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Induction

A ONE-TIME RIVAL TO RADIO BECOMES ITS ALLY

By G. A. V. SOWTER, B.Sc. (Eng.) Lond., A.M.I.E.E.

A FEW months ago on lifting the domestic telephone receiver the writer was astonished to hear a voice announce that a well-known compère was about to present one of his "Discoveries." Curiosity getting the better of discretion, the reason for telephoning was forgotten and at least a minute of interested listening took place before it was appreciated that here, unintentionally, was what might be a demonstration of the proposed National Broadcasting Service by telephone wires. It was quickly remembered that a radio set was operating at that time in the house and the telephone earpiece was raised and lowered from the ear a few times to confirm that the broadcast programme was actually being reproduced by this earpiece.

THE experiments described in this article show that there is a right and a wrong way of wiring a house for extension loud speakers, but it is also explained that the wrong way can serve a useful purpose by functioning as an inductive deaf-aid system.

It was evident that some unusual phenomenon was occurring and, in order to solve the mystery, domestic aid was vociferously solicited by requesting that the radio be turned off for a moment. This proved definitely that the programme was emanating from the writer's own set, but the loud speaker in use was incapable of being heard in the vicinity of the telephone, and consequently there must have been some electrical association between the loud speaker distribution system and the telephone wires.

Thoughts of common earth connection, or no earth connection, immediately arose and led to an early examination, but everything appeared to be in order in that respect. The next step was to examine the wireless set, and it was evident that the telephone only "picked up" the radio programme when the extension speakers were in operation. A little thought soon gave the following satisfactory explanation of the action: When the house was built there had been installed in every room one or more loud speaker points connected by a four-wire cable, of which only one wire was being employed for this service. The cable had been laid ring fashion, which meant that there was a loop of wire round the upper storey and a similar loop downstairs, as in sketch, Fig. 1a, carrying the output low frequency current from the radio set. This current was of good strength since it was supplied from the secondary winding of a suitable step-down transformer for the low impedance external speakers.

Obviously an alternating magnetic field was being created by these loops carrying current and, as indicated in Fig. 1b, the small transformer in the housing of the G.P.O. telephone instrument, T, was being thereby influenced. This transformer consists of a short core of magnetic material suitably wound, and because the magnetic circuit is not closed is quite susceptible to external fields. Although enormous improvements have been made in magnetic materials of recent years, the basic pattern of this transformer is still retained because the design is particularly suited to the operating conditions. To verify the fact that this transformer is easily influenced by magnetic fields a length of wire, actually No. 22 SWG, was joined to the radio set and arranged to carry the loud speaker current. When a loop of this wire was bent to form a *single turn* round that portion of a telephone similar to the G.P.O. equipment containing the transformer, the broadcast programme could be heard at good strength, while with three or four turns the audio output was increased very considerably. At the same time an experiment was conducted where one and more turns were placed near the telephone earpiece, and here again the programme could be easily reproduced. Lest a number of readers be tempted to carry out these experiments without using a separate telephone, it should be pointed out that the Post Office have some arrangement on their system whereby a delay switch operates after a short period of listening, and introduces a noise tone which nullifies artistic appreciation of the broadcasting.

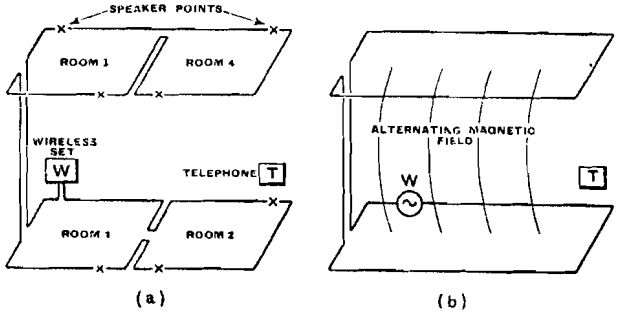


Fig. 1.—Layout of loud speaker extension wiring which by induction affected the telephone system is shown in (a), while in (b) is the equivalent circuit showing how the magnetic field is distributed.

However, to return to the aforementioned domestic induction display, it is obvious that the alternating magnetic flux picked up by the core of the telephone trans-

Induction—

former will generate voltages and currents and these will be converted into sound in the telephone earpiece. This effect, whilst of interest, was certainly not welcome for normal operation of the telephone, and was easily eliminated by utilising *a pair* of wires for external loud speaker distribution. As indicated in Fig. 2, this means that the magnetic field is annulled in a manner similar to that adopted for non-reactive windings in the construction of precision resistance boxes.

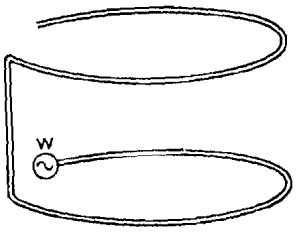


Fig. 2.—By using parallel or twisted twin wires no appreciable magnetic field is created.

Whilst the discovery of the magnetic field surrounding a conductor carrying current is due to Oersted, it was Faraday who first demonstrated the fact that when an intermittent current is passed through one coil of wire it will induce currents in a similar coil arranged as a closed circuit and which is suitably placed in the vicinity.

In 1882 Willoughby Smith, the well-known scientist, wrote a paper[1] on induction which in a modified form was read subsequently in 1883 before the Society of Telegraph Engineers and Electricians. (This society was the immediate forerunner of the present Institution of Electrical Engineers.) In this paper he refers to the work of Faraday, Henry, Felice and others, and describes some of his own experiments wherein he used two flat helices about 12in. in diameter arranged as in Fig. 3. When the current in coil P is interrupted, the telephone reproduces loudly a note corresponding in frequency with that of the tuning fork. He mentioned that this note was audible up to distances of 50 feet, and he employed as a volume control a plug type resistance box R. In the following words he states . . . " *I discovered an important fact, that the telephone was affected even when entirely disconnected from the circuit and several feet from the inducing spiral.*" This led him to construct a much larger flat helix—similar to the so-called "pancake coil," but 36in. in diameter, supported between two square sheets of cardboard fixed in a wooden frame as shown in Fig. 4. The winding consisted of 800 turns of 0.018in. diameter copper wire, silk covered, i.e., No. 26 SWG, the length being 1,220 yards and the resistance 122 ohms (actually the ohm which existed in 1882). The amazing fact concerning this coil, to the writer's mind, lies in this extract from that ancient paper . . . "*If such a spiral be placed in the centre of a large room, sounds such as speech or music affecting the transmitter can be distinctly heard in every part of the room by any person placing a disconnected telephone to his ear,* provided, of course, that his hearing is not seriously defective, and that the telephone is held in a favourable position with regard to the inductive lines of force."

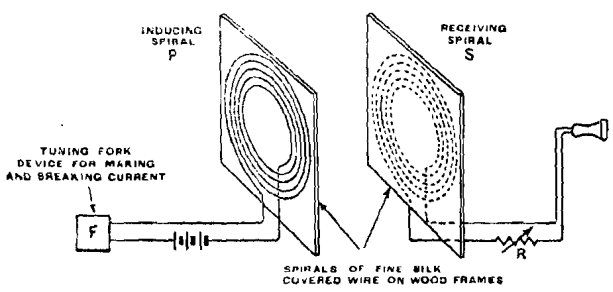


Fig. 3.—Circuit and layout of the apparatus used for the early induction experiments described in the text.

[1] Published by Hayman Bros. & Lily, Hatton House, London, E.C.

From the paper it would seem that the "transmitter" might refer to the tuning fork interruptor, which obviously was not seriously affected by sound. On the other hand, the striking fact exists that, without realising it, Willoughby Smith had invented the equivalent of our modern moving coil microphone. In his case he had used a coil 36in. in diameter and taken advantage of an appreciable amount of the earth's magnetic field as his source of unidirectional flux. To make this clear, assume that sound of some kind impinges on one portion of the cardboard diaphragm supporting the 36in. coil. This will cause some of the turns to move and cut the earth's flux, thereby causing currents to circulate in the coil which is closed through the transmitter. These varying currents will set up corresponding alternating flux variations which will affect the telephone as described. It is interesting to note that the coil resistance is not incomparable with that of a practical moving coil

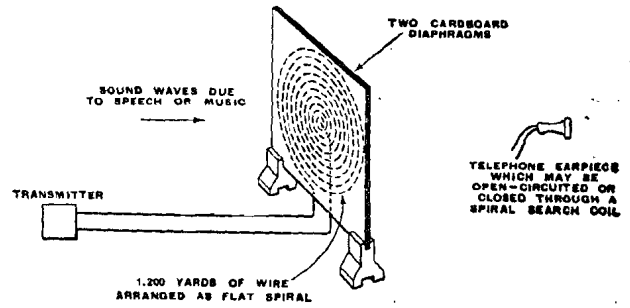


Fig. 4.—Large spiral of wire employed by Willoughby Smith in 1882 and which might be regarded as the first moving-coil microphone.

microphone, although, of course, the diaphragm is at least outsize.

Unfortunately the inventor did not regard this discovery as important, and devoted the rest of his paper to other matters which included, nevertheless, sound reproduction by magneto-striction and shielding properties of different metals. The latter effect, which he termed "interception of inductive energy," was investigated over a wide range of frequencies, the highest of which was 2,000 reversals per minute. In the same paper he demonstrated the practicability of an inductive system of railway signalling which, in principle at any rate, is comparable with modern practice.

Now no doubt many readers will have carried out experiments at schools or technical colleges during the study of inductive effects, and Lenz's Law, but it is only quite recently that use has been made of induction in connection with deaf-aid apparatus.

Induction—

There were brief mentions in *The Wireless World* some time ago[2] of inductive systems suitable for use in cinemas and theatres which consist basically of the installation of a loop conductor around the auditorium arranged to carry the low-frequency output current from an amplifier handling the speech or music associated with the film or microphone on the stage. A magnetic field is set up in a manner very similar to that already described, but being alternating in character follows exactly the variations of the audio frequency currents.

The normal deaf-aid equipment is really a self-contained battery-fed midget amplifier and it is possible to remove the microphone and substitute a suitable pick-up device which may be termed an inductor. In its simplest form the latter consists merely of a coil of copper wire which may be incorporated in the amplifier container or employed as a separate unit. This is influenced by the alternating magnetic field specifically provided in the auditorium, and the output from the deaf-aid unit may be considerably better than when its own microphone is used in the normal manner in a theatre or cinema. A notable improvement in the signal/noise ratio is one advantage of this system.

The design of the best pick-up device is of extreme importance, and the writer has made a brief but specialised study of the problems involved with a view to suggesting an efficient unit. The experimental work carried out and details of the final design will be described in a future article.

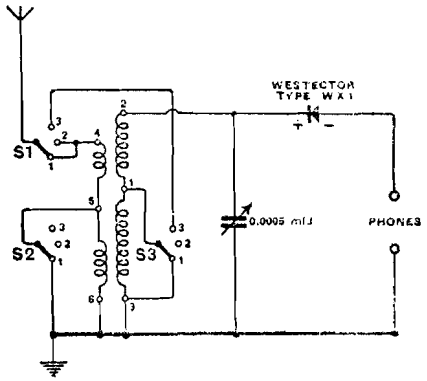
[2] May 19th, 1938, page 446, and June 23rd, 1938, page 561.

Emergency Receiver

NEW TYPE WESTECTOR IN PLACE OF A CRYSTAL

UNDER emergency conditions a simple receiver which will operate without any form of power supply would be exceedingly useful for the reception of certain essential programmes, such as news bulletins. Under such conditions headphone reception must suffice, bearing in mind that the main essentials are simplicity, reliability and independence of power mains or batteries.

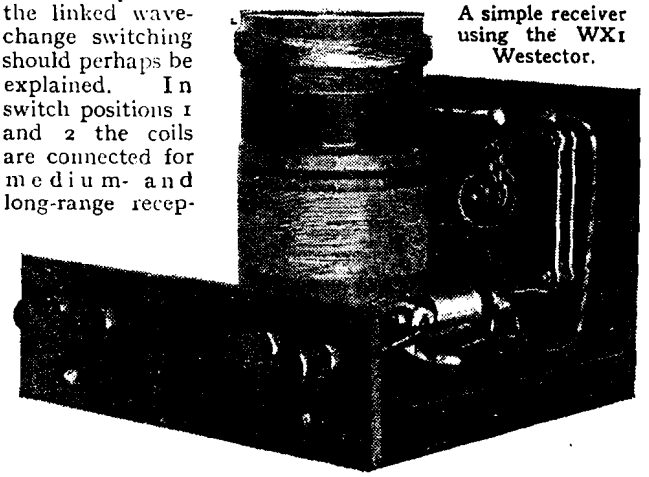
A receiver using a crystal detector hardly meets these requirements, as the crystal cannot be described as reliable under strenuous conditions. The Westinghouse WX1 Westector, on the other hand, provides an entirely satisfactory detector under such conditions, as it is robust and permanent. It is similar to the well-known WX6 Westector used in multi-valve receivers, but is designed to work at the lowest possible signal voltages. In spite of this modification of design it must not, however, be compared too closely to a crystal detector. It still requires a bigger voltage than the crystal detector for efficient and good quality demodulation, but, of course, given this greater input voltage it has the advantage of giving correspondingly greater output.



As this circuit diagram shows, the new low-input, low-capacity Westector is used in exactly the same way as a crystal detector. Numbering of terminals relates to the types of components specified in the List of Parts.

The circuit arrangement suitable for use with this detector is shown in the accompanying diagram. Providing it is used in conjunction with an efficient aerial and earth system within a service area of a transmitter, it can meet the requirements of an emergency receiver while at the same time being extremely inexpensive.

A list of suitable components is given in the accompanying list. Construction is so simple that comment is unnecessary, but the linked wave-change switching should perhaps be explained. In switch positions 1 and 2 the coils are connected for medium- and long-range reception respectively, using the coupled aerial circuit in both cases. Increased signal strength on long waves (but lower selectivity) is obtained in position 3, in which the aerial is switched over to the junction point of the tuned secondary coil.



A simple receiver using the WX1 Westector.

Under present conditions the set described may obviously be simplified by omission of provision for long-wave reception. In certain circumstances the connection of an 0.002-mfd. condenser across the phone terminals may improve reception.

LIST OF PARTS

As used in the receiver illustrated.

1 Westector.	Westinghouse, Type WX1.
1 Coil, dual range.	Bulgin, Type C69.
1 Variable Condenser, 0.0005 mfd.	Bulgin low-loss midget, Type CV19.
1 Switch, 4-pole, 3-way (S1, S2, S3).	Bulgin midget rotary selector, Type S204.
4 Terminals.	Bulgin, Type T2.
2 Knobs.	Bulgin, Type K26.
1 pr. Headphones, high resistance.	