case an interesting exception was observed. A piece of iron which had not rusted on long exposure to the action of air and water was placed in a strong solution of copper nitrate; after some time beautiful crystals of copper were deposited on parts of the iron, whilst other parts remained quite unaffected.

SOUTHERN HEMISPHERE SEASONAL CORRELATIONS.

THE first of a proposed series of articles on this important subject by Mr. R. C. Mossman, of the Argentine Meteorological Office, appears in *Symons's Meteorological Magazine* for February. Notwithstanding the great labour involved in this kind of research, it has received increasing attention from leading meteorologists during recent years. Mr. Mossman has collected a large mass of material relating to the climate of South America, which is now available for testing whether the sequences of weather in that continent "show as pronounced resemblances or contrasts, when compared with data from other regions, as do those in the northern hemisphere."

The inquiry now in question refers to the relation between the Nile flood and the winter rainfall of Santiago (Chile). The data used for the Nile floods are the percentage values for the years 1869-1906, published by Captain Lyons in "Rains of the Nile," 1906, and, for rainfall, the percentage values at Santiago for May-August of the same years. When plotted on a diagram, it is seen that, on the whole, there is a strongly pronounced opposition between the two sets of values. The author points out that the winter rainfall of Santiago, in common with other stations between 32° and 39° S., varies with the position of the South Pacific high-pressure area.

The Chilean Meteorological Office has recently supplied a complete set of instruments to Juan Fernandez, and the island is in radiographic communication with the mainland. This, with observations from a new station on Easter Island (27° S., 109° W.), should, Mr. Mossman thinks, afford useful information regarding the seasonal relations of the South Atlantic and South Pacific anticyclonic belts, and later on, when these data are compared with those at St. Helena, there is little doubt that the chain linking up the rainfall of Abyssinia with the Antarctic circulation will be complete. Captain Lyons has shown that the height of the Nile flood is dependent on the June to September rainfall in Abyssinia.

SOME METHODS OF MAGNIFYING FEEBLE SIGNALLING CURRENTS.[1]

TELEGRAPHY over long submarine cables is continually on the increase, and I think it may be brought forward as a fairly accurate statement that the number of messages sent doubles itself every ten years. It is therefore important that, besides the increase in the number of the cables laid down each year, means should be devised to increase the carrying power.

The instruments which I have invented and am about to describe were designed primarily for cable work, but they are equally applicable to recording many other kinds of signalling impulses.

For good reasons, recording by photographic means is objected to by nearly every telegraphist. If the photographic method were permissible, great advances in speed would be available, but it is important that the record should be of a simple, cheap, and immediate nature.

Lord Kelvin invented the siphon recorder in 1867—that is, about forty-five years ago; he designed it so carefully that no improvement in its sensitiveness has been brought about until now.

Short Siphon Recorder.

In siphon recorders of the moving-coil type what has to be done consists of—

(1) Overcoming the inertia of the coil and siphon.
(2) Overcoming the back E.M.F. of the coil.
(3) Overcoming the control of the suspensions.
(4) Overcoming the friction of air, suspensions, and inking.

As the siphon has to return to zero in a certain time after the current in the coil ceases, it is necessary for the coil and siphon to have a definite frequency of oscillation depending on the speed of the signals. For submarine telegraphy this frequency lies between about 3 and 10 per second, and is adjusted by varying the control on the coil. As the control necessary to give a certain natural period to the moving system is proportional to its moment of inertia, it follows that by reducing this inertia we reduce the forces required both to accelerate the coil and to overcome the control.

The ordinary siphon recorder employed is a siphon tube about $2\frac{1}{2}$ in. long and from 8 to 12 mils in

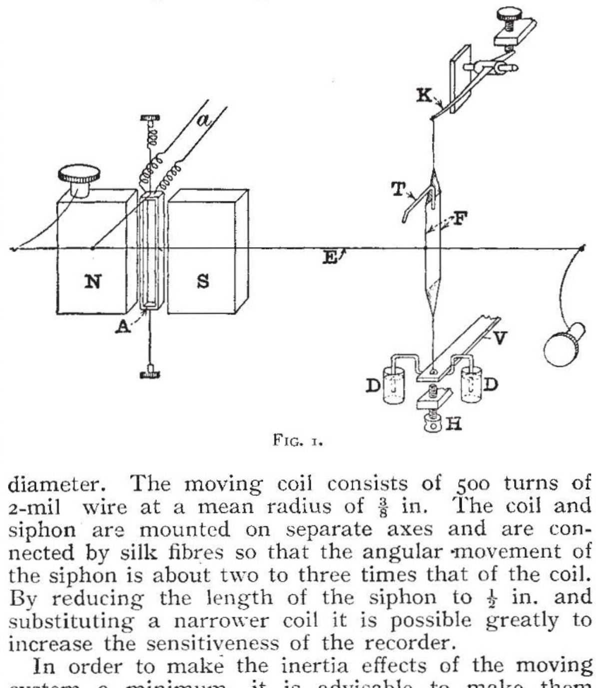

FIG. 1.

diameter. The moving coil consists of 500 turns of 2-mil wire at a mean radius of $\frac{3}{8}$ in. The coil and siphon are mounted on separate axes and are connected by silk fibres so that the angular movement of the siphon is about two to three times that of the coil. By reducing the length of the siphon to $\frac{1}{2}$ in. and substituting a narrower coil it is possible greatly to increase the sensitiveness of the recorder.

In order to make the inertia effects of the moving system a minimum, it is advisable to make them equal for the coil and the siphon. Even a narrow coil of 300 turns has about 100 times more inertia than the siphon, so that it is necessary to move the siphon through $\sqrt{100}$ times the angle moved by the coil.

By reducing the number of turns on the coil and increasing the field it is possible to reduce the natural period for a given sensitiveness and back E.M.F., but as the mass of the mountings and insulation of the coil only decrease slightly as the turns are reduced the gain is not very marked. In practice it is inadvisable to reduce the turns on the coil below 50 or 100 turns, as with lower values the power required to overcome the friction of the

[1] Discourse delivered at the Eighth Exhibition of Apparatus, held by the Physical Society on December 17, 1912, by Mr. S. G. Brown.

air and inking becomes too limited. This precludes the possibility of attaching the siphon directly to a coil of a few turns, and means of magnifying the motion of the coil and transmitting it to the siphon have to be used. In this instrument (Fig. 1) it is accomplished by means of a fine fibre, E, which is kept in tension by flat springs at each end. The fibre is attached to an arm carried by the moving coil A, and to a vertical fibre, F, on the siphon suspension.

The siphon is carried on an aluminium carrier to which a single central fibre is attached at the top and two parallel fibres, FF, 0·2 in. apart below. One leg of the siphon (Fig. 2) lies on the axis of the suspension and dips into a small opening in a pipe extending from the ink-pot. This arm goes in between the two vertical fibres, and as the opening in which the siphon dips is only a small one, the ink level remains practically constant, whether the reservoir is full or not. The siphon turns round on the axis in which the leg lies, and this makes the drag between the moving siphon and the ink very much less than if the siphon cut across the surface of the ink.

In order to produce an ink line on the paper without introducing friction, the siphon must not touch the paper even momentarily, and arrangements have been made to jerk the ink in fine drops on to the paper. To accomplish this the whole of the siphon suspension is vibrated rapidly up and down between the springs V and K by means of the spring V, which is attached to the vibrator. As the spring V is very weak in comparison with the reed, the vibrations of the latter are not affected by the movements of the spring. To impart a jerk to the siphon a stop, H, is fixed directly under the axis of suspensions, and two little dash-pots, DD, on either side prevent the spring bouncing on the stop.

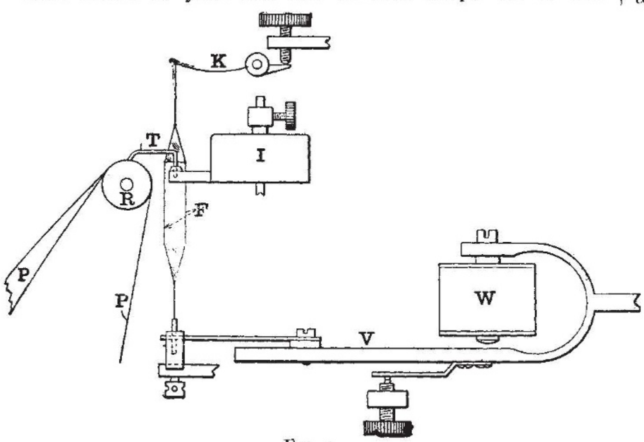

FIG. 2.

The working end of the siphon is ground flat, and an aniline dye with a small proportion of methylated spirit or ordinary red ink is used for recording on the paper. In this way a fine line of very closely spaced dots can be obtained without introducing any appreciable drag on the siphon.

For signalling purposes, the distortion due to the radius of the siphon being only ½ in. is not at all troublesome as the velocity of the paper moving round the wheel R masks this.

When the instrument is adjusted to have a natural frequency of 10·5 per second, with a 300-ohm 300-turn coil, a current of 50 microamperes gives a full-sized signal corresponding to a deflection of 0·1 in. on the paper. Under these conditions the back E.M.F. of the coil is only about one-quarter to one-fifth of that of the ordinary recorder coil.

Trials with this instrument have shown an increase of speed of 30 per cent. on the largest Atlantic cables.

Thermoelectric Magnifying Relay.

In this instrument (Fig. 3) the power in the relay circuit is generated by means of five thermo-junctions at different temperatures. The heat is supplied by two little flames, CC, and a very light thermopile, B, is suspended so as to swing in and out of the flames, and is coupled to a moving coil through which the received currents pass.

The thermopiles consist of alternate junctions of platinum and platinum + 20 per cent. iridium, wires being used of 1 mil diameter. The joints are made by twisting the ends of the two wires together and holding the junctions in a Bunsen flame for a short time. In this way a perfectly good and permanent joint is ensured. The wires are melted on to a fine glass tube about 10 mils in diameter, and one connection is brought down inside the tube to the first junction and the other connection comes along the outside of the tube.

For moving the thermopile in the flames similar arrangements to those just described for the siphon recorder are employed. Under the saddle which carries the thermopile the two silk fibres are stretched, and on to one of these the cross fibre which transmits the movements of the coil to the thermopile is attached. The top and bottom suspensions are of fine phosphor bronze wire and serve as leading-in wires to the thermopile.

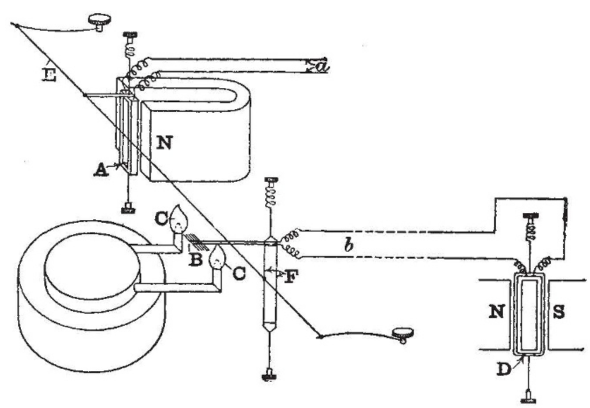

FIG. 3.

To supply the heat two little flames are fed by two or three strands of cotton wick with alcohol or methylated spirit. If the wick just protrudes above the opening a small steady flame is produced, and the lamp is provided with adjustments to vary the distance between the flames and the position of both flames relative to the thermopiles.

Instead of burning directly on the lamp wicks, a simple vapour burner can be fitted which will give good results even with very impure spirit. This consists of a brass cap which is kept hot by a copper wire attached to it at one end, and is heated at the other end by the flame. By altering the amount of wire in the flame the size can be varied.

An alternative arrangement which gives greater sensitiveness and enables heavier thermopiles to be used is to fix the thermopiles and vary the flames by means of a valve or shutter actuated by the coil movements.

As the thermopile current depends on the difference of temperature between the junctions a certain time is required to heat the wires. It is found that for cable work, where the frequency seldom exceeds

10 per second, the lag is inappreciable, but for considerably faster movements it becomes important.

In duplex working when the sending current has to be balanced so as not to affect the receiver, quick, "jarry" movements are very difficult to eliminate, but the lag in the thermo instrument reduces these movements very considerably and is a valuable property.

When the thermopile is in its central position and no current is flowing both junctions are at a dull red heat, and when fully deflected one junction becomes bright red and the opposite one is black or very faintly red. In intermediate positions the current generated by the thermopile is nearly proportional to the deflection.

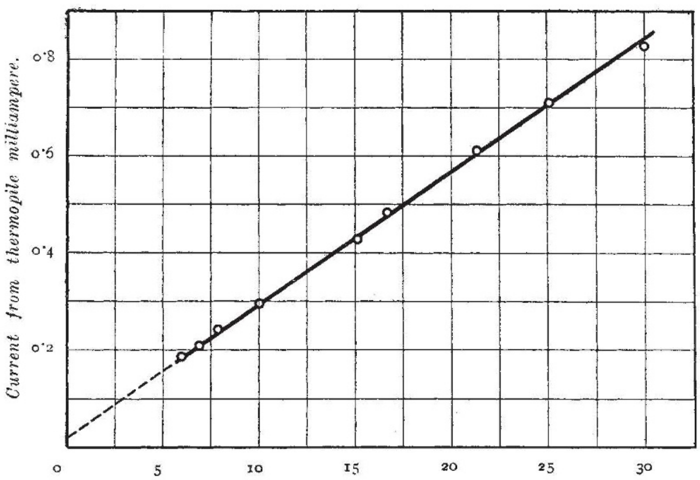

FIG. 4.

The curve (Fig. 4) was taken from a thermopile with seven junctions on each side. When the thermopile was deflected 0·075" the current it sent through a resistance of 42 ohms (equal to its own resistance) was 0·81 milliampere. With the natural period of the coil equal to 8·7 per second and a 480-ohm 480-turn coil, a current of 0·03 milliampere through the coil gave a current of 0·81 milliampere from the pile through an external resistance of 42 ohms. For slowly changing currents this corresponds to a magnification of power of about twenty-seven times, and, of course, this can be greatly increased by reducing the period of the coil. For quickly changing movements the power magnification is not so great, owing to the back E.M.F. of the coil.

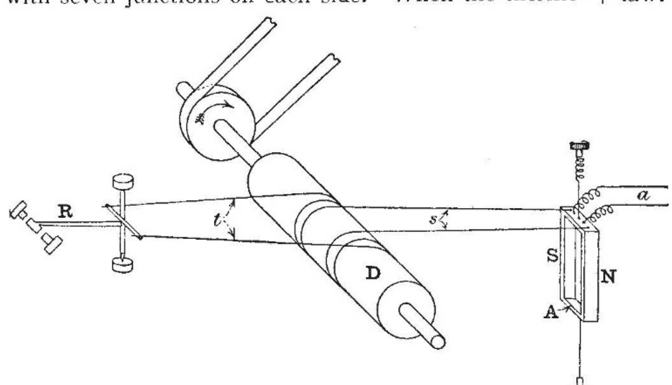

FIG. 5.

Trials of this instrument on an Atlantic cable have shown an increase in speed of about 40 per cent.

Mechanical Relay.

The instrument just described is a magnifying relay—that is to say, it multiplies the impulses received in exact proportion to their strength. This form of relay is quite distinct from an ordinary make-and-break relay, which delivers a constant current for any impulse over a certain strength. For very many purposes it is essential that received impulses should be magnified without altering their shape, and this can only be done by an instrument with a constant magnifying power.

That this is the case in the thermo relay is shown by the diagram (Fig. 4), where the current supplied to the coil and the current delivered by the thermo-junctions are plotted. Within the range of the instrument the points lie on a straight line and represent, in this case, a constant magnification in current of about twenty-seven times.

This property I will now illustrate in an entirely mechanical relay in which movements operated by very small forces are largely increased in strength without affecting their motion. The relay consists in principle of a rotating spindle around which are wound one or more turns of a flexible cord. The spindle is revolving in such a direction as to pull away from the magnified forces and towards the small forces that control the movement. Suppose a heavy weight has to be raised by a force of one-tenth of the amount, it will obviously be necessary to supply 90 per cent. additional energy, and this is supplied by the motor driving the spindle. The magnification of force and energy depends on the number of turns which the cord makes round the spindle and follows a compound interest law.

In the model shown it will be seen that a large magnification of power can be easily obtained by very simple means. Thus I can move this 14 lb. weight rapidly up and down by pulling upon this silk fibre.

Fig. 5 shows an application of the principle to cable work, in which the small forces operating the coil A are intensified sufficiently to work the coarse relay arm R. The spindle rotates away from the relay arm R and towards the coil, and produces a much greater tension in the fibres *t* than in *s*. When the coil swings on its axis the tension is increased in one of the fibres and diminished in the other, and a similar change in a magnified degree takes place in the fibres *t*.

By using means of this sort it is possible to work an ordinary siphon direct writer which normally requires some 3 milliamperes by a current of 10 microamperes.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

A SUMMER School in Geography will be held at the University College of Wales, Aberystwyth, on July 28–August 16. Among the subjects included in the scheme of work are:—Human geography, Prof. H. J. Fleure; climatology and trade routes, W. E. Whitehouse; land forms and natural regions, E. S. Price; field classes and excursions.