Papers on Meteorology and the Pantagraph

Publication/Creation

1867-1870

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f. 1

THE SUSPENSION OF STORM WARNINGS.

THE COUNCIL OF THE ROYAL SOCIETY AND THE METEOROLOGICAL DEPARTMENT OF THE BOARD OF TRADE.

Reprinted from the MANCHESTER COURIER *of Tuesday, March 26th*, 1867.

The following letter has been addressed to Gen. Sabine, president of the Royal Society, by Mr. Baxendell, F.R.A.S. :—

Cheetham-hill, Manchester, March 22, 1867.

Sir,—The course taken by the president and council of the Royal Society in recommending the suspension of storm warnings, and thus interfering most injuriously with the interests and welfare of certain important classes of the community, has drawn general attention to the entire proceedings of the president and council in reference to the meteorological department of the Board of Trade, and especially to certain points which have excited much surprise, and which obviously require some explanation. Throughout the whole of the correspondence of the President and Council with the Board of Trade, and the report of the Meteorological Committee of the board, which is but an extended echo of this correspondence, not the slightest allusion is made to the Royal Observatory at Greenwich, the Oxford, Liverpool, and other observatories which have for many years done good service to meteorology. They are utterly ignored, and the whole subject treated as if such observatories had never existed, and as if the land meteorology of the British Islands was an entirely new thing about which nothing whatever was yet known. As the Royal Observatory is maintained at the public expense, and as it has hitherto been regarded as the chief among national observatories, the omission of all mention of it by the president and council, and the recommendation to establish another public observatory at only a few miles distance, has excited a strong feeling of surprise among scientific men, and it is naturally asked, what are the reasons or motives that have induced the president and council to take this extraordinary course? Why on the contrary did they not recommend the national observatory to be adopted as the central meteorological station for the kingdom, as is done in other countries? Is it possible that the astronomer royal and Mr. Glaisher declined at the outset to allow the Royal Observatory to occupy the position it ought to hold? Or, were they ever consulted at all in the matter? It is seen clearly that it will be a most unwarrantable waste of public money to maintain two public observatories so near to each other as Greenwich and Kew, and that before it can be shown to be necessary to expend public money in erecting new buildings at Kew, and furnishing them with expensive instruments, it must first be proved that the metereological department at Greenwich is no longer worth keeping up, and ought therefore to be abolished. Are the president and council prepared to prove that the meteorological department of the Royal Observatory is no longer worthy of public confidence, or that it is unfit to be made the central meteorological station for the kingdom? If it cannot be proved that Greenwich is unfit to be made the central meteorological station for the British Islands, and also shown that other existing observatories have declined to take part in an organised system of observation, then Parliament will not be justified in voting the money proposed to be expended in establishing six new observatories and maintaining them for an indefinite number of years. Moreover, the establishment of new observatories, and the making of original observations was not contemplated as forming part of the duties, or as coming within the province of the Meteorological Department of the Board of Trade when it was first formed. Its duties are simply to collect reliable meteorological observations from as many observatories and stations as possible, both home and foreign, and also observations made at sea in every quarter of the globe; reduce, arrange, and discuss them, and turn them to practically useful account with as little delay as possible.

Previous to the retirement of the late ministry, the president and council admitted the importance and utility of storm warnings, and recommended that they should be continued under the superintendence of Mr. Babington; but immediately after the accession to power of the present ministry a sudden change took place in their views and they then recommended that storm-warnings should be at once discontinued. The public are curious to know the reasons which led to this sudden and remarkable change in the views of the president and council at such a juncture.

When the late Admiral Fitzroy established a system of forecasts and storm warnings, he gave the public the best guarantee he could possibly offer that the duties of his department would be discharged zealously and conscientiously, and as efficiently as the means at his disposal rendered possible; and that practical utility, and not the pursuit of scientific crotchets, was his aim and object. The test afforded by the working of a system of storm warnings is in fact the only satisfactory test that can be applied to show whether the duties of the department are being efficiently performed, and whether its labours are tending to any practically useful results; but it is a significant fact that the president and council, and the scientific committee appointed by them, shrink from the application of this test to their management of the business of the meteorological department.

The late Admiral Fitzroy and Mr. Babington have proved that the leading principles of meteorological science are now sufficiently well understood to be made the means, if properly applied, of saving annually many valuable lives and an immense amount of valuable property; and is it reasonable or just that the public should be expected to forego this important saving of life and property while the scientific committee of the Royal Society are wasting many years of valuable time, and large amounts of public money in establishing six new meteorological stations, and making observations which will be merely needless repetitions of observations made at numerous stations already existing within the limits of the British islands? There is no lack of the raw materials of observation, and there can be no justification for a government department undertaking to do that which is willingly and efficiently done by local bodies and private individuals.

The President of the Board of Trade stated in the House of Commons, on the 15th of February, that "the committee of the Royal Society considered that no advantage was derived by receiving observations from Paris, Brussels, and St. Petersburg, as they were not on the sea coast." This fact shows clearly either that the committee have no serious intention of attempting to improve the rules on which storm warnings are based, or that they are totally unacquainted with some of the most important published results of recent meteorological research. No well-informed practical meteorologist would venture to commit himself to the opinion thus attributed to the committee.—I am sir, yours faithfully, JOSH. BAXENDELL.

Lieut.-General Edward Sabine, R.A., D.C.L., &c.,
President of the Royal Society.

Apparatus for Co-ordinating the results of Self-recording Meteorological Instruments

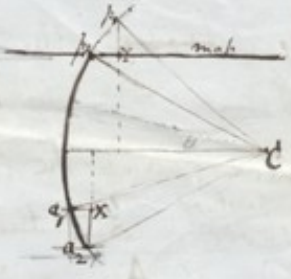
In order to do complete justice to the Kew system of self-recording instruments, we must not content ourselves with measuring the ordinates of their tracings at periodical intervals and with making Synchronous charts corresponding to those periods. It is necessary that we should attempt much more than that, by means of which the tracings may be co-ordinated at each successive instant of time. This could be effected by a Map on the one hand, bored with holes, corresponding to the geographical positions of the different stations, and on the other hand by Pins being caused to move up and down in those holes, their heights above the Map at any moment being respectively identical with the ordinates of the tracings upon which the machinery that worked the pins, was at that moment resting.

I enclose herewith the drawing of a very simple piece of mechanism by which this result may be effected without sensible error. I have confined the drawing and the following description to one element, say the Barometer, (To avoid confusion) but it will be obvious that the same machinery can be extended to the other elements.

First then, let the Barometer Curves be traced on a thin sheet of Brass and be cut out, to be firmly fixed in a saw-cut made in a wooden Slide which slides between Cheeks, in the plane of the paper, as seen in Fig I, from right to left. An Arm of thin brass, turning round C and working between Guides, rests with its point A upon the Barometer Curve, or rather, it does so through the intermediium of a small piece of steel shaped like an H, of which the upper half tightly embraces the Arm and is screwed to it, while the lower half loosely embraces the Barometer Curve. The object of the shape of this implement is to ensure that the Arm shall never be thrown out of gear with the Curve, and the object of its material is to diminish friction. This is easily understood when it is obvious that when the Slide is shifted forwards, the Arm will rise and fall, following the contour of its movements; variations in the Curve. However no precipitous rises in the Curve would however be tolerated by the machinery; such, when they occur, must be filled away to a slope. The Arm is prolonged to D and there turns upwards at right angles to P.

DP is circular having C for its centre & projects through a ~~hole~~ perforation in the board above, upon which the map is supposed to be drawn. In fact DP represents the Pin, of which I spoke in the beginning of this paper.

It will be observed that the motion in arc (or the approximately vertical motion) of DP is to that of A (the point where the Arm is in gear with the curve) as the radial distance CD is to CA. Consequently if several Arms are required for stations at unequal distances, mounted along the [illegible] if it were desirable to prolong AD & at the same time to retain unaltered the ratio of the movement of P to that of A, we have simply all that is necessary is to make the an alteration in the position of C, by which the above described ratio should be maintained. On this principle several Curves may be (in the same Bar set side by side) and be made to work Pins at the same number of various unequal distances from the line along which the situated) the points A of the several Arms. Fig 4 shews an instance of this arrangement. It also shews how by giving not a single but a double curvature instead of a single one to the Arms at D, they may be made to work Pins situated to their right or left. In short, there is no difficulty in working Pins, corresponding to stations in any required Geographical position, within the bounds of the map.



The small machinery (which this arrangement is attended with) practically speaking will I believe be unexceptionable. though it is of a complex nature. It will be understood by the annexed diagram, which is an exaggeration of Fig I. the angular movement of the C Arm being very greatly increased shortened. Let a_1 a_2 be the positions of A, according as it touches the Curve at a place where its ordinate is high, or where its ordinate is low, then p_1, p_2, will be the corresponding positions of P. Now p_2p_1 or a_2a_1, differs from the height a_2X, which it is intended to represent in a ratio dependent on the angle between both Ca_1 & Ca_2 with the horizontal line. Also if we estimate the projection of the Pins by their vertical

height above the map, that is by $p_1 \frac{x}{z}$ & not by $p_1 p_2$ this kind of false proportion is redoubled. The elliptical error is due to the portion of a_2 not being vertically above a_2 but differing from it by the amount of the curve $a_1 x$. Consequently when the Arms are simultaneously engaged with ordinates of different elevations, their indications never refer, as they ought to do, to the same instant of time. I have already referred to the impossibility of dealing with this apparatus with precipitous increases of curvature.

All this could be avoided by a contrivance of pistons pressing on the Curves & conveying their motion through tracing of link work to pistons working in the holes in the Map. But as I believe the simplicity of this apparatus I have described will meet our practical needs, I do not advocate & forth think it worth while to extend this suggestion & say, more about it.

Neither do I at present give any drawing for the mechanical re-translation of the tracings of Wind & Direction into motion of rotation. It clearly admits of being easily done; and the necessary apparatus for doing it would naturally be placed on the left side of the map opposite to that occupied by the Arms.

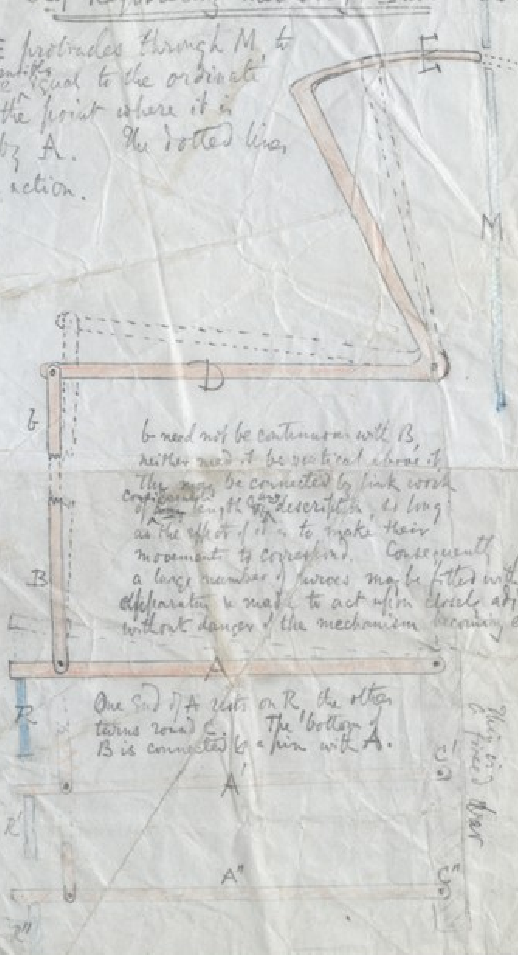
I would propose to the Committee to have an instrument made by Mr Bradley from my drawings, for making experimental experiments by myself, & to work them with a pair of arms, and not by single arms; & to work them with Barometer & Thermometer simultaneously.

To prevent the ugly effect of the partly filled holes, it is best to have the map black and the pins light colored. [Small Photographs could be taken at succession intervals, from the machine & illustrate the course of any particular type of weather. It is not at all impossible that they might be recombined by an (Thaumatrope?) & look forward to the time when we shall possess a machine large enough to include all the existing records & drawings of Europe, and the Curves belonging to all notable types of weather, being ready mounted, in order to supply it; and lastly a method of throwing the Curves referring to any one or more Elements, out of gear by depressing them simultaneously, so that we could study without confusion, the mutual influences of the 2 or more residual Elements in any combination, the mutual - relation we desired.

Francis Galton April 11. 1867

Apparatus for coordinating the records of Self Registering Meteorolog. Instruments

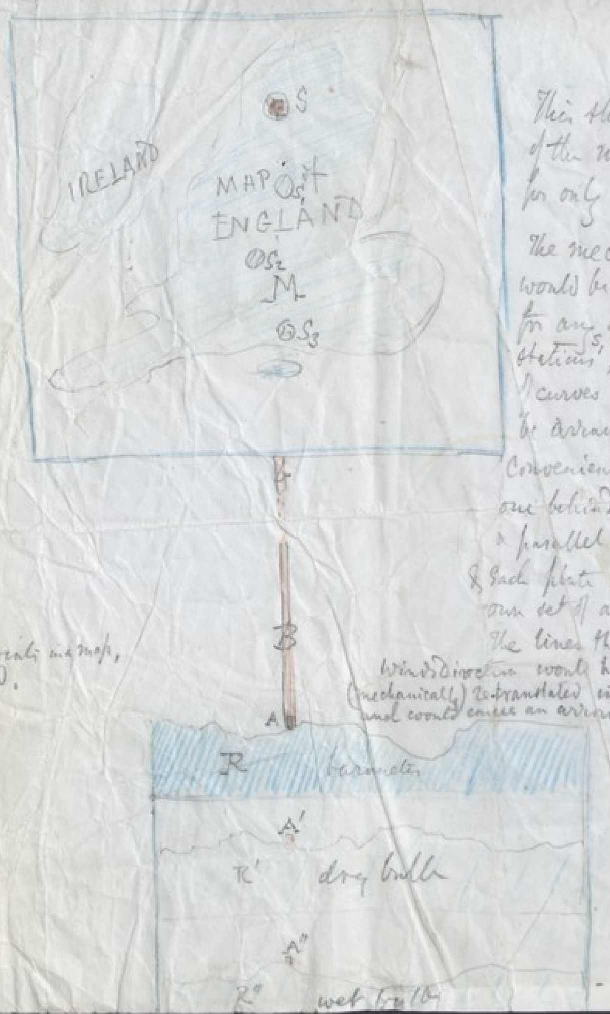
E protrudes through M to a distance ^identically equal to the ordinate of R at the point where it is touched by A. The dotted lines shew the action.



b need not be continuous with B, neither need it be vertical above it. They may be connected by link work of any length & any description, as long as the effect of it is to make their movements to correspond. Consequently a large number of levers may be fitted with apparatus & made to act upon closely adjacent points in a map, without danger of the mechanism becoming entangled.

One end of A rests on R, the other turns round C. The bottom of B is connected by a pin with A.

[illegible] fixed bar



This shews part of the machinery for only one station S.

The mechanism would be identical for any number of stations S_1, S_2 &c. Each set of the plates & curves R, would perhaps be arranged most conveniently, ~~[illegible]~~, one behind the other, & parallel to one another, & each plate would have its own set of arms.

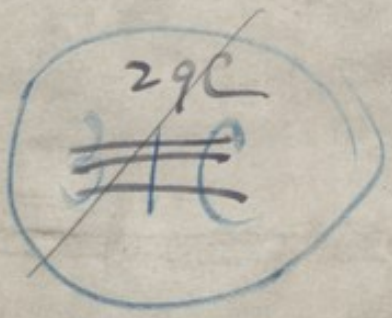
The lines that shew the wind direction would have to be (mechanically) retranslated into rotatory motion and would cause an arrow to turn.

Francis Galton
April 6 1867
Sorrento, Italy

Pantagraph

some of the earliest correspondence
also a design to me
to be worked by one hand
but never made (&
probably not worth making)

1869



Description of the Pantagraph designed by Mr. Galton.

A full account of the principle of this instrument was published in the Annual Report of last year, page 32; its construction will now be described. I have been much indebted to Messrs. Beck, who made it, for many points of detail.

It is very difficult to draw the machine as a whole, in an intelligible manner, and it is impossible to do so by simple plans and sections, because its parts overlay and hide one another to a remarkable degree, and also because its appearance in different states of adjustment is greatly changed. Nevertheless, its construction may be made sufficiently clear by the perspective view of the complete instrument, Fig. 11, and by a few outlines of its principal parts, when they are placed in extreme positions.

The machinery may be separated into two independent stages, whose actions are governed by the same principle, though their details differ. The lower stage of machinery is worked by the operator's right hand, turning the milled head R, which gives a lateral movement ⟷ to two frames P and Q; the photograph intended to be reduced being set on Q, and the zinc plate, on which the reduction is to be scratched, being clamped to P. The upper stage of the machinery is worked by the operator's left hand, turning the milled head L, which gives a movement in the direction at right angles ↕ to that just described, to the pointer M which has to follow the outline of the photograph, and to the style N, (or drill, if one be used), which engraves the reduction on the zinc.

The connecting link-work attached to each of these separate stages of machinery, admits of adjustment through a wide range, and may be made to produce either a direct or a reversed reduction. But before entering into these somewhat complicated details, let the attention be confined to a single one of these stages, say to the lower one, which we will suppose adjusted to reduce to some definite scale, and we will disregard and exclude from our diagrams (1), (2), (5), and (6) all parts of the machine which are non-effective in that condition. First as regards direct reduction; two extreme positions are indicated in Figs. (1) and (2).

Q is the frame on which the photograph is set, P that on which the zinc plate is clamped; they both run on parallel tramways, shown by the dotted lines. C A B is a bar turning round C as a centre; it is connected with P by the link A a, and with Q by B b, and the conditions of adjustment are, that when C A B lies perpendicularly across the tramways, then both A a and B b shall lie parallel to them, and also that the ratio of A a to B b shall be the same as that of C A to C B; from which it follows, as can easily be shown, that C, a, and b are always situated in a straight line. To effect these adjustments, the position of C in the bar C A B (produced) admits of being shifted, just as the centre of a pair of proportional compasses admits of being shifted, and the same is the case as respects the position of a on the link A a (produced). The diagrams (3) and (4) show the bar and the link (produced) as they actually exist in the machine, when it is placed in precisely the same position as in Figs. (1) and (2). The positions of C and the other centres are indicated in (3) and (4) by dots, the darkly shaded line is a slot in the iron frame of the machine, in which the sliding centre travels, when the adjustments are altered.

For reversed reduction, the position of C must lie between A

and B, and the links A a, B b, must be on opposite sides of A C B, as in Figs. (5) (6); the proportions of A a to B b, and the parallelism of A a and B b being attended to in just the same way as before.

Figs. (7) and (8) show the bar and link (produced), as they appear when the machine is in the position indicated by Figs. (5) and (6).

To effect a change in the adjustments, the machinery is brought into the position shown in Fig. 9, where A C B is perpendicular and A a and B b are both parallel to the tramways, and it is secured in that position to the iron table by pegs G, thrust through A C B and A a. Then the clamps that hold the sliding centres firmly in their places are released; the winches W V are turned, that screw the sliding centres to their new positions (as indicated by graduations at the side); these are again clamped, and, lastly, the pegs are taken out. The principle on which the graduations are made, was fully explained in the Annual Report of last year, already referred to. The result is as follows: A B is divided into 120 parts (being a convenient number of graduations, and one that is divisible in many ways); the graduations are numbered from A to B, and the word "reverse" is engraved by them. The same scale is continued on the other side of A, where it is separately numbered, beginning also from A, and the word "direct" is engraved by them. Then in order to reduce in "reverse," so that the scale of the reduction shall be that of the original, as 1 to c, set C at the graduation on the "reverse" side corresponding to $\frac{120}{c+1}$; if direct reduction be wanted, set on the "direct" side at $\frac{120}{c-1}$. The graduations on A a are determined graphically by the instrument maker, who sets C at each successive graduation, and rules a line through A a from C to b, and numbers the graduations on A a to correspond with those of A B and A B produced, and the words "direct" and "reverse" are engraved in the appropriate places. Thus, suppose the reduction was to be one-fourth of the original, then for "direct" the required number of the scale of graduations would be 30, and the "reverse" 24.

The minor details connected with this part of the machinery are as follows:—The handles H are used for clamping purposes; they are the long arms of levers, which, when pushed perpendicularly to the limb, squeeze powerfully by means of the bluntly curved heads of their short arms. The shaded square on P is the zinc plate, on which the reduction is made; this is clamped by two handles on to a brass slide, which is slid into grooves in P, and there clamped fast by the screw, whose head is seen in Fig. 9. The six milled heads on Q are screws with projecting flanges, to nip and hold firmly a long deal board, to which the photograph has been securely pinned.

As regards the upper stage, Fig. 10, which carries the pointer M, and the style or drill N, it consists of two brass bars sliding in solid iron cheeks; the bars are connected together by links, on precisely the same principle as those already described. The link work is necessarily hidden in Fig. 10, but the position of the sliding centres is easily to be guessed; the link work is better seen in the perspective view, Fig. 11. The three pegs to fix this part of the instrument, when adjusting, are shown at G. In connection with the framework which carries the pointer R, there are several matters of detail, as follows. A second pointer, M^1, will be observed outside the arm; and it will be seen that MM^1 is always parallel to the tramways; the use of M^1 in connection with M is to enable the operator to set the board to which the photograph is pinned in such a way, before it is clamped to Q, that the fiducial line of the photograph shall be truly parallel to the tramways. For, if when one point of the line is brought

under M, and another point is brought under M^1, the board be clamped in that position, the required object is attained. The framework that carries the pointers can be moved at will along the arm on which it is set by turning a milled head, M M^1 always remaining parallel to the tramways. Also the pointer itself can be screwed out and in laterally without of course affecting the parallelism in question. These movements are necessary to enable the operator to get the pointer without difficulty upon the beginning of the photographic trace, at the time when the style is at the edge of the zinc plate. Below M, a lens with a jointed arm, movable in all directions, is attached, to help the operator to follow the trace more closely. A handle will be observed at K, lying across the bar, with which a rod is connected that runs alongside the bar, up to the style (or drill); by turning the handle to the right, the style is lowered. There is a regulating screw to the style, best seen in the perspective view of the instrument, which enables the operator to control the depth of the scratch made by it.

The style is, in fact, a drill, and can be used as a drill if it be connected by a bend with a wheel turned by a treadle. The original intention was, to cut a deep groove in the zinc, and the drill afforded the most promising means of effecting this. But experience shows that a very slight scratch, such as a common graver can make, is amply sufficient for what is wanted, and the drill is now never used as such.

FRANCIS GALTON.

Proposed

A reduction of the days tracings of Bar & 2 Therms

into a space 1 inch in width by 1½ inch in depth

Of the winds force & direction in

a space of 1 inch by ¾ inch

headed by (1) a rough wind & bar: map

(2) about a "second" similar map

for temper: & closed.

The "data" to be uniform throughout the series (viz) the lines for degrees Fahr: & inches pressure

Where the Meteo: Office map that part of is 18 inches square, which includes its stations. Wind arrows 1 inch long are hardly practicable in that map which when reduced as I propose would be $\frac{1}{18}$th inch. Quite long enough for the purposes.

f.9

1

On the Publication of the Meteo: Curves

F. Galton. May 2/69

Objects. To obtain ~~an~~ idea of the

1. General aspect of the records, in connection with different types of weather

2 Means to supply weather maps inter-mediate between those of 8 a.m., ~~on consecutive days.~~ (So as to ~~match~~ the identically same periods, in corresponding types; for the purpose of just inter-comparisons

3 The utmost compactness consistent with clearness, for the sake of (1) ~~and also~~ to save expense.

4. Preservation of the ~~[illegible]~~ records from decay, by making accurate tracings ~~copies~~ of them.

The wooden blocks could be used
more than once.
(1) as a series.
(2) in sets showing types of weather.
They would be most convenient for printing
as they are made separately any error
in making one of them would not be ~~dis~~
serious. It could be rejected & another made
in its stead.

f. 11

<u>To obtain the reduction</u>

A pantograph carrying a drill, working upwards & cutting a line into a wood block. Separate blocks for the tracings of each day. Viz

1. The self recording
2. The maps 1 to each map.

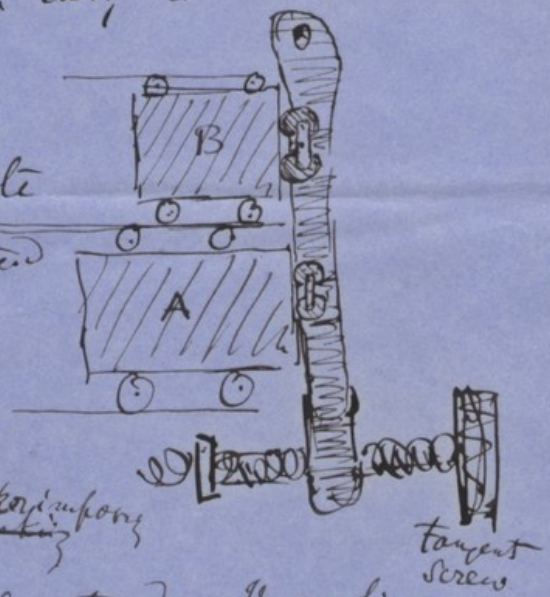
The tracing to be laid on paper carbonized on both sides & laid on a ledger so that the point of the pantograph shall cause a line to be traced on <u>the reverse</u> of the photos: & also a tracing on ~~copy~~ ~~to be made~~ the ledger. We shall thus have a clear copy of the original in a form easy of reference, we shall preserve the original intact but with a line at the back to explain future misconception when the photo shall

after the lapse of time have faded & an immediate means of checking the justness of the tracing by holding the photo to the light & seeing if it agrees with the line at its back

Pantograph required

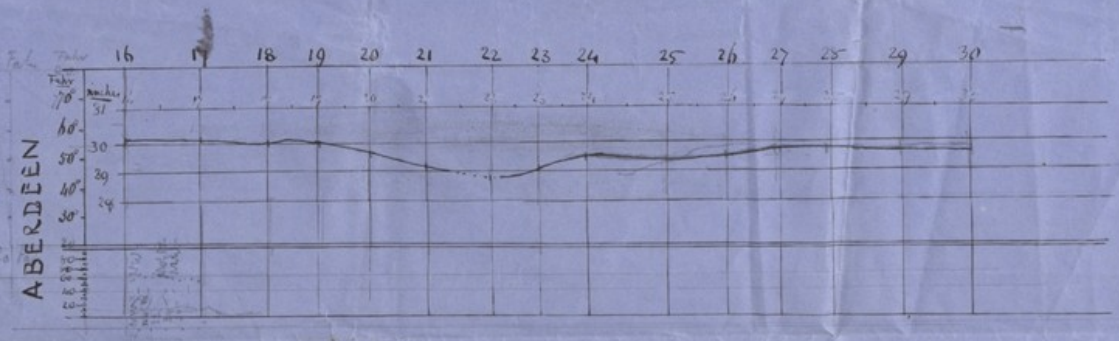
I believe no existing apparatus would answer our purpose. It would be easy to make one

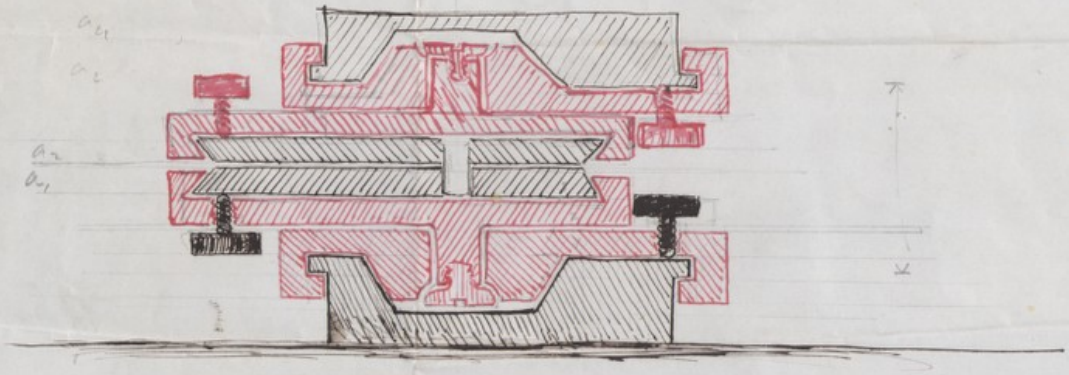
A machine like this would reduce, as desired to it, in one ordinate & if the whole were mounted on a similar machine it could be reduced, to the other also as desired along the other ordinate. There is no mechanical difficulty in superimposing the movement of B on to B'

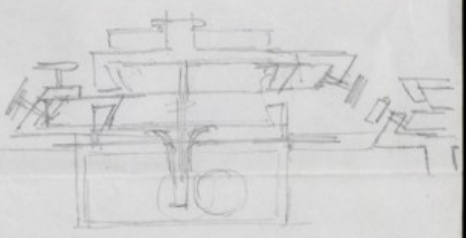


The drill apparatus is well understood. It was first used by Watt in his sculpture copying machine. It is used by Colonel Stanhope in engraving figures on astronomical instruments.

Barom. Aberdeen 15 days
reduced by a Camera Lucida







31, Cornhill.
London, E.C.

May 5 1869

Sir.

I have at present great doubts as to whether our Instrument would effect your object without going carefully into the matter I cannot say what amount of distortion I should have to contend with in a reduction of 8 by 2. However I am about making a large Instr. for our own use & will bear the matter in mind & if I think it can be done will let you know.

Believe me Sir
Yours truly
J.B. Beck

F Galton Esq F.R.S.
42. Rutland Gate. S.W.

July 15/ 1869

Sir I examined the exceedingly beautiful instrument in the possession of Mr Silverlock but found that its differential movement was - as I had been afraid, - not sufficient to fulfill our requirements. It can only reduce breadthways, in certain definite scales as many scales as there are changes of wheels; but it cannot reduce to intermediate proportions. Now that latter power is essential to us. Our reductions will be of one uniform size, say, a square thus,- [ ] but the original from which the reductions are made are themselves of slightly various

as will reduce them to the proper uniform size for our work.

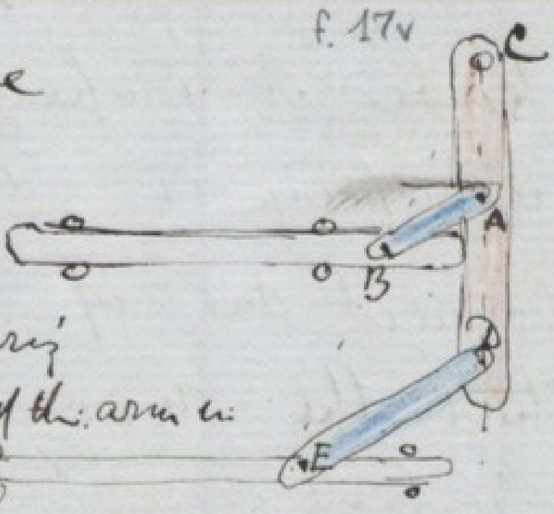
sizes and therefore a minute adjustment would be required in every case. You may possibly have the intention of interposing some link work between the frame moved by the small screw & the holder of the diamond point to give that means of adjustment; - but it did not exist in Mr. Silverlock's instrument.

Again, as to the pendulum movement, I fear there is also an objection, but I candidly confess that when examining the instrument, I was thinking so much more of the other movement that I did not pay sufficient regard to this and may have altere-

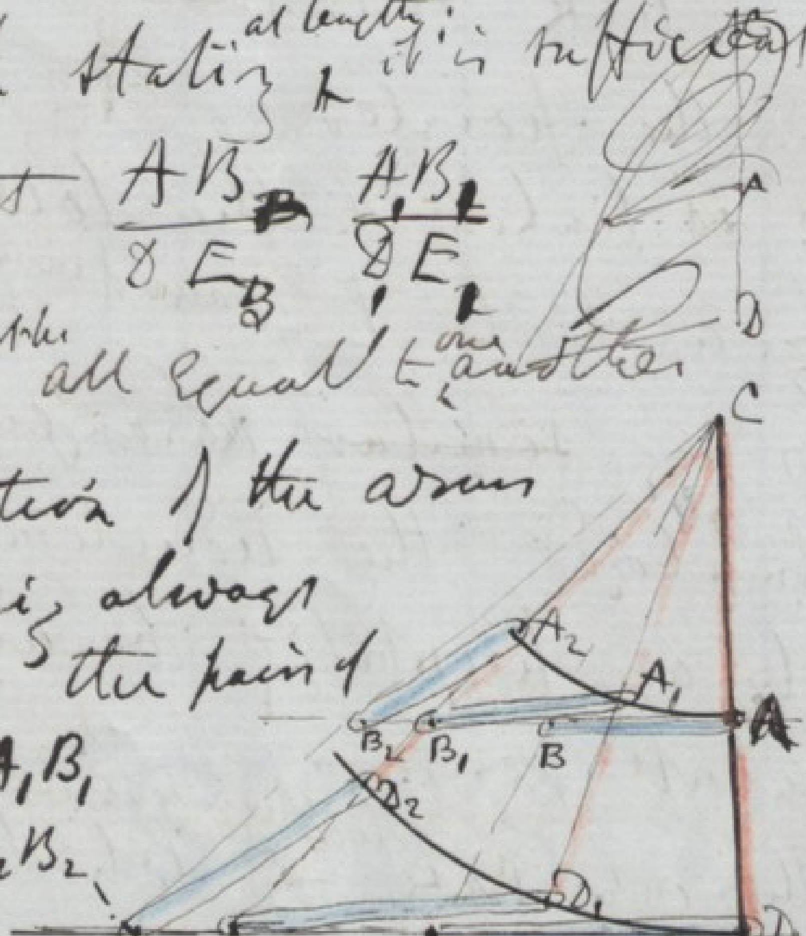
-tended it imperfectly, but my impression is and I beg you will correct me if I am in error - that the movement is essentially this - the arm BC that holds the diamond pointer is linked (by a variable adjustment) to the pendulum by a link AB of invariable length and the pointer E is linked to the lower frame by a link ED also of invariable length. If this or any ~~similar~~ arrangement in the same principle be adopted (i.e. the invariable links) employed the reduction cannot by any possibility be uniform in all positions of the pendulum. The only ~~case~~ conditions where such work is used under ~~in~~ which the

f. 17v

required uniformity exists, that is where the length of the links BA, ED are ~~[struck through]~~ maintained during all the varying adjustments of the arms in the constant proportion of CA to CD. — I mean ~~that~~ where



$CA : AB = CD : DE$. The proposition by which this may be proved is ~~almost~~ too simple to be worth stating at length: it is sufficient to note that $\frac{AB}{DE}$ $\frac{A_1B_1}{D_1E_1}$ $\frac{A_2B_2}{D_2E_2}$ must be all equal to one another as the condition of the arms AB DE being always parallel & the pair of triangles CA_1B_1, CD_1E_1, — CA_2B_2, CD_2E_2, always similar.



I know that the work performed by such machinery is such as thoroughly to please the eye for artistic purposes but it does not

therefore follows that the proportions are as rigorously maintained as we require them to be for our work.

Kew observatory
1st May 1867

My Dear Lii

Buckley & myself have looked carefully over your memoir regarding an instrument for exhibiting graphically the results of our daily recording meteorological instruments.

There can be no question that an instrument similar to that you describe can be made but that the expense will be very considerable. For my own part I think that the curves themselves when obtained will suggest to us what arrangement will be the best for getting as much good & profit out of them at present as far as a comparison of Kew and Oxford Curves is concerned we appear to derive most information by comparing together two mechanisms, which take place at different moments of time at the two stations

You will see what I mean by the enclosed short memoir

In the meantime I shall receive your communication

Yours very truly

B Stewart

f. 19

[*From the* PROCEEDINGS OF THE ROYAL SOCIETY, No. 91, 1867.]

"A Comparison between some of the simultaneous Records of the Barographs at Oxford and at Kew." By BALFOUR STEWART, LL.D., F.R.S., Superintendent of the Kew Observatory.

Through the kindness of the Rev. Robert Main, director of the Radcliffe Observatory, Oxford, certain marked features of the curves produced by the barographs at Oxford and at Kew were compared together on four separate occasions in the year 1863.

These comparisons are the more interesting that they were all made during squalls or storms; for on such occasions it is found that the barograph curves exhibiting the height of the barometer from moment to moment present curious characteristic points, without which indeed no such comparisons could be made.

The result for these four occasions in 1863 was as follows:—

Nature of disturbance.	Date G. M. T. Oxford.	Kew.	Oxford is before Kew.
Sudden increase of pressure during squall of 30th October 1863	2.30 P.M.	3.9 P.M.?	39 minutes (probably).
Sudden increase of pressure during squall of 21st November 1863	4.0 P.M.	4.45 P.M.	45 minutes.
Peculiar points in the curves of December 3, 1863 (a stormy day)	2.40 A.M.	3.35 A.M.	55 minutes.
	6.50 A.M.	7.40 A.M.	50 minutes.

Mr. Main has kindly called my attention to a well-marked minimum in the Oxford curve for February 6, 1867, which was also a stormy day. This minimum occurred at Oxford at 2.20 A.M. of that day, while at Kew it did not occur until 3.15 A.M. Oxford was thus on this occasion 55 minutes before Kew.

The peculiarity of this last occasion is the singular likeness between the two curves. I have not compared together any other features of these curves, nor perhaps could this be done with exactness; but the general

impression is that the changes of pressure at Oxford were followed by similar changes at Kew, only nearly an hour later.

It is premature (until we obtain more information) to enter into a discussion of the rate of progress of storms; but we are quite justified in considering the barograph an instrument extremely well adapted to extend our knowledge of atmospheric disturbances.

We see that on those very occasions when this knowledge is most interesting the barograph comes forward to our assistance, and presents us with results which could not possibly be obtained otherwise than by a system of continuous registration. It does not, however, follow that, while a continuous record is by far the best, other records are of no value; for should an observer be placed beside an ordinary barometer during the crisis of a storm, observations made in rapid succession and accurately timed would be of very great assistance. Such an observer would in fact produce approximately a record similar in kind to that of a barograph, although inferior in value.

It ought here to be noticed that two stations are not enough to enable us to determine either the direction in which an atmospheric disturbance is propagated or the rate of propagation. It is only on the improbable supposition that all such disturbances travel in a direct line from Oxford to Kew that barographs at these two places might be deemed enough. In order to obtain the greatest amount of information which such instruments are capable of affording, it is evidently necessary to multiply our stations and to distribute them judiciously over the surface of the country. Nor is it desirable to confine ourselves to one meteorological element, but the barograph should be accompanied by a thermograph and a self-registering anemometer. As this is the system about to be pursued by the Board of Trade in their chief meteorological stations in the British Isles, we may reasonably hope that before long we may by this means receive a large accession to our knowledge of the laws which regulate atmospheric disturbances.

f. 20

I replied Jan 18 that I had followed Mr. Wagner's instructions & had ordered the instrument forwarded from the Works F. Galton

116, Cunhill Row
E. C.

January 17 1870

Dear Sir,

Mr Wagner happens to be in town it would therefore perhaps be better if you ordered the pantograph direct from him & for this purpose he will attend at Victoria Street today at three o'clock.

We are dear Sir

Yours faithfully

Jno D Siddall

Francis Galton Esq.

f. 21