

XII. *The Radiograph.* By D. WINSTANLEY, F.R.A.S.

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Read January 13th, 1880.

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I HAVE described already one of the several arrangements which I have devised for the automatic registration of the solar radiance\*. The instrument in question places a lead pencil on a sheet of paper and writes down therewith when and for how long the sun may chance to shine, but it makes no record of the intensity of his rays. I will now ask your attention to the description of another and much more perfect apparatus, one which continuously records the intensity of thermal radiation to which it is exposed. This instrument I have called the "radiograph." It consists essentially as follows:—A differential thermometer of which the stem is circularly curved is mounted concentrically upon a wheel of brass in a groove cut with that object for its end. This wheel is supported with its plane in a perpendicular position by a knife-edge of hardened steel, which passes through its geometric centre and rests on agate planes. The tube of the thermometer is partly filled with mercury (preferably through half its curve), and, for the reason given in my description of the simple sunshine-recorder, to which I have alluded, a little sulphuric acid is introduced as well. If we now arrange it that the centre of gravity of the solid portion of the system here described shall be below the surface of the planes on which it turns (and the apparatus is provided with adjustments by means of which the point in question can be moved) it is clear that the arrangement may be made to swing in

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pendulous oscillations, notwithstanding the presence of the liquids it contains; for these remain substantially at rest whilst the tube which holds them does, in fact, slide over them (and with very little friction too) in swinging to and fro through arcs of the circle of which its parts are curves. Both bulbs of the thermometer are closed. It is obvious therefore that the tension of the air or gas which they contain will be uninfluenced by the barometric variations of the outer air, the temperature of which latter being experienced equally in each bulb will also leave the equilibrium of the apparatus undisturbed. When, however, one bulb is more heated than the other, the air contained therein will press more strongly on the heavy liquid piston in the tube and wheel the swinging portion of the system round until a fresh position of equilibrium is gained, and this will be (providing that the centre of gravity of the system has previously been made coincident with the point on which it turns) when the tension of the gases is equal in both bulbs. In fact, in so far as now described, the instrument is a differential thermometer, and is that alone—differing in this from Leslie's, that it is a solid and accessible portion of the thing which moves and not the liquid it contains. When, however, one of the bulbs is blackened and the other one is silvered or left clear, the apparatus becomes a "radiometer" in the proper meaning of the term\*—that is to say, a measurer of the thermal radiance to which it is exposed and the intensity of which it indicates by variations in the angular positions of a needle prolonged from one or other of the radii of the wheel.

It is only needful now so to arrange it that this needle

\* The "radiometer" of Crookes should in its simple form have been called a "radioscope," as it merely makes visible the effects of radiance, but does not measure their amount.



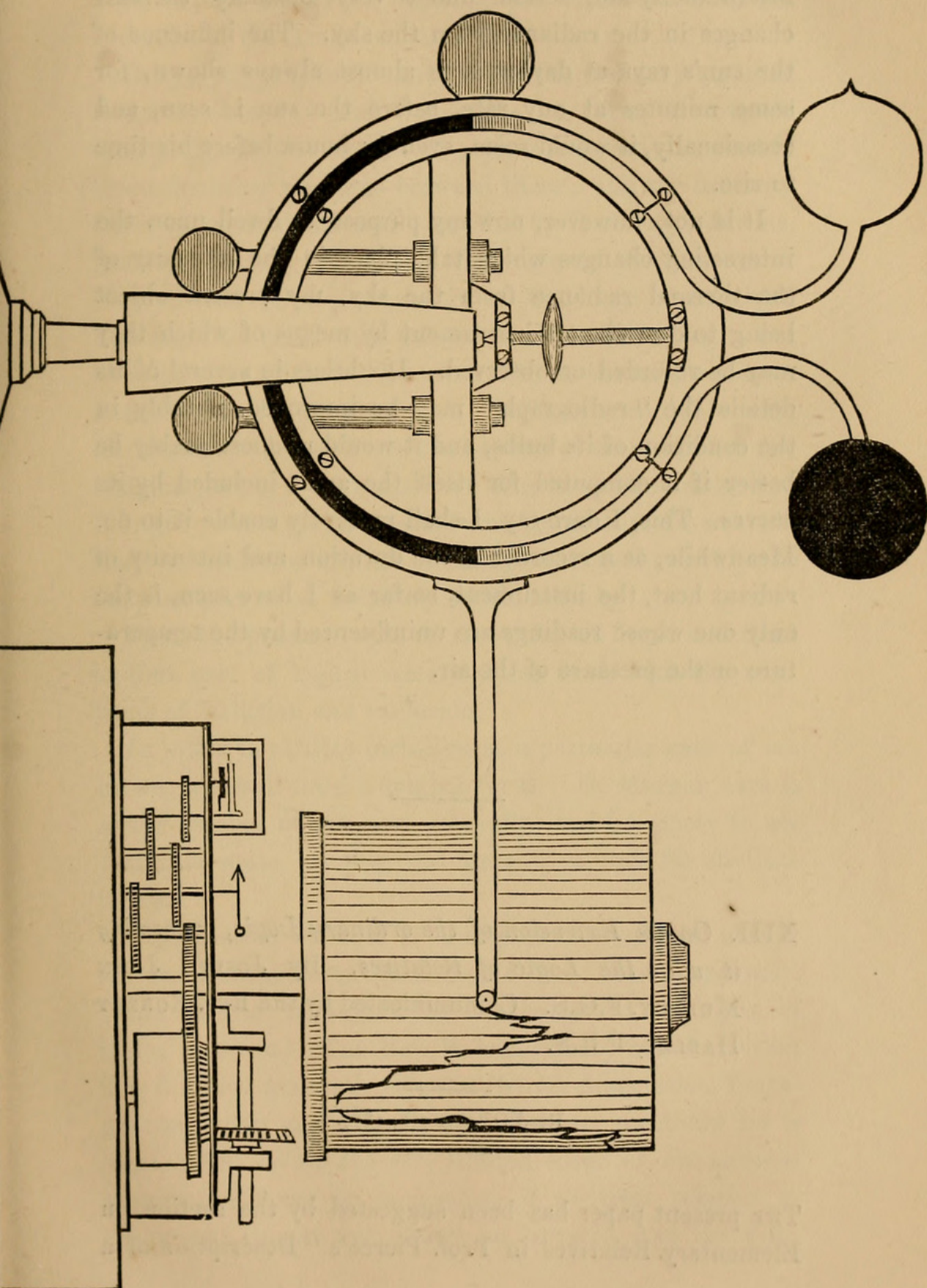
shall make a tracing of its curves on a cylinder driven by clockwork at an even speed, and the "radiograph" is complete.

Concerning the actual instrument I use, its wheel is 7.3 inches in diameter, and the weight thereof a trifle more than two pounds. The other portions of the apparatus are of the same dimensional proportions as are indicated in the sketch. Of course some delicate method of recording has to be employed, and I have thus far used the smoked-paper process so much adopted in the observatories of France. In this way the "radiograms" which illustrate this paper were obtained.

When using the instrument to record the radiance of the sun, I have hitherto exposed it in a box of copper surmounted by a dome of glass into which the bulbs of the thermometer project. The line which joins them is in the plane of the meridian of the place and the black bulb to the north. The box itself is supported, at an elevation of four feet or thereabouts, upon a stand of wood, the legs of which are firmly embedded in the ground. The stand itself is located at the extremity of a garden which overlooks a valley and the sea. A small window in the box permits the movements of the train to be seen and the promptness with which the apparatus acts to be observed. If a cloud "no bigger than a man's hand," and "light as a feather" in its texture, floats before the sun, and occupies but three or four seconds in its transit, its presence, the duration of its passage, and the degree of thermal obscuration its effects are at once set down.

The cylinder of the radiograph passes over a space of .875 of an inch per hour, a somewhat open range; but, as will be seen on reference to the tracings, the needle often moves for some considerable distance in both directions along the same thin line, thereby showing a practical







instantaneity of action under very ordinary thermal changes in the radiance from the sky. The influence of the sun's rays at daybreak is almost always shown, for some minutes at any rate, before the sun is seen, and occasionally, it would seem, even for hours before his time to rise.

It is not, however, now my purpose to dwell upon the interesting changes which take place in the intensity of the thermal radiance from the sky, my present object being to describe an instrument by means of which they may be recorded or observed. Doubtless in several of its details the "radiograph" may be improved, notably in the condition of its bulbs, and it would unquestionably be better if it computed for itself the areas included by its curves. This, I dare say, I shall presently enable it to do. Meanwhile, as a recorder of the duration and intensity of radiant heat, the instrument, so far as I have seen, is the only one whose readings are uninfluenced by the temperature or the pressure of the air.

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XIII. *On an Extension of the ordinary Logic, connecting it with the Logic of Relatives.* By JOSEPH JOHN MURPHY, F.G.S. Communicated by the Rev. ROBERT HARLEY, F.R.S.

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Read October 7th, 1879.

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THE present paper has been suggested by the section on Elementary Relatives in Prof. Pierce's "Description of a



Winstanley, D. 1882. "The Radiograph." *Memoirs of the Literary and Philosophical Society of Manchester* 7, 86–90.

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