ing, respectively, the plate coated with the substance to be exposed to light, and the plate uncoated—that we shall, for shortness denote them by the letters S and U. As already stated, any current produced by agency other than that of light will be denoted by D. C.

5.—*Disturbing Current.*—It may be well to state at once that the D. C. varies, both as to duration and to direction, in an irregular manner, and that Grove's observation, to the effect that its direction is always the same as that of the current generated by light in his experiments, is not true with regard to photo-electric currents generated in other ways.

6. *Chloride and Bromide of Silver.*—If an emulsion is formed by shaking up in a test tube a little finely powdered chloride of silver mixed with collodion (the test-tube being, of course, completely screened from light by a covering of black paper), a silver plate coated with it in the dark, immersed in presence of an uncoated plate in a cell containing distilled water and a few grains of common salt, will, when exposed to light, give rise to a current, the direction of which is

from U to S in the cell.

If the liquid employed is dilute H_2SO_4 , the same result follows, and apparently the current is of the same magnitude.

Sunlight (dull) is quite sufficient to give the current, and the deflection of the spot on the scale will be observed to rise or fall according as the intensity of the incident light increases or diminishes.

I have also tried the experiment by using the light of a candle placed at different distances from the cell, and each distance of the candle produced a corresponding deflection of the spot.

The effects of light of different colors were studied by interposing colored glasses in the path of the incident light, and it was found that, while the effects of blue and violet rays were very great, the red rays gave a hardly appreciable effect. Light falling on the plate after having passed through a thick cell containing a dense solution of ammonia sulphate of copper gave also a large deflection. The galvanometer used was a Thomson reflecting galvanometer, of about 7,000 units resistance; the screen was usually placed at a distance of about a yard from the mirror; and a piece of burning magnesium ribbon, held at a distance of a foot from the plate, would cause a very rapid motion of the spot off the screen.

The plate may be coated with an emulsion of bromide of silver made in the same way, but I have preferred to use the well-known "Liverpool emulsion." In this case the liquid in the cell was usually distilled water, with a few grains of bromide of potassium.

The current appears to be of about the same strength as in the case of the chloride cell, and the direction is still from U to S in the cell.

It is scarcely necessary to say that chloride and bromide plates must be prepared in a photographic dark room.

I have not systematically kept a note of the direction of the D. C. with these plates, but I have noted some instances at least in which it is opposite to that of the photo-electric current.

7. *Iodide of Silver.*—Let a silver plate be coated, in the usual way, with silver iodide, by first pouring a layer of iodized collodion over the plate, and then immersing the latter in a nitrate of silver bath. If the liquid in the cell is distilled water, with a few grains of iodide of potassium, it will be found that the direction of the photo-electric current is

from S to U in the cell,

that is, opposite to the direction of the chloride and bromide currents.

8. *Nitrate of Silver.*—A solution of silver nitrate was mixed in a test tube with rather thin gelatine, and a silver plate coated with the mixture was immersed, in presence of an uncoated plate, in a cell containing distilled water and a few grains of nitrate of barium. D. C. from U to S in cell, rather strong, and of very long duration. Light falling on the plate gave a comparatively small result.

The plate was then further washed over with the silver nitrate solution, and there was an improved result. The cell was connected up with the galvanometer all night; and next day, the spot having come to rest at two hundred and fifty divisions of the scale from the zero (which was its position when no current passed), magnesium light was used with great effect.

When no glass was interposed, the spot moved a long way off the screen in the direction opposite to that of the D. C. With an interposed blue glass the current appeared to be nearly as strong as when no glass intervened. An interposed red glass gave a very small current indicated by a motion of only ten divisions in the opposite direction. From such a small motion, however, no conclusion can be safely drawn, for the current may be only a Grove's current.

Professor Minchin further described the "Photographic Effect of Current," "The Action of Light on Current," and other interesting phases of his subject.

AN ELECTRICAL FIRE-DAMP PHOTOMETER.

HITHERTO there has existed no really practical apparatus for ascertaining at any instant the amount of explosive gases contained in the atmosphere of coal mines. There has been no want of instruments which, according to their inventors, would effect the object, but all have failed when put to the practical test. Recently, Mr. E. H. Liveing has brought to the notice of the Physical Society of London a device which, it is claimed, solves the problem satisfactorily. In this apparatus, called the fire-damp photometer, the inventor has utilized the resources both of physics and chemistry. He uses the electric current for causing the combustion of the fire-damp, and then compares the lumi-

nous intensity by means of a very ingenious photometric arrangement. In the construction of his apparatus Mr. Liveing has taken advantage of the following fact: If a platinum wire be made red-hot by the passage of an electric current, the incandescence will be brighter in a mixture of air and fire-damp than in pure air, and the brilliancy will increase in proportion with the increase of the fire-damp. It will be readily seen that if we choose as means of comparison the brilliancy of incandescent platinum in pure air, and if we observe successively the brightness of a platinum wire, made incandescent by a current of the same strength, in prepared mixtures of air and fire-damp, we shall be able to establish a ratio between the luminous phenomena observed and the proportion of explosive gas in a mixture. To render such comparisons easy, Mr. Liveing adopts the arrangement shown in the cut. Two spirals of platinum wire, A, B, placed in the same circuit, are traversed by the current from a small hand magneto-electric machine. The two wires, having the same resistance and the same cooling surface, are heated equally by the current, and exhibit the same brightness in pure air. One of them, B, is inclosed within a metallic gauze, through which the air from the mine can enter. The other one, A, is inclosed in a brass tube containing pure air. At their extremities both tubes are closed by a piece of glass. To measure the differences of intensity of light in the two spirals, Mr. Liveing has devised a very simple photometer, composed of a wedge-shaped screen, C, the sides of which are made of oiled paper, and which receive the rays from the inclosed spirals. These two inclined planes are viewed through the tube, G, which, as well as the screen and outer tube, can be moved longitudinally. In using the apparatus, the outer tube, which is graduated, is pushed out or in until the luminous intensity of the two screens is equal. The proportion of fire-damp contained in the mixture submitted to experiment is then shown by the graduation on the tube. The difference in brilliancy produced by the combustion of certain definite mixtures is given by Mr. Liveing in the following table. It is well to state that these results appear to be independent of the speed of rotation of the small electrical machine employed:

Proportion of C_2H_4	Comparative Brilliancy of the Spirals.	
	Closed Tube. Pure Air.	Metallic Gauze. Mixtures.
Pure Air.....	1	1
0.25 per cent.....	1	1.21
0.50 ".....	1	1.65
1 ".....	1	2.78
2 ".....	1	5.10
3 ".....	1	22
4 ".....	1	64

THE HELIOGRAPH.

IMPROVED HELIOGRAPH OR SUN SIGNAL.*

By TEMPEST ANDERSON, M.D., B.Sc.

THE author claims to have contrived a heliograph, or sun telegraph, by which the rays of the sun can be directed on any given point with greater ease and certainty than by those at present in use.

When the sun's rays are reflected at a small plane surface considered as a point, the reflected rays form a cone, whose vertex is at the reflector and whose vertical angle is equal to that subtended by the sun. Adding to the size of the mirror adds other cones of light, whose bounding rays are parallel with those proceeding from other points of the mirror, and only distant from them the same distance as the points on the mirror from which they are reflected. Hence increasing the size of the mirror only adds to the field to which the sun's rays are reflected a diameter equal to the diameter of the mirror, and this at any distance at which the sun signal would be used is quite inappreciable. Adding to the size of the mirror adds to the number of rays sent to each point, and hence to the brightness of the visible flash, but not to the area over which it is visible.

By the author's plan, an ordinary field glass is used to find the position of the object to be signaled to, and to it is attached, in the position of the ordinary sunshade, a small and light apparatus, so arranged that when the mirror is turned to direct the cone of rays to any object within the field of view of the glass, an image of the sun appears in the field, at the same time as the image of the distant object, and magnified to the same degree, and the part of the field covered by this image is exactly that part to which the rays are reflected, and at which some part of the sun's disk is visible in the mirror.

A perfectly plane silvered mirror, A, takes up the rays of the sun, and when in proper position reflects them parallel with the axis of D, which is one barrel of an ordinary field glass. The greater part of the light passes away to the distant object, but some is taken up by the small silvered mirror, E, which is placed at an angle of 45° to the axis of D, and reflected at a right angle through the unsilvered plane mirror, F, and the convex lens, K, by which it is brought

to a focus on the white screen, H, which is placed in the principal focus of K. The rays from this image diverge in all directions, and some are taken up by the lens, K, and restored to parallelism; some of these are reflected by the unsilvered mirror, F, down to the field glass, D, and if this is focused for parallel rays, as is the case in looking at distant objects, an image of the sun is seen projected on the same field of view as that of the distant object.

As the mirrors, E and F, are adjusted strictly parallel, the rays proceeding from F into the field glass are parallel and in the opposite direction to those going from the mirror, A,

to E, which form part of the same pencil as those going to the distant object. Hence the image of the sun seen in the field exactly covers the object to which the sun flash is visible, and in whatever direction the mirror, A, is moved so as to alter the direction in which rays are reflected to the distant object, and the angle at which part impinge on E, and are reflected through the lens, K, the image visible in the glass moves in the same direction. Several attempts to produce this result were made by the use of mirrors and prisms, before the lens, K, was introduced, but they all failed. It was easy to make the image of the sun cover the object when the two occupied the center of the field of view, but directly the mirror was inclined so as to direct the rays not strictly parallel to the axis of the field glass, the apparent image diverged generally in the same direction along one co-ordinate, and in the opposite along one at right angles to it, so that nowhere but in one line across the field did the image lie in the desired position. The mirrors, E and F, are adjusted parallel once for all, by noticing the position on a screen of the small spot of light reflected from the front of F, as the light passes from E to K. The mirrors are moved by the adjusting screws till this spot has, to the bright reflection from the mirror, A, the same relative position that the center of mirror, F, has to the mirror, A.

In actual use the field-glass is first fixed in position pointing to the object, either by holding steadily in the hand, or better by a clamp attached, by which it can be screwed into a tree or post, or fixed in the muzzle of a rifle. The instrument is turned on the barrel of the glass till the sun is in the plane passing through the two axes of the instrument, and the mirror, A, is turned till the bright image of the sun is seen on the screen, H, through a hole left for the purpose in the side of the tube. On looking through the glass the sun's image is seen, and by then slightly rotating the instrument, or moving the mirror, is made to cover the object. The mirror, A, is connected not directly to the body of the instrument, but to a lever, B, on which it works stiffly, so as to retain any position in which it is placed. Lever, B, works easily, and has a limited range of motion, to one end of which it is pressed by a spring; slight pressure with the finger moves it and its attached mirror, so as to throw the light on and off the object in a succession of long and short flashes by which letters and words may be indicated. Flashes may also be given by moving the instrument if held in the hand. The above instrument answers well for all positions of the sun except when very low behind the observer's back. For this case another mirror is provided by which the light is reflected on to the mirror, A.

THE DISTANCE OF CLOUDS.

ON DETERMINING THE HEIGHTS AND DISTANCES OF CLOUDS BY THEIR REFLECTIONS IN A LOW POOL OF WATER, AND IN A MERCURIAL HORIZON.*

By FRANCIS GALTON, M.A., F.R.S.

THE calm surface of a sheet of water may be made to serve the purpose of a huge mirror in a gigantic vertical range finder, whereby a sufficiently large parallax may be obtained for the effective measurement of clouds. The observation of the heights and thicknesses of the different strata of clouds, and of their rates of movement, is at the present time perhaps the most promising, as it is the least explored branch of meteorology. As there are comparatively few places in England where the two conditions are found of a pool of water well screened from wind, and of a station situated many feet in height above it, the author hopes by the publication of this memoir to induce some qualified persons who have access to favorable stations, to interest themselves in the subject, and to make observations.

The necessary angles may be obtained with a sextant and mercurial horizon, but it is convenient, for reasons shortly to be explained, to have in addition a tripod stand, with a bar of wood across its top to support the mercurial trough, and some simple instrument for the rapid and rough measurement of altitudes. I have used the little pocket instrument sold by Casella, of Holborn Bars, London, called a "pocket alt-azimuth," and have employed Captain George's mercurial horizon on account of its steadiness and ease in manipulation. The observer has to determine:

1. The difference of level between the mercury and the pool of water (call it d).
2. The angle between the reflections of a part of a cloud in the mercury and in the pool (call it p). This should be carefully measured.
3. The angle between the portion of the cloud and its reflection in the mercury (call it $2a$). This may be roughly measured; its altitude, a , may most conveniently be taken at once by the pocket alt-azimuth or other instrument. The subjoined tables will then give the required result with great ease.

If p be not greater than 3° , and if n be the number of minutes of a degree in p , the error occasioned by writing $n \sin^2$ for $\sin n^2$, will never exceed 6 in 1,000 ft., and may be disregarded. Other errors of similar unimportance,

* Read before section A of the British Association, Swansea meeting.

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