Aircraft Wireless Section

Edited by J. J. Honan (late Lieutenant and Instructor, R.A.F.).

These articles are intended primarily to offer, as simply as possible, some useful information to those to whom wireless sets are but auxiliary "gadgets" in a wider sphere of activity. It is hoped, however, that they may also prove of interest to the wireless worker generally, as illustrating types of instruments that have been specially evolved to meet the specific needs of the Aviator.

CRYSTAL RECEIVERS.

THE development of the capabilities of the thermionic valve as a rectifier and amplifier, and the consequent design of exceedingly sensitive multi-valve receiving-sets employing both high and low frequency amplification has rendered the crystal receiver obsolete as regards work in the air.

In the earlier days of the war, however, crystal sets, such as the R.N.A.S. type Tb, were used for reception during flight with considerable success, particularly when employed in conjunction with the Brown relay, or with valve amplifiers.

But as a land instrument for the reception of messages sent from the air, the crystal "short wave tuner" proved most successful, and remained in general use right up to the end of the war. In fact the Armistice found some thousands of these sets still on active service in and about the front line area. They were mostly employed in the reception of messages from aircraft engaged on patrol or short-range reconnaissance duties, and more particularly for recording the observations of planes working on "target spotting" in co-operation with the artillery.

The "tuner" and Wireless operator were located under ground, usually somewhere in the vicinity of Battery Headquarters, and it was their combined duty to be always on the alert. Information from the sky-patrol was too valuable to be lost through any carelessness on the part of the W/T Watchdog. Sometimes an emergency S.O.S. from the air would call for barrage fire against an unexpected infantry attack, and occasionally would come the welcome news that a "plum" target was asking for trouble at, say, B5C82 to B8d46. Or, more frequently, a petulant succession of "B's" would signify that observer number so and so of X Squadron was sitting up aloft over a certain Hun target waiting for our battery to finish breakfast and show by means of the usual ground-strip that they were ready to carry on the good work. When this was forthcoming, there would ensue a busy time for the short-wave tuner and its attendant slave, until after an uncertain spell of more or less eloquent Morsing, the aerial spotter would recollect that there was a matter that required his immediate attention in the Mess, and the "pack up" signal CI would indicate that he was going back to see the bar-orderly about it.

Then, with some luck, the S.W.T. and operator might enjoy a little break, for crystal recuperation and mental relaxation respectively until the next R.A.F. cloud arose in the sky.

Meanwhile perhaps it will be as well to give a description of the actual instrument. It is of considerable interest as a type of receiver which was specially evolved to take the unusually short wavelengths radiated by the No. 1 Transmitter, this being the sending-set mostly used by patrol and "target spotting" planes.

As stated previously, the wavelength range of the No. 1 varied between 100 and 300 metres. Specified wavelengths were allotted to adjacent squadrons, and to the component flights of each squadron within these limits. For example the three flights of one squadron would employ lengths of, say, 140, 180, and 220, whilst to the adjacent squadron would be allotted the lengths 160, 200 and 240.

Bearing in mind the number of planes that might be operating simultaneously over a busy area, and the extent of overlapping that was bound to ensue in the areas of active operation allotted to each squadron, it is not difficult to realize that a receiver employed on such work must be an efficient instrument, reliable in operation under the unfavourable conditions inseparable from actual warfare, and capable of a high degree of selective tuning in face of the extraordinary amount of jamming through which it must be able to identify and follow the particular bus with which, for the time, it is working.

ACTION OF THE CRYSTAL RECEIVER.

As a preliminary it may be useful to summarize shortly the general theory of reception by such a set.

The open or aerial receiving circuit responds to electromagnetic disturbances travelling through the ether, the impact of such waves setting up corresponding variations of e.m.f. (and consequently an alternating current flow) in that circuit. The energy so transferred from the ether to the circuit will be a maximum when the induction and capacity values of the latter are adjusted so that its natural period of electric oscillation synchronizes with the periodicity of impact of the ether waves. When so adjusted the aerial circuit is said to be "tuned" to the given wavelength, and the impact upon it of the series of damped electromagnetic waves radiated during the time-interval of one spark-passage at the transmitter creates a corresponding series of damped e.m.f. variations, each of which forces a small uni-directional current surge through the one-way channel afforded by the crystal, the cumulative effect of these surges being sufficient to give rise to one click in the phones for each spark at the transmitter. It follows therefore that if the spark frequency of the transmitter is, say, 300 per minute, this frequency of "clicks" will be recorded by the receiver telephone and will determine the pitch of the signal note received.

The detector may be placed directly across the open circuit, in which case it is sensitive to all energy impulses received by that circuit and is said to be on the "stand by" position.

Or the energy flow existing in the open circuit may be first transferred inductively to a closed circuit, across which the detector is then placed. This cuts out extraneous disturbances existing in the open circuit, the arrangement being equivalent to a kind of filter which excludes wavelengths other than those to which it is tuned. Such disturbances may exist in the open circuit, but, being relatively weak, are eliminated in the process of inductive transfer between the circuits.

The detector when placed across the closed circuit gives selective tuning, and is said to be in the " tune " position.

SHORT-WAVE TUNER (Mark III) GENERAL.

With a standard 125-foot ground aerial of R4 seven-stranded wire arranged as a single inverted L, wavelengths varying from 100-700 metres can be received on this instrument.

A photograph of the set is shown in Fig. 24, whilst the complete wiring arrangement is shown in Fig. 25.

The detector circuit can be placed either on " stand by " or " time " by means of a change-over switch.

Either a Perikon or carborundum crystal can be used at will, a potentiometer circuit being included with the latter so that the carborundum may be adjusted to the point of maximum sensitivity.

Provision is also made for calibrating and testing the circuits by means of a buzzer, which is automatically inserted in the closed circuit when the detector is used across the open-circuit inductance (i.e., when on " stand by ") and is similarly thrown into the open circuit when the detector is across the closed circuit (i.e., on " time "). In both cases the buzzer is inoperative until a special key is closed.

It will be seen from the wiring diagram that the closed circuit is normally broken at K when on " stand by," in order to prevent any transfer of energy between the open and closed circuits, and consequent weakening of signal strength received. For the same reason and as an additional precaution it is advisable, when searching for weak signals on " stand by," to keep the capacity and inductance of the closed circuit at a minimum and the coupling at " loose." In order that the buzzer may operate in

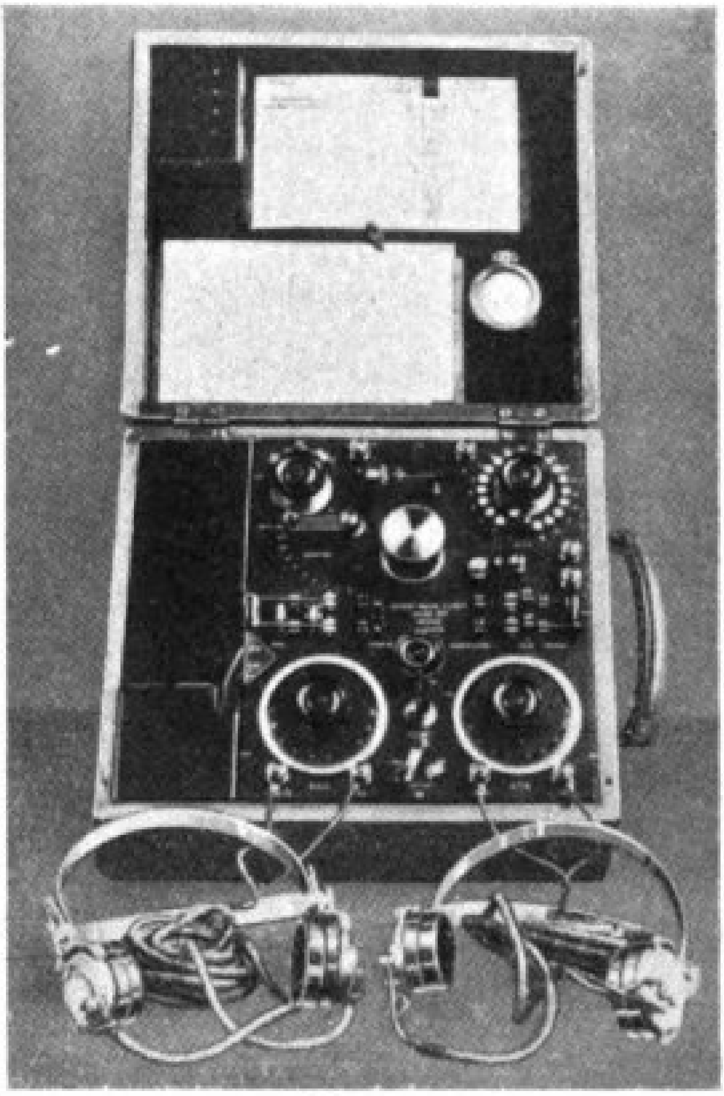

Fig. 24.

this gapped circuit, a key is provided which (a) closes the buzzer circuit, and (b) simultaneously through the insulator block L, shorts the two " gap " leads from the closed circuit.

Having thus broadly surveyed the characteristic features of the set; it may be of interest to describe in brief detail the main circuits involved.

THE BUZZER CIRCUIT.

This consists of a small shunted buzzer fed from two of the four dry cells forming the potentiometer battery. The circuit is normally open, but is brought into action by depressing a small lock button switch, which, as previously explained, simultaneously shorts the "gap" in the closed circuit. The buzzer is used to test and calibrate the circuits,

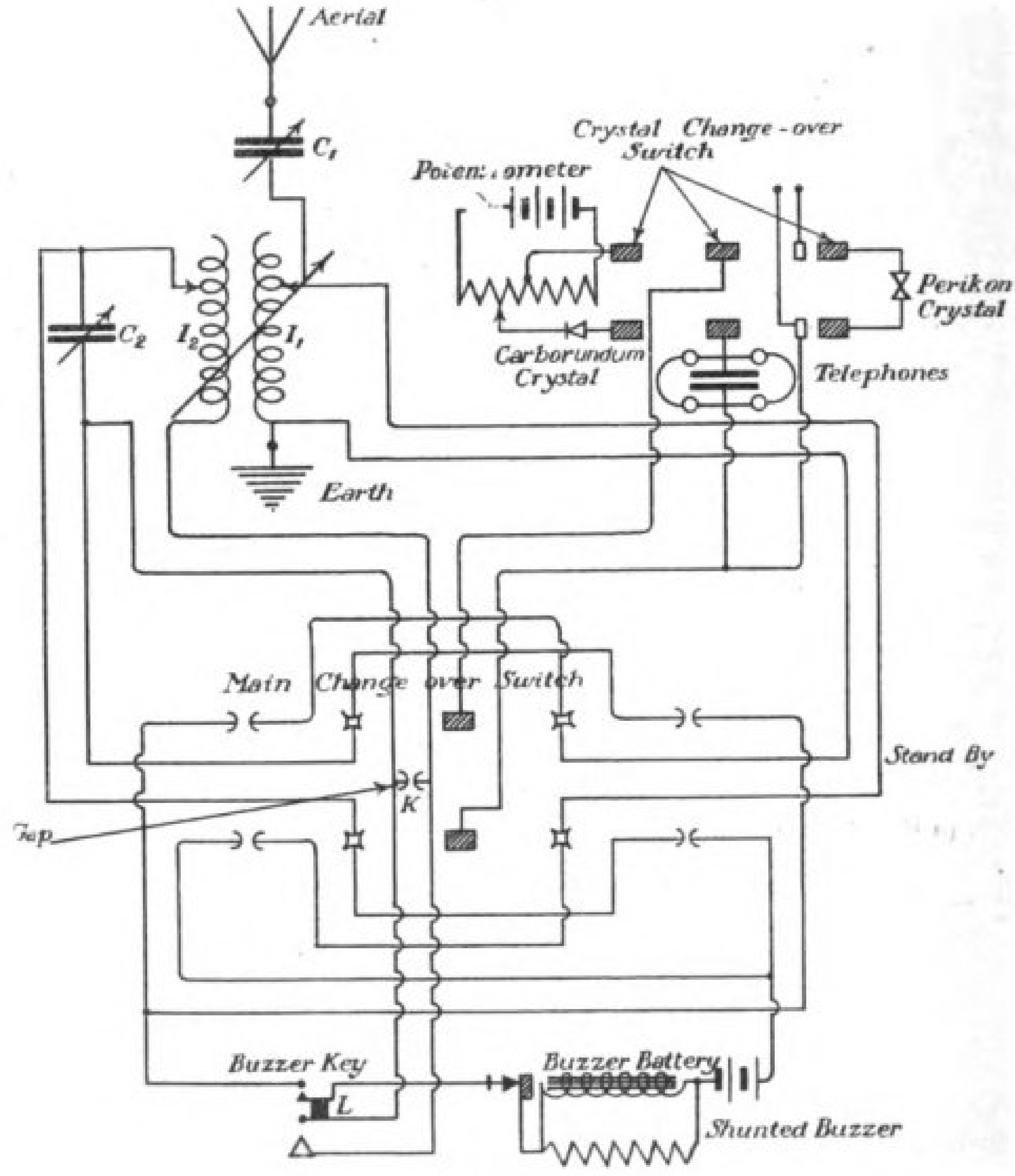

Fig. 25.

and to adjust the crystals to maximum sensitivity.

In testing the crystals, the main switch should preferably be on "stand by" so that the crystals are placed across the closed circuit, this being more constant than the open. The coupling should be "loose", and the two main circuits set out of tune in order to reduce interaction effects to a minimum.

The phones should similarly be tested by means of the buzzer, and the earpiece adjusted for maximum sound.

(To be continued.)

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SHORT-WAVE TUNER, MARK III. *(Continued).*

THE AERIAL CIRCUIT.

As shown in the schematic diagram, given in Fig. 26, this circuit comprises the aerial variable tuning condenser, variable tuning-inductance, and earth.

The condenser is of the movable-vane type with aluminium plates and air dielectric. It is graduated in degrees from 0-180° and has a maximum capacity of 0.0015 mfds.

The inductance consists of seven-stranded wire wound upon an horizontally-mounted drum from which non-inductive leads are taken to 19 studs, giving the following values:—

Stud	1 = 6	mhys.
,,	2 = 12·2	,,
,,	3 = 20·5	,,
,,	4 = 30·6	,,
,,	5 = 40·6	,,
,,	6 = 53·2	,,
,,	7 = 67·4	,,
,,	8 = 83·5	,,
,,	9 = 97·5	,,
,,	10 = 112·3	,,
,,	11 = 126·3	,,
,,	12 = 143·8	,,
,,	13 = 158·2	,,
,,	14 = 177·6	,,
,,	15 = 195·0	,,
Stud	16 = 213·4	mhys.
,,	17 = 230·8	,,
,,	18 = 250·0	,,
,,	19 = 280·0	,,

The earth is preferably of the capacity type consisting of one or more copper-gauze mats spread out on the surface of the ground. Both the aerial lead-in and the earth lead should be as short as possible, the former being well insulated and the latter of stranded low-resistance wire.

THE CLOSED CIRCUIT.

The variable condenser is of similar design to that contained in the open circuit, but has a maximum capacity of 0·0005 mfds.

The stranded-wire inductance is wound on a drum of the same size as that used for the aerial inductance, and has five tappings, giving the following values:—

Stud	1 = 13.5	mhys.
,,	2 = 23·5	,,
,,	3 = 40	,,
,,	4 = 115	,,
,,	5 = 280	,,

This drum is also mounted horizontally, but is rotatable about a perpendicu-

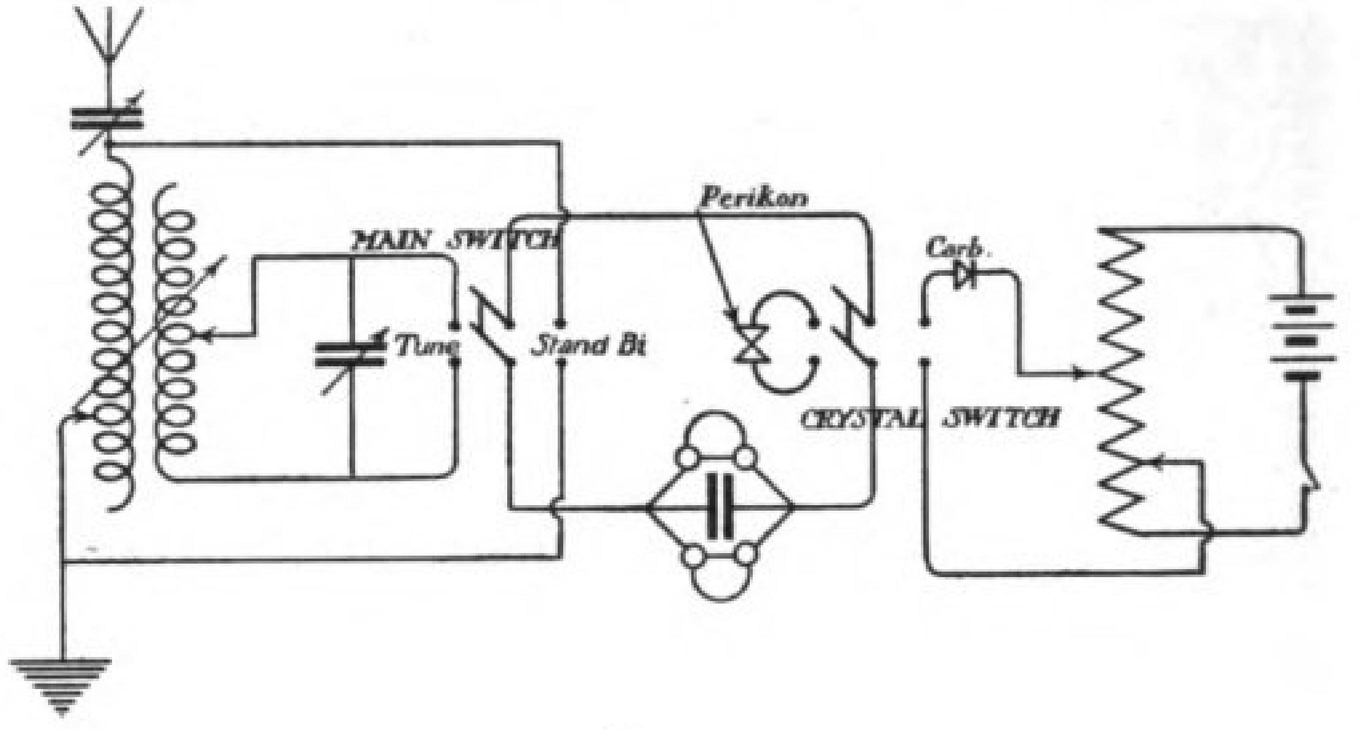

Fig. 26.

lar axis so as to increase or diminish its magnetic linkage with the open-circuit coil, and thereby vary the inductive coupling between the two circuits. This is controlled by means of a handle mounted on the axis of the drum and brought out to the ebonite face-plate of the set.

THE DETECTOR CIRCUIT.

As shown in Fig. 26, either the Perikon or carborundum can be placed in series with the phones at will by means of the " crystal " switch. As a general rule the carborundum crystal is more stable than the Perikon, though the latter is more popular in use as no potentiometer adjustment is necessary.

It is advisable to test the Perikon from time to time with the buzzer, readjusting the contact point between the two crystals when necessary. Sometimes it is impossible to get satisfactory results with any contact point, in which case the crystals are probably "fatigued" and should be replaced by fresh ones. In all cases a light contact-pressure should be used. A forced pressure gives poor results, and, moreover, shortens the effective life of the crystal.

The potentiometer circuit used with the carborundum is fed from a battery of four dry cells giving a potentiometer difference variation of $+3$ to -3 across the crystal. The potential applied is adjusted by means of a handle which controls the position of the variable point along the rheostat. A switch is provided to open the circuit and save the cells from running down when the potentiometer is not in use.

The two pairs of high-resistance phones (4,000 ohms. per earpiece) are used in parallel and are shunted by a small condenser which is inserted in order to compensate for the lag in the passage of the signal current caused by the high inductance of the telephone windings.

The detector circuit as a whole is thrown on " stand by " or " tune " position by means of the main change-over switch.

CALIBRATING THE CIRCUITS.

The buzzer is also used to calibrate the open against the closed circuit with the object of securing rapidity and accuracy in tuning-in.

The closed circuit is first tested against a wavemeter for varying wavelengths, the results being recorded, so that a definite series of wavelengths corresponds to ascertained values of closed-circuit inductance and capacity.

Corresponding values of open-circuit inductance and capacity are then obtained by tuning the open circuit against the known wavelengths now emitted by the closed circuit, when set at the previously recorded values of inductance and capacity and excited by means of the buzzer.

This series of results is tabulated on a calibration card so that when a signal is first received on " stand by " the operator will be able by rapidly noting the open-circuit condenser and inductance readings for maximum sound and comparing them with his calibration card, not only to ascertain the signal wavelength, but also to set the closed-circuit condenser and inductance to the correct value before switching-over to the " tune " side, thereby obviating the risk of losing weak signals when changing-over.

Though involving a certain amount of intial trouble, the calibration card was found in practice to be most useful, particularly in the case of operators who were " learning the ropes."

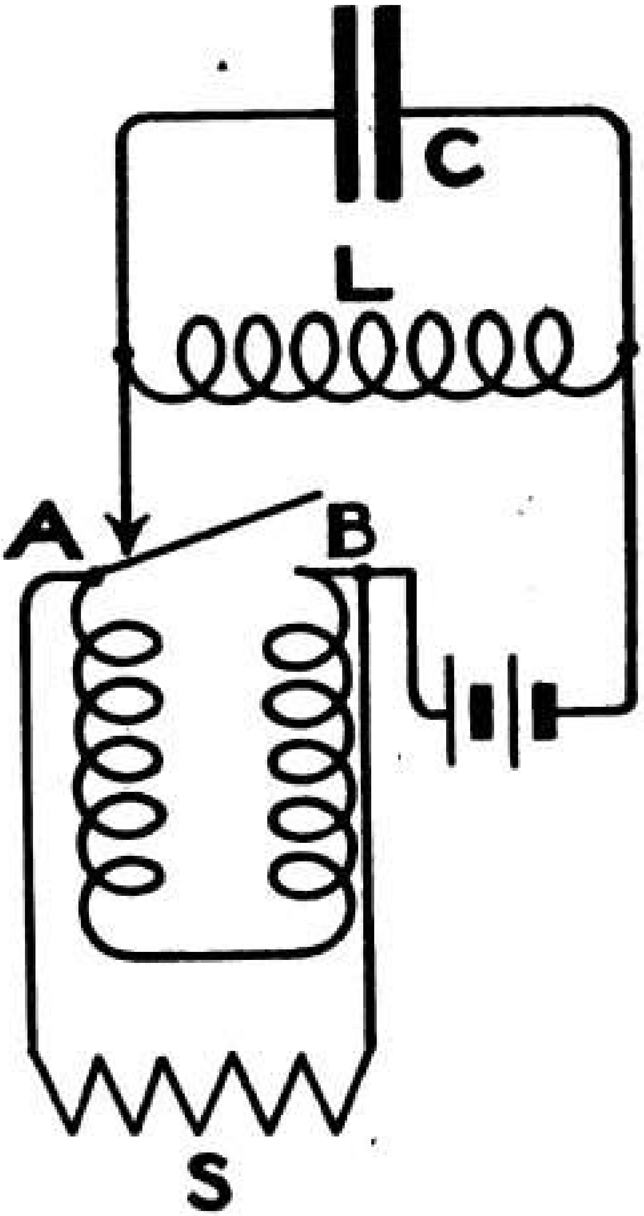

Fig. 27.

THE SHUNTED BUZZER.

The buzzer itself, as shown in Fig. 27, is shunted across the poles by a non-inductive resistance S. This affords a discharge path for the high e.m.f. induced across the armature winding when each " break " occurs, and prevents a spark discharge between the points, which would in effect prolong the current and so lessen the inductive impulse applied to the oscillatory circuit L.C.

In addition, whilst the contact points are closed, the shunt is in parallel with the high-resistance of the solenoid and thereby allows a higher value of current to pass through the points. As the magnetic field created about the inductance L increases as the square of the current, the extra current passed by the shunt considerably increases the vigour with which the buzzer energises the oscillatory circuit L/C.

Though forming but a comparatively unimportant detail of the tuner, it is as well, perhaps, to have a clear conception of the exact significance of the "shunted buzzer," as owing no doubt to the appealing qualities of the name itself it is frequently and widely applied by experts and others in a sense which, to put it mildly, indicates a regrettable lack of technical precision.