SUPPRESSION OF CONTACTS IN ASTRONOMICAL CLOCKS.

by R. F. P. LEJAY

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In the experiments carried out at the BUREAU INTERNATIONAL DE L'HEURE, General FERRIÉ and his collaborators pointed out that certain irregularities of the time signals emitted by astronomical clocks were due to defects in the mechanism for making the contacts each second. These irregularities may reach the hundredth of a second and, therefore, any attempt to measure a thousandth part will be illusive.

Obviously it would be advantageous to suppress these contacts, especially in cases where great accuracy is required.

General FERRIÉ proposed a method of registering the oscillations of pendulums, based on the use of photoelectric cells: a luminous pencil falls on a mirror fixed to the pendulum; it is reflected at each oscillation onto a cell. The current produced, considerably amplified, is sufficient for the purpose of registration, and for the synchronisation of a small auxiliary pendulum second-counter.

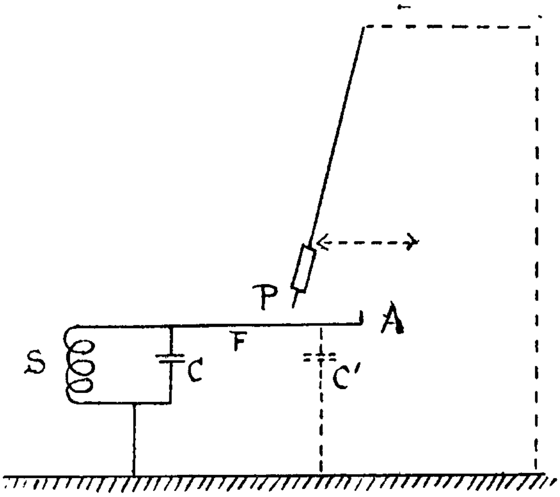

Fig. 1

I have applied a different principle, which consists of making the pendulum itself actuate radiotelegraphic emissions at the instant when it occupies a particular position, for example, when it passes the vertical (1).

A small, short wave transmitter, which will be described farther on, constantly maintains oscillations in an oscillating circuit, composed of a self induction *S* and a capacity. (Fig. 1) To one of the terminals of the capacity, a wire *F* is fixed in such a way that a point *P*, united to the pendulum, passes, at each oscillation, near the free extremity *A* of the wire.

The wire makes with the earth a capacity *C'*, which is added, in parallel, to the capacity *C* to fix the wave length on which the oscillating circuit usually oscillates. At the instant of passing the vertical the value of the capacity *C'* is modified; it is increased by another capacity *C''*, formed by the extremity of the wire *F* and the point *P* of the pendulum. The length of the wave sent out is changed; it passes progressively from a value *L* to a value *L'* as the pendulum draws nearer the wire, to return progressively to a value *L* when the pendulum recedes from the wire after having passed it.

If an ordinary receiving set, tuned to the wave length *L'*, be placed near the pendulum, it will be actuated each time the pendulum passes the vertical, and at this instant only if the difference between *L* and *L'* is sufficient. In fact, it is known that a set, tuned to a particular wave length, is sensitive to the waves included in an interval *L1 L2* (Fig. 2). If *L* be situated outside this interval, the receiver will remain silent throughout the whole oscillation, and will be actuated only during the instant that the parts *P* and *A* are in proximity.

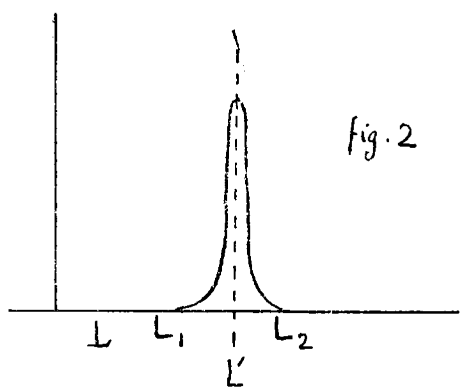

fig. 2

In order that the registrations may be sharp enough, and may be accurately read, the change of wave length must be sudden and, in consequence, the parts *A* and *P* must be as delicate as possible. If, for example, they are one millimetre in width, the total duration of the passage of the wave length *L* to *L'*, and for the return from *L'* to *L*, will scarcely exceed two 100ths of a second, in the case of an ordinary astronomical clock.

Fig. 3 represents the record of a Fénon pendulum, connected to a short wave transmitter, an experiment carried out at the Paris Observatory, Bureau International de l'Heure.

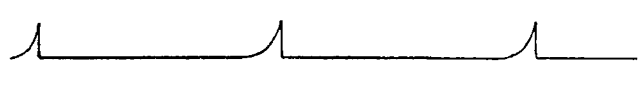

fig. 3

(1) P. LEJAY. Reports of the Acad. of Sc. 184, 1927, p. 321. — *This principle can be applied in many ways. Here we have described but one procedure, but intend later to discuss another which is at present in course of realization.*

It must be noted, however, that the reduction of the parts *A* and *P* makes the value of the capacity *C*" very small; therefore, to obtain a sufficient variation of the wave length, the capacity *C* itself must be very small; the natural period of the oscillating circuit will be very short.

Thus, the only limitation is the difficulty of the stable tuning of present day receiver sets for very short wave lengths. It has been found that wave lengths between 20 and 100 metres are perfectly suitable. Within these limits, the receivers may be henceforward entrusted to the least experienced.

DETAILS OF THE CONSTRUCTION OF THE SHORT WAVE APPARATUS.

The transmitter has no peculiarities; anyone can understand it in a few moments. For example, an ordinary valve (called the reception valve) may be mounted according to the diagram (Fig. 4) which represents the classic heterodyne arrangement.

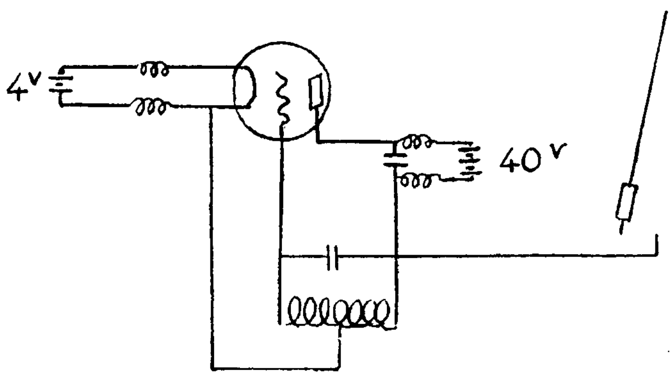

Fig. 4

The self induction *S* would be composed, if desired, of 15 spires, 10 to 15 centimetres in diameter, which can be wound, in form of batch winding, round a piece of thick cardboard. The condenser could be composed of three or four plates of the ordinary dimensions used in variable condensers.

The wire *F* of some tens of millimetres, should be as short as possible (50 to 100 c/m) placed symmetrically with regard to the pendulum, so that only its extremity approaches it. Thus, variations of parasitic capacities, which would cause variations of wave length and, consequently, registrations out of time, would be prevented during the oscillations.

An ordinary receiver set is used, without any modification, which is one of the advantages of the system. The triumph of short waves being now aasured, in spite of all contrary interests which have temporarily retarded the development of it in some countries, all observatories should, from now, be compulsorily provided with modern receiving apparatus. This apparatus will permit the hearing of our clock; if in addition there are recording machines, it will also be possible, without modification, to record the clock. For comparing several clocks, transmitting on different wave lengths, it would, however, be necessary to place at the reception several separate oscillating circuits, actuating, for preference, separate detector valves, to prevent interferences.

In any case, the reception arrangement is very simple since, in proximity to the clock, the reception is exceedingly intense. More usually, we suppose that the clock is at some distance from the receiver. If they could be placed in the immediate vicinity of each other, the transmitter could be connected direct to the receiver.