189	219	
From G, a point on O H, 186 feet from O - G T " 57° " -	-	-	75	126	180	At 330 strikes lake.
" " G E " - " -	-	-	66	87	114	
From C, a point on O B, 240 feet from O - C E " - " -	-	-	72	135	177	
" " C F " - " -	-	-	-	60	96	
From K, a point on O Q, 318 feet from O - K L " 100° " -	-	-	60	147	249	

GEOMETRICAL DRAWING.

14. Construct accurately a scale of feet, inches, and sixteenths of an inch, on the diagonal principle. The foot to be made = ⅔ of an inch.

15. From the data given in the rough sketches (Figs. 5 to 10), represent the bridge shown therein in isometrical perspective on a scale of 20 feet to an inch.

10 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 June 1863.

George Preston White, C.E., Examiner.

[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. In those cases in which free-hand sketches or diagrams are used to illustrate the subject, it is requested that they may be carefully executed, in order to show the Candidate's proficiency in this style of Drawing. Candidates must not, during the Examination, refer to any book or MS., nor communicate with each other; their doing so will disqualify them. Candidates are required to produce *bonâ fide* finished drawings, with certificate, respecting which there will be a *vivâ voce* examination.]

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.

RAILWAY ESTIMATES.

— Calculate the quantity of earthwork in the accompanying Table; explain how the Tab. Numb. is obtained, and the different modes of calculating earthwork.

Cuttings.

Base 30 feet. Slope $1\frac{1}{2}$ to 1.

Number on Section.	Depths.		Lengths in Links.	Tab. Numb.	Cont. C. Yds.	Total in C. Yds.	Price.
1	0	22	7.00	21.19			
"	22	28	8.00	62.76			
"	28	17	15.00	53.69			
"	17	0	29.00	14.80			
2	2	7	20.00	6.24			
"	7	9	10.00	12.46			
"	9	3	10.00	8.83			
"	3	7	20.00	7.02			
"	7	7	15.00	10.50			
"	7	2	15.00	6.24			
3	3	9	25.00	8.83			
"	9	2	25.00	8.02			
"	2	8	10.00	7.11			
"	8	7	5.00	11.46			
"	7	0	10.00	4.80			
4	4	16	20.00	17.33			
"	16	16	20.00	32.00			
"	16	25	25.00	46.50			
"	25	23	20.00	58.69			
"	23	0	10.00	22.57			

£. s. d.

RAILWAY ESTIMATES.

Fill up the prices and amount in the accompanying Table for a Parliamentary Railway Estimate, and state at what distances usually it becomes desirable to throw stuff to spoil, and use side cutting.

Base, 30 feet. Slopes, 1½ to 1.

Number on Section.	Contents in Cube Yards.	Material.	Where taken to,	Average lead in Chains.	Price per Cube Yard.	Amount.
					£. s. d.	
1	18,334	Brown and blue clay	No. 1 Bank -	20 chains		
"	43,118	Ditto - ditto -	No. 1A Bank -	40 "		
"	301	Ditto - ditto -	No. 2 Bank -	8 "		
	5,600	Ditto - ditto -	{Subsidence in No. 1A Bank 10 per cent. on contents -}	40 "		
	19,500	{Stuff for burning into ballast for 1 mile 5 furlongs, includ- ing fork, or to widen bank -}		40 "		
	37,507	{Clay to spoil or to widen banks -}				
2	12,000	{Stuff for burning into ballast for 1 mile up to 2d mile, or to go to spoil -}		40 "		
	36,128	Clay - - -	To spoil - -			
3	786	Yellow and blue clay	No. 3 Bank -	8 "		
"	12,000	{Stuff for burning into ballast for 1 mile to 3d mile, or to go to spoil - -}		40 "		
"	26,660	Clay - - -	To spoil - -			
4	88,229	Yellow and blue clay	No. 4 Bank -	60 "		
"	9,577	Ditto - ditto -	{Subsidence in No. 4 Bank 10 per cent. on contents -}			
"	24,000	{Stuff for burning into ballast for 2 miles up to 5 miles, or to spoil bank - -}		40 "		
"	112,402	Yellow and blue clay	{To widen banks or to spoil -}	40 "		
TOTAL - - -					£.	

RAILWAY ESTIMATES.

Fill up the prices and carry out the amounts in the accompanying columns, for a Parliamentary railway estimate.

No.	Description.	Road.	Span.	Quantity.	Price.	Amount.	Total Amount.
	Parish road level crossing } at 25 miles 1½ fur., gates, culverts and cottage - }					£. s. d.	£. s. d.
	Road diverted, including } metalling and fencing } on one side - - }			L. Yards 270			
	Earthwork to approaches			C. Yards 600			
	One road bridge at 25 } miles 4¼ fur. in 12 feet } embankment, brickwork } in bridge - - - }	25	12	C. Yards 350			
	Backing up bridge, ex- } cavated approaches, and } metalling roadway - }						
	3 feet culvert in 14 feet } embankment at 25 miles } 4¼ fur. - - - }			L. Yards 25			
	2 feet culvert at 25 miles } 6½ fur. in 10 feet em- } bankment - - - }			L. Yards 20			
	Parish road level crossing } in 8½ feet embankment } at 25 miles 7 fur., in- } cluding gates, culverts } and cottage - - - }						
	Earthwork - - -			C. Yards 3,000			
	Metalling - - -			S. Yards 1,250			
	Single fencing - -			L. Yards 276			
	2 feet culvert at 25 miles } 7¾ fur. in 7 feet bank - }			L. Yards 20			
				TOTAL - - £.			

Make an estimate for one mile of double railway.

	£. s. d.	£. s. d.
Tons of rails, 75 lbs. to the yard - - - - at		
Tons of chairs - - - - - "		
Sleepers - - - - - "		
Cube yards of ballast - - - - - "		
Lineal yards double road laying, including pins and keys "		
Lineal yards double 4-rail fencing, including quick mound and ditch - - - - - "		
Field gates and making good fences, say - - - -		
Trespass and compensation for damage by carting - - - -		

Roofs.

5. Make a free-hand sketch of a Mansard roof, an M roof, and a Hammer-beam roof, and explain the object of the hammer-beam.
6. Explain the objects of the following parts of a roof, viz., king post, queen post, tie beam, straining beam, rafters, purlins, braces, ridge piece, struts; and make a free-hand sketch of a truss for a roof 45 feet span, showing the connexion of the different parts, and explain the different strains.
7. Give the names of some remarkable examples of roofs in wood and iron, stating the span.
8. Make a free-hand sketch to show the mode employed to counteract the thrust and settlement in a mediæval roof, that is where an ordinary horizontal tie beam cannot be introduced.

Irrigation.

9. In carrying out works of irrigation in tropical countries, state what are the chief circumstances requiring attention.
10. 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.
11. 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. What is the maximum and minimum gradient per mile you would recommend for the main canals in works of irrigation?
13. Assuming the evaporation in Southern India to be half an inch per day, how many tons of water would be evaporated from an acre of land completely irrigated per day?

Foundations.

14. Describe the different methods in practice for making foundations under water. State the comparative advantages of the different systems, and make free-hand sketches to illustrate the subject.
15. State which are the best and which are the most difficult soils to form foundations on.

Bridges and Viaducts.

16. Describe the different forms of girder, viz.:—The trellis, the Warren, the tubular, the bow and string, and Brunel's girder; state the comparative advantages and cost.
17. What are the circumstances which would guide you in employing cast iron, wrought iron, stone, brick, timber, or wire, in the construction of bridges and viaducts?
18. Make a design for a centre, of simple construction, for a brick elliptical arch of 50 feet span and 20 feet rise, and name any important example of bridge centering.
19. Give transverse sections of the best forms for girders of cast, wrought, and boiler plate iron, and state the general results arrived at from the experiments of Messrs. Stephenson, Fairbairn, Hodgkinson, and Barlow.

Miscellaneous.

20. Enumerate some of the scales most commonly used for plans, elevations, and sections.
21. In what strata is coal, iron, lead, copper, tin, fire-clay, most commonly found? What are the surface indications of the existence of minerals? State

14 PAPERS RELATING TO EXAMINATION OF CANDIDATES FOR

briefly the usual methods employed for exploring, working, draining, and ventilating mines; and describe the principle of the Davy lamp.

22. Explain the uses of the fly-wheel, the governor, and the parallel motion of a steam engine; make free-hand sketches of the two latter, and state by whom they were invented.

23. How is pig-iron, wrought-iron, and steel manufactured; and what is the object of employing the hot blast. Give the letters or marks used in the trade, and in specifications to denote the different qualities of iron.

24. State how you would test a wrought-iron and cast-iron bridge-girder; what load per foot run you would subject it to; and what is the weight of a platform loaded with men per square yard.

25. What is superheated steam, and what is the object of employing it? What is the advantage of working steam expansively?

26. Describe the materials employed in the manufacture of bricks; the mode of manufacturing and burning bricks; the names of the different qualities; and what constitutes good bricks.

27. Give the names of standard professional works of reference on the following subjects:—

Architecture.	Limes, mortars, and cements.
Bridges of brick, stone, timber, cast and wrought-iron and wire.	Masonry.
Building materials.	Mining.
Carpentry.	Machinery.
Canals of navigation and irrigation.	Preserving timber from dry rot and decay.
Drainage.	Road making.
Engineering biography.	Railways.
Engineering reports.	Surveying.
Embanking land from the sea and from rivers.	Specifications.
Foundations.	Strength of materials.
Harbours.	Steam engine, locomotive and stationary.
Iron (manufacture of).	Tunnelling.
India, reports on public works, and works of topography.	Tables for earthwork, quantities, and to facilitate calculations, &c.
Law of contracts.	Water supply to towns.
Lighthouses.	

28. Explain the meaning of the following terms:—Abutment, adit, level, ashlar, backing, balustrade, batten, batter, bay, bond, bracket, breaking joint, bressumer, butting joints, buttress, caisson, camber, cantalever, crank, catenary curve, chamber (lock), clamp, coffer dam, collar beam conduits, coping, cornice, counterforts, coursed masonry, cross beam, culverts, deflection, discharging arch, dove-tail, dry rot, eaves, entablature, extrados, fascines, façade, fender piles, flying buttress, footings, gable, girder, groin, groined arches, grillage, grout, Gunter's chain, grooved and tongued, hammer-beam, haunches of an arch, headers, herring-bone work, hip roof, intrados, invert, joggle joint, key, lewis, malleability, neutral axis, pediment, pilaster, pontoon, puddling, purlins, puzzolana, quoins, rafters, rendering, retaining walls, ruling gradient, scantling, scarfing, soffit, spandrel, specific gravity, springing course, strut, templet, tensile strain, tie beam, torsion, truss, under pinning, wire gauge, water shed, spigot, and faucet joint.

29. Name some of the principal works of the following Civil Engineers:—Sir Cornelius Vermuyden, Sir Hugh Myddleton, James Brindley, James Watt, John Smeaton, John Perry, William Murdoch, Ralph Walker, R. Trevethick, Joseph Huddart, William Jessop, William Chapman, Robert Mylne, Thomas Telford, John Rennie, Alexander Nimmo, Sir Mark Isambard Brunel, George Stephenson, Robert Stephenson, M. P., Joseph Locke, M. P., Robert Stevenson of Edinburgh, Sir William Cubitt, Isambard Kingdom Brunel, Sir John Rennie, Sir John Macneill.

30. Explain the principle of the Artesian well, the cause of the water in some instances rising above the surface of the ground, the usual mode of construction, and the best water-bearing strata.

31. Name

31. Name the best kinds of stone for building, specifying those most durable for works under water.

32. Describe the characteristics of the different kinds of timber employed in building, and state their comparative cost and durability.

33. Name the different kinds of lime and cement used in building ; describe their properties, and specify those which are hydraulic. What is the chemical difference between ordinary and hydraulic limes? Explain how artificial hydraulic limes can be made, according to the experiments of Vicat and others; and state how you would test the quality of limes and cements.

34. Describe the advantages of the slide-rest principle, and mention some of its most important applications to machinery.

35. Describe the means employed in Holland and other countries for em-banking land from the sea and from rivers.

36. Explain the various means employed for improving the navigation of rivers ; and describe some successful example, such as the Clyde.

37. Describe the usual means employed for raising water ; state what per centage of useful effect can be obtained respectively from overshot, breast, and undershot wheels, and from the turbine; and describe their comparative advantages, and the head of water required.

38. Explain the different systems employed for supplying towns with water, and give examples.

39. Explain briefly the principal features of the system for the drainage of London now being carried out by Mr. Bazalgette.

40. Describe briefly the principal parts of the locomotive engine ; and state the improvements introduced by Stephenson.

[The candidates were required to make a finished drawing on the accom-panying skeleton map.]

EAST INDIA
(PUBLIC WORKS DEPARTMENT).

RETURNS of the Names of EXAMINERS appointed to examine the CANDIDATES who presented themselves, since the last Return, for Admission to the ENGINEER'S ESTABLISHMENT and PUBLIC WORKS DEPARTMENT of *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. 76, of Session 1863).

(*Mr. Adam.*)

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