The Problem of Synchronism in Television

A Description of the Method which has been Adopted in John L. Baird's Apparatus

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ONE of the greatest problems of television is that of securing and maintaining *synchronism* between the transmitting and receiving mechanisms. In phototelegraphy, as distinguished from television, the problem is relatively simple, for the speed of transmission is so very much slower that greater errors in synchronism are permissible. Also, as will be made clearer later, synchronism in phototelegraphy need only be carried out in what might be described as a single dimension: whereas, in television, it must be carried out, in a sense, to two dimensions.

In phototelegraphy the problem resolves itself into the rotation at precisely equal speeds of two cylinders, one at the transmitter and one at the receiver. Simultaneous starting can be effected by a prearranged signal.

The maintenance of equal speeds of rotation can be accomplished in several ways, the commonest being by means of electrically-operated tuning forks or clockwork-operated pendulums. Whichever system is employed, it is caused to send perfectly timed electrical impulses to the receiver, and at the receiver these impulses are caused to control the speed of rotation of the receiving cylinder.

At the end of the transmission of a picture, and before commencing to transmit another, the two remotely separated mechanisms can, if desired, be stopped and simultaneously restarted, thus ensuring that the receiving mechanism starts at the beginning, in step with the transmitter.

In television, however, both mechanisms are running continuously, and sixteen complete pictures are transmitted per second. Under these conditions it is possible that both mechanisms may run at the same speed and still the image will be incorrectly received at the distant receiver.

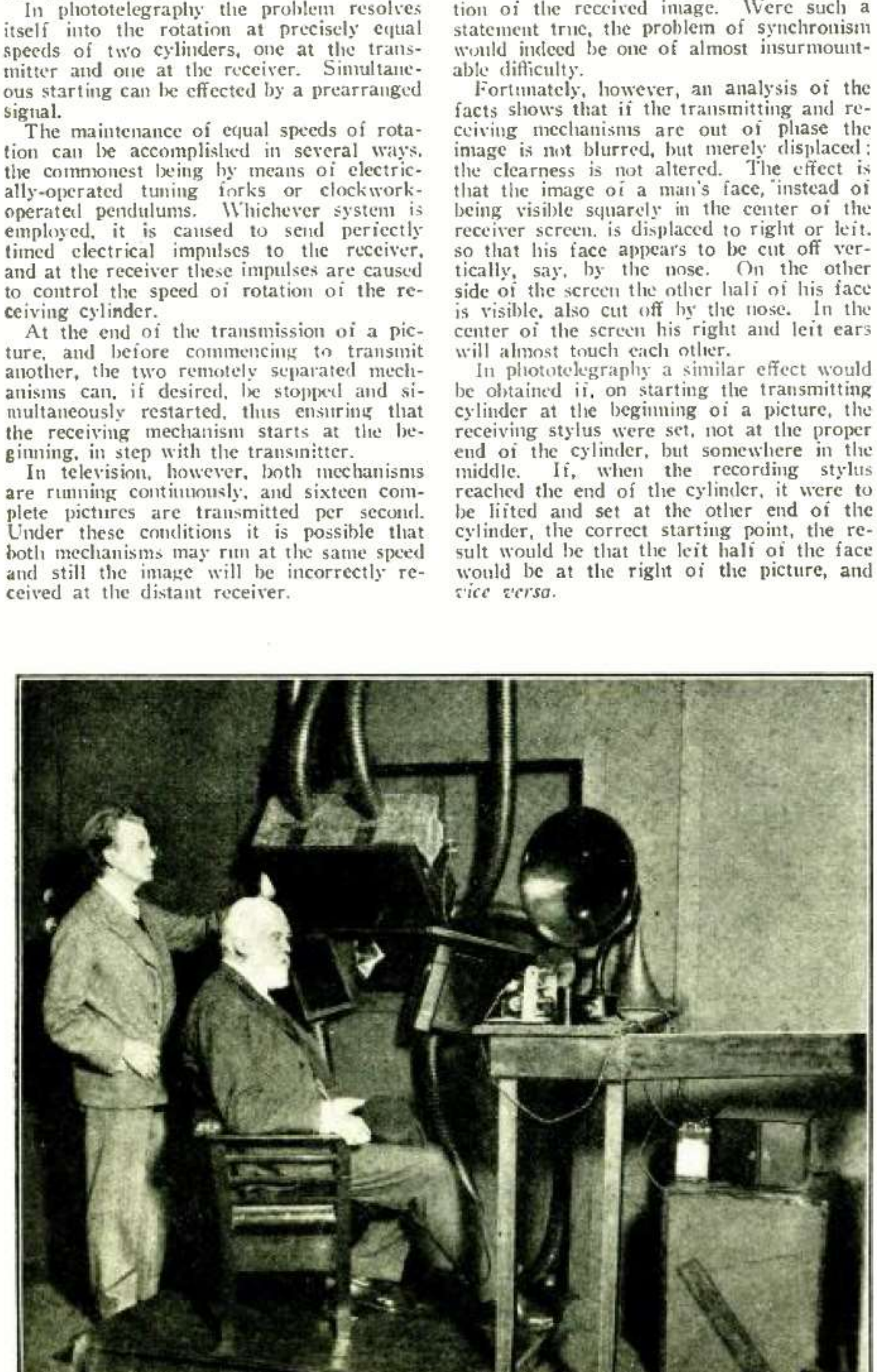
RESULTS OF IMPERFECT SYNCHRONISM

This difficulty has given rise to a common misunderstanding, prevalent even in technical circles, which, in turn, has caused the difficulty of synchronism in television to be, to some extent, overrated.

Quite commonly the statement has appeared that a difference of phase of only one per cent between the transmitter and the receiver is sufficient to spoil the definition of the received image. Were such a statement true, the problem of synchronism would indeed be one of almost insurmountable difficulty.

Fortunately, however, an analysis of the facts shows that if the transmitting and receiving mechanisms are out of phase the image is not blurred, but merely displaced; the clearness is not altered. The effect is that the image of a man's face, instead of being visible squarely in the center of the receiver screen, is displaced to right or left, so that his face appears to be cut off vertically, say, by the nose. On the other side of the screen the other half of his face is visible, also cut off by the nose. In the center of the screen his right and left ears will almost touch each other.

In phototelegraphy a similar effect would be obtained if, on starting the transmitting cylinder at the beginning of a picture, the receiving stylus were set, not at the proper end of the cylinder, but somewhere in the middle. If, when the recording stylus reached the end of the cylinder, it were to be lifted and set at the other end of the cylinder, the correct starting point, the result would be that the left half of the face would be at the right of the picture, and *vice versa*.



Sir Oliver Lodge, the eminent British scientist, posing before the television transmitter, which is being operated by its inventor, John L. Baird.

The distortion, or blurring of a television image is caused only by different speeds prevailing at the transmitter and receiver, that is to say, by lack of *isochronism*. The problem of isochronism is much simpler of solution than that of synchronism. Possibly these words are not familiar to readers, and it is not out of place to define them here.

ISOCHRONISM AND SYNCHRONISM DEFINED

When two mechanisms are said to be running in *isochronism*, what is meant is that they are running at the same speed, but are out of step. For example, two clocks which are running at the same rate would be in exact isochronism, although the hands of one might point to 2.30 and the hands of the other to three o'clock. To be in *synchronism*, the hands of both clocks must indicate exactly the same hour.

When the first efforts were made to achieve television, attempts were made to obtain isochronism by means of the methods used in phototelegraphy; *i.e.*, by means of pendulums and tuning forks. Such methods, however, do not lend themselves to television, for they are not sufficiently accurate.

By using synchronous motors, however, perfect isochronism can readily be obtained, and the mechanical and electrical arrangements involved are not so complicated as is the case with the other methods. It was with the aid of such motors that the first successful results in television were achieved by John L. Baird, the British inventor.

One of these motors comprises, essentially, an armature, or rotor, supplied with an alternating current, and a stator supplied with direct current. Or the rotor may be supplied with D.C. while the stator takes the A.C. The speed at which such motors run is dependent entirely upon the periodicity, or frequency, of the alternating-current supply, and upon the number of poles in the rotor or stator, whichever is receiving the A.C.

At first glance it might be supposed that synchronism between two television mechanisms could be obtained by using two exactly-similar motors, controlled by rheostats and run at exactly the same speed, as indicated by a form of speedometer. This can not be done, however, for ordinary electric motors continually vary in speed, due to small variations in the supply current and other reasons. This habit of variation is known as "*hunting*," and, before television can be successfully achieved, the hunting propensities of at least one of the motors must be brought under exact control. The task of the synchronous motor is to act as controller.

HOW ISOCHRONISM IS OBTAINED

At the transmitting end the image-exploring mechanism is driven by an ordinary electric motor, either A.C. or D.C., depending upon the supply available. Mechanically coupled to the same shaft is a small A.C. generator. The periodicity of the output of this machine may have any convenient value; but the higher it is, within very reasonable limits, the better are the results.

This A.C. output is then conveyed (as will be discussed later) to the receiver, where it is caused to drive a synchronous motor which is mechanically coupled to the same shaft as the main driving motor which operates the image-exploring mechanism of the receiver. This main driving motor, like the main driving motor at the transmitter, is

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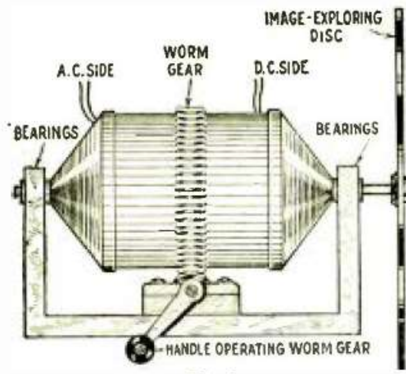

Fig. 2
The outer view of the driving motor and synchronous motor, which can be adjusted by means of the worm gear.

an ordinary electric motor operating off any convenient supply.

The main driving motor at the transmitter has the usual tendency to "hunt," and it is allowed to do so unchecked; the periodicity of the A.C. generator coupled to it varies in accordance with its speed wanderings.

At the receiver, however, the main driving motor is not allowed to hunt independently. Its speed is under the absolute control of the synchronous motor coupled to it; and as the speed of the latter varies in exact sympathy with the periodicity changes of the distant A.C. generator, it follows that the main receiver motor must at all times be revolving at exactly the same speed as the main transmitter motor. The fact that they both hunt slightly does not matter, for they hunt in unison. Therefore, isochronism is achieved.

There remains now the question of synchronism. That is to say, although we have the two machines running at exactly the same speed, we have, as yet, no means for keeping them in the *same phase relation.*

OBTAINING SYNCHRONISM

As stated previously, a difference of phase does not cause blurring or loss of definition. It merely causes a shift of the image as a whole, and this image shift is very simply rectified by the expedient of rotating the receiver's driving mechanism as a whole about its spindle until the picture comes into view in its proper place.

The action may be compared to that performed by the operator of a moving picture projector when the picture appears with people's feet at the top of the screen and their heads at the bottom, with a dividing line across the middle. All that is required is simply an adjustment to bring the picture properly into its "frame." The descriptions given above will be understood more clearly if reference is made to the accompanying diagrams.

In Fig. 1 a cross-sectional view is given of the receiver's driving mechanism. At the extreme right-hand end of the shaft is the image-exploring disk. Further to the left, within the "carcase" (frame) is the D.C. main driving motor. To the left of that is the synchronous motor, which controls the speed of rotation of the D.C. motor, giving isochronism.

The carcase of these motors is mounted on bearings, so that it can be rotated bodily by means of a handle operating through a worm gear. This feature is more clearly shown in Fig. 2.

It will be seen that this mechanism has the merit of extreme simplicity, and it seems to work extremely well in practice; for it is essentially the method used not only by Mr. Baird, but also by the American Telephone & Telegraph Co. in their recent demonstration of television between Washington and New York.

Mr. Baird's British patent (No. 236,978, of March 17, 1924) describes this device for rotation of the mechanism; although it is questionable if any patent involving the use of a synchronous motor as a means of obtaining synchronism can be considered valid, because the synchronizing principle, to use the phraseology of the Patent Office, has been "long known to the art." However, to Mr. Baird belongs the credit of being the first successfully to apply this principle.

THE TRANSMISSION MEDIUM

It has been mentioned that the output from the A.C. generator at the transmitter is "conveyed" to the receiver.

It is, of course, impossible at the present time to transmit power by radio or over a telephone line. Therefore, some other means must be provided to supply the A.C. impulses to the receiver. This is done by causing the A.C. to modulate either the carrier current, in the case of wire communication between the two points, or the carrier wave, in the case of radio communication. This modulation, of course, takes the form of a continuous note of audible frequency, corresponding to the periodicity of the generator output. It can, without difficulty, be carried over the same channel which carries the television impulses, filter circuits being used at the receiver to separate the two sets of impulses.

At the receiving station the synchronizing note, after being filtered out from the transmission channel, is amplified and used to control the supply of the A.C. synchronous motor.

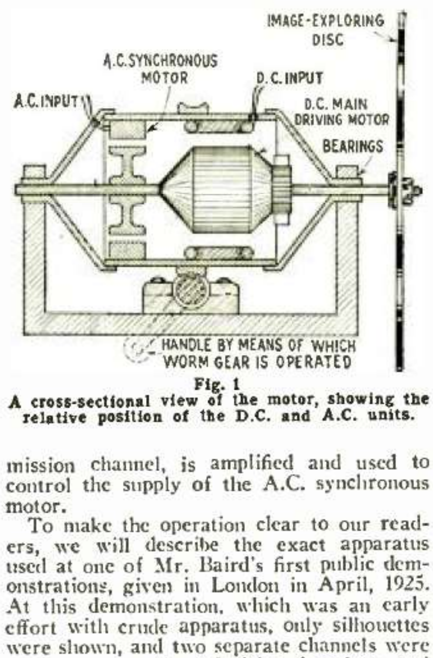

Fig. 1
A cross-sectional view of the motor, showing the relative position of the D.C. and A.C. units.

To make the operation clear to our readers, we will describe the exact apparatus used at one of Mr. Baird's first public demonstrations, given in London in April, 1925. At this demonstration, which was an early effort with crude apparatus, only silhouettes were shown, and two separate channels were used, one for the television impulses, and one for the synchronizing impulses. However, the method of synchronism employed was essentially the same as that described above.

The transmitter was connected to two small loop antennas, one of which transmitted the television signals, while the other transmitted the note caused by the A.C. generator. At the receiving station, which was at the other end of the same room, two similar loops were employed to pick up the two sets of impulses.

BAIRD'S ORIGINAL APPARATUS

The note, after being picked up by the loop and its associated tuning apparatus, was passed through a 3-tube A.F. amplifier, the output of which was connected to a telegraph relay. The amplified alternating current caused the reed of the relay to make contact first in one direction and then in the opposite direction. That is to say, the reed was caused to vibrate, or oscillate, between the two fixed contacts set on either side of it. The output of the relay was therefore an alternating current, directly in phase with the alternating current generated at the transmitter.

In order to synchronize the two machines, the receiver's main driving motor was first run up to speed, under the control of a rheostat. The input to the synchronous motor was controlled by means of a double-pole switch, which connected it to the output of the relay. Across the poles of the switch were connected two little lamps.

As the synchronous motor and the output of the relay came into phase the lamps flickered, the flickering becoming less and less as the speed of the synchronous motor (driven by the receiver's main driving motor) approached that of the generator at the transmitter. When the speeds became exactly isochronous the flickering ceased and the lamps went out entirely. At that instant the switch was closed and the current from the relay fed to the synchronous motor. This current was sufficient to prevent the synchronous motor creeping out of phase, which, in turn, prevented the main driving motor from hunting.

The above method is essentially similar to that used by Baird at present, with the exception that the telegraph relay is, it is understood, no longer employed. The output of the last tube of the amplifier is now applied direct to the synchronous motor.

It will be understood, of course, that the synchronizing current is almost infinitesimally small; but where well-balanced mechanisms are used, only a very small synchronizing current is necessary to keep the main driving motor of the receiver from hunting.

As already explained, any convenient supply may be used to run the main motor. Mr. Baird uses D.C. motors, because the current supply to his laboratory happens to be direct. The A. T. & T., whose synchronizing methods are essentially the same as Mr. Baird's, used A.C. motors, simply because the power supply was in that form.

During the course of his original experiments, Mr. Baird used a synchronizing frequency of 60 cycles; but, as already mentioned, the higher the periodicity used, within limits, the better the results; and I understand that at present Baird is employing a synchronizing frequency in the neighbourhood of 200 cycles. The employment of this frequency enables him to obtain a much finer degree of synchronism, and this improvement, in conjunction with greatly-perfected and better-finished mechanisms, has resulted in a vast improvement in the quality of the received image.

Whereas his original television images were somewhat lacking in detail and marred by a constant flicker, his present-day results are remarkable for their improved detail and the almost complete absence of visible "grain" and flicker. To these improvements the writer can personally testify, having witnessed both the earliest and the most recent demonstrations given in Mr. Baird's laboratories.

The receiver of Mr. Baird's television system, which is used with great success, it is stated.

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