AN AUTOMATIC READING APPARATUS FOR « CONSOL » SIGNALS

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It is becoming increasingly accepted that the Consol radio-navigation system is proving itself, in the field of range and accuracy, an invaluable means of position-finding for ships and aircraft.

By the erection of new Consol radio beacons at Bushmills and Ploneis, and by the utilization of old German stations of the Elektra-Sonne type at Stavanger, Lugo and Seville, the Consol net-work has gained the monopoly of the west coast of Europe. In the maritime field, hundreds of reports from merchant and naval vessels have testified to the growing confidence of navigators

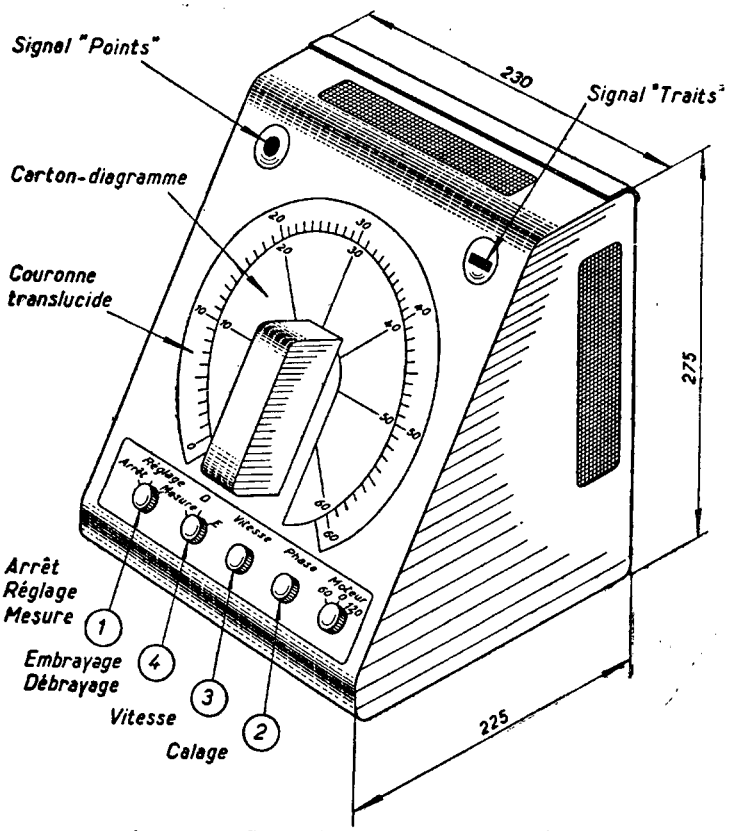

Fig. 1. — General view. Esco Recorder

in the system despite very marked suspicion or indifference in the early stages. In the field of aviation, the adoption of the Consol system for trans-Atlantic aircraft landing on the west coast proves the importance of the process, while in the field of fishing and submarine navigation over long distances, the Consol process can even become the basis for the steering of the vessels.

Among the various radio-navigation systems which came to the fore after the war, the chief advantage of Consol lies in its adaptability to vessels and aircraft supplied with only a regulation, medium-frequency receiver, because it requires no special equipment nor any operation other than the reading of signals.

The other advantage of the system lies in its range, which, in the case of aeroplanes, easily reaches a distance of 1,200 miles and is almost as great of vessels equipped with tall aerials, using up-to-date transmitters of 2 kW. operating on frequencies of 250 to 320 kc.

As to its accuracy, detailed studies in this connection can be summarized by saying that, amongst the directional systems, it is superior to radio direction finding, and even if, like this system, it is subject to instability over a wide area of interference that varies from between 350 to 600 miles, it often regains, on reflected waves of more than 1,000 miles, a remarkable stability involving angular discrepancies of 2/10 degree in areas of favourable reception.

These results have been confirmed by numerous observations made by vessels following the Consols of Europe beyond the Azores.

At medium and short distances, apart from local irregularities, and in angular zones of good reception, the linear ambiguities that have been observed drop to less then three miles and make the system suitable for navigational control that is sufficiently adequate, and better, at any rate, than D. R.

The results obtained in the field of aerial navigation, where the requirements of accuracy are naturally less exacting, have conferred on the system a reputation which, in the long run, overcame American lack of interest and resulted, in the United States of America, in a series of extensive tests of experimental, high-powered, Consol-type equipment equal to 7 kW. on 193 kc. The results of such tests finally led to a broad programme involving the establishment of Consol equipment on American territory.

There was, however, one objection to be found in the working of the system. Without wishing to be drawn here into an account of the Consol technique, mention should be made of the fact that the system establishes, by a process of interference between two transmitters of continuous waves, a set of fixed angular sectors, with an aperture of 15 to 20°, which are periodically swept by an equiphase line at a constant speed equal to the transmission of sixty dot and dash morse signals.

The vessel or aircraft that picks up this equiphase or equisignal line, when it sweeps over it, can determine its bearing by comparing the time that elapses between the beginning of the sweeping and the occurrence of the equi-signal line with the time of the cycle.

To avoid the complications of a phase-metre or of a special receiver, the transmission is effected by the same technique as that used for mixed signals applied to radio beacons. The passing of an equi-signal line reveals itself by

an alteration in the transmitted signal which changes, for example, from dot to dash. The wireless operator on the ship or the aircraft has, therefore, the following two duties:

1. to separate aurally the dashes from the dots;

2. to count the number of signals preceding and following the equi-signal.

The ratio of this number to sixty (which is the number of signals transmitted in a cycle) establishes the angular position of the mobile station in the sector. With this number, the navigator refers to a table or a chart which gives him his bearing or locus.

This form of transmission necessitates this calculation which demands, on the part of the navigator, an experienced ear, an unflagging attention and an absorbing vigilance if errors in the reckoning are to be avoided. Furthermore, it is known that the equi-signal line is naturally ill-defined and that, in practice, it produces an equi-signal band which is more difficult to determine than the silent band in radio-direction finding. Frequently, on an aeroplane or a vessel of small tonnage, such as a fishing vessel, this operation is long, tiring and subject to all the risks of accidental omission or of individual perception.

The apparatus described below aims at making this operation mechanical, abolishing the personal factor and obtaining for the navigator a continuous and direct reading of the number of signals that will become the argument to be entered in the tables or the special charts. It will form a cheap and compact accessory to the medium-frequency receiver and will indicate at each cycle the position of the equi-signal line.

THE ESCO RECORDER

Two methods (one optic, which is temporary, the other graphic, which is permanent) of establishing the middle of the equi-signal sector and of reading the number of signals, by means of dots and dashes which precede or follow the equi-signal, are offered the navigator by the Esco recorder.

The apparatus is in the form of a small desk cabinet attached by two double-conductor cables to the power supply and to the vessel's radio receiver.

OPTICAL INDICATING SYSTEM

The front panel has a transparent sector on which are marked two graduated circles, each divided into sixty sections and each corresponding to the two respective cycle periods of the Consol transmission at present in use, that is to say, 60 s and 30 s.

A lamp connected with a revolving arm rotates beneath the sector at a constant speed that corresponds to the period of transmission of a complete cycle.

Two methods, both actuated by a knob (1), are provided for lighting the lamp. They are:

1. a *control* system in the operation of which the light flashes on for a brief second at the time that the signal is received (except during the equi-signal

period and during the blank interval, represented by the station call-signal and the circular transmission, if any);

2. a so-called *measurement* system in the operation of which the light burns steadily, but only during the equi-signal period.

The lamp and the arm that actuates it revolve continuously by means of a synchronous motor fed at a constant frequency at a stability rate better than one-hundredth.

To work the control system, the operator, having allowed one revolution to be completed undisturbed, actuates the zero set control (2) and, at the beginning of the cycle, brings the light-indicator into line with the zero division of the scale. He then verifies that the last flash of the light coincides with section 60 of the scale. If this should not be so, he can always effect a second adjustment by regulating the speed of the motor through a knob (3), but it is very unlikely that this should prove necessary if the Consol transmission cycle is kept correctly synchronized.

To work the measurement system, the operator makes a note of the divisions that correspond with the beginning and the end of the steady operation of the light, the average giving him the reading data which form the basis of the readings.

The nature of the signals received is shown by means of two luminous windows situated above the indicator, to the right and to the left respectively. One is reserved specially for dots, and only lights up during the transmission of dots; the other is reserved for dashes.

GRAPHIC RECORDING

A ring of sensitized and reinforced paper with a large sector cut out of it is set inside the transparent circle. An upper revolving arm, resting motionless in the empty section in the « rest » position, can, by actuating knob (4), be brought into action by the motor when required. Having arrived at the zero division on the scale, it then locks with the lower moving arm carrying the bulb and travels with it.

At the tip of this moving arm, facing the paper, is an electro-magnet which forces a metal stylus perpendicular to the paper to deviate about 2 mm. in a radial direction each time a dot or dash signal is received. It remains stationary during the equi-signal and then inscribes an arc. After each cycle, the magnet undergoes a radial displacement, related the next cycle, of 3 mm. towards the centre, the stylus being raised by a rack during this change of position. The stylus is then ready to inscribe another cycle.

Six consecutive cycles can thus be inscribed concentrically on the diagram.

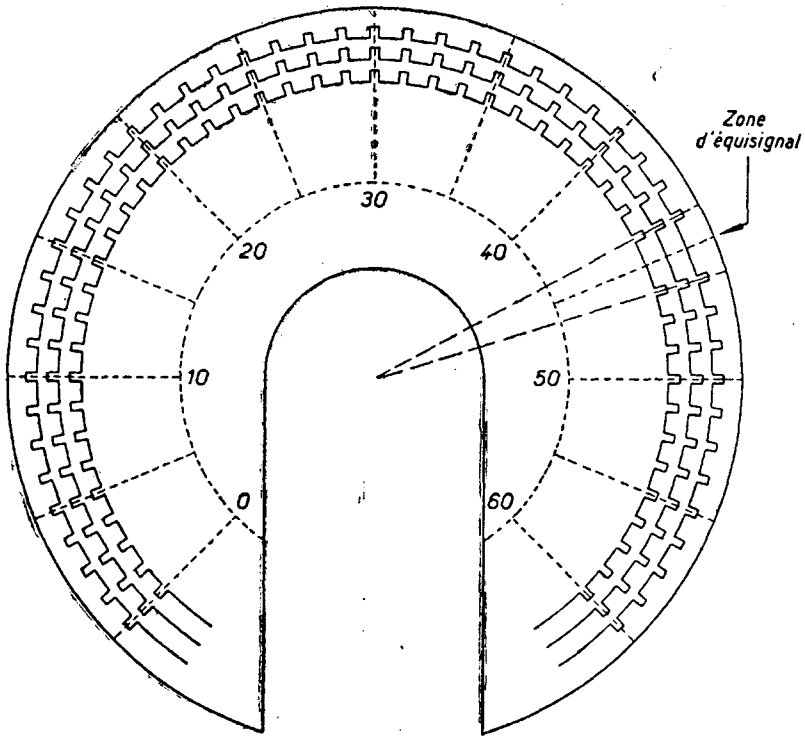

Fig. 2. — Recording sample.

The paper can then be removed and on it will be found, in concentric graduation markings, the position of the equi-signal line and especially its angular displacement from one cycle to another. If the aircraft is « homing », that is, if it is navigating according to a constant station bearing, the spaces which establish the successive positions of this equi-signal line will fall on one and the same radius. The chief advantage of this graphic recording is that it completely frees the navigator's attention for the duration of several Consol cycles; he is no longer compelled to give his time and attention to following difficult sounds or fleeting light indications; all that he is required to do is to examine carefully, at the end of a few minutes, a diagram, the consecutive cycles of which are self-verifying.

Another use to which this recording can be put, but one which rarely appears to be necessary, is the comparison of the number of signals marked on the diagram with the number of signals registered by the spot of light on the circle, an operation which reveals all irregularities in the synchronization of the transmission.

THE FEEDING OF THE LIGHT INDICATORS AND THE ELECTROSCRIBER (Fig. 3)

The conductor (1) that links the apparatus to the receiver feeds an electronic discriminator (2), housed in the cabinet and the function of which is to emphasize each dot or dash signal regardless of the strength of the signal or of

the intake level. The outlet of this discriminator feeds two relays (3) and (4), one reserved for the dots and the other for the dashes. It is these two relays that supply the power, on the one hand, to the fixed identification lamps (5) and (6), and, on the other hand, to the revolving internal lamp (7), operated by the motor (8) by means of two rings concentric to the shaft.

CONCLUSION

To sum up: for aviation purposes, once the receiver is adjusted to the Consol frequency to be received, the mere operation of a starting switch enables the pilot, after a quick zero set, to read at a glance, on the circle of the Esco apparatus panel set up on the instrument board, the number of signals corresponding with the equi-signal line; for slower and more accurate navigation, a continuous indication of the position of this line can be obtained on a lasting document.

As it stands, the Esco apparatus, of which a prototype constructed in the workshops of the « Société Industrielle de Télécommande et de Télémécanique » is in the course of being tested and presented, gives every indication of being simple to operate and resistant to sea and air conditions. Naturally, in spite of all the filters used, the signals emanating from the background noises will inevitably be exposed to atmospherics of all kinds. In the most extreme cases, the regularity of the recordings will allow for the separation of the real signals from the atmospherics of erratic strength. As for the jamming so well known to navigators, which is experienced during transmission in the area of radio beacons in the Spanish Consol system, this is destined to disappear in August, 1953, when the programme arranged by the international agreement arrived at in Paris in 1951 for radio beacon equipment in the European area is carried out. At that time, the transmission stations at Lugo and Seville — which are at present functioning on 303 and 311 kc., i. e., on a maritime band — will be changed to 285 and 315 kc. on the aeronautical band.

At the same time, the Consol 60 s direction cycles, which are considered by navigators to be too slow, will be brought into line with the Bushmills and Ploneis Consols on 30 s. This standardization will make it possible to eradicate the graduation at present appearing on this cycle on the Esco apparatus and to bring the sweep of the revolving arm to a standard speed.

Thus, the use of the Consol system, facilitated by an automatic recording apparatus, will become increasingly popular with aerial and marine navigators, particularly since it is planned to extend Consol beaconing along our coasts by the erection of new stations with particular reference to the Mediterranean, where the use of the Seville and Lugo Consols has proved far too inaccurate.

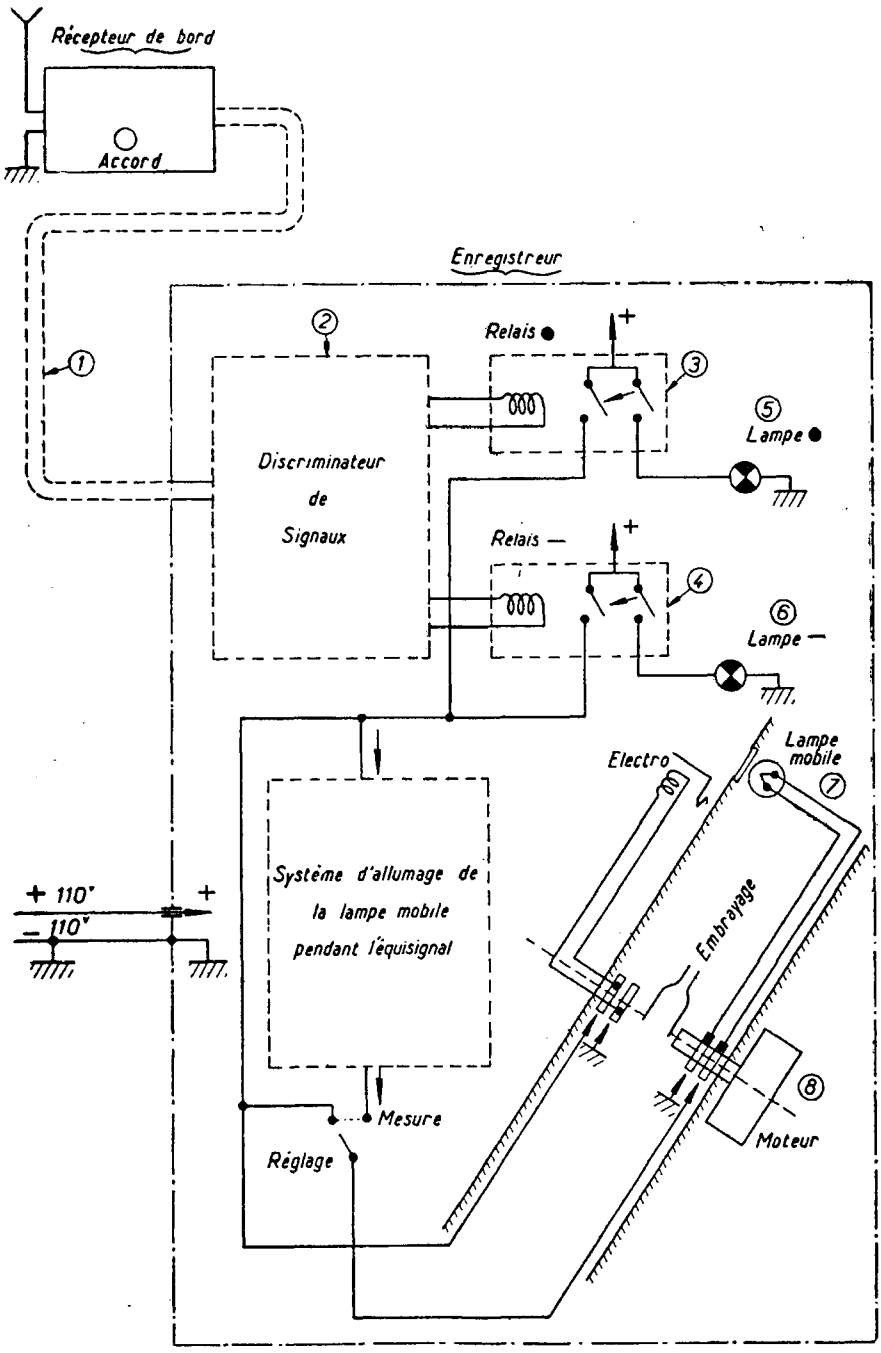

Fig. 3. — Basic principle of recording unit.