PART II.

No. 1.—Description of the Trace Computer, designed by Mr. Galton.

(Constructed by Messrs. Beck, 31, Cornhill.)

This instrument, which is at present employed in deducing and dotting out a vapour tension trace from the corresponding traces of the dry and wet bulb thermometers, is applicable to all kinds of similar work, by using appropriate templets. It may be used to deduce and dot out a trace, whose ordinates shall be any given function of the ordinates of two other independent traces, the abscissæ of all three being identical.

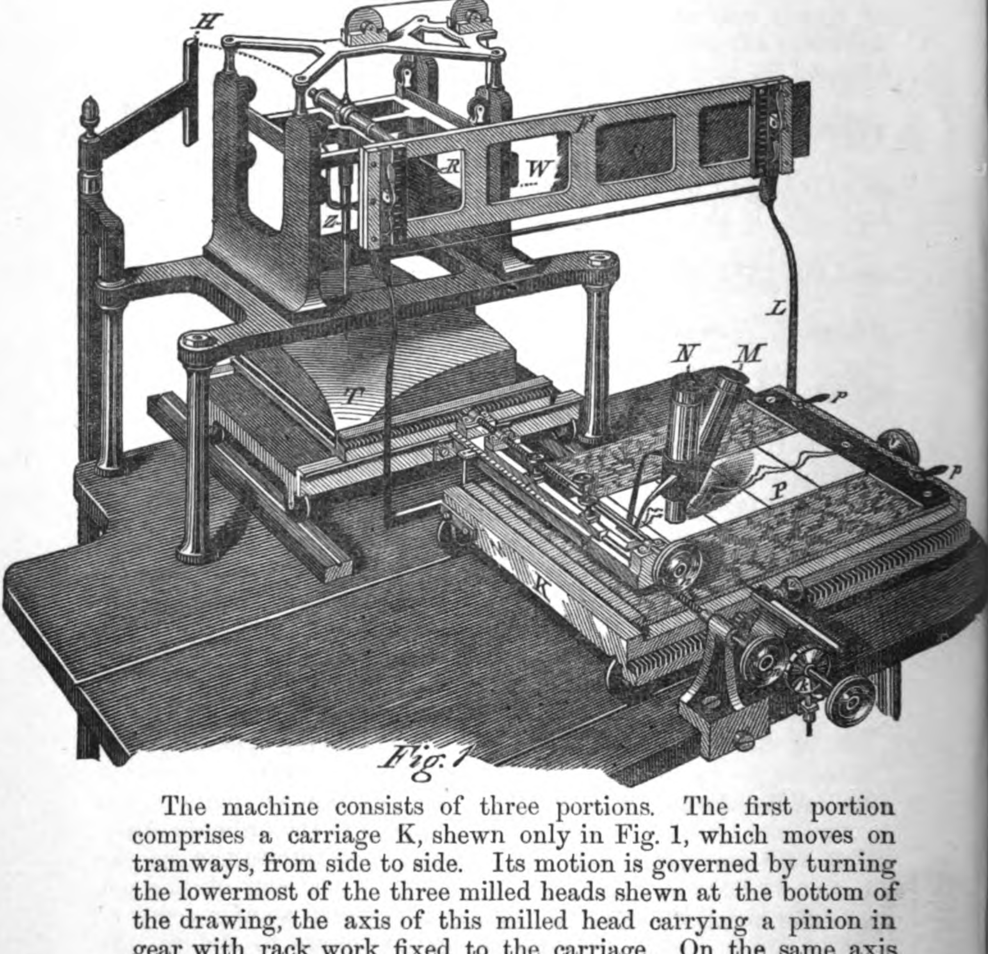

Fig. 1

The machine consists of three portions. The first portion comprises a carriage K, shewn only in Fig. 1, which moves on tramways, from side to side. Its motion is governed by turning the lowermost of the three milled heads shewn at the bottom of the drawing, the axis of this milled head carrying a pinion in gear with rack work fixed to the carriage. On the same axis another wheel is attached, it is the middle one of the three wheels shown at the bottom of the figure, and is marked *k*; this has notches into which a light spring falls as a click, to enable the operator to move the carriage through definite small steps. On the carriage K, a stage is mounted, so as to slide to and fro upon it, by turning the milled head just seen at the extreme right hand of the carriage and marked V. This stage has clamps *p*, *p*, and is otherwise conveniently arranged for holding firmly a row of five zinc templets, marked P, on which the dry and wet bulb traces have previously been scratched, by the pantagraph, invented by myself (see Report for 1871, p. 31.) To the carriage K is attached a vertical frame F, parallel to the front of the instrument, by means of two standards, of which the outside one is marked L in the drawing. Into the frame F is slipped a long zinc plate Q, intended to receive the trace to be dotted out by the machine. This plate is imperfectly shown in the figure, to enable the machinery to be drawn, which lies behind it. It is represented as not being quite thrust home, which accounts for the piece projecting on the right of the frame, and all the left hand part of it is broken away out of the frame, its position being indicated only by the jagged edge lying under, and to the left of, the letter F. It follows, from this description, that the plate which receives the trace of vapour tension, and that bearing the wet and dry thermogram traces, move together, and therefore the intersections of all three of them by any vertical plane, parallel to the sides of the instrument, will give ordinates having identical abscissæ. Now the optical position of the cross wires of the microscope M, which is directed on the dry bulb trace, that of the microscope N, which is directed on the wet bulb trace, and the pricker R, which dots the vapour tension trace, are, by the construction of the instrument, always in the same vertical plane, parallel to the sides of the instrument, and therefore in every position of the carriage they deal with ordinates having identical abscissæ.

The second stage is shown in the lower part of Fig. 2 more clearly than in Fig. 1. It comprises a templet T, having a curved surface, which slides from side to side on a carriage, the carriage itself running to and fro on a tramway. The carriage is of the shape of a **T**, its leg, which is prolonged towards the front, is in gear with a screw *m*, so that by turning the milled head the carriage is made to move to or fro on its tramway. A microscope M, pointed to the dry-bulb trace (furnished with a sliding adjustment, for use before commencing operations,) is fixed to the leg, and therefore follows the to-and-fro movements of the templet T. In short, to use well-known phrases, the movement of the templet in Y corresponds to the ordinate of the dry-bulb trace, at an abscissa, made by the intersection of the trace with the vertical plane spoken of at the end of the last paragraph. Again, on the same leg, is mounted another screw *n*, which, as it turns, does two things: it screws to and fro the microscope N which is pointed to the wet-bulb trace, and also by a pinion at its end, in gear with rack work fixed to the templet, it causes the latter to slide from side to side on its carriage. In short, the movement of the templet in X corresponds to the ordinate of the wet-bulb trace, just as that of the templet in Y corresponds to the ordinate of the dry-bulb trace, both ordinates having identical abscissæ.

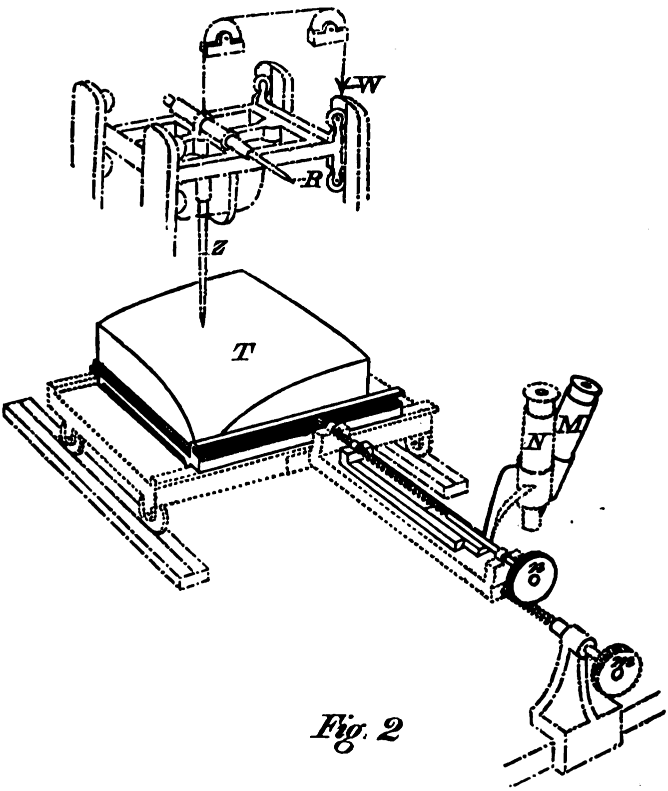

Fig. 2

The templet T is a curved surface, fashioned according to the Vapour Tension tables. Supposing its sides (Y) to be graduated to degrees of temperature, ranging from 17° to 93°, and its front and back (X) to be graduated to the range of ordinary differences between the dry and wet bulbs, that is from 0° to 23°, the height, z, of any point in its surface corresponding to the ordinates x, y, has been made proportionate to the tabular value of the vapour tension corresponding to y° = temperature of the dry bulb, and to x° = excess of temperature of the dry bulb over the wet bulb. The mechanical construction of a templet suitable for any required function of two variables, is neither difficult nor costly, owing to the excellent machinery now used by first-class makers. About 400 holes are drilled by an accurately graduated drill, to the depth given by the tabular values; and the intervening surface is filed and smoothed away. The points intermediate between those that are actually measured are thus, in fact, graphically interpolated. There has been occasion to make two templets for this instrument; both were carefully tested and found exceedingly accurate;* yet their cost did not exceed 6*l*. each.

The third stage is more clearly shown in the upper part of Fig. 2 than in Fig. 1. It consists of a style Z, partly counterpoised by a weight W, allowed to rest vertically and with slight pressure on the templet. It carries an horizontal tube, in which a pricker R slides. This is struck, when desired, by a hammer H worked by the foot, which swings through the dotted arc shown in Fig. 1, and delivers its dot upon the plate Q, at a height varying with the height of the surface of the templet at the point on which the style rests at the moment of delivering the blow.

The action of the instrument will now be clearly understood: the carriage is moved through a short space, the screws *m* and *n* are turned until the cross wires of the microscopes M and N respectively intersect the dry and wet-bulb traces; then a pressure of the foot causes the pricker to deliver a blow. This is the whole proceeding: the contrivance of the spring click mentioned in the second paragraph ensures the dots being made at half-hourly intervals, that interval being considered the most suitable to the present case. In this way a succession of dots are rapidly made, which are joined together by a graver, and so form the zinc original from which the mechanical reduction by Wagner's pantagraph is made on the copper plates of the Quarterly Weather Report.

There are many small matters of detail, especially of adjustment, in the instrument, which it is impossible to draw except on a large scale, and difficult to describe except at much length. A few more important points may be mentioned. Thus, the frame F can hold Q at various heights, to allow of a number of traces being dotted out, each below the other. In this way a single plate Q contains the vapour tension traces for the usual five-day period at each of our seven stations. Again, as this instrument may require to be used with other traces for purposes when x and y are replaced by $x-w$ and $y-w$, w being also a variable, there is a slide rest at u, in front of the carriage, in which a pointer maybe fixed (and adjusted) in the same vertical plane with the pricker, and with the optical position of the cross wires of the two microscopes. As an example, suppose it was desired to obtain the inclination to the horizon of the barometric plane passing through three stations; then, three rows of zinc plates (one row corresponding to each of those stations) would be placed one above the other. The microscopes M and N and the pointer would be severally adjusted to the fiducial lines in each of these rows; then, for each consecutive position of the carriage K three operations would be required—first, to turn v (the screw to the

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* *See* Report for 1871, p. 30, for a description of the tests applied to the first of these templets. This templet was abandoned, because the absolute scale on which it was constructed was found inappropriate. It was replaced by the one now in use, which is just as accurate.

extreme right of Fig. 1,) until the stage, containing all the plates, is so moved that the trace in the lowermost row comes beneath the pointer; then to bring M and N respectively on the traces on the topmost and on the middle plates, and then to make the dot as before.

FRANCIS GALTON.

No. 2.—SUMMARY OF THE RESULTS OBTAINED FOR SQUARE 3 FOR JANUARY.

The district referred to lies in Latitude between the Equator and the parallel of 10° N., and in Longitude between the meridians of 20° and 30° W. The Committee have directed that a specimen chart showing the results for each degree square should be lithographed and distributed to men of science and to seamen to obtain opinions as to the value of the proposed method of publication.

Remarks explanatory of this chart have been drawn up, and from these the following observations have been extracted:—

" ISOBARS AND ISOTHERMS.

" *Air and Sea.*—With the object of showing more clearly the relative distribution of pressure and temperature, the accompanying isobars and isotherms of air and sea-surface have been drawn.

" In all cases the means of four single-degree squares have been combined.

" They seem to show a relation between the lowest pressure and highest temperature, also between the temperature of air and sea. The isobars and both isotherms are very similar in their direction, and the air is just one degree colder than the sea, which might perhaps be expected in the winter months.

" Table 3, page 35, shows that between 4° and 7° N. a south-easterly current prevails, and as it is said in remarking on the currents that this is probably a back drift of water heaped in the doldrums by the counter actions of the N.E. and S.E. trades on each side of them, it is not remarkable that to the eastward or south-eastward of this zone of the square we find the warmest water, as it is water that has been accumulating for some time in this low latitude.

" So far as we can judge, the zone of easterly current shifts north or south with the doldrums and hottest water, depending for its latitude on the position of the doldrums in the month.

" By referring to the Monthly Charts of " Currents and Surface Temperature of the North Atlantic," published by this office, it will be seen that the sea surface isotherm of 70° dips to the south-eastward, and comes very near the north-eastern corner of