RADIO SCIENCE

Vol. 1.—No. 4. Registered at the G.P.O., Sydney, for transmission by post as a periodical. MAY, 1948

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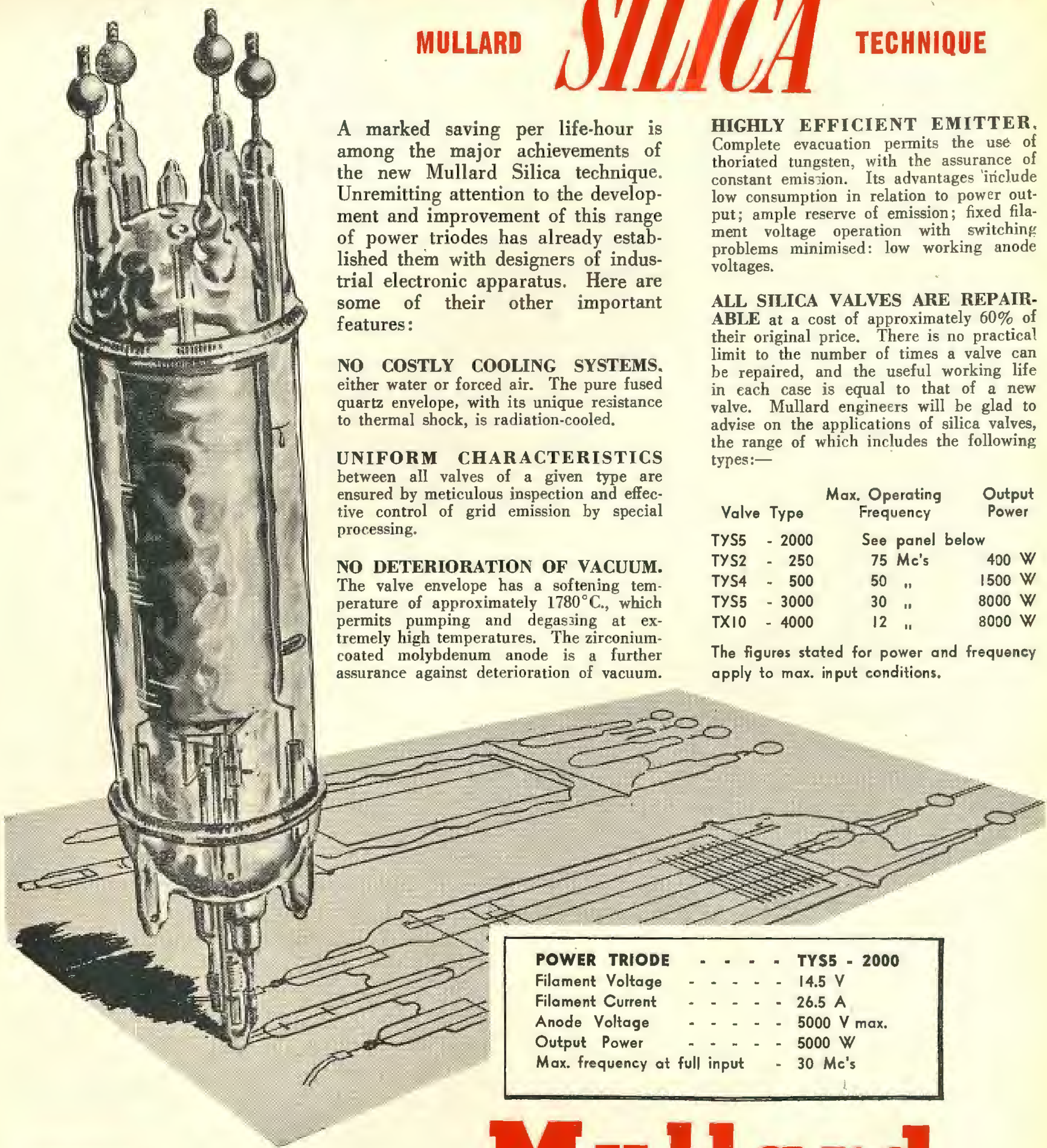

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editorial.

Education . . . and the Radio Technician

Recently the Education Department celebrated the Centenary of Education in this State. Thus it seems an opportune time to stress the necessity to all radio personnel of the desirability of keeping abreast of modern developments in this particular field.

Despite the technical educational facilities readily available to all interested, it appears strange that many are still loathe to take advantage of the opportunities offered whereby they may increase their knowledge. Whilst this statement is directed to all branches of radio, it is more applicable to the radio serviceman in whom is entrusted the maintenance of the domestic receiver.

At the moment, to quote "there is nothing to prevent a person with or without experience, with or without equipment and with or without conscience" from setting himself up as a radio serviceman—usually to the detriment of the fully qualified technician and to the public.

With the introduction of F.M. transmissions a foregone conclusion, and with the possible introduction of Television at an early date, the problems of the radio serviceman will be considerably aggravated. Both these types of equipment are more complex and critical in their adjustment than the present average receiver and, consequently, cannot be serviced properly by untrained personnel. In each case, special test equipment and techniques are applicable, and unless these are thoroughly understood by the radio serviceman, considerable difficulties will be encountered in adjusting this high frequency equipment.

The question of licensing radio servicemen is once again being seriously considered in this State as a measure of public protection, but it is felt that the real remedy lies in the hands of the radio serviceman himself. By serious study and application to the new circuit techniques now being developed, he can ensure his individual success in this new "era" in radio and electronics.

In This Issue

Although many may consider the term Radar as being solely connected with World War II, peace-time applications of this war-time technique are now becoming more numerous.

Two examples of this are detailed in this Issue, namely, one in the field of Surveying and the other in providing a new aerial navigational aid. This latter application is a great achievement for Australian Scientists who developed the system, as it is now considered to be far in advance of similar research in overseas countries. It appears most likely that, in the near future, much will be heard of this M.T.R. system.

The lack of constructional articles for the beginner in recent issues has now been remedied and the Two-Valve Battery Receiver described this month should prove very popular with the younger readers. For those whose thoughts turn to "bigger and better" equipment, the 7 Valve Dual Wave Receiver should provide much food for thought. Of an unorthodox design it contains several ideas which the active home constructor can apply to existing sets with a noticeable improvement in their performance.

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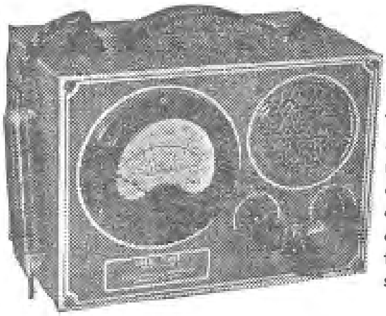

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RADIO SCIENCE

FOR THE ADVANCEMENT OF RADIO AND ELECTRONIC KNOWLEDGE.

Vol. 1.—No. 4. :: MAY, 1948

EDITORIAL CONTENTS

OUR COVER: "Transmitter Adjustment." This excellent photograph was made available by courtesy of Westinghouse-Rosebery Ltd.

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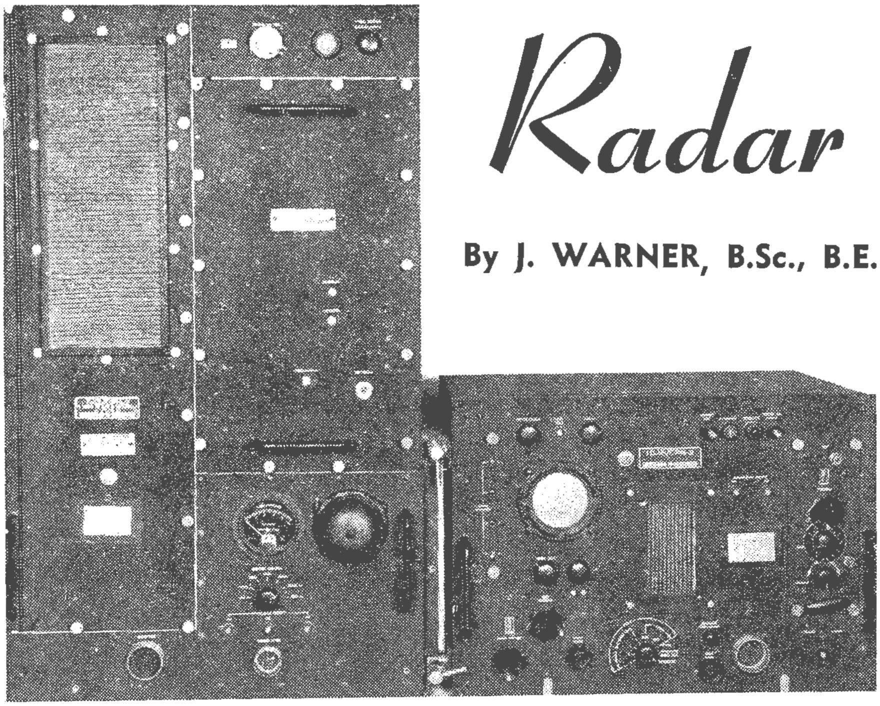
SURVEYING BY *Radar*

By J. WARNER, B.Sc., B.E.



Shoran Ground Station Equipment. The transmitter unit is at the left and the monitor and receiver at the right.

One of the latest but less publicised uses of radar is its application to aerial and geodetic surveying. Whilst a considerable amount of experimental work has been done in both England and America during the past two or three years, it is only recently that work along these lines has commenced in Australia and Canada.

In Australia, large inland areas still remain to be mapped, and it is probable that radar will be eventually used as an aid in speeding up and reducing the cost of this work.

THE AUTHOR

J. Warner, B.Sc., B.E. graduated in Science in 1938 and in Electrical Engineering in 1940 at Sydney University. In 1940 he joined the staff of C.S.I.R. Radiophysics Laboratory and undertook radar research with special emphasis on transmitter and modulator design. In 1944 he was transferred to the Australian Scientific Liaison Office in London for a year where he investigated British developments in radar, especially in the fields of navigational aids and survey applications. Before returning to Australia in 1946 he spent three months in U.S.A. investigating American research in these fields. Since 1946 he has been engaged in research for C.S.I.R. into the applications of radar to surveying.

Aerial Surveying

Before discussing the method in which radar is used it would be desirable to describe briefly how an ordinary aerial photographic survey is carried out and how maps are produced from the photographs.

The survey aircraft, carrying a precision camera, is flown at a fixed height along a series of parallel straight tracks in the manner indicated in the figure, and photographs are taken at equal time intervals at points shown by the crosses. The time interval is chosen so that on the average the overlap between successive pictures amounts to about two-thirds of the width of the photograph, and the spacing between aircraft tracks so that up to one-third lateral overlap results. Thus when the finished photographs are assembled into a mosaic as the first stage in producing a map we could have a state of affairs such as that indicated by the overlapping squares in Figure 1.

As can be seen any point on the ground will appear on at least two photographs. This is desirable so that small scale differences between the pictures due to tilt of the air camera, or to varying aircraft height, can be corrected, and is essential if ground contours are to be obtained from a stereoscopic examination of adjacent air photographs.

In what has been said above, it has been assumed that the aircraft can be flown accurately along a series of equally spaced parallel tracks and that no pictures are missed. The former is difficult when the pilot has few landmarks to define his course, as the aircraft will drift due to varying winds. As a result, upon occasions the tracks are not parallel and gaps occur in the photo-mosaic that have to be filled by a subsequent flight. If the country being mapped has no prominent landmarks it may be difficult to find the area required and many more than the necessary number of photographs may be taken.

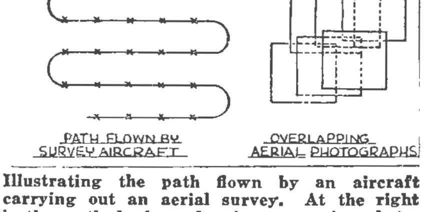
Another common cause of gaps is due to clouds obscuring areas of the picture, and again in this case, it is necessary to locate the area and take more pictures. It is obvious that some form of radio navigational aid would be very useful in reducing aircraft flying time and expenditure on film.

Reduces Cost

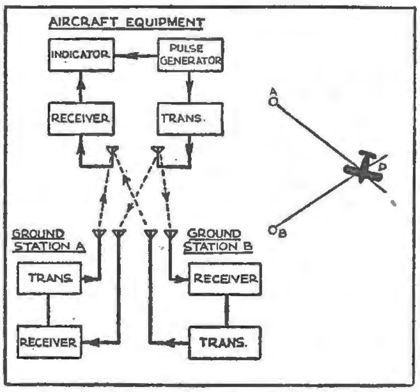
Such an aid can, in addition, be used to define the aircraft tracks and thus allow the degree of overlap between successive pictures to be reduced to the minimum required for stereoscopic work. This results in a worthwhile saving of film and labour. If, of course, gaps should occur due to the presence of cloud, the aircraft can readily return to the desired spot and no time or film is wasted.

In preparing a map from the air photographs, scale and tilt corrections must be made as indicated before, and it is usually necessary to have on the photographs a number of easily recognisable points whose position on the ground is accurately known. This is essential so that progressive errors do not occur when the photographs are extended for any distance by fitting corresponding points together.

If new country is being mapped, these points on the ground, or *ground control points* as they are called, must be surveyed by a ground party before the final map is produced. This ground control is essential for nearly all the maps that are produced from aerial photographs and can only be avoided if the area being mapped



Illustrating the path flown by an aircraft carrying out an aerial survey. At the right is the method of overlapping successive photographs to form the required mosaic.



Block schematic of Secondary Radar equipment.

is very small or the map is to be drawn to a small scale — one inch to equal ten or more miles for instance. As can be imagined the survey work necessary to obtain this ground control is both slow and expensive.

The same radar that is used for navigating the aircraft can also be used either partially or wholly to supplant ground control. The method in which this is done is simple and basically consists of fixing the position of the aircraft, and hence the camera, at the instant each photograph is taken. Thus the position of the point on each photograph that is vertically below the aircraft is known.

Unfortunately, if the axis of the camera is tilted, even by a small amount, the point vertically below the aircraft, or the *plumb point,* is no longer at the centre of the photograph, and unless the degree of tilt is known precisely, the necessary corrections for the distortion caused by tilt cannot be made. However, for a large amount of the mapping required in this country the errors introduced by the amount of tilt commonly experienced can either be neglected or corrected by fairly simple procedures.

For larger scale maps the removal of tilt errors without any ground control is exceedingly difficult, and even with ground control is a laborious process. With the centre point of each photograph known from a radar determined position further control is unnecessary, or at least can be reduced very considerably. In effect, this means that it is possible to produce accurate maps of an area without any ground survey.

Radar For Aerial Survey

Radar equipment measures the distance and direction to any desired object by sending out a narrow beam of radio energy in short pulses and measuring the time interval between transmission of any one pulse and its reception after reflection from the distant object. The azimuth is, of course, obtained from the use of a narrow beam pointed in the appropriate direction or by the use of special aerial polar diagrams suitably orientated.

Another form of radar, sometimes referred to as *secondary radar,* depends upon the co-operation of the distant object in receiving, amplifying and re-transmitting on a different frequency the original signals from the primary radar set. In this way the primary radar, whose receiver is tuned to the frequency of the distant beacon transmitter and not to that of its own transmitter, will not pick up echoes from surrounding hills and other reflecting objects, but only the wanted beacon signal. This principle of "secondary radar" was used extensively during the war in various navigational aids and is now being used both here and abroad in navigational aids for Civil Aviation. It is this form of radar that is most useful for surveying.

Method of Operation

The method of using this type of equipment can best be explained by referring to the accompanying figures. The equipment in the aircraft sends out pulses of radio energy at fixed time intervals. These are received at both ground stations A and B, amplified and re-transmitted on a different frequency, and then picked up by the airborne equipment at P. This measures the time delay between sending and receiving pulses, and by combining this information with the velocity of propagation of radio waves, determines the distances PA and PB.

Two types of radar equipment developed during the war as a navigational aid, primarily for blind bombing, have been applied in the way just described for surveying. These are the British *G-H* equipment and the American *Shoran* equipment. Both these sets are highly accurate, being capable of giving the position of the aircraft to within a few hundred feet when it is at distances of up to two or three hundred miles from the ground stations. *G-H* operates in the 20 Mc/s.-80 Mc/s. region and *Shoran* between 200 Mc/s. and 300 Mc/s., the highest frequency and later development of the latter giving it a somewhat greater inherent accuracy than the former.

As an example of the method of operation of this type of radar, a brief description will be given of *Shoran.* The *G-H* equipment differs in detail but not in principle from *Shoran,* the main difference being in the method of measuring and displaying the measured distances in the airborne set.

Airborne Equipment

The *Shoran* airborne set consists of two main units, the first comprising transmitter, modulator and power supplies, and the second, receiver, timing and measuring circuits, and cathode ray tube display. All timing is related to a quartz crystal oscillator operating at a frequency of 93.109 Kc/s. This frequency is chosen since one period is equal to the time required for a radio wave to travel out and back a distance of one mile.

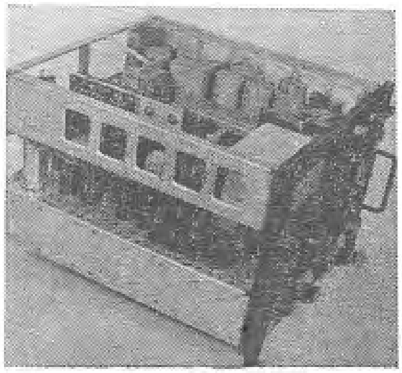
The accompanying simplified block schematic shows the main features of the airborne equipment. The crystal oscillator is used to provide a circular time base for the cathode ray tube by applying quadrature sine wave signals to the pairs of deflecting plates. By selection from the frequency division circuits it is possible to apply either 93 Kc/s., 9.3 Kc's., or 930 c/s. sine wave signals, and hence have time bases corresponding to one mile, 10 miles or 100 miles respectively round the circle. In addition, a pulse is formed and applied to the radial deflecting electrode of the cathode ray tube to produce a marker pulse which appears in a fixed position on the sweep.

The sine wave signals from the oscillator and frequency division circuits are also passed through a calibrated precision phase shifting network and used to form a second pulse at a repetition frequency of 930 c/s. which triggers the transmitter.

The transmitted pulse, after being received and re-transmitted by the ground station, is pulsed up at the aircraft, amplified in the receiver, and applied to the radial deflecting electrode to form the second pulse indicated in the block schematic.

Phase Shift Network

The phase shifting network is used to advance the phase of the transmitted pulse relative to the marker pulse so that the total delay time in the aircraft to ground station link just allows the received pulse to coincide with the marker pulse. When this is done the phase shift of the 930 c/s. signal is a measure of the distance from the aircraft to the ground station, and, in fact, the phase shifter dial can be calibrated directly in miles. Since the maximum time base length is 100 miles, it is possible for some ambiguity to exist as the same indication would be given when the aircraft was at, say, either 40 miles, 140 miles or 240 miles from the ground station. However, in practice the aircraft position is almost certainly to be



This view of the Shoran Airborne Receiver Indicator gives some idea of the layout and complexity of the equipment.

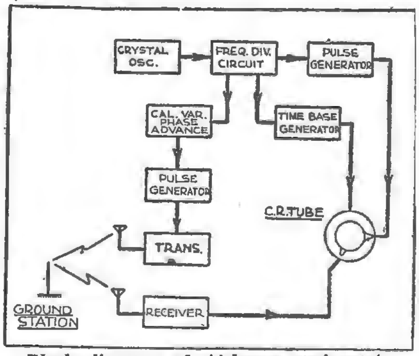
known better than 100 miles so that no difficulty arises.

In order that the same equipment can be used simultaneously to measure the distance to a pair of ground stations and thus fix the position of the aircraft, the following procedure is adopted. The transmitter radio frequency signal can be switched alternately at 10 c/s. to either of two pre-selected values and to which the two ground station receivers are respectively tuned. Simultaneously with the switching one or other of a pair of independently variable calibrated phase shifters is used to adjust the phase of the transmitter pulses relative to the marker pulse, and the receiver output is switched so as to apply either a positive or negative signal to the radial deflecting electrode on the cathode ray tube. For simplicity this switching arrangement has been omitted from the block schematic. One phase shifter controls the position of the received pulse from one ground station and the second phase shifter controls that from the second ground station. Their calibrated dials, which indicate in hundredths of a mile, give the distance to each ground station when the signal and marker pulses are aligned.

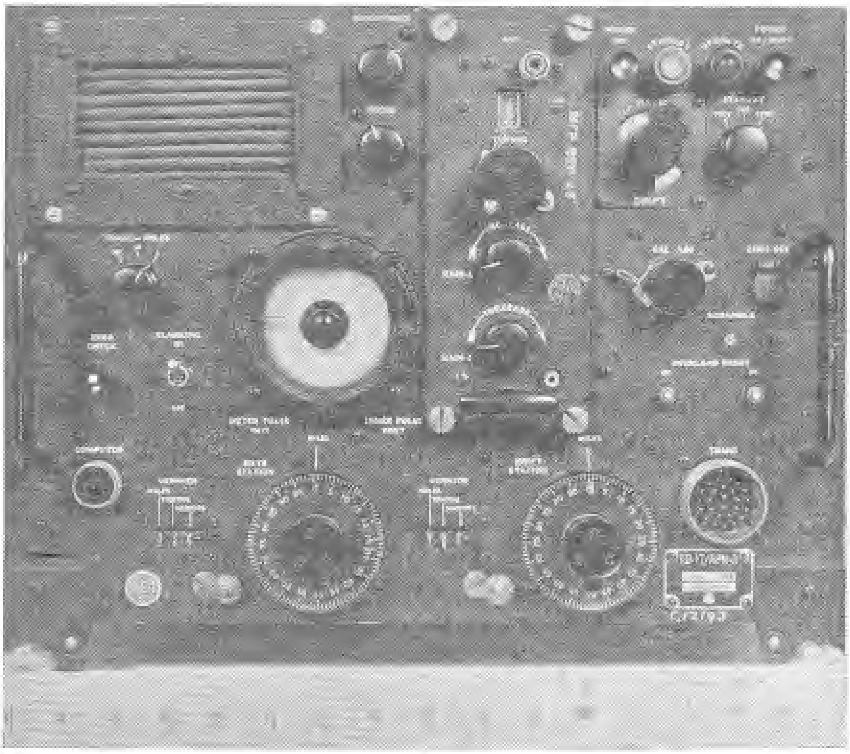
In addition to the equipment already mentioned, facilities exist for setting a given range to one ground station and presenting on a meter for the guidance of the pilot the departure of the aircraft from the chosen range about the beacon. This enables the aircraft to be flown on circular tracks about either ground beacon. In order that straight parallel tracks may be flown when taking air photographs, additional equipment is necessary. This equipment exists only in experimental forms.

Ground Station

The ground beacon consists of two units. The transmitter and modulator, with associated power supplies, and the monitor unit. The latter contains the receiver, an accurate temperature controlled crystal oscillator with associated frequency division circuits, and facilities for observing and keeping constant the time delay between the reception of a pulse by the beacon and its re-transmission.



Block diagram of Airborne equipment.

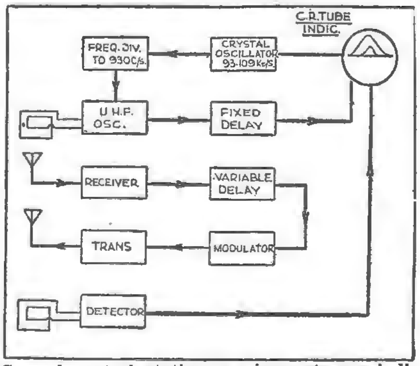


Shoran Receiver Indicator. The mileage dials and vernier counters are driven by handwheels through the gears shown, so that the marker and signal pulses are aligned at the top of the C.R. Tube. The dials then indicate distance to responder beacons.

The method of observing the delay through the beacon is apparent from the block schematic. A small oscillator is pulsed by signals derived from the crystal oscillator. This pulse, after undergoing a standard time delay, is viewed on the cathode ray tube. It is also picked up by the beacon receiver, which amplifies it and passes it on to the modulator and transmitter after going through a variable delay. The transmitted pulse is picked up and also displayed on the cathode ray tube. The time base for the latter is derived from the crystal oscillator output and suitable arrangements are made for intensifying only those parts of the sweep necessary for viewing the pulses. By adjustment of the variable delay, which consists of a tapped artificial transmission line, the pulses can be made to coincide. When this is done the total delay through the beacon, consisting of receiver delay in passing the pulse, the variable delay, and any delay in triggering the transmitter, is at a constant value related to the fixed delay network.

During the period in which the beacon delay is being measured the transmitter will be sending out pulses at a rate approximately equal to the repetition rate of the airborne transmitter, but accurately locked on its own highly stable crystal oscillator. These will be displayed in the airborne set along with the pulses received in reply to an interrogation. But unless the pulse repetition frequency of the airborne set is exactly equal to that of the ground station, and hence the crystal frequencies are identical, the ground station monitor pulses will drift relative to the reply pulses. Provision is made for adjusting the airborne crystal oscillator frequency over a small range so that any drift can be stopped and its frequency thus made equal to that of the ground station crystal.

While it would have been possible to put a highly accurate crystal oscillator in the airborne set in the first place, such oscillators require accurate temperature control and a warming-up period of about an hour before stability is reached. Both these requirements are undesirable in airborne equipment and consequently the procedure outlined above has been adopted. **(To be continued.)**



Ground control station requirements are indicated in this layout.

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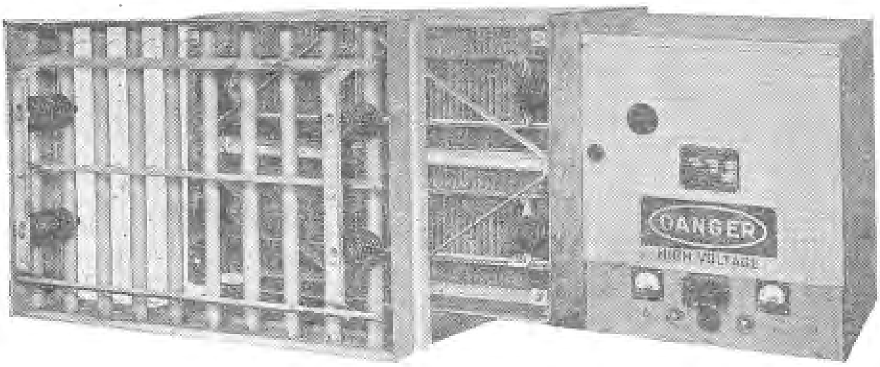

By

MAURICE M. LUSBY
B.Sc., B.E.

Fig. 1.—The Precipitron power pack, collector cell and ioniser.

Details of an electronic air filter having wide application in many industries where a dust-free atmosphere is essential.

In the midst of the gathering clouds of soot and dust, created by the increasing tempo of industrialisation it is heartening to preceive a thin but growing and swelling line of cleaned and purified—breathable air; air that has been laundered thoroughly of all the fumes, dust, soot, smoke—even germs—which we have come to associate automatically with stifling city air or foggy industrial atmospheres.

In Australia to-day Precipitron air cleaners are silently serving commerce and industry as well as Medical Institutions in dozens of different ways; keeping germ-ridden dust out of hospital operating theatres, off food processing lines; serving super cleaned air to the precision manufacturing industries. In stores and in movie theatres clean air is saving cash losses from merchandise and lavish furnishings, keeping relay contacts clean in telephone exchanges, saving re-takes in commercial photography by keeping negatives free from tell-tale spots and so on—the scope of application is almost boundless.

Lodge-Cottrell System.

There is nothing really new about the fundamentals of electrostatic precipitation, the basic principle of the Precipitron. The classical names of Sir Oliver Lodge and Dr. Cottrell came together forty years ago to establish the well known Lodge-Cottrell dust precipitator which has enjoyed immense popularity in heavy industrial material recovery processes. The same principles have been refined since that time and applied to the problem of cleaning the effluent from industrial smoke stacks.

The Lodge-Cottrell system is, however, limited to large installations of an industrial type, where its several characteristics do not run foul of the requirements for normal ventilation air.

In operation the Lodge-Cottrell system utilises a phenomenon frequently encountered in the handling of very high voltages; that of corona discharge. Briefly, this occurs when the relationship between electrostatic charge of a conductor and its area are such that the terrific concentration of electric field causes a break down of the molecules of air in the vicinity and consequent ionisation and gas discharge through the air.

High Voltage Required.

Dust of all sizes tends to avoid areas where corona exists. In industrial precipitators of the Lodge-Cottrell type one arrangement consists of a series of electrically grounded metal tubes having small diameter rods or wires running axially through them. A voltage of between 40,000 and 100,000 volts is applied to the central rods. At this voltage, corona takes place and an "electrostatic wind" blows dust to the grounded inner surface of the tubes allowing the air or gas to continue through and out of the tubes free of the dust. (See Figure 2.)

In applying this system to the cleaning of normal ventilation air, certain additional requirements must be met. These are:—

(a) The very high voltage generates ozone in toxic concentrations. To be successful the concentration should not exceed one part per million.

(b) The power of consumption must be vastly reduced to attain economy of operation.

(c) The space requirements must be reduced considerably and the overall weight lessened.

(d) First cost and maintenance must be reduced and simplified.

Basic Improvements By Penney

The pioneering work in bringing these modifications to established forms of elec-

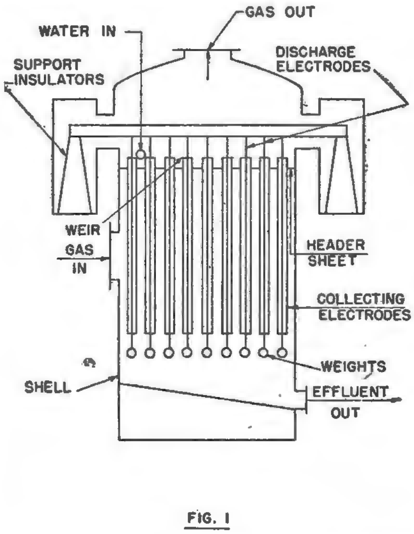

Fig. 2.—High voltage electrostatic precipitator of the Lodge-Cottrell type.

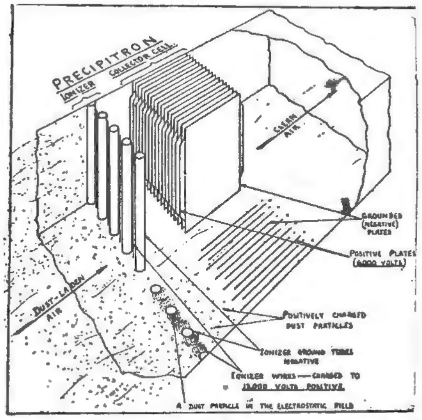

Fig. 3.—Physical and diagramatic layout of Precipitron.

trostatic precipitators was done during the early nineteen thirties by Gaylord W. Penney of the Westinghouse Research Laboratories, Pittsburgh, U.S.A. Initially an important object of the work was to develop an efficient means of removing pollens and other allergens from ventilation air in order to provide air which would bring relief to sufferers from Hay Fever and Bronchial Asthma. Only after five years of behind-the-scenes trials and after the basic patent had been secured in 1938, was the broader destiny of Precipitron recognised—a destiny which carved a healthy track through the many precision war industries, during the 1940's.

In his Precipitron, Penney adopted a technique originally discussed as a possibility earlier in the century. This was to establish two distinct processes within the precipitator—to charge the dust electrically at one stage and subsequently to divert it electrostatically out of the air stream in the second stage. This separation of functions allowed the physicist to design each stage for optimum performance, economy and efficiency.

As a result of this work Penney achieved an electrostatic precipitator with the following improvement which made it immeditely applicable for use as an efficient filter for ordinary ventilation air:—

(a) The operating voltages were reduced to below 13,000 volts and power consumption to a few hundred watts.

(b) Ozone concentration is about one-hundredth of one part per million.

(c) Size and weight are commensurate with normal air conditioning and ventilation practice.

(d) Simplicity of construction (there are no moving parts) and ease of maintenance are good. First cost is well within economic limits.

(e) The efficiency by weight arrestance test is 99.9% or by the more rational discolouration test, 90% compared with a top efficiency of 25-30% for mechanical filters. This efficiency is held on all dust particles down to about four millionths of an inch in size (tobacco smoke).

Principles of Operation

It was mentioned earlier that in the Precipitron the functions of charging and collecting the dust from the air are performed separately in two stages. The simple explanation of operation is that in the first stage or ionizing zone dust has a positive charge supplied to it, so that on entering the collector zone, the positive charge serves to *pilot* the dust over to the negative plates, because of the fact that positive charges are attracted to negatively charged objects. Provided that the dust remains on the plates, the air is then free to move on clear of dust.

For a more intimate and detailed explanation of the operation reference may be made to Figure 3. In this diagram

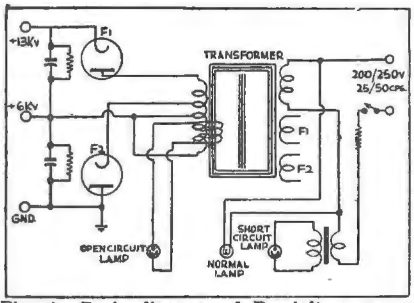

Fig. 4.—Basic diagram of Precipitron power supply unit.

a pictorial disposition of the essential parts of the Precipitron is laid down along side the diagramatic representation. Whilst reference is made to the diagramatic section of the illustration, the physical form of the parts will immediately be apparent.

In the ionizing zone or ionizer, a series of cylindrical tubes is disposed side by side and electrically grounded. Running centrally between each pair of tubes is a fine tungsten wire .007 inch in diameter. All such wires are connected in parallel and charged to 13,000 volts by the Precipitron power pack. By virtue of the 13,000 volts potential difference between the wire and the grounded tube, an electrostatic field exists which is shown by thin lines on the diagram.

Electrostatic Field.

It will be noticed that the concentration with which these lines pack into the limited area of the wire is much greater than the concentration at the ground tube surface. Thus a very high electrostatic field exists at the surface of the fine wire. Actually, conditions are such that a small amount of corona normally occurs at the wire. In other words, the field is strong enough to break down the individual molecules into positive and negative *ions.*

The negative ions so produced are immediately attracted back to the wire mostly in the form of electrons which find their way back in the form of an electrical current to the power pack. The free positive ions produced travel towards the ground rods, and in doing so they must follow the lines of electrostatic force. Now a property of solid matter is that it has a dielectrical constant greater than unity. It has the faculty of bending the lines of electrostatic force inwards and through its own area. In other words, it acts as a sponge for the electrostatic field. It can, therefore, be seen that each particle of dust contained by the air passing through the ionizer sponges up its quota of positive charges in so doing.

There is a limit to the number of charges which each particle can collect, since a point is reached where the charge acquired is such that the particle itself repels oncoming charges. In general, the larger the particle the greater the charge which it acquires. On the finer dust

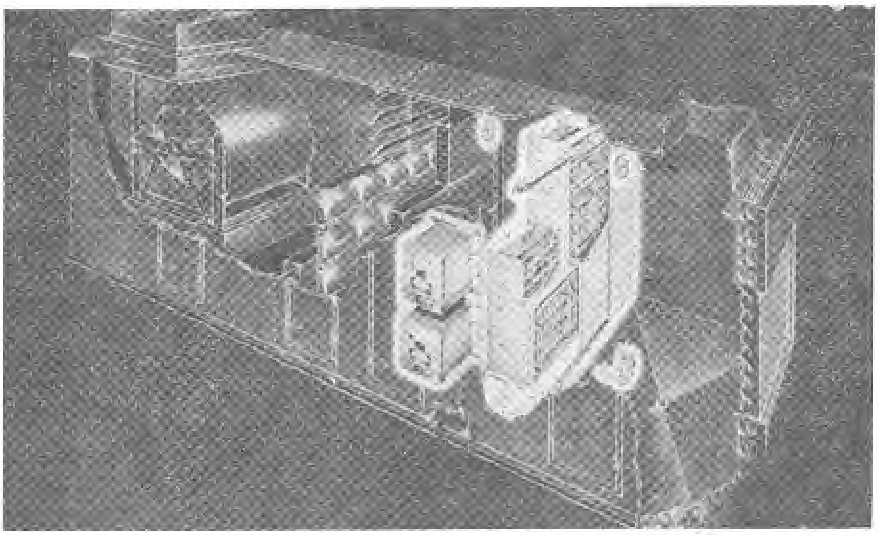

Fig. 5.—Disposition of Precipitron unit in a typical Air Conditioning System.

particles, in addition to the charge collected by the ionizing action, an additional charge is acquired due to thermal agitation of the molecules of air. The result is that even on very fine particles quite an appreciable charge is acquired.

Collector Cell.

The particles of dust thus charged by the ionizer are now carried by the air movement to the entrance of the collector cell. The collector cell consists of a series of parallel plates, one set of alternate plates being grounded, whilst the in-between plates are bonded together, insulated and charged to 6,000 volts positive by the Precipitron power pack. Thus a series of narrow passages is provided in which opposite faces are charged to opposite polarities. By virtue of the 6,000 volt potential difference between these faces a transverse electrostatic field exists which is strong enough to divert the dust, carrying its positive charge, over to the negatively charged plate. In this way the dust particles are side-tracked out of the air stream permitting air of an extremely low dust content to pass through with very little static resistance.

A condition must now be taken care of at the surface of the grounded collector plates, which have on them the accumulated dust. Dusts vary in their electrical conductivity. A highly metallic dust with good conductivity, upon reaching the grounded plate, would immediately give up its charge and take on the same charge as the plate to which it has adhered. Under this circumstance, the now negatively charged particle would tend to fly off the negative plate by electrostatic repulsion. On the other hand, a highly insulating dust could adhere to the negative plate without being repelled away, as the resistance of the dust material itself would prevent the

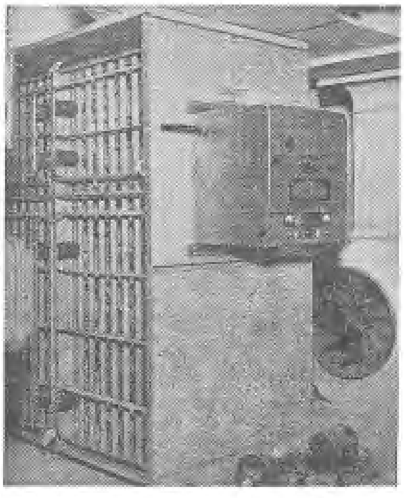

Fig. 6.—A 12,000 cfm. Precipitron unit under erection at National Standards Laboratory, Sydney.

leakage of its positive charges through to the plate. To take care of variations in electrical conductivity of the dust, and for other reasons, the Precipitron collector cell plates are sprayed with a special adhesive material. This insures that once particles reach the plate, they are gripped firmly, irrespective of their electrical conductivity.

After a period of about three weeks in normal city or industrial air the accumulation of dust reaches a stage where the clear passage between plates may become restricted. At this stage the plates must receive their periodical clean down.

Power Supply Unit

The basic circuit of the Precipitron power supply unit, as shown in Figure 4, is essentially that of a voltage doubler. However, certain extra provisions are incorporated to take care of the unusual performance requirements of the Precipitron.

Briefly the special considerations involved are:—

(a) Ability to withstand repeated short circuits due to occasional heavy bursts of dust.

(b) Facilities for indicating internal fault conditions, such as broken ionizing wires, etc.

(c) Provision for indicating short circuit conditions, both for fault detection purposes and as a reminder when cleaning down becomes necessary.

The combination of a voltage doubler circuit, which normally has poor voltage regulation and a high leakage transformer gives the desired short circuit and load voltage characteristics. A tertiary winding is wound around the high voltage secondary, giving about 65 volts under normal circumstances. This voltage follows the fluctuations in secondary volts which may be occasioned by heavy load or short circuit conditions. A neon lamp is connected across the tertiary winding and will glow only when the load is interrupted and open circuit conditions exist within the Precipitron.

Short circuit conditions are also indicated on a neon lamp which is introduced in the primary circuit through a small transformer. In addition a thermal switch is provided in the primary circuit so that if the unit is not switched off under serious fault conditions the thermal time delay will isolate the unit after several hours.

Commercial Form of Precipitron Equipment

For convenience in meeting the diverse requirements of commerce and industry

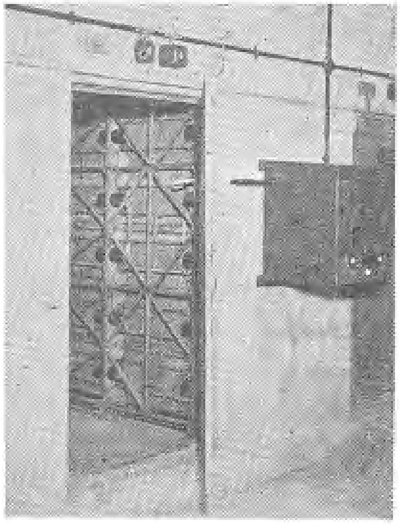

Fig. 7.—A 27,250 cfm. Precipitron complete at National Standards Laboratory, Sydney.

Precipitron equipment is made up in standardised cells which may be stacked or otherwise accumulated to a size which will accommodate practically any requirement of air volume. The basic cell units are two in number:

(a) 24in. x 24in. Precipitron cell, capacity 1,200 cubic feet per minute.
(b) 36in. x 24in. Precipitron cell, capacity 1,800 cubic feet per minute.

Three sizes of power packs are made to serve different combinations of cells. The smallest unit serves up to two cells and the largest unit serves up to 15 cells or about 27,000 cubic feet per minute.

Australian Installations

Numerous installations of Precipitron have already been made or are now in process of erection in Australia. They range from small installations where only 400 cubic feet of air is treated per minute to large, where up to 167,000 cfm is under treatment. Future installations for which contracts have been let will take Precipitron equipment into almost every field of air conditioning and ventilation practice.

As an example of the advantages to be gained by the full exploitation of industrial electronics Precipitron equipment is unique. It yields air cleaner by many times than was hitherto possible with conventional mechanical filters; is extremely simple in employing no moving parts, and requires the absolute minimum of maintenance. Public acceptance has been so good, and the demand so great, that several specialised applications are now under development to meet the specific needs of heavy industry where the bulkier high voltage equipment is beyond the reach of so many, and is often inadequate for other reasons.


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A Technical Survey of Latest Overseas Developments

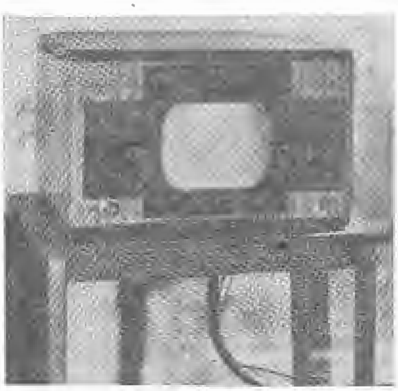
CENTRAL CONTROL TELEVISION FOR HOTELS

With the great and growing increase in television broadcasting facilities throughout the U.S.A., there has come a heavy demand for multiple outlet systems which will accommodate large numbers of viewers.

Typical System.

A typical central control system for such a purpose is shown in the accompanying photograph. This control unit contains three separate channels, two for video and one for FM. Starting at the top, the rack contains the power switching panel, FM receiver, monitor viewer, monitor selector and VU panel, two television tuners, the monitor speaker and distribution amplifier. Each of the television tuners can be tuned to any television channel. Separate antennas are generally used, although in a high signal area one antenna with isolating pads may be suitable.

The video signal is monitored for picture quality on a 10 inch magnetic tube monitor. The video level is checked by a switching arrangement which converts the VU meter to a peak reading vacuum tube voltmeter to measure the synch. amplitude.



One of the individual "slave" viewing screens as used in guest rooms.

Tunable traps are used in the antenna lines to eliminate any residual radiation which might interfere on other picture cbannels. The television tuners have low impedance unbalanced systems witb resistive input terminations. This ensures good performance where the antenna lead-in run is long, as may be expected in hotel installations.

The cathode follower output of each tuner is coupled to a distribution amplifier located at the bottom of the rack. The distribution amplifier provides sufficient cathode follower outputs to take care of the required number of lines leaving the control unit with signals for each unit.

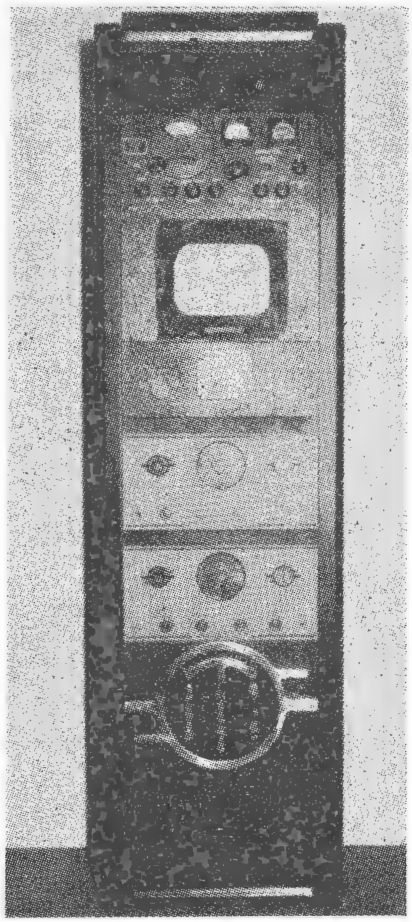
The monitor selector panel enables the operator to monitor both the video and sound signal from any tuner. Tbe sound is monitored for level by means of a standard VU meter, and in addition aural monitoring is provided by a high quality audio amplifier system. Sound is distributed on balanced low level lines, although in the case of small installations where the advantages of balanced operation are not necessary, high level unbalanced lines are used.

Distribution Network.

The distribution network for the video signals is perhaps the most important part of this system. The use of separate coaxial conductor for each channel together with an audio pair for the accompanying sound presents a considerable installation problem. A custom built video cable for use in the system with three television channels and providing one spare coax. is approx. ½ inch diameter. The accompanying sound cable which includes audio pairs for three additional sound channels together with spares and control circuit lines is somewhat smaller in diameter.

Each viewer location has a special cable outlet box and connector to the viewer. By careful design of the cable and switching system which connects the viewer to several lines, a minimum of mis match at the receiver location is maintained.

A typical 10 inch table model suitable for private rooms is shown in the photograph, and this has provision for three television channels and one FM channel. The only operating controls are combination sound volume "off-on" control and contrast control, thus ensuring proper operation by even those inexperienced in using television sets.



The main receiver rack which holds the receiver units and distribution facilities.

RADAR AIDS TO NAVIGATION

MULTIPLE TRACK RADAR RANGE

By JOHN G. DOWNES, B.Sc., A.M.I.E.E.

This article deals with a new radar navigational aid which has been extensively developed in Australia. The Multiple Track Radar Range is a system for guiding aircraft along well-defined tracks which may be laid down in a permanent form along any desired air route.

It is proposed in this article to deal with a new aid to the development of aircraft which has been extensively developed in Australia. The Multiple Track Radar Range is a system for guiding aircraft along well-defined tracks which may be laid down along any desired routes and which are accurate and permanent in their positions.

Before dealing with this Australian development, however, it is necessary to consider in some detail the principles and operations of existing systems of track guidance, so that the requirements for a new system may be properly understood. The present part of this article will be occupied principally by these considerations.

Subsequently we propose to discuss the idea underlying the Multiple Track Range, namely, the principle which has now become known as "hyperbolic navigation," and we shall then consider in some detail the ground and airborne equipments of the new range system and their method of operation.

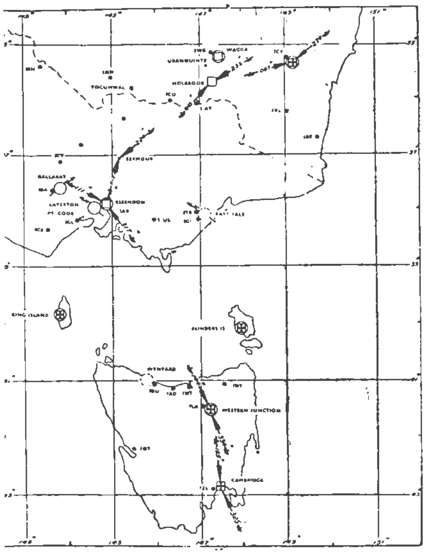


Fig. 1.—Map of radio range tracks in S.E. Australia. The heavy arrows indicate track direction.

The Need For Track Guidance

In a previous article dealing with distance measuring equipment the need for a system of reliable track guidance was mentioned. It is an essential requirement on civil air routes to-day that aircraft should be able to follow a clearly-defined track or "highway" through the air, and that there should be laid down a network of such tracks linking up the major airports of the country. Unless such tracks, fixed in space, are provided there is a very real danger that in bad weather aircraft may become lost and possibly fly into mountainous country where there is a serious risk of collision with peaks. (It is interesting to notice that the existing track system between Sydney and Melbourne has been intentionally "bent" so as to keep aircraft clear of the mountainous country of the Great Dividing Range; this "bending" may be seen in Figure 1.)

A track system, in addition to ensuring that aircraft are flying in clear country, has an additional function in the vicinity of an airport, for it is here used to guide aircraft working "procedure approaches" under conditions of bad visibility. Such "procedure approaches" involve the aircraft flying a clearly-defined manoeuvre, for which track guidance is essential, in the vicinity of the airport. They find their application in cases where there are several aircraft close to the airport, and it is necessary to separate them safely while they land in turn; on other occasions the procedure is followed in order to give the pilot a clear indication of the location of the airship when bad weather has made this invisible to him.

It should be remembered that the important advantage of a track system over a direction-finding procedure (such as that provided by the radio compass) is that the track system is fixed in space, whereas the path followed when homing on a station with a radio compass is not fixed in this way; the latter path is a straight line in the absence of wind, but under windy conditions the aircraft, although it must eventually arrive at the station on which it is homing, follows a curved and possibly quite roundabout route. Consequently, the radio compass, although a valuable auxiliary navigational aid, does not guide aircraft along fixed tracks.

Existing Methods of Providing Track Guidance

The principal method of providing track guidance to civil aircraft has, until quite recently, been by means of the so-called *radio range.* Such radio ranges have taken various forms in different countries, but they all depend essentially on radiation from a transmitter in the form of overlapping coverage diagrams. Figure 2 illustrates the principle in its application to the radio range now used on Australian air routes. The overlap of the two radiation patterns provides a line of intersection along which the *intensity of the signal* due to each pattern is the same, and if suitable equipment is provided in the aircraft to compare the relative intensities of the two signals and indicate when these are equal, such indication can be used to fly the aircraft along the track provided by the intersecting patterns.

By suitably orientating the transmitting aerials the track can be located along any desired bearing. Usually, because of the symmetrical arrangement of the aerials, there emanate from the transmitter either two tracks, approximately 180° apart, or four tracks, 90° apart; these systems are known as two-course and four-course ranges respectively.

In America, radio ranges of this kind have been operated on the principal air routes over a period of many years. The frequencies used lie in the m.f band (200-400 Kc) and such ranges are still one of the main navigational aids for civil aircraft; they are of the four-course type.

In Australia a radio range system has been operating over the major air routes since about 1939. This system operates at the 33 Mc approximately, and uses two-course ranges. Figure 1 illustrates the track system provided by the radio ranges in S.E. Australia. The Australian radio range system was adapted from a German system, the Lorenz range, which was originally developed for the blind landing of aircraft.

Disadvantages of Existing Ranges

It might be wondered why, with these various types of radio range available, further intensive effort has been directed towards the development of new systems. The answer is that radio ranges of the kinds described, although having a good record of performance and being still in continuous use, have some fundamental disadvantages which tend to become more serious as the density of air traffic increases.

It has been mentioned that the radio ranges used in America operate at comparatively low carrier frequencies (200-400 Kc). Experience with these systems over a long period has shown that electrical interference, both atmospheric and man-made, presents a serious obstacle to their satisfactory operation. Noise often tends to blot out the radio range signals in the aircraft on those occasions when track guidance is likely to be most needed, that is to say in bad weather conditions, which are often accompanied by electrical storms.

A further disadvantage in the use of low frequencies is that the signals from the range are likely to be interfered with by signals from distant transmitters, possibly other range transmitters, which reach the aircraft over long paths by means of the well-known mechanism of ionospheric reflection. Considerable confusion may result from such interference.

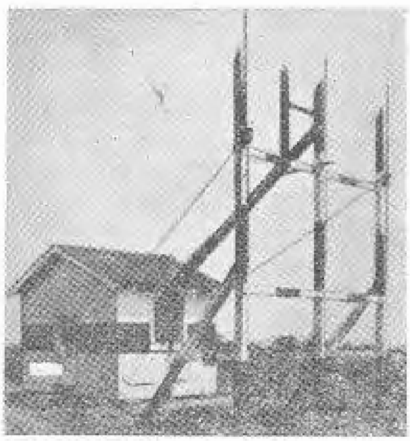


Fig. 3.—The aerial system of a 33 Mc. radio range as used in Australia. These aerials are placed at the top of towers approx. 90 feet high.

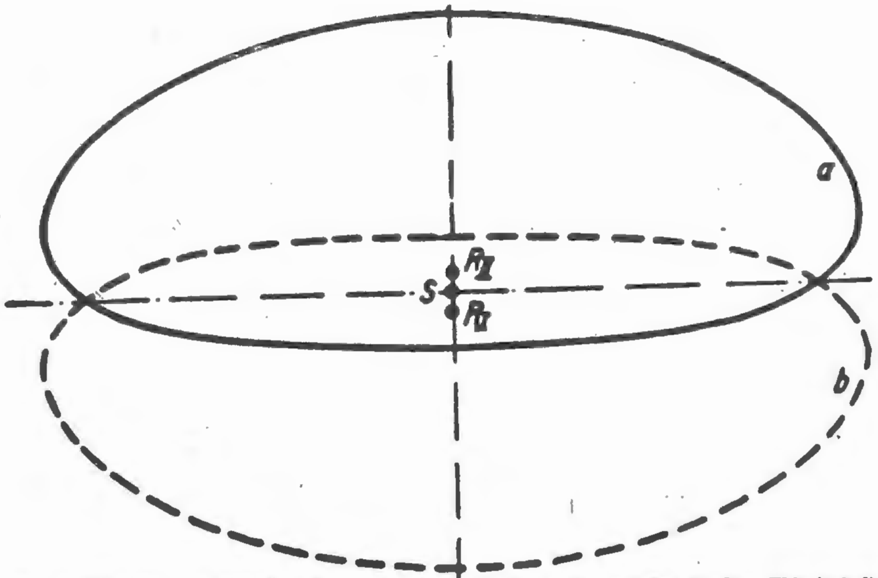


Fig. 2.—This drawing shows how the overlapping radiation patterns define tracks. This is indicated by the horizontal broken line.

Now it has been quite well established by much experiment that the intensity of electrical interference decreases with wave length; that is to say, the higher the frequency used the less will be the electrical noise experienced. Furthermore, it is known that propagation by means of reflection from the ionosphere, the so-called sky-wave tranmission, is difficult to achieve at frequencies above about 30 Mc, so that interference from distant stations might be expected to be much reduced at these higher frequencies.

It was therefore logical that designers of radio range systems should turn to mind higher frequencies to improve the immunity of their systems to interference for both electrical noise and sky-wave transmissions, and this trend has already been noted in the frequencies chosen for the present Australian range system. Also, in pursuance of this trend, a good deal of effort has been expended in the U.S.A. in recent years on the development of radio ranges of the 2- and 4-course types to operate in the V.H.F. Band (i.e., at frequencies of 100-150 Mc). The improvement in the reduction of interference in these cases has been marked. A useful corollary of the change to shorter wavelengths was that the aerial systems, both ground and airborne, became much smaller.

Traffic Density.

However, two disadvantages still remain in radio range systems of the kind described. Firstly, with increasing air traffic and the opening of new routes it has become highly desirable to have a large number of tracks emanating from and leading to each major airport; in fact, quite often a full 360° coverage is required. But no easy way of providing more than the usual two or four tracks from a radio range station has yet proved its worth. Further, the tracks which are available from a given range station are, as we have seen, at angular spacings which can be changed only within narrow limits; if the radio range is required to provide tracks along several air routes the chance is therefore low that the available tracks coincide with those routes.

The second disadvantage from which radio ranges suffer has, curiously enough, been aggravated by the increase in frequency which has rendered them much less susceptible to interference. For with the change to much higher frequencies a basic characteristic of the propagation of radio waves becomes more apparent, namely, the ability of the waves to be reflected from obstacles such as mountains, cliffs and buildings. The possibility of wave reflection from obstacles means that the intensity of the signal at any point in the service area of the range station is no longer solely due to the characteristics of the transmitter aerial system; the signal at a point may be the resultant of both direct and reflected waves.

It will now be realised that unwanted reflection can constitute a most serious and fundamental disadvantage in radio range systems which depend for their operation on the proper relation being maintained between the intensities of two signals. Due to the presence of reflected signals, the distribution of intensity of either or both radiations may be altered, or expressing it another way, either or both radiation patterns may become distorted. Since the range systems so far described derive their tracks from the lines of intersection of the overlapping patterns, distortion of the patterns can result in tracks becoming bent, displaced or *split* (the term used to described the appearance of additional spurious tracks).

Careful Testing Necessary.

Furthermore, since reflections may occur in numerous ways and from a large number of obstacles, it is very difficult to foretell, before a range station is installed, what defects are likely to appear in the tracks. Consequently, after each installation a series of flight tests usually has to be carried out and great care taken to determine what peculiarities, if any, exist in the track system. Procedures of this kind make the installation of such ranges lengthy and costly.

Another possibility which cannot be overlooked is that track defects resulting from unwanted reflections may change their character with time, as for example if propagation conditions along the path of a reflected wave change, or if the reflecting object changes its form.

As an illustration of the latter possibility it may be mentioned that in one actual case at an airport where a range transmitter was installed, the alignment of a track was found to alter appreciably according as the large door of a nearby hangar was open or closed. Peculiarities of this kind introduce an element of uncertainty into the location of the track system which cannot be disregarded.

Reflections Problem.

The difficulties associated with unwanted reflections are fundamental, and it is largely towards overcoming these difficulties by a quite new approach that effort has been directed in recent developments, which we shall describe in due course. It should be remarked that in general, our increase in frequency means an increase in the number and intensity of unwanted reflections, because objects tend to reflect more effectively when the wavelength of the radiation is small compared with the dimensions of the object. Difficulties may therefore be expected until a frequency so high is used that waves can be directed in beams of great sharpness, much as the beam of a searchlight is directed. By suitably orientating the beam, reflections can then be minimized; however, techniques of this kind leave the problem of providing our indirectional track guidance still unsolved.

Record of Operation.

The foregoing paragraphs appear to present a gloomy picture of the behaviour of radio range systems which depend on the relative intensities of transmitted signals (often known as equi-signal ranges). In fairness it must be pointed out, however, that ranges of this kind, despite their disadvantages, have established a remarkably good and long record of operational service, and have no doubt contributed a great deal to the safety of air navigation. Ranges of this kind are still in everyday use in many parts of the world.

It is worth noting as a matter of interest that the problem of interference to radio range signals has not been entirely solved by changing to frequencies higher than 30 Mc. In the Australian range system operating at about 33 Mc, there have been a number of occasions on which signals from range stations distant some hundreds of miles have been picked up. These have been propagated by ionospheric reflection under somewhat anomalous conditions. It would be possible under these circumstances for a pilot, unless he made a continuous check on the identity of the station he was using, to be quite misled as to his correct bearing; the effects of such anomalous propagation can therefore be serious, and must be given consideration.

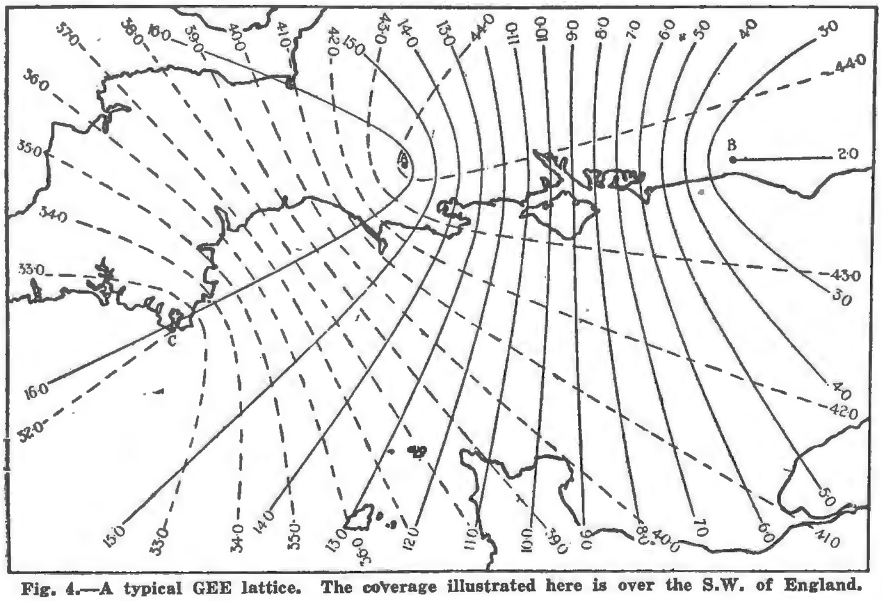


Fig. 4.—A typical GEE lattice. The coverage illustrated here is over the S.W. of England.

Fig. 5.—A typical M.T.R. track system.

Recent Developments In Track Systems

Since the end of the war a good deal of effort has been put into the development of track systems which will meet the demands of modern civil aviation and which will be free from some or all of the defects discussed in the earlier part of this article.

Of these systems, three have been brought to such a stage of development as to warrant consideration by the International Civil Aviation Organisation (I.C.A.O.), the world body which lays down standards for international aviation. At its meetings in the U.S.A. and Canada in late 1946, I.C.A.O. considered these three systems; they are:

The British "Gee" system, first developed during the war for military purposes.

The American C.W. "Omni" range.

The Australian Multiple Track Radar Range (M.T.R.).

To provide a picture of current developments we shall briefly discuss each of these systems, and we shall subsequently consider the Australian system in detail.

"Gee"

The Gee System is one based on the use of pulses, and employs on the ground a master station and several slave stations, suitably located. The stations emit streams of pulses, those of the slaves being synchronized with those of the master. The basis of the system is quite similar to that of *Loran*, the long-range navigational aid which was described in the February issue of "Radio Science." Gee is, in fact,

(Continued on page 46.)

New SUB-MINIATURE Valves

Originally designed for use in the new British Hearing Aid, these new sub-miniature valves should find wide application in many other types of electronic equipment.

Special subminiature valves recently developed by the Mullard Wireless Service Co. Ltd., in collaboration with the British Ministry of Supply and the British G.P.O. have contributed largely to the successful development of an all British Hearing aid. This hearing aid will be made available to all persons suffering from defective hearing when the National Health Service Act comes into operation in England on the 7th July.

These new valves are particularly remarkable for their low filament current rating. In this respect they are considered superior to the equivalent valves of American manufacture, and which up to the present time, have been widely used in commercial British-made Deaf Aid equipment. The development of this series represents a marked advance in British valve manufacturing technique, and also demonstrates that, even in the face of formidable labour and material difficulties, Britain is keeping well ahead in valve design.

This major development of British miniatures will possibly open up vast new fields of application where size is a limiting factor. Their use in the hearing aid will contribute in no small measure in bringing happiness and a renewed interest in life to many thousands of people suffering from defective hearing, and who will benefit under the National Health Scheme.

After the sub-miniature has been pumped, it is processed before testing. This breaking-in stage is carried out in banks of 60.

Main Features

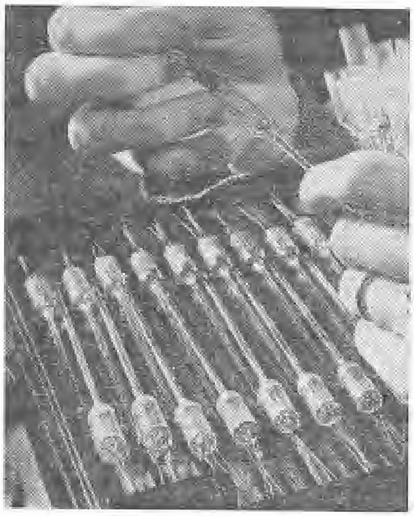
The main features which distinguishes this new development is the remarkably high standard of performance which is obtained in valves of such small size and power consumption. The valves are for example, only 10mm. (2/5in.) in diameter, the voltage amplifying pentode DF70 being 30mm. (1-1/5in.) long, whilst the output pentode DL71 and DL72 are not more than 38mm. (1½in.) long.

In spite of their extremely small size, these valves are of a robust construction and can be relied upon to give a high order of performance over long periods of service. They embody the advantages of the all class technique, perfected in England by the Mullard Coy., and are characterised by short internal connections, rigid electrode supports, and marked absence of microphony.

They have tinned lead-out wires for soldered connections, and their design, size and shape are such that it has been possible to reduce the dimensions of the Hearing Aid to the very minimum consistent with reliable performance. The result is an extremely compact unit weighing little more than four ounces and having the overall dimensions 3¾in. long x 2¼in. wide and 1in. thick. L.T. and H.T. batteries are supplied separately and are of such a size and shape that they may be readily disposed about the person of the wearer.

Hearing Aid Circuit

The Hearing Aid circuit consists of a three stage resistance-coupled amplifier employing two Mullard voltage amplifying pentodes DF70, followed by either a DL71 or DL72 output pentode, depending on whether the circuit is for use with a crystal or magnetic type earpiece. The filaments of the DF70 valves are connected in series across the 1.5 volt LT battery, whilst the filament of the output pentode is connected directly across the



Inserting the plates into the small glass envelope for the production of the DF70 subminiature valve.

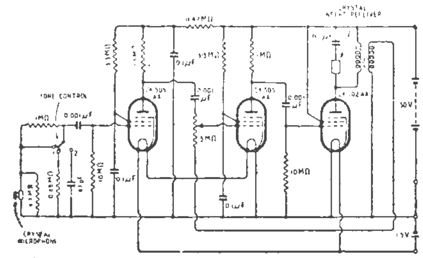
1.5 volt LT source. The current taken by the filaments is remarkably low being no more than 0.025 amps for all three valves. This means that the total current taken by the filament circuit of the new Hearing Aid is no more than 50 ma. at an average of 1.2 volts. The current taken by a similar circuit employing equivalent valves of American manufacture is 75 ma.

The use of the new British sub-miniatures, therefore, results in a 30 per cent. reduction in filament current. It will be readily appreciated that this leads to a considerable saving in LT battery replacement and running costs, a matter of no small importance in equipment such as hearing aids in which compactness, lightweight, wearability and low maintenance costs are the generally accepted design criteria.

Taking into consideration the high performance obtained with these minute valves, the anode current is also of an extremely low order, being 0.15 ma. at 30 volts for the DF70 and 0.6 ma. and 1.25 ma. respectively at 45 volts for the DL71 and DL72.

Reduced Power Consumption

As a result of these extremely low filament and anode ratings it has been pos-



Although the prototype circuit used American type valves, they are now being replaced by the new British sub-miniatures.

sible to reduce to a very considerable extent the total power consumption of the new Hearing Aid. The unit for example, designed for use with a crystal type earpiece, normally consumes only 1/10th watt whilst the total power consumption of the unit intended for use with the magnetic type earpiece is not greater than one watt. This means that less electrical energy is consumed by 450 of either of these extremely compact and lightweight amplifiers than is consumed by a single 60 watt electric lamp.

In spite of this, however, it has been possible to retain a reasonably high gain. For example, with the voltage amplifying pentode DF70 operating at a potential of 30 volts into a load of 1 megohm, a value of the order of 35 is obtained. This is more than is at present demanded by the National Hearing Aid circuit which, operating under optimum conditions, is capable of showing an overall gain of 250, equivalent to 48 dbs. without introducing appreciable distortion.

It will be realised that this is a remarkable achievement in an amplifier unit of such small dimensions. It may be well that as a result of this development in sub-miniature valves, a new world opens not only to the deaf, but also to the electronics designer.

★Technical data and photographs in this article were made available through the courtesy of Mullard-Australia Pty. Ltd.

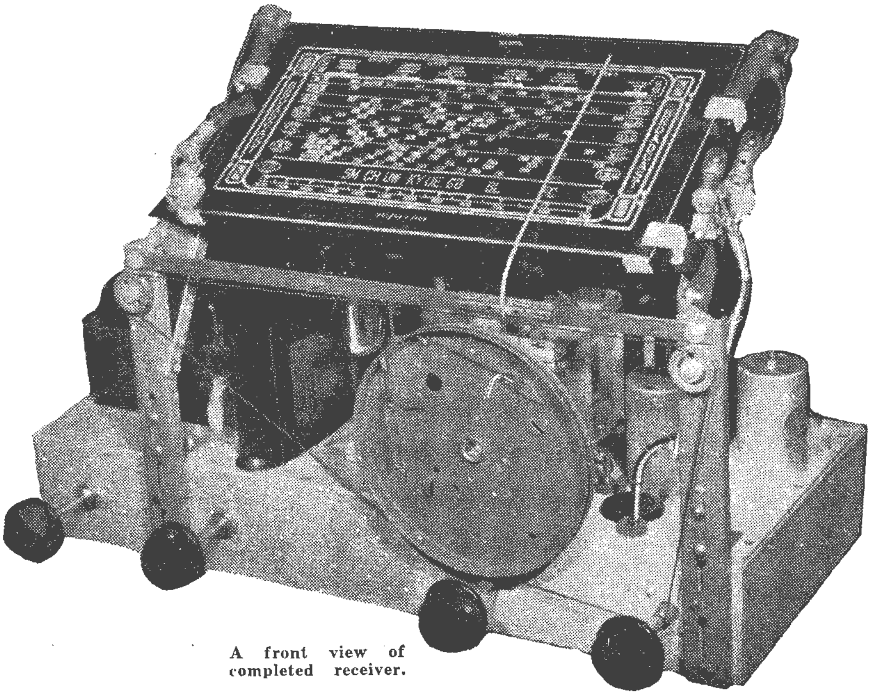
TENTATIVE OPERATING DATA FOR SUB-MINIATURE VALVES

	DF70	DL71	DL72
FILAMENT.			
Voltage:	0.625	1.25	1.25
Current:	0.025 a.	0.025 a.	0.025 a.
CHARACTERISTICS.			
Plate Voltage:	30	45	45
Screen Voltage:	30	45	45
Grid Voltage:	0	1.25	4.5
Plate Current:	0.15 ma	0.6 ma	1.25 ma
Screen Current:	0.05 ma	0.15 ma	0.4 ma
Slope:	0.175 ma/v	0.55 ma/v	0.5 ma/v
Voltage Gain:	35*	—	—
Power Output:	—	6mW.†	23 mW.
LIMITING VALUES.			
Plate Voltage: (Maximum)	45	45	45
Screen Voltage: (Maximum)	45	45	45
DIMENSIONS.			
Diameter: (Maximum)	10.1 mm.	10.1 mm.	10.1 mm.
Length of Glass: (Maximum)	29.5 mm.	38 mm.	38 mm.
Length of Pins: (Minimum)	32 mm.	32 mm.	32 mm.

* Ra is 1 megohm and Rg2 is 3 megohms.
† Total distortion 10%.

A Set for the Connoisseur!

The Dual Wave Seven



A front view of completed receiver.

MAIN FEATURES

- **High performance on both broadcast and S/W bands.**
- **Special negative feedback circuit and bass boost control.**
- **New type of detector circuit.**

Here are full constructional details of a new and unusual seven valve dual wave receiver. It has been specially designed for the reader who wants something really "different" and worthwhile.

The set has been designed around an effective dual wave coil unit, and is capable of excellent results on both broadcast and short wave bands. In addition provision has been made to include a gramophone pickup for the record enthusiast.

To provide high quality reproduction on both radio and gramophone, the audio end of the receiver has not been neglected. In using a pentode audio stage where the inherent distortion is high, the results required have been achieved by the use of negative feedback, in conjunction with a bass boost control. This ensures a high quality output with low distortion, and is quite comparable to a triode stage.

Of particular interest is the novel detector circuit, featuring a cathode coupled circuit which will handle any likely signal input without distortion or overloading. Although not a new circuit, its inclusion, together with the feedback circuit was suggested by E. Holdaway, B.Sc.

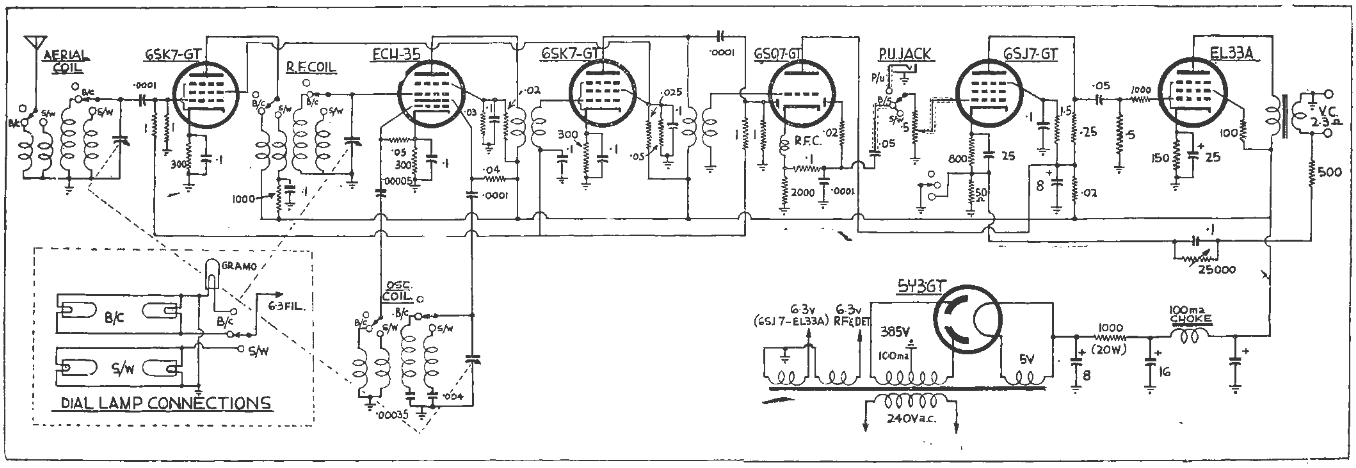
The Circuit in Detail.

The valves employed in the circuit are all standard types and consequently call for little comment. The RF stage uses a 6SK7-GT, connected up in the conventional manner. It wil be noticed that the short wave RF plate lead has been decoupled resulting in slightly greater efficiency and stability on that band.

The converter valve is an ECH-35, and the oscillator section is shunt fed using a .0001 mfd coupling condenser and a .04 meg resistor, in place of the usual series feed. In addition the plate circuit has been used as the tuned circuit instead of the grid circuit. Both these changes are not radical, but simply ones recommended for the ECH-35 by the valve manufacturers.

The general effect of the plate circuit tuning is to decrease any cross modulation effects as well as provide increased stability on the short wave band by reducing frequency drift. In wiring up the circuit it

Voice Coil Impedance	Feedback Resistor	Tone Control Resistor	Tone Control Condenser
Ohms	Ohms	Ohms	Mfd
1.5	400	20,000	.5
2.3	500	20,000	.5
8.4	1000	40,000	.25
12	1200	40,000	.2
15	1350	50,000	.2
40	2250	50,000	.1



Although somewhat unorthodox, this circuit is capable of excellent results. Necessary feedback resistor changes for different voice coil impedances are given in the text.

should be remembered that the oscillator coil connections must be reversed—that is the terminals marked OG and padder, now become OP and B plus—and vice versa.

A second 6SK7-GT is employed as the I.F. amplifier, and this in conjunction with the two iron core intermediates will provide ample gain for the circuit. The RF and IF amplifier screen are connected together and taken to the HT through a common resistor network.

The functions of the second detector and AVC rectifier are combined in the 6SQ7-GT. The AVC control is obtained from the 6SK7-GT plate circuit, via the .0001 mfd feed condenser and the resulting voltage applied to the IF and RF stages only.

In the latter case, shunt feed is employed to simplify coil connections. Also a voltage divider consisting of two 1.0 meg resistors is used to reduce the control voltage applied to this valve.

Unusual Detector Circuit.

The detector circuit employed is somewhat unusual, and whilst by no means new, has not been featured to any great extent in this country. It was originally developed in America, by F. C. Everitt during 1942, and featured fairly prominently in technical journals about that time.

As can be seen the circuit differs from the more usual diode detector arrangement, in that the diode is now driven from an RF cathode follower circuit. The main advantages of this circuit is that it does not appreciably load the preceding tuned circuit because of the high input impedance of the cathode follower stage.

Although the operation of this circuit is not difficult to understand, the following brief remarks will interest those meeting this detector circuit for the first time. As can be seen the modulated signal input is applied to the grid of the valve instead of to the diode circuit. As the grid is varied at the RF rate, the plate current will also vary, which means the potential across the cathode impedance must also vary in sympathy with the signal fluctuations applied to the grid.

When the cathode is negative with respect to the diode plate, current will flow with the result a voltage is developed across the diode load resistor in exactly the same manner as in the conventional diode circuit. The only difference in this case is that the cathode is being varied at the signal frequency instead of the diode.

The net result of this change is that the AC shunting effect of the diode load is minimised, and in consequence this has been reduced to 0.1 megohm. Also the shunting effect of following grid resistor is negligible.

It should be realised that there is no amplification from this type of detector, and therefore it is only suitable for use in large receivers where an audio stage can be conveniently added. The audio output is taken from the diode load in the normal manner through a .05 mfd condenser to the .5 meg volume control.

PARTS LIST

1 Chassis 17¾ x 12¼ x 2½.
1 3 gang "H" tuning condenser.
1 Tuning dial to match.
1 B/C Aerial, RF and Osc. coil (H type).
1 S/W Aerial, RF and Osc. coil (H type).
1 3 bank, 3 x 3 wave change switch.
2 455 kc/s. I.F.T.'s.
1 Power transformer, 100 ma. 385v. HT, 5.0v. @ 2 amps., 6.3v. @ 3 amps.
1 Filter choke, 100 ma.
1 RF choke.

CONDENSERS.

2 25 mfd electrolytics.
2 16 mfd electrolytics 525v. or 600v.
2 8 mfd electrolytics 525v. or 600v.
9 .1 mfd tubular.
2 .05 mfd tubular.
1 .004 mfd mica.
1 .00035 mfd mica.
4 .0001 mfd mica.
1 .00005 mfd mica.

RESISTORS.

1 1.5 meg ½ watt.
4 1.0 meg ½ watt.
1 .5 meg ½ watt.
1 .25 meg ½ watt.
1 .1 meg ½ watt.
2 .05 meg ½ watt.
1 .03 meg 1 watt.
1 .025 meg 1 watt.
1 .04 meg 1 watt.
2 .02 meg ½ watt.
1 .02 meg 1 watt.
1 2000 ohm ½ watt.
2 1000 ohm 1 watt.
1 1000 ohm wire wound 20 wat
1 800 ohm ½ watt.
1 500 ohm ½ watt.
3 300 ohm wire wound 3 watt.
1 150 ohm wire wound 3 watt.
1 100 ohm carbon.
1 50 ohm ½ watt.
1 .5 meg potentiometer.
1 .025 meg potentiometer.

VALVES.

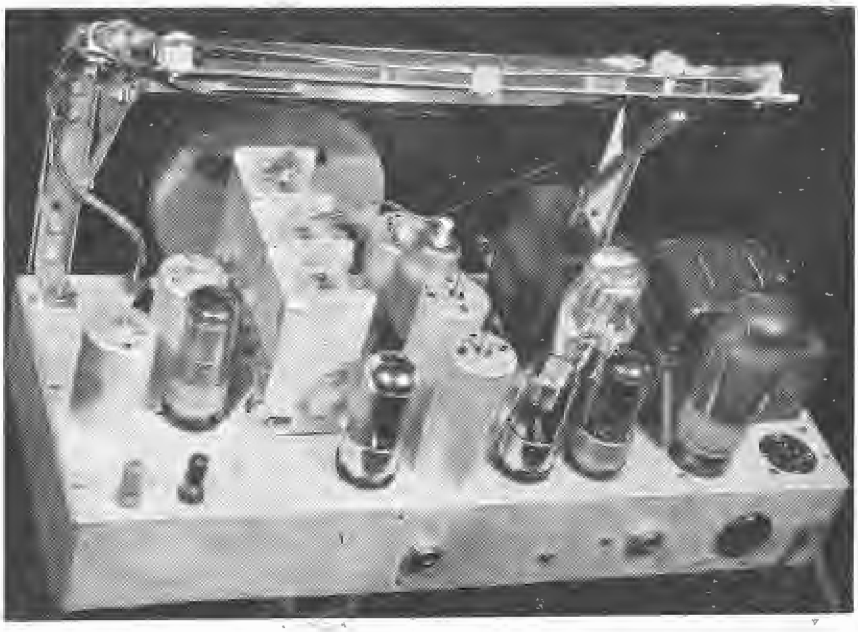
2—6SK7-GT, 1—ECH-35, 1—6SQ7-GT, 1—6SJ7-GT, 1—EL33, 1—5Y3-GT.

SPEAKER.

Output transformer, 7000 ohms load.

SUNDRIES.

7 octal sockets, 2 phone jacks, 2 terminals, 6 Philips air trimmers, shielded wire, hook up wire, solder lugs, nuts and bolts, 4 knobs, 5 dial lamps and holders, mounting strips, power flex, rubber grommets.



This excellent photograph shows the general layout of the chassis.

The audio amplifier is a 6SJ7-GT connected as a pentode. With a .25 meg plate load, 1.5 meg screen resistor and an 800 ohm cathode bias resistor, the overall gain of this stage is more than enough to drive the EL33A to full output.

The screen and plate of this valve as well as the plate of the 6SQ7 are decoupled through the .02 meg resistor and bypassed with an 8 mfd condenser to remove any residual hum. If necessary the 6SQ7 plate circuit can be decoupled separately using a .05 meg resistor and 8 mfd condenser, but it is doubtful whether this extra precaution will be warranted.

Output Stage.

The output stage uses an EL33A—a high mutual conductance type only requiring 6v. peak input to give the rated 4.5 watts output. A characteristic of these high slope valves is the tendency to produce parasitic oscillations, and to avoid this series resistors, known as *stoppers,* have been connected in the control and screen grid circuits. The screen stopper is 100 ohms, whilst that in the grid circuit can be any value from 1,000 ohms up to approx. .05 meg.

The inclusion of these resistors is very essential and the manner in which they prevent the radiation of these parasitic oscillations is as folows. In conjunction with the internal grid-cathode capacity, the grid stopper forms an effective and simple low pass filter system. If by chance the wiring layout and other internal valve capacities tend to form a small tuned circuit, with resultant production of these spurious oscillations, this simple filter system will prevent them building up to any degree.

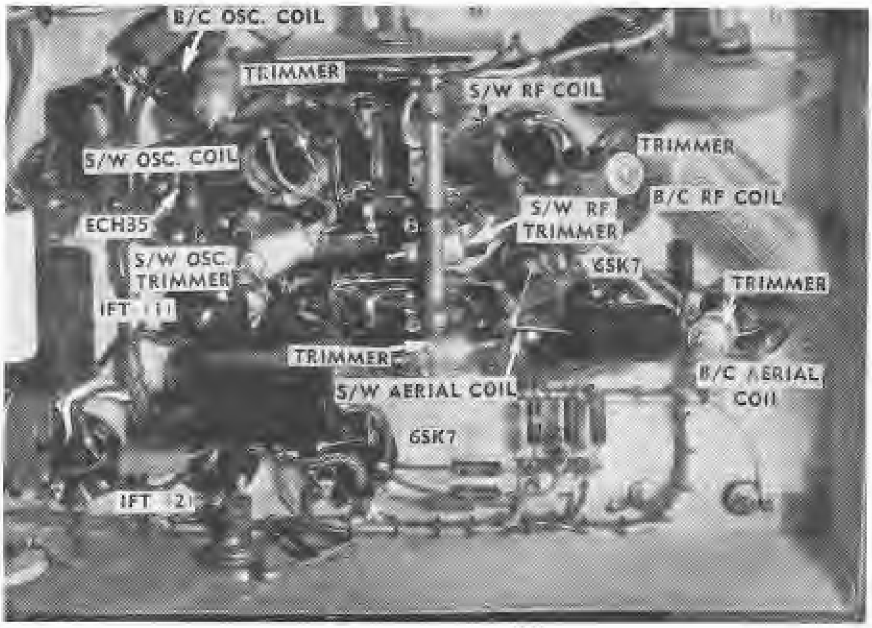
To be fully effective it is necessary to solder them right on the actual valve socket pin otherwise much of their effectiveness as a parasitic stopper will be nullified.

Negative Feedback.

The negative feedback circuit is applied from the secondary of the speaker output transformer to the cathode circuit of the 6SJ7. This system of feedback is now fairly well known and the main precaution in its use is to ensure the correct phasing of connections is made. Unless this is done it is possible to obtain positive instead of negative feedback. The former is characterised by uncontrollable oscillation, and the latter by a reduction in gain.

An important factor in the successful application of this feedback circuit is the use of the high gain EL33A. This additional gain allows a higher degree of feedback to be applied, with the result the overall frequency response is improved and harmonic distortion is reduced to a very low value.

It should be noticed that this feedback is only used on the Broadcast and gramo switch positions, where the higher fidelity is necessary. However, for short wave listening where maximum sensitivity is usually more important than high fidelity, this feedback circuit is switched out thus enabling the full gain of the circuit to be utilised.



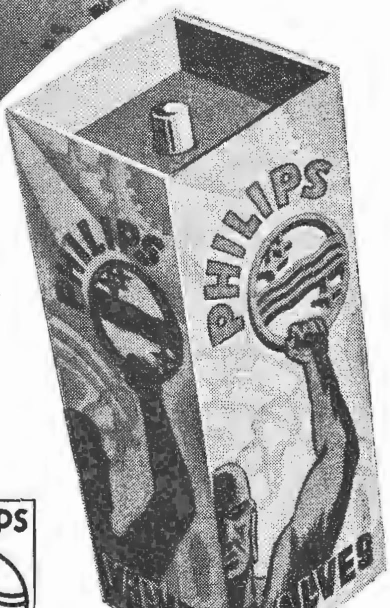
A close-up of the coil unit. The various trimmers are mounted as close as possible to their respective coils.

Tone Control Circuit.

A tone control in the form of Bass Boost is provided, and this is connected in the feedback circuit. This consists of a .1 mfd condenser and .025 meg potentiometer, and permits an effective bass control to be achieved. It is only the amount of bass that is the controlled factor leaving the treble response of the receiver unaffected.

When the moving arm of the control is at its maximum value the shunting effect of the condenser is negligible, except at lowest frequencies. Consequently it may be regarded as being in series with the feedback loop, with the result that at all frequencies where the reactance of the condenser is comparable with or

When it comes to valve replacements or valve selection, the radio owner or the radio hobbyist should indeed "Stop, try a Philips, and listen". Philips valves are designed and made to give *better listening.* Philips valves are precision built but at the same time are ruggedly constructed to assure long life under difficult conditions. Philips valves have stamina, sensitivity and the traditional Philips quality. It's full steam ahead to better listening when you fit . . .



PHILIPS

VALVES

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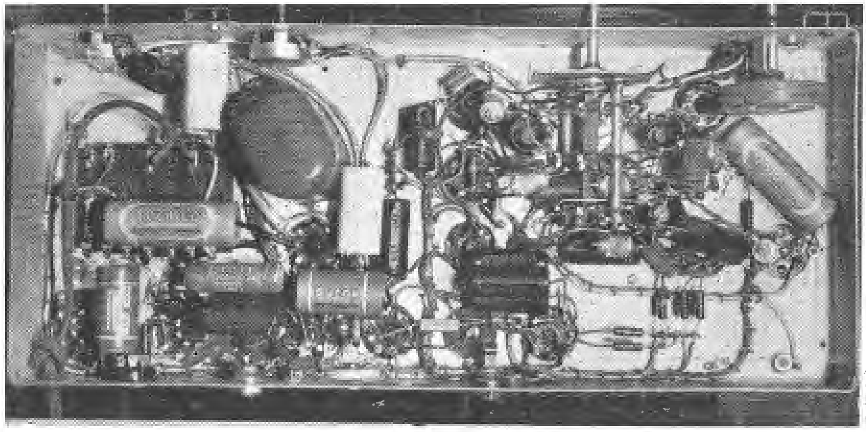
higher than 550 ohms there is a reduction in negative feedback and an increase in gain. Varying the values of the condenser will provide different degrees of boost, and consequently this can be experimented with to suit the reader's own tonal taste.

The values shown in the circuit have been worked out for use with the 500 ohm feedback resistor. Should this be changed due to a different voice coil impedance being used, the requisite condenser and resistor values can be ascertained from the accompanying chart.

Layout and Construction.

The layout of the completed receiver is shown in the photographs and reference to the chassis drawing will indicate where the various components are mounted. The only point to watch in this respect is the orientation of the valve sockets, coils and I.F. transformers. These should be positioned so that the critical leads—plate, grid and diode—are kept short and direct.


An underneath view of the completed receiver.

The gang used in the original was an "H" type, but any type will suit providing that the coils and dial are all matched to it. This is most important, otherwise the tracking of the stations will be found to be out of position either at the centre or one end of the band.

Wave Change Switch.

The wavechange switch is mounted immediately below the gang condenser, and the connections to each switch bank are shown in the separate drawing. Although a commercial unit could have been used, it was decided to build up the complete unit using separate coils, and if each coil is taken in turn there should be little difficulty with this wiring.

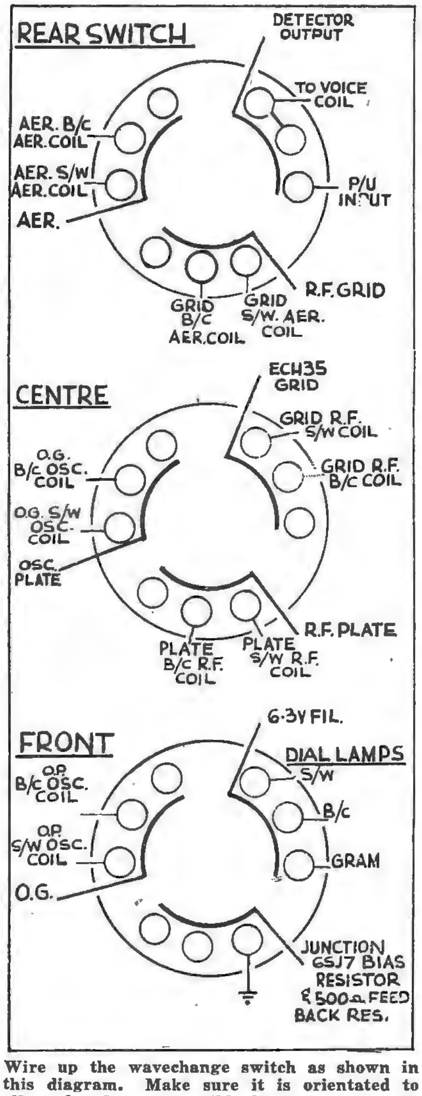
The three spare switch contacts are used for dial lights, pickup and the means of earthing the feedback network on the shortwave bands.

Alignment.

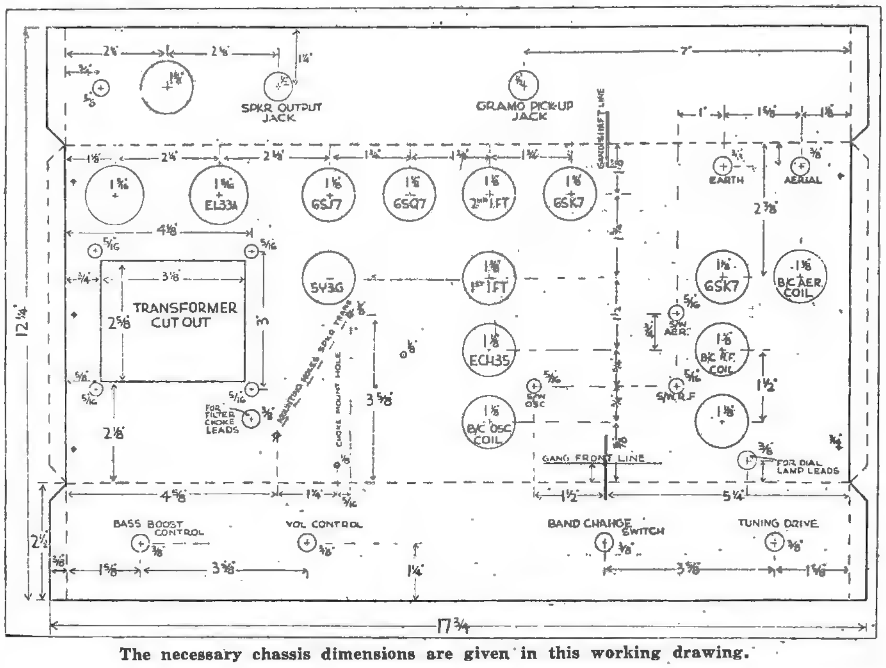
With the set completed, the next step is to align the tuned circuits for maximum results. Whilst this should be done with a modulated oscillator, the following simplified procedure is generally satisfactory if such equipment is not available.

1. Tune in a weak broadcast signal in the vicinity of, say, 1400 kc. Peak the aerial and RF trimmers for maximum output.
2. Next tune in a weak signal at the LF end of the band and adjust the aerial and RF slugs for maximum output.
3. Tune in a known station at the LF end, and adjust the dial pointer to its correct position on the dial scale.
4. Re-tune the set to another known station at the high frequency end, e.g. 2SM and then move the station to its correct position by varying the oscillator trimmer. Recheck the aerial and RF trimmers

The procedure on the short wave bands is very similar to that outlined above.



Wire up the wavechange switch as shown in this diagram. Make sure it is orientated to allow the shortest possible leads to each coil.



The necessary chassis dimensions are given in this working drawing.

RADIO SCIENCE QUIZ

> Here is the fourth radio quiz to test your general radio I.Q. To obtain your rating, take 10 points for each question answered correctly and 5 points if only half right.
>
> As a guide to your ability, the scores are: Beginner, 50% and under; Experimenters and Servicemen, 50 to 75%; Experts, 75 to 95%; and Genius, over 95%.

Q.1.—*Most modern broadcasting stations nowadays employ a vertical type of antenna. An important advantage of this type of aerial system is—*

(a) Less space is required for its erection.
(b) Extends the service area of the station.
(c) Provides a radio beacon for aircraft.

Q.2.—*Whilst on the subject of broadcast transmitters, here is another problem. During construction photographs frequently indicate the presence of radiating ground wires surrounding the antenna system, and the purpose of these is to—*

(a) Keep the tower from sinking too far into the ground.
(b) Improve the radiation from the antenna.
(c) Act as a lightning arrester and prevent the mast from being struck by lightning.

Q.3.—*In broadcasting and general sound work the term "VU" is often encountered. This is—*

(a) A measure of volume level.
(b) A unit of sound absorption.
(c) A measure of field intensity.

Q.4.—*If a voltage doubler is a valve used in a circuit to increase the voltage apprimately two-fold, a voltage multiplier—*

(a) Increases the circuit voltage many times.
(b) Increases the apparent grid bias voltage.
(c) Increases the range of a voltmeter.
(d) Increases the effective plate circuit voltage.

Q.5.—*As most readers know, the audio transformer is an effective method of coupling two stages in a receiver. Under actual operating conditions, pulsating direct current is fed through the primary of the transformer and this results in the secondary winding producing—*

(a) A higher voltage pulsating direct current.
(b) A higher voltage alternating current.
(c) A higher voltage non-pulsating direct current.
(d) A higher amperage alternating current.
(e) A higher amperage non-pulsating direct current.

Q.6.—*Now one for the home recording enthusiasts. In making recordings on acetate blanks the proper depth of the cut should be—*

(a) 0.015 inch.
(b) 0.025 inch.
(c) 0.0015 inch.
(d) 0.0025 inch.
(e) 0.0005 inch.
(f) 0.005 inch.

Q.7.—*If you were able to answer the previous question, then you should also know that the ratio of cut depth to cut width should be—*

(a) 5:1.
(b) 2:1.
(c) 1:2.
(d) 1:1.
(e) 1:5.

Q.8.—*The final RF stage of Australian broadcast transmitters uses which of the following types of modulation—*

(a) Frequency.
(b) Phase.
(c) Amplitude.
(d) 110%.

Q.9.—*One form of coaxial has the space between the inner and outer conductor filled with gas under pressure. The purpose of this gas is to—*

(a) Keep the moisture out.
(b) Raise the inductance of the cable.
(c) Increase the capacity between the two conductors.
(d) Provide a ready means of detecting any electrical leaks in the outer conductor.

Q.10.—*The long distance radio communications we now consider commonplace are really made possible by the reflection of waves from an ionised layer surrounding the earth. This layer is usually referred to as the—*

(a) Heviside layer.
(b) Kennely-Heaviside layer.
(c) Heaviside layer.
(d) Kennelly-Heviside layer.
(e) Kenneally-Heavyside layer.
(f) Kennelly-Heaviside layer.

Q. 11.—*Reference to many valve data sheets show that certain valves are listed as "general purpose valves." Although this means that such types are suitable for more than one purpose, for which of the following applications are they unsuitable—*

(a) RF amplifier.
(b) AF amplifier.
(c) Power output.
(d) Detector.
(e) Rectifier.
(f) Oscillator.

Q.12.—*The "tank" circuit of a transmitter is—*

(a) The watercooling system for the valves.
(b) Any tuned circuit in the transmitter.
(c) The circuit which is coupled to the antenna circuit.

Q.13.—*Recently a great deal of controversy has centred around the validity of some of Marconi's early claims, but you should know that he was—*

(a) The man who invented radio waves.
(b) The first person to demonstrate radio.
(c) The first man to span the Atlantic Ocean by radio.

Q.14.—*Two of the following, in a dilute form, will be found in an "A" storage battery. Can you name them?*

(a) CO_2
(b) Na_2OH
(c) H_2S
(d) H_2SO_4
(e) $C_{10}H_8$
(f) C_5H_{10}

Q.15.—*It is usual to couple the grid and plate of a triode together when the valve is to be used as an—*

(a) RF amplifier.
(b) A beat frequency oscillator.
(c) A half-wave rectifier.
(d) An AM amplifier.
(e) A modulator.

(For answers, see page 46.)

AMATEUR RADIO IN ANTARCTICA

By ROTH JONES—VK3BG

Amateur radio is a hobby full of thrills. The deeper one gets into it, the more involved it becomes. Perhaps the greatest thrill is the establishment of two-way communication with other countries.

This year, radio amateurs throughout the world will have an opportunity of adding two more "countries" contacted to their already comprehensive lists. They will be Heard and Macquarie Islands—remote bases of the 1948 Australian Antarctic Expedition.

Another station will be on H.M.A.S. Wyatt Earp, the supply ship. Sponsored by the Wireless Institute of Australia, this station will have a very attractive QSL card which will be eagerly sought by every amateur. However, since it is mobile, it cannot be classed as a new country.

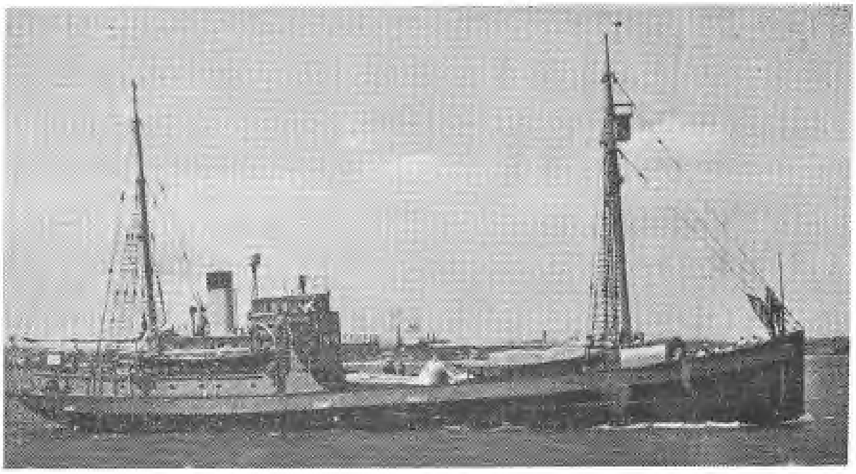
Four Operators

Late last year the Postmaster General's Department issued four experimental licences to radio operators accompanying the expedition. All licensed operators, they will be contacted by thousands of amateur radio operators during their twelve months sojourn in the Polar regions.

When the 3,000 ton H.M.A.S. LST (Landing Ship, Tank) No. 3501, captained by Lieut.-Commander G. Dixon, left Melbourne for Heard Island, via Fremantle, it took three of these operators — Messrs. A. Campbell Drury (VK3ACD), G. S. Compton (VK3AMG), L. E. Macey (VK3OY) and their radio gear. The fourth operator, Mr. Gersham Major (VK7AE), left last month on the ship for Macquarie Island.

THE AUTHOR

Roth Jones, the author of this article is a Melbourne journalist who has been active in amateur radio in this country for many years. His own station VK3BG is known throughout the world, and his own countries' worked list is rapidly approaching the century mark. He was a signals officer in the R.A.A.F. during the war years, entering the service as a member of the R.A.A.F. Wireless Reserve.



H.M.A.S. "Wyatt Earp" being used by the Australian Government as the supply ship for the Antarctic expedition. The length is 135ft., beam 29ft., of wooden construction, and has an endurance of 63 days at 8 knots (12,096 n. miles).

Operating Conditions

Both islands are uninhabited, except for thousands of seals and penguins, and it will be the first time amateur radio equipment has been used in these remote areas. Due to an Australian Government regulation, none of the operators will be able to send private messages to their friends. They will, however, enjoy the privileges and conditions applying to Australian operators.

The Aurora Australis, or "southern lights," is known to play havoc with radio transmission and reception. As the phenomenon occurs regularly in the summer months, and almost nightly during the winter, all contacts may be seriously interrupted. It will, however, give endless scope in transmission and reception experiments.

The amateur stations will use the AT5-AR8 tranmitter and receiver combination, which was designed for the Royal Australian Air Force during the war. With an output of approx. 50 watts to a pair of 807's on CW and half that for grid modulated phone work, the stations should be easily worked throughout the world. Although the transmitters were not originally designed to operate on 10 metres, it is understood the equipment will be modified to include this band.

All stations are expected to be on the air this month. It will then be plenty of competition to work them as they will only be on for limited times each day.

The main control room, Bunnerong Power House.

A general view of the Power House.

The automatic-electric-pneumatically controlled raising plant.

POWER FOR SYDNEY

The Bunnerong Power Station is controlled by the Sydney County Council on behalf of the citizens of Sydney. It is situated on the eastern shore of Botany Bay and commenced operations in 1929.

The present installed capacity at Bunnerong is 325,000 Kw. which will eventually be increased to 375,000 Kw. The installed plant consists of 7 turbo-alternators, each of 25,000 Kw. and 3 of 50,000 Kw. The installation of one more 50,000 Kw. turbo-alternator will complete the Station's capacity.

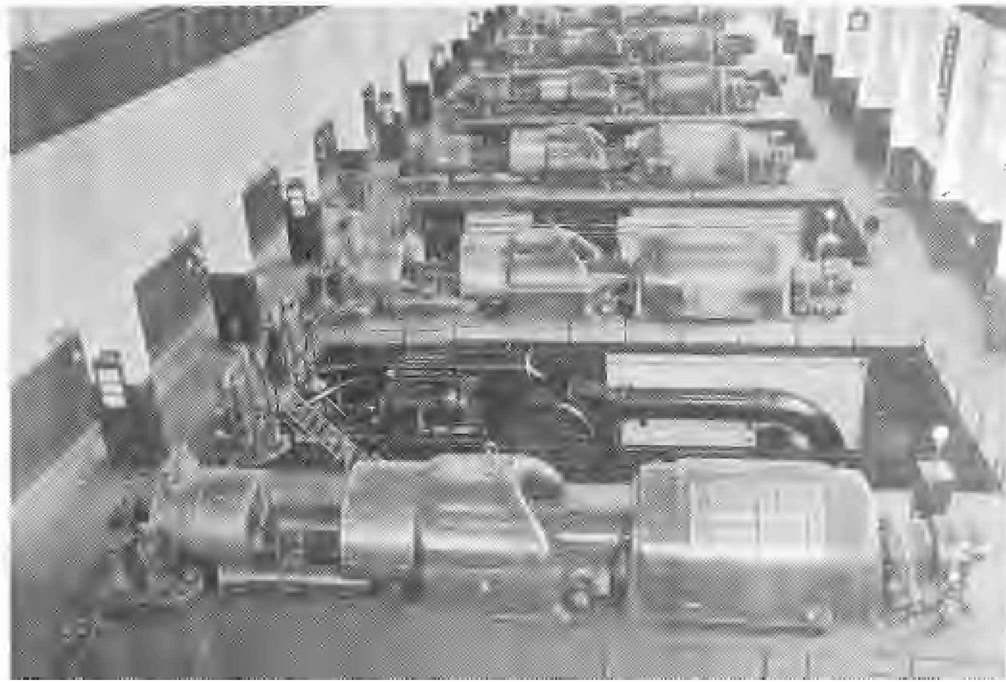
Bunnerong Power Station is modern in every respect and is one of the largest steam generating plants in the Southern Hemisphere.

RADIO SCIENCE, May, 1948

Another view of the generating equipment.

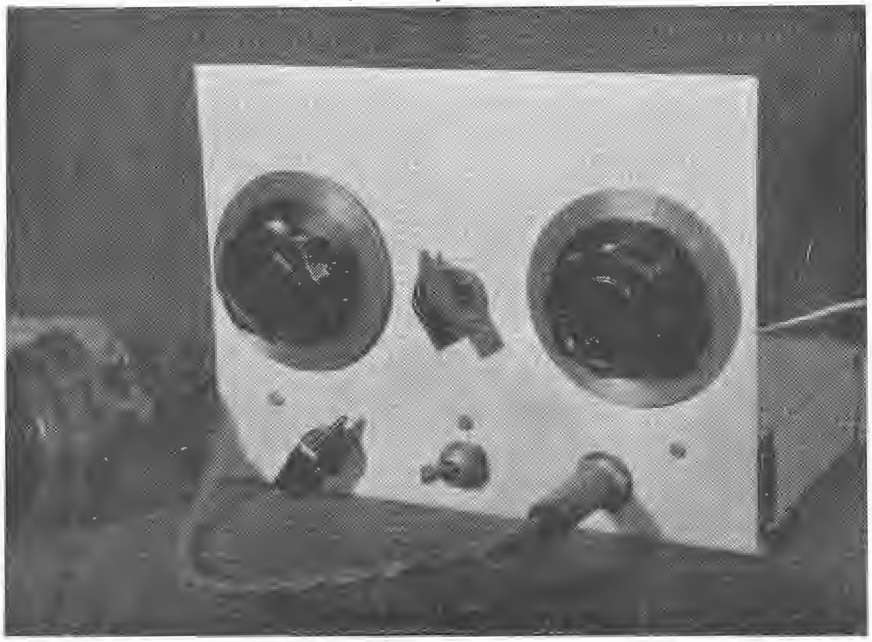
The boiler firing aisle. Furnaces are ignited by a 10,000 volt sparking device.

A section of the 25,000 Kw. Turbo-alternators.



Specially Designed for the Beginner —

ALL-WAVE BATTERY TWO



This front view shows the attractive appearance of the completed receiver.

Here is a new two valve all wave battery receiver which should appeal to the junior constructor. Using two of the latest miniature 1.4 volt valves, it is capable of excellent results on both broadcast and short wave bands.

Of a compact and attractive design, the main features include:

★Complete coverage on broadcost and two short wave bands.

★Will tune to the 20, 40 and 80 metre amateur bands.

★Bandswitching included, obviating usual plug in type of coils.

★Has bandspread tuning.

★Completely self contained power supply.

As the beginners' interests—and capital for that matter usually centres around the smaller type of receiver the two valve all wave receiver described here should undoubtedly have a definite appeal to the younger reader.

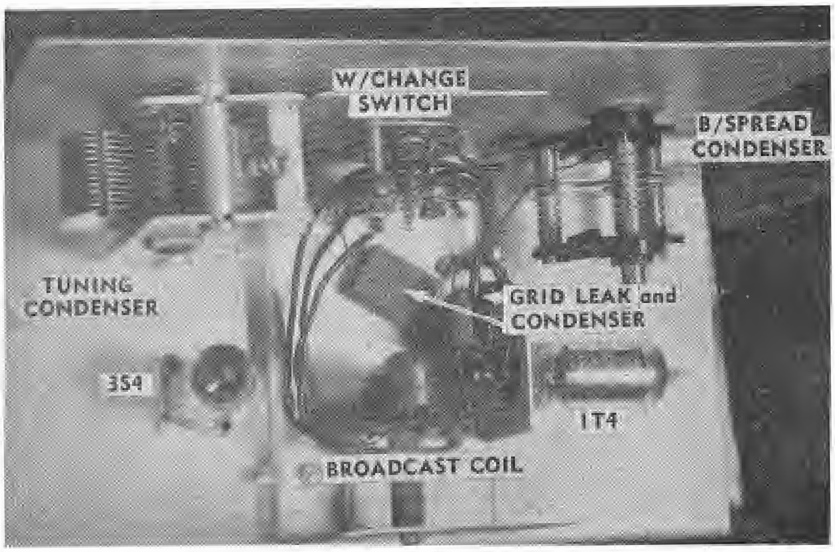
Using two of the latest 1.4 miniature valves, this set will be found very economical to operate and at the same time provide excellent results on the bands covered. So for a small outlay, here is a set that will give efficient world wide coverage, and hours of enjoyment and pleasure.

Frequencies Covered.

The frequencies covered by this receiver are the standard broadcast band—550 to 100 Kc/s and 2.5 to 8.00 Mc. and 6.5 to 18.00 Mc on the two short wave bands. As will be noted there is sufficient overlap on these two latter coils to provide a complete coverage from 2.5 to 18.00 Mc. This will enable the listener to tune in the 20, 40 and 80 metre amateur bands as well as the most popular short wave frequencies.

Under actual tests in one of the suburbs, all the local stations were received at excellent strength whilst it was consistently possible to hear the BBC as well as American Armed Forces programmes on the short waves with nothing more than about 6 feet of hookup wire as an aerial. However, we could recommend something better than this for the consistent listener and suggest where possible, that a good outdoor aerial in conjunction with an earth lead be used. This will ensure maximum results—especially when trying for those elusive short wave stations.

For convenience, the description of this receiver has been divided into two sections. In this first article, full constructional details will be given for building



The location of the main components can be seen in this top chassis photograph.

up the chassis and wiring in the broadcast coil, leaving the winding and wiring in of the short wave coils until the following issue. This has been done to enable the construction and operation to be adequately covered in the available space.

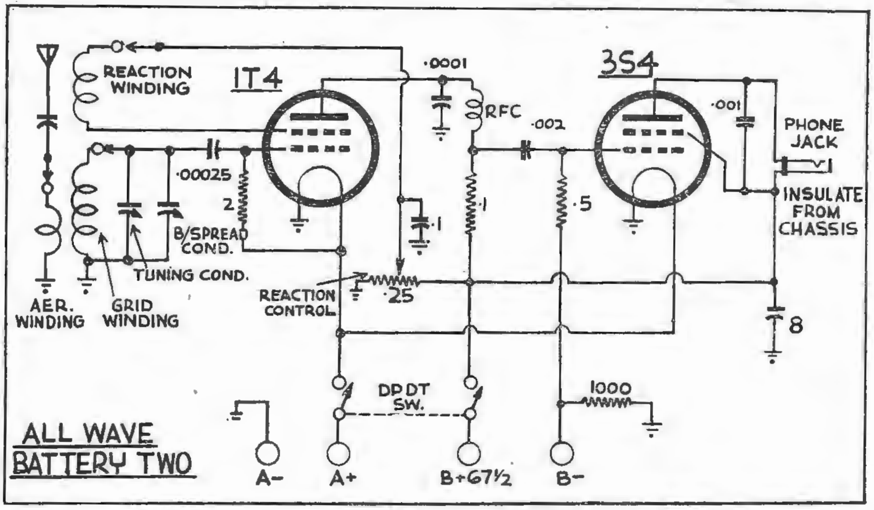
Circuit Details.

As can be seen the circuit used is of the conventional design usually found in a receiver of this type, and consists of a regenerative detector stage using a IT4. The output from this stage is then resistance coupled to the 3S4 output stage. This is a well tried circuit arrangement capable of excellent results and one which presents a minimum of difficulty to the novice constructor.

The use of the 1.4 V series of valves enables the current drain to be kept to a minimum, resulting in a less frequent renewal of batteries.

Although the operation of such a circuit is probably well known to most readers, it is considered that the following details will prove of interest to those building up their first valve type receiver. Starting from the tuning end of the receiver the operation of the most important sections will be discussed in some detail thus giving the builder some theoretical as well as practical details.

The type of coil used in the circuit is a standard unshielded F.N. Reinartz, and this has three windings—aerial, grid and reaction. Selection of the desired station frequency is carried out by rotating the main tuning condenser, which in conjunction with the grid winding forms a tuned circuit.



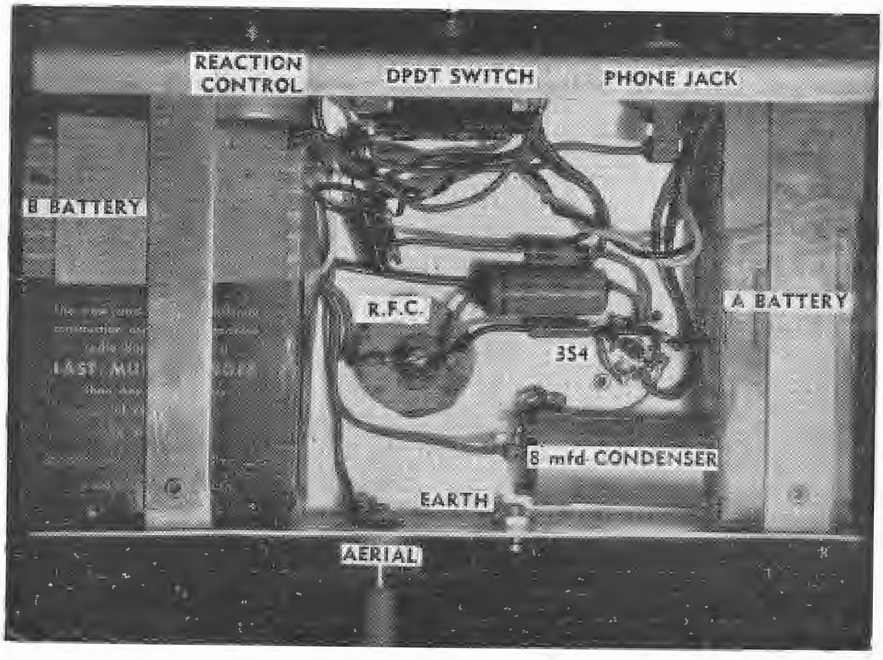
The circuit follows standard practice and should not present any constructional difficulties.

The r-f signal currents received by the aerial flow from the antenna to earth through the aerial coil winding and in so doing induce a current in the grid winding. The current induced in this grid winding develops a voltage across the coil and condenser, which becomes a maximum value at resonance—that is when a particular station frequency is exactly tuned in. This voltage is then applied to the grid of the IT4 through the condenser.

Grid Leak Detection.

The form of detection used in this circuit is known as *grid leak* detection, the operation of which may be briefly summarised as follows: When the positive half cycle of the applied voltage arrives at the grid of the IT4, via the .0001 mfd condenser, current will flow between the filament and the grid—that is electrons will be attracted to the grid by virtue of the positive potential. On the negative half cycle there is no reversal of this grid current flow which means that after a few successive cycles, the grid will have collected so many electrons that it will have an effective negative grid bias.

It can now be realised that with the valve operating under such conditions as those outlined, the plate current will increase more during the positive half cycles than it decreases during the negative half cycles. The net result of this is that



This underchassis photograph should assist in the wiring up. Note how the two batteries are held in position by an aluminium strip rivetted to a small bracket.

PARTS LIST

1 Chassis as detailed.
1 Single gang tuning condenser.
1 Reinatz type coil (unshielded).
1 5 plate midget condenser.
2 Tuning dial plates.
1 3 x 3 Rotary wafer switch.
1 DPDT switch.
1 RF choke.

RESISTORS.
1 2 meg ½ watt.
1 .5 meg ½ watt.
1 .1 meg ½ watt.
1 1000 ohm ½ watt.
1 .25 meg potentiometer.

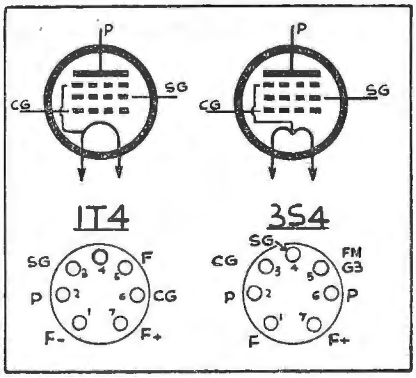
CONDENSERS.
1 8 mfd electrolytic.
1 .1 mfd tubular.
1 .00025 mfd mica.
1 .002 mfd tubular.

VALVES.
1T4, 3S4.

SUNDRIES.
2 miniature sockets, phone jack, rubber grommet, aerial and earth terminals, 2 pointer knobs, 1—67.5 volt B battery, 1—1.4 volt A battery, earphones, hook up wire, solder lugs, etc.

rectification of the incoming signal has been accomplished, and the output at the plate circuit is essentially of an audio character. Any traces of the RF component is removed by means of the RFC (Radio Frequency Choke) and .0001 mfd mica condenser in the plate circuit.

With the valve operating as described some means must be provided for the electrons accumulating on the grid to leak off, otherwise the negative potential would simply continue to increase on each positive half cycle resulting in eventual plate current cut off and non-operation of the valve. The 2 meg resistor inserted in the grid circuit is generally referred to as the *grid leak* and its prime function is to obviate the difficulty mentioned by allowing some of the electrons to flow from the grid back to the filament. In this way the grid is not allowed to become excessively negative.



The socket connections for the two valves. The 3S4 has provision for either series or parallel filament connections. Since the parallel arrangement is used in this circuit, pins 1 and 7 should be connected together for the A plus lead and pin 5 becomes the A minus lead.

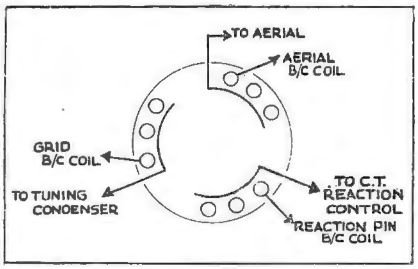
Regeneration Used.

To increase sensitivity and selectivity of the tuned circuit, the principle of *regeneration* has been employed. The signal applied to the aerial is amplified by the valve, and then part of this output energy is fed back into the grid circuit by means of the reaction winding.

When the energy fed back into the grid circuit is of the proper phase, it will add to the incoming signal and consequently, increase the output from the detector—that is, provide a much stronger signal.

If the feed back and grid coil coupling as well as the gain of the valve is sufficient, then enough voltage may be induced in the grid circuit to cause the detector to oscillate. When the detector is oscillating it is actually generating r-f power, and consequently, the greatest sensitivity and optimum results can be obtained from this stage when it is on the verge of oscillation.

In this circuit the reaction is obtained from the screen circuit of the 1T4 instead of the more usual plate circuit connection.



Here are the connections to the wave change switch. The unused lugs are for the SW coils to be added later on.

The reaction is controlled by means of the .25 meg. potentiometer connected from B plus to earth as shown. One end of the reaction winding is taken to the centre moving arm and this is bypassed to earth by means of .1 m.f.d. condenser. It will be found in practice that this form of control is very smooth and effective in operation.

Probably the only disadvantage with this form of control is that in being across the high tension supply it causes a steady bleed current. Although the actual current through this resistor is quite small, it is still sufficient to provide a steady drain on the B battery at all times, and because of this the high tension lead should be broken when the set is not in use. This is most conveniently done by using a DPDT type of switch, since it allows the filament circuit to be open at the same time.

The output from the 1T4 is taken through an RFC, bypassed on the plate side by means of a .0001 mica condenser, to the 3S4 grid via the 0.002 mfd coupling condenser and 0.5 meg grid leak.

It should be noticed that this grid leak is connected to the B minus return and not directly to earth. This is because a back bias system is used to obtain the grid voltage for the 3S4.

The 1,000 ohm resistor connected from the B minus lead to earth provides the necessary bias voltage thus obviating the need for a separate C battery.

Receiver Layout.

The layout of the components on the chassis can be seen by referring to the photographs and the chassis diagram. The main tuning condenser, wave change switch and bandspread condenser are mounted in the position shown on top of the chassis. The coil bracket and 1T4

IN THE NEXT ISSUE.

The concluding part of this article dealing with the winding and wiring in of the short wave coils will be presented in the next issue.

MAKE SURE OF YOUR COPY NOW!!

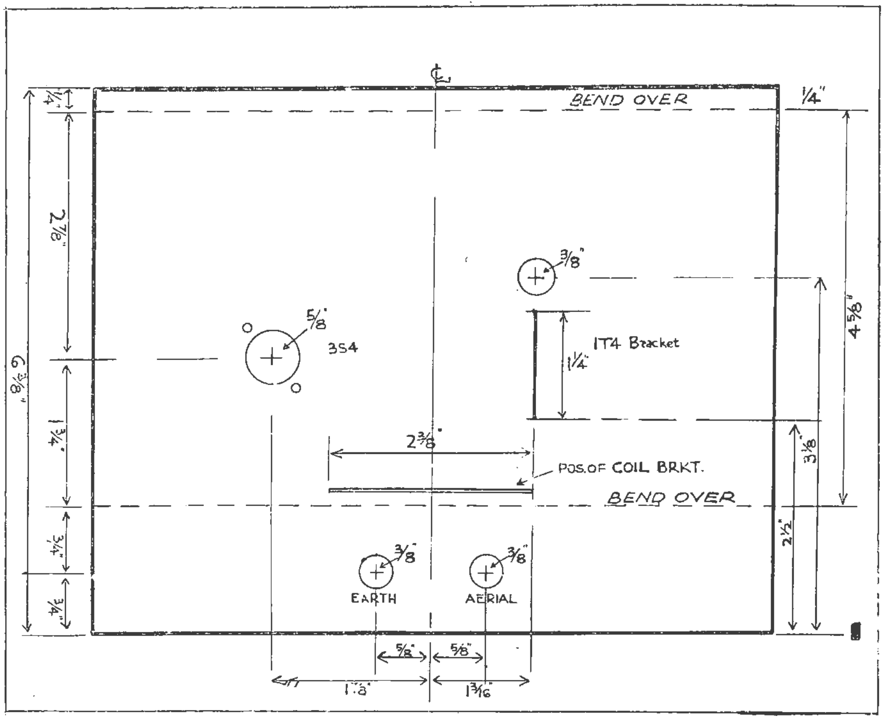
valve bracket are rivetted near the rear of the chassis, making sure the valve socket clears the broadcast coil.

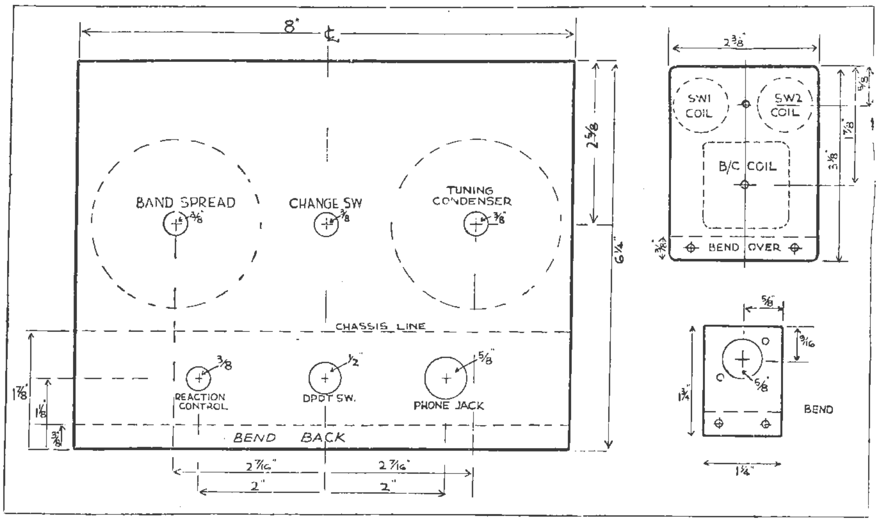
The reaction control, DPDT and phone jack are all mounted under the chassis The phone jack must be insulated from the chassis and this is most easily done by drilling a 5/8in. hole, to take a rubber grommet. Then mounting the phone jack in this grommet will hold it quite firm.

The various components are wired in taking care to keep the leads short and direct. The switch connections are shown in the separate diagram and should cause little trouble. The moving arms connect to the aerial lead, grid lead and reaction lead respectively. Then the first connection of each switch section is taken to the respective lead on the coil socket.

Operating the Set.

When the set is completed and all connections have been re-checked, connect up the batteries and switch on. Evidence of correct functioning wil be indicated by





Complete details are given in this drawing for those desirous of constructing their own chassis.

a *squeal* as the regeneration control is advanced. If this noise is not heard then it is suggested you immediately re-check the coil connections as probably the reaction winding leads have been reversed.

As the control is further advanced without any stations being tuned in, a slight rushing sound will be heard before the *squeal* commences, and it is at this point that regeneration begins. Any further advance of control is both unnecessary and undesirable.

With the aerial and earth connected to the set rotate the main tuning condenser and it should be possible to hear the local stations. If there is a *whistle* in the set as each station is approached and passed, this indicates that the receiver is oscillating slightly. Under these circumstances, the amount of regeneration should be reduced until the detector is on the verge of but not quite oscillating. This condition will be found most suitable for the reception of any modulated carrier such as that of broadcast stations or any amateur phone work.

Although the tuning scale is graduated from 0-100 some readers may prefer to mark the position of the stations on the aluminium front panel, or to paste on a piece of paper with these markings. Either method will enable the position of each station to be quickly and easily located for future use.

ANTENNA *F-M* TRANSMISSION LINES

An analysis of Two-Wire and Coaxial Lines, with Data on Types of Line, Line Impedance, Characteristic Impedance, Resonant and Non-Resonant Lines, Standing Waves, Quarter Wave and Half-Wave Lines.

The transmission line is a major factor in v-h-f antenna systems. Its characteristics determine the manner and effectiveness in which a signal is conducted or guided from the antenna to the receiver.

There are four common types used for the transfer of r-f energy, namely: **two-wire, four-wire and coaxial lines, and wave guides.** The two-wire and coaxial lines are most often employed in home receiver installations.

Transmission Line Impedance

If the length of a transmission line is short compared to the wave length of the r-f voltage it carries, then the opposition presented to this r-f voltage is chiefly at the load connected across the receiving terminals. If the line is long compared to a wavelength, the line itself may present even more opposition to the r-f voltage than the actual load. This is because a long line (compared to a wavelength) exhibits not only resistance but also reactance to the flow of a-c.

This reactance is in the form of series inductance and shunt capacitance uniformly distributed over the length of the line, as shown in Fig. 1. This can be understood if we think of each conductor in a parallel line as being a simple air-core inductor unwound. We know that every current-carrying conductor has both an electromagnetic and electrostatic field about it. It follows that every conductor carrying an alternating-current must be an inductor and therefore, must present an inductive reactance to the flow of this a-c.

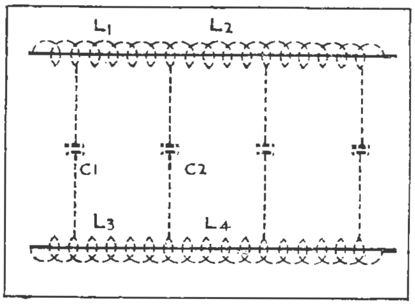


Fig. 1—The distributed constants of a transmission line.

The distributed capacitance can be accounted for by considering the two conductors of a transmission line as two plates of a capacitor upon which an r-f voltage is impressed. From a study of Fig. 1 we note, therefore, that the distributed inductance opposes the r-f voltage transfer over the line and the distributed capacitance acts as a shunt across the line, thus short-circuiting part of the signal or power from the load connected at the receiving end of the line. Both of these effects represents a loss between the sending and receiving end of the line and must be carefully taken into account when working with the transmissioin of r-f energy at 100 mc.

Characteristic Impedance

One of the most important properties of an r-f transmission line is commonly referred to as its *characteristic impedance* Z_0 (Impedance is the resultant of the d-c resistive, inductive and capacitive components with an a-c circuit). The characteristic impedance of a line is important because the load value at which minimum line losses occur is determined by the ratio of Z_0 to the load impedance. The characteristic impedance, Zo, may be defined as: **the impedance a line of infinite length would present to an electrical impulse induced in the line.**

We can obtain a picture of how this characteristic impedance is determined by studying Fig. 2. Here we have a purely resistive network made up of the resistances indicated. If only the first section, r_1, r_2, is connected across 100 volts, the current flowing will be 0.01 ampere and the resistance will be

$$R = \frac{E}{I} = \frac{100}{.91} = 110 \text{ ohms}$$

If three sections are connected across 100 volts the current will be 2.06 amperes and

$$R = \frac{100}{2.06} \text{ or } 48.4 \text{ ohms}$$

Similarly it can be shown that the resistance of 6 sections is 38.6 ohms. At this point it will be noted that the resistance has decreased less than 10 ohms even though the number of sections in the circuit have been doubled. This leads to the assumption that if a sufficient number of sections were added a point would be reached where an increase in the number of sections would not decrease the total resistance of the circuit by any noticeable amount. It can be shown mathematically that the total resistance of such a circuit composed of an infinite number of sections is 37 ohms.

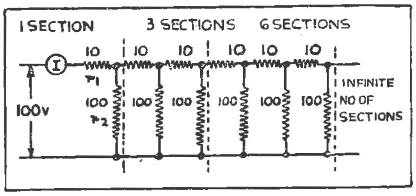


Fig. 2—Parallel-series resistance network of an infinite number of sections.

Although the mathematics for calculating the characteristic impedance of an r-f line is much more involved than this resistance network example, it should be evident that the same reasoning applies to both cases. In other words, an infinitely long line must present a certain impedance to an applied r-f voltage.

Resonant and Non-Resonant Lines

Every transmission line regardless of physical construction may be classed as either *resonant* (tuned) or *non-resonant* (untuned). If it is terminated in its characteristic impedance it is non-resonant or untuned. Non-resonant lines are usually employed for receiving antennas. Although a perfect match is difficult to obtain in practice, a close approximation is possible. It is important to remember that the line must be terminated in a pure resistance; a reactive component in the terminating load will cause reflections of voltage and current even though the load impedance in ohms equals the characteristic impedance. The reactive component in a load can be tuned out in order to obtain a pure resistive effect.

Standing Waves

If the load is not resistive and matched to the line impedance it reflects signal back into the line. The combination of the outgoing and reflected signals produce what are commonly referred to as *standing waves* on the line. An r-f voltmeter may be used for measuring the voltage waves and an r-f ammeter inserted in series with one conductor for measuring the current wave providing the line is carrying sufficient power when used for receiving purposes; therefore, it is necessary to couple an r-f oscillator to measure the standing waves. It is important to remember that even though the maximum and minimum points of the waves are stationery (as long as the load does not vary) that the actual voltage and current are alternating at the r-f frequency. There is no d-c component of either voltage or current.

The presence of standing waves on a transmission line indicate a mismatch between the line and the load. If the load does not match the line the length of the line becomes critical. The ratio of mismatch is approximately equal to the standing-wave ratio, providing there is little or no reactive component in the load impedance.

$$\text{The standing-wave ratio} = \frac{Emax}{Emin}$$

where Emax is the voltage at the peak of a wave and Emin is the voltage minimum. A standing-wave ratio less than 2 to 1 is to be desired for a satisfactory non-resonant line. For example, if an r-f voltmeter indicated a voltage peak of 12 volts and a voltage minimum of 4 volts—

$$\text{the standing wave-ratio would} = \frac{12}{4}$$

or 3 to 1. This indicates that the load impedance is either 3 times greater or one-third the characteristic impedance of the line.

Line and Load Impedance

Previously it was stated that the signal was reflected back along the line unless the load impedance equalled the line impedance and was purely resistive. Also, that the impedance presented to the r-f generator by the line, plus the load, equals the load impedance *only* when the two are matched. This suggests that the line terminated in other than its characteristic impedance might be used either as an impedance matching transformer, or as reactive (inductive or capacitive) elements in an r-f circuit.

If a line is terminated in a short circuit, there is no load resistance in which to dissipate the energy, therefore, it is reflected back toward the r-f generator. The standing waves of voltage and current along the line are 90 deg. out of phase, which also indicates that no power is being dissipated. It will be noted that a voltage minimum and a current maximum occur at the shorted end. This is logical since high current and low voltage are to be expected at a short circuit.

If the line is terminated in an open circuit, the voltage and current loops are reversed and a voltage maximum and current minimum appears at the open circuit end. Again these are the conditions to be expected at an open circuit and indicate that no power is radiated.

The foregoing discussion dealt with a line of specific length. It was emphasised that location of the voltage and current maximums were determined solely by the value of load impedance at the receiving end of the line. If a line is shortened by one-quarter wavelength the impedance seen by the generator will be reversed from a high to low impedance, or vice versa, as the case may be, regardless of whether the line is terminated in a short or open circuit. A quarter-wave section of line, therefore, presents either a high impedance when shorted or a low impedance when open circuited.

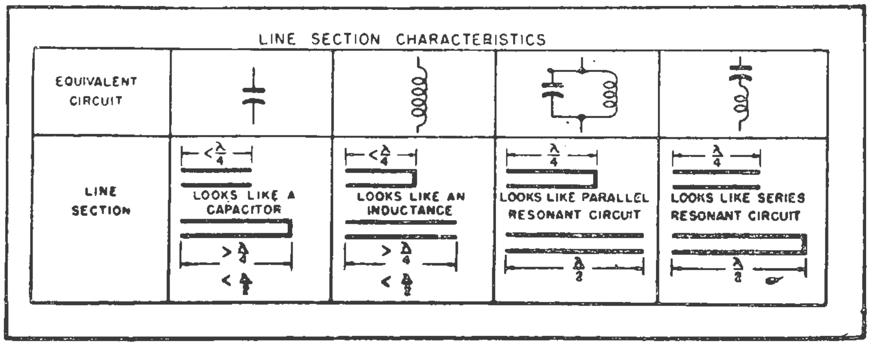


Fig. 3—Characteristics of line sections.

Resonant Circuit Effect

It is apparent that the characteristics of a quarter-wave section of line, are similar to a resonant circuit. For example, a parallel tuned circuit presents a high impedance at *one* frequency; a shorted quarter-wave line also presents a high impedance at one frequency. Likewise, a series tuned circuit presents a low impedance path for r-f at its resonant frequency and an open quarter-wave is practically a short circuit to r-f induced at its input end. The characteristics of open and shorted sections of line are shown in Fig. 3. These characteristics repeat when multiples of an electrical half-wave are added and are inverted as *odd numbers* of electrical *quarter-wave* sections are added.

If the input frequency applied to either a parallel or series resonant circuit increases, the circuit becomes inductive. If the frequency is decreased below the resonant frequency, the same circuit becomes capacitive. Quarter-wave transmission lines behave in exactly the same manner. Fig. 3 shows this relationship for both quarter and half-wave lines.

From the foregoing discussion it is evident that transmission lines may be used as: **(1) Impedance matching transformers, (2) voltage or current transformers, (3) parallel or series resonant circuits, and (4) phase inversion transformers. (A quarter-wave line shifts the phase 90 deg.).**

Propagation Constant

Because r-f energy travels more slowly on a wire than in free space, the wavelength is shorter on the wire than in space.

This is because the:—

$$\text{wavelength is equal to} \frac{\text{velocity}}{\text{frequency.}}$$

The velocity of an r-f wave in free space is equal to the velocity of light or 300,000,000 meters per second. Therefore,

$$\text{a wavelength in meters} = \frac{300{,}000{,}000}{f}$$

when f is in cycles per second. The electrical length, previously mentioned, then differs slightly from the length in terms of the free space wavelength. The capacitance effects between the wires themselves and between each wire and ground decrease the velocity of propagation on the line. The insulating material between the wires have a dielectric constant greater than air, which increases the effective capacitance, which also affects the wave velocity. The factor by which the velocity in a line is reduced from the velocity in free space is called the *propagation constant*. It is always less than one.

The propagation constant for some common lines are:—

Parallel line (open, bare)	0.975
Parallel tubing	0.95
Parallel line (polethylene insulated 300 ohm f-m leadin)	0.85
Coaxial line (air insulated)	0.85
Coaxial line (rubber insulated)	0.60
Twisted pair	0.60

Most manufacturers give the propagation constant on every spool or roll of line intended for r-f transmission. To find the wavelength of a certain frequency on a specific line multiply the wavelength in free space by the propagation constant.

Analysis of Different Types of Lines

The following types of lines are recommended for use as antenna lead ins:—

(1) **Parallel polethylene insulated line.**
(2) **Coaxial plastic insulated line.**
(3) **Shielded pair, rubber covered line.**
(4) **Twisted pair.**

The parallel polethylene insulated line has become the most popular type transmission lines for f-m antenna lead in in the average home. It is economical, easy to install, has low losses (about 1.5 db per hundred feet) and is available in a variety of impedances (Zo) including 300 ohms, which is the RMA suggested standard input for f-m receivers. For relatively short lead ins (75 to 100 feet) this line is very satisfactory.

Coaxial Lines

The chief purpose of coaxial lines is to keep down radiation losses. In two-wire parallel lines, the electric and magnetic fields extend out into space thus causing radiation losses and noise pickup from other sources. In a coaxial line, however, no fields extend outside the outer conductor. All fields exist in the space between the two conductors. The coaxial line is, therefore, perfectly shielded. (This is not actually true in the flexible coaxial line, for there is some leakage through the flexible metal braid of the outer conductor). Losses also occur in the rubber or plastic insulation used between the inner and outer conductor.

Shielded Pair

Shielded pair lines usually consist of two parallel conductors separated from each other and surrounded by an insulating material, usually plastic, and contained in a copper braid tubing which acts as a shield for the conductors. This copper braid is usually covered with a protective coating of rubber to protect it from moisture and mechanical damage.

The most important advantage of the the shielded pair is the fact that the two conductors are *balanced to ground;* that is, the capacity between each conductor and ground is uniform along the entire length of the line. To appreciate this improvement, let us consider the open pair or unshielded line. If radiation in such a line is to be prevented, the current flow in each conductor must be equal in amplitude to set up equal and opposite magnetic fields and thereby cancel out.

This condition can be obtained if the line is well in the clear of all obstructions; but suppose that the line runs near some ground or conducting surface, and that one of the two conductors is nearer that obstruction than the other. A certain amount of capacity will exist between the two conductors and the conducting surface over a length of the line, depending upon the size of the obstruction. This capacity acts as a parallel conducting path for each half (conductor) of the line, causing a division of current flow between each conductor and the interfering, or stray capacity. Since one conductor is nearer the obstruction than the other, the current will be greater on one line than on the other; therefore, incomplete cancellation will result and radiation will take place.

Since the spacing between the two conductors of a shielded pair is considerably less than that of an unshielded pair; the characteristic impedance of the line is lower. Also the propagation constant of a shielded pair is usually lower than that for an open line.

The twisted pair, as the name implies, consists of two insulated wires twisted to form a flexible line without the use of spacers. It generally is used as an untuned line for low r-f (standard broadcast band). It is not used at the higher frequencies because of the losses occurring in the rubber insulation. Its chief advantage is that it may be used where more efficient types of lines would not be practical, due to mechanical problems of installation and increased cost.

Summary on Choice of Lines

(1) An open or unshielded pair is commonly used as a lead in for f-m receiving antennas if the run is less than 100 feet and economy is a factor.

(2) Coaxial lines are used as *an unbalanced line* where it is convenient to ground one leg of the circuit and where radiation losses from an unshielded pair might be excessive. A practical application of a flexible coaxial line is as a lead-in for an a-m antenna in which the lead in must pass through a high *noise area.*

(3) The shielded pair is used where radiation losses from an unshielded pair would be excessive, but where it is desirable to maintain a *balanced line.* The cost per foot of the shielded pair is greater than either the open pair or the flexible coaxial line.

(4) The twisted pair is used as a lead in for centre-fed or balanced a-m antennas designed for maximum noise suppression at nominal cost.

★This article first appeared in "Service" and is reprinted by special arrangement with the publishers.

U.H.F. Techniques

By

HARRY N. EDWARDES, B.Sc., B.E.

Microwave radar, more than any other radio application was responsible for the development of the magnetron as an efficient generator of power at centimetre wavelengths.

PART 3
THE MAGNETRON

The resonant cavity magnetron had been the *secret weapon* of the British radar scientists in the earlier years of World War II; the *boffins* had fought the military leaders for months to gain its release from the sacred precincts of the laboratory, so that it could be used in the airborne equipment which made possible the precision bombing of Germany.

By the end of the war, magnetrons capable of peak powers ranging from 50 kilowatts to 3,000 kilowatts at wavelengths from 3 to 50 centimetres had been produced in large quantities in England, U.S.A., Canada and Australia.

The magnetron is a diode in which the behaviour of electrons is governed by a magnetic as well as an electric field. The cathode and anode take the form of co-axial cylinders. In the early modes the anodes were single continuous cylinders, whilst later types have split or multi-segment anodes. The modern magnetron is far removed from its pre-war forerunner, which resembled a conventional diode and was used in conjunction with an external circuit. A typical example of an early magnetron is shown in Figure 1, whilst Figure 2 is a modern 3 cm. tube. This latter has a multi-segment anode with self-contained circuits in the form of resonant cavities.

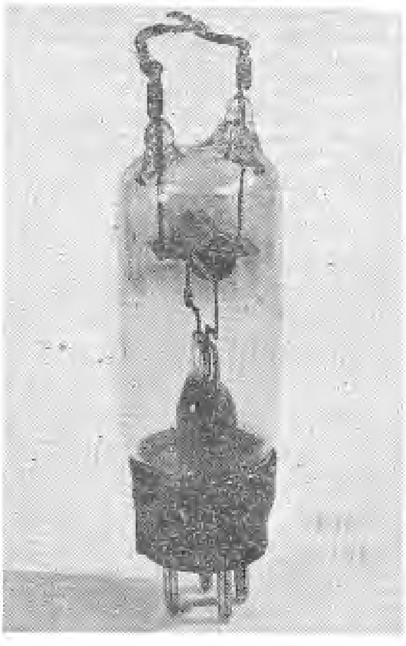


Fig. 1.—Early model of a split anode magnetron.

Historical.

The principle of the magnetron tube was discovered in 1921 by Hull of the General Electric Co., U.S.A. It resulted from the study of electron motion in a diode with both electric and magnetic fields.

Many scientists, in various countries have contributed to the development of the magnetron. Different types of oscillation or *modes*, depending upon the mechanical construction and operating conditions, have been discovered.

For example, a German, Habann, in 1924, first discussed the *negative resistance* or *dynatron* mode, later work being performed by Magow in England and Kilgore in the U.S.A.

In 1924 also, another mode, known as the *electronic* or *transit-time* oscillation became evident to Zacek in Czechoslovakia. This was analogous to the oscillations in a positive grid of Barkhausen and Kurz oscillator.

Further investigations by Yagi and Okabe in Japan led to improved operation in the electronic mode with split anode magnetrons.

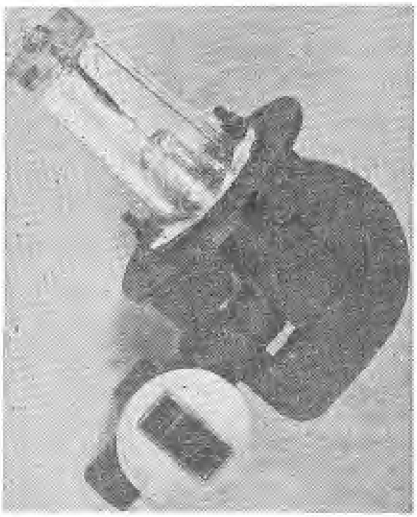


Fig. 2.—The Western Electric magnetron type 725A. This is capable of 40 kW peak at 3.2 cm with 40% efficiency.

The aims of the scientists were to improve the efficiency and power output, as well as to increase the frequency of operation (i.e., to decrease the wavelength). These aims arose from the demands of pure science rather than the possibility of any practical application.

In this quest for power, efficiency and frequency notable results were obtained in the U.S.A. by Linder of R.C.A., who produced 2½ watts at 12 per cent. efficiency and 10 cm. wavelength in 1936; Cleeton and Williams in the same year reached the extremely short wavelength of 0.64 cm. with a split anode magnetron.

Maintaining strict chronological order, the next step in the history of the magnetron was made by the two Soviet scientists, Alekseev and Malairov, who in the years 1936, 1937 developed the resonant cavity magnetron—the modern form of this tube. This development apparently did not become known in England and

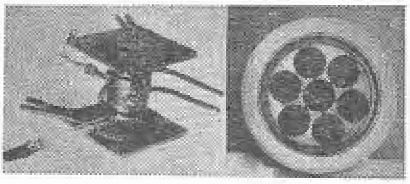


Fig. 3.—The first magnetron produced at Birmingham. The power output was 400 watts at 10 cm.

the U.S.A. until 1944, when a translation was published in the Proceedings of the Institute of Radio Engineers of America (1) of a paper presented in the Russian Journal of Physics in 1940. The Russians obtained 300 watts at 9 cms. with 20 per cent. efficiency. A magnetron giving 2 watts at 2.6 cm. was also produced.

The equivalent milestone was not reached in England until 1940, when Boot and Randall (2), under Professor Oliphant at Birmingham, made an experimental magnetron capable of 400 watts at 9.8 cm. with an efficiency of 10 per cent. Figure 3 is a photograph of this first English cavity magnetron, showing the cavity in detail. This was a considerable achievement for those concerned in view of the fact that the task of developing a high power 10 cm. generator had been assigned to them only about six months previously.

After preliminary investigations of the Klystron which showed no promise of producing high power, effort was soon concentrated on the magnetron. However, some of the Klystron principles were recalled and the result was the application of cavity resonators to the magnetron. Cylindrical resonators were found more convenient than *rhumbatrons* which were used in Klystrons.

There has been no major change in the design of magnetrons since 1940. Less spectacular development has comprised the design of magnetrons suitable for pulsed operation, *strapping* for improved efficiency, theoretical work by Slater and others in the U.S.A. and the production of tunable magnetrons. The wavelength limit has been forced down to a few millimetres.

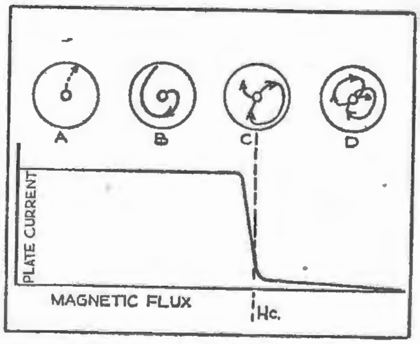


Fig. 4.—Electron trajectories with the corresponding plate current v. magnetic field characteristic.

Magnetron Characteristics.

A magnetron is operated with a high positive potential on the anode; this provides a radial electric field. The magnetic field is applied in the direction of the axis of the electrodes. Thus, electrons emitted from the cathode tend to move outwards under the influence of the radial electric field; the magnetic field applies a force to the electrons at right angles to the radius in the same way as a magnetic field through a circular conductor causes electrons (i.e., current) to flow in the conductor.

Under the influence of the two fields the electrons describe paths in the interelectrode space approximating to *epicycloids* (see Fig. 4). An epicycloid is the curve that would be generated by a point on the edge of a circular disc rolled round on the cylindrical cathode.

The magnetic flux governs the extent of the curving of the electron paths, and for any anode voltage there is a certain value of flux called the *critical* or *cut-off* field, beyond which no electrons reach the anode. They return to the cathode to be either re-absorbed into the latter or attracted again towards the anode. (Fig. 4 c and d.) This cut-off characteristic may be depicted graphically as shown in Fig. 4 beneath the drawings of the electron trajectories; plate current is here plotted against magnetic field for constant anode voltage. The level portion of the characteristic up to the vicinity of the critical field represents the limiting valve of cathode emission.

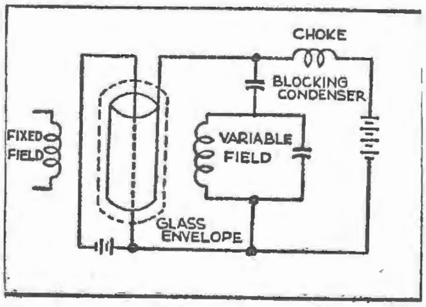


Fig. 5.—Feedback type of magnetron oscillator suitable only for audio frequencies.

Thus, in the magnetron, the magnetic field plays an analogous role to the grid of a triode.

Feedback Oscillations.

Of academic interest rather of practical value is the magnetron feedback oscillator which is somewhat analogous to a triode oscillator.

By arranging for the alternating plate current to pass through the field electromagnet winding, feedback of energy from the plate circuit is possible and audio frequency oscillations may be produced with a magnetron. A circuit for an oscillator of this type is shown in Fig. 5.

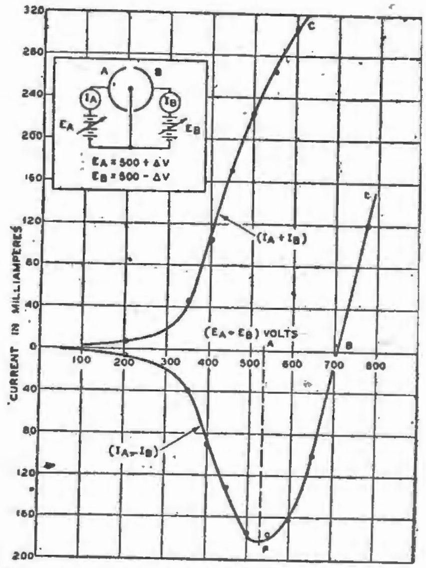


Fig. 6.—Static characteristics of a two-segment magnetron illustrating the negative resistance.

U.H.F. Magnetron Oscillations.

A complete answer to the question *"How does a Magnetron Oscillator work"* would require a lengthy explanation because of the many different modes of operation and the complexity of the processes involved. The literature available on the subject is copious, so that in this article simplified qualitative explanations will be given which will serve to illustrate the methods of analysis which are employed.

Referring to the characteristic curve and the diagrams of Fig. 4 it is seen that, beyond the cut-off point, electrons do not reach the anode but are able to perform complete epicycloids. All U.H.F. magnetron oscillators are operated in this region (i.e., for the quiescent state). Oscillations depend upon the interchange of energy between the electrons and the electric fields with the magnetic field applying the appropriate control: Electrons obtain energy as a result of acceleration by the D.C. electric field; the magnetic field moves most of them into positions where they have to deliver their energy to the U.H.F. alternating field resulting from the voltage applied to the anode by the tuned circuit (s) thus maintaining oscillations in these circuits.

If the anode cylinder of a magnetron

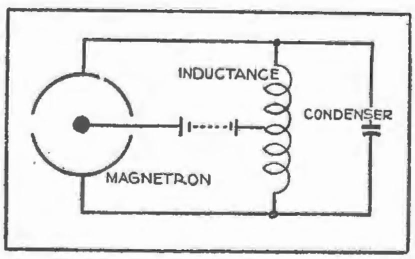


Fig. 7.—Circuit of a split anode negative resistance magnetron oscillator.

is split into two halves about a plane through its axis the tube exhibits a negative resistance characteristic for certain voltage conditions, when the magnetic field was somewhat beyond the cut-off valve. This behaviour is illustrated in Fig. 6; a negative resistance effectively exists between the two segments for potential differences between them up to 500 volts (i.e., Ea—Eb).

If an external tuned circuit is connected between the segments, sustained oscillations, of the natural resonant frequency of the circuit, will result.

Negative Resistance.

Fig. 7 depicts the usual circuits of a split anode *negative resistance* magnetron oscillator. The tuned circuit may consist of a coil and condenser at low frequencies or a resonant line at higher frequencies.

To discover the reason for this negative resistance behaviour Kilgore (3) of R.C.A. analysed the paths of electrons for various potential conditions. His theory was confirmed by experiments with a special magnetron in which gas ionisation enabled a visual study of electron paths to be made. Photographs compared favourably with predicted paths (see Fig. 8). With the field configurations corresponding to the negative resistance region, some electrons, starting towards the high voltage plate may reach it, but most of these electrons spiral round and finally reach the low voltage plate (see Fig. 8A). The result is that if the voltage Ea—Eb is increased the current Ia—Ib is decreased as shown in Fig. 6.

The negative resistance split-anode magnetron will operate with good efficiencies up to a frequency of 600 Mc/s. It has been found that electron transit time is responsible for the falling off in efficiency at high frequencies.

In later developments the oscillatory circuit, consisting of a Lecher system of heavy cross section copper was placed inside the tube envelope. Dissipation of about 200 watts was possible with this construction whilst with water cooling, tubes dissipating 500 watts and delivering 100 watts at 600 Mc/S with an efficiency of 25 per cent. have been made.

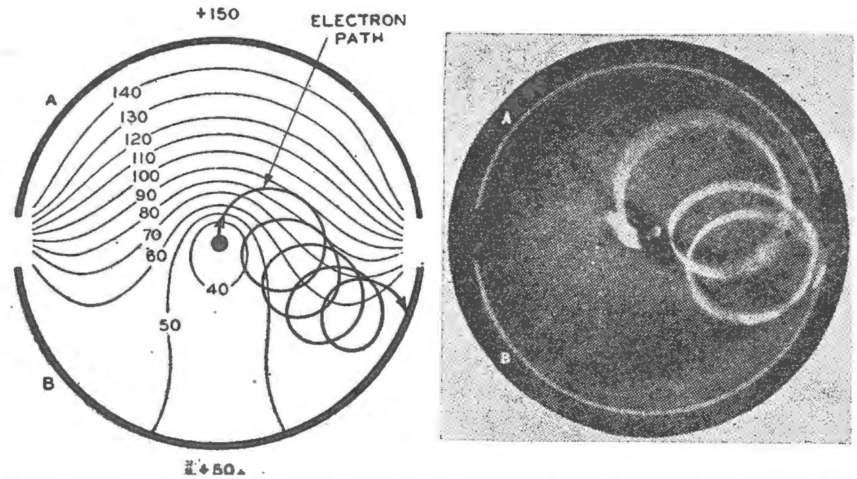


Fig. 8.—Paths of electrons in a split anode magnetron with unequal voltages on the two halves. On the left is the theoretical path, whilst at the right is a photograph of an electron path in Kilgore's experimental magnetron.

An output of 80 watts at 10 cm. has been obtained with a negative resistance magnetron by using water cooling and continuous evacuation.

Electronic Magnetron Oscillations.

Whilst the single anode electronic magnetron of Zacek was an important step in the development of the magnetron, it will be of more interest to examine the mechanism of the split anode electronic magnetron. Much of the theory of this tube applies to the modern multi-anode type.

For this mode the magnetic field is appreciably above the cut-off value; the paths of electrons with equal and constant voltages on the two halves of the anode would be roughly epicycloids as shown in Fig. 4. Consider now the effect of an alternating voltage between the two halves of the anode, on the motion of electrons leaving the cathode. Electrons emitted from the cathode surface opposite the gaps between anode segments are subject to a transverse as well as a radial field (due to the steady D.C. potential. The motion of the electron depends upon the direction of the resultant field which alternates between the two extremes indicated in the small vector diagrams in Fig. 9 c and d).

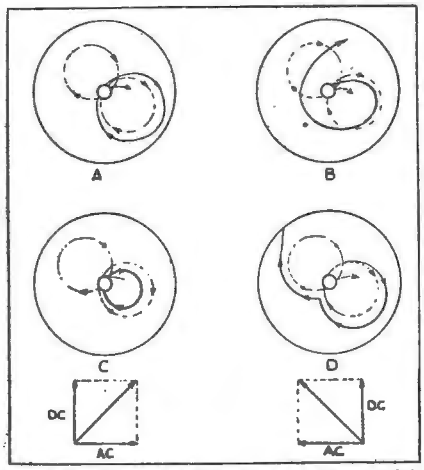


Fig. 9.—Electron paths in magnetrons. (a) Energy absorbing electrons; (b) Energy giving electrons—single anode magnetrons; (c) Energy absorbing electrons; (d) Energy giving electrons—split anode magnetron.

The effect of the alternating field is to deflect the electron orbits from their D.C. configuration in the direction of the displacement of the resultant field from the radial field (refer to vector diagrams in 9 c and d). Electrons of the group which are swung into a smaller radius experience angular acceleration and hence gain energy from the alternating field, whilst those deflected outwards are regularly decelerated and deliver energy to the alter-cathode after one excursion, the latter being able to perform several epicycloids before reaching the anode. (Fig. 9d.)

Since those electrons delivering energy remain in the field longer than those absorbing energy they are able to deliver more energy to the source than is extraced from it. Thus if a suitable oscillatory circuit is connected between the anode segments, sustained oscillations would be produced once they had been started by some slight change of anode voltage. The frequency of oscillation is determined by electron transit time.

The electrons returning to the cathode cause a *bombardment* which gives rise to heating and secondary emission from the cathode. Precautions are necessary to overcome ill-effects resulting from this phenomenon.

Anode Tank Circuit.

A great advance was made when Linder (4) in 1939 developed the *anode-tank circuit* magnetron which was capable of 20 watts at 8 cms. with an efficiency of 22 per cent. The increased power and efficiency of this tube was due to the incorporation of the tuned circuit into the anode as indicated in Fig. 10. The anode was a quarter wave length long and the two halves were short circuited at one end to form a resonant line. Connections to the load were made by a two wire transmission line from the opposite end of the anode as shown in Fig. 10. The inter-electrode capacitance thus became the distributed capacitance of a transmission line and no longer limited the frequency. The "Q" of the tank circuit was higher due to the lower resistance tuned circuit and the anode dissipation was improved as a result of the larger anode

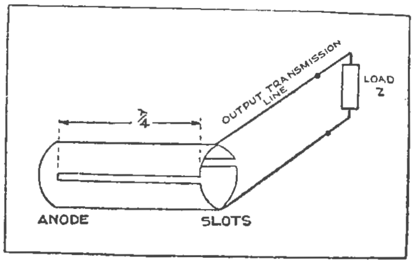


Fig. 10.—Linders' "anode-tank-circuit" incorporating the tuned circuit in the anode.

radiating surface which was available; the short circuiting end of the anode was made very large in order to dissipate heat.

The Multi-Segment Anode Magnetron.

The operation of the multi-segment resonant cavity magnetron can be explained by a concept similar to that employed in the case of the split anode electronic magnetron.

Considering two gaps on opposite sides of the cathode, assuming that the alternating voltages across them are of the same amplitude and are in phase, the motion of the electrons would be the same as for the split anode case. Fig. 11 illustrates this motion; the paths of the two classes of electrons, together with the "D.C." electron path are drawn. If the fields due to the alternating voltages between alternate segments were of opposite polarity as depicted by the curves surrounding the sketch (Fig. 11) a rotating field system or travelling wave of voltage on the segments would result. The effect would be for the field to move round in synchronism with the electrons so that the favourable decelerating electrons would deliver energy continuously.

If tuned circuits in the form of resonant cavities are connected between the segments they will receive the energy from the electrons. A small amount only of this energy would be necessary to provide the necessary field. The alternate anode segments would of necessity be of opposite polarity at any instant so that the required rotating tangential field would be provided at the cathode.

Energy may be led to an external circuit by means of a coupling loop in one of the cavities which are all fairly closely coupled together.

The higher efficiency of the multi-segment resonant cavity or *travelling wave* magnetron results from the greater overall rate of exchange of energy and the use of higher Q. circuits in the form of resonant cavities.

Other Modes Possible.

A phenomenon which occurs in multi-segment magnetrons, however, is the possibility of other modes, associated with different numbers of *repeats* or cycles of the alternating field round the anode system. For example, 4, 2 and 1 cycles are possible with the 8-segment anode depicted in Fig. 11. Those are analogous to harmonics in a triode oscillator and result in oscillations at different frequencies corresponding to slightly differing voltage and field conditions. The mode considered above corresponds to 4 cycles and is called the "T" mode because there is 180 deg. or π radians phase change between segments.

Sayers in 1941 discovered that *strapping* of the segments by means of wire bridges reduced the tendency to *moding*. Higher modes could occur in strapped magnetrons

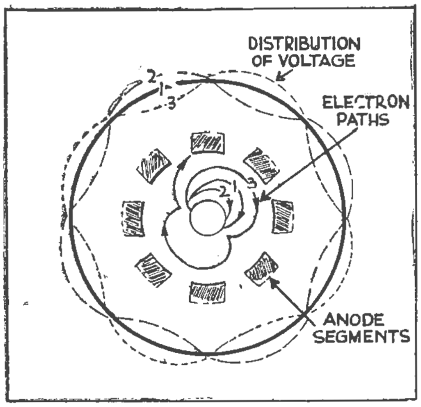


Fig. 11.—Electron orbits in a multi-anode magnetron. (1) DC; (2) Decelerated; (3) Accelerated.

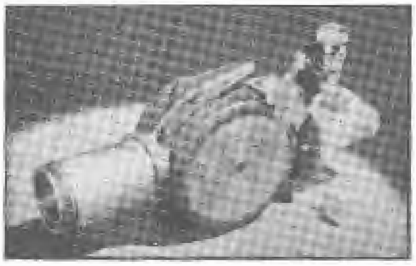


Fig. 13.—Tunable cavity magnetron type AJ51.

but only with greatly differing voltages between modes. This technique improved efficiencies from 25 to 40 per cent. Later it was found that strapping provided a means of adjusting the frequency of magnetrons during assembly; bending of the straps slightly alters the circuit constants. This adjustment is performed by the *cold resonance* method with C.W. signal, before the tube is sealed.

Modern Magnetrons.

All modern radar magnetrons are constructed on the multi-segment resonant cavity principle. Magnetrons have been produced to cover the range from 50 cm. wavelength down to 1.2 cm. Efficiencies range from 30 per cent. at moderate powers to 60 per cent. at high powers (over 200 kw peak). Several types of one megawatt (1000 kw) magnetrons have been produced in the 10-20 cm. region, whilst 3.4 Mw has been obtained by Boot at 10 cm. wavelength. Average powers in the region of 250 watts are common but CW operation at high powers of these magnetrons is not practicable because of overheating of the anode and cathode and consequent low efficiency.

A typical 25 cm. radar magnetron is shown in Fig. 12 with one of the end plates removed, and minus its air cooling finds. This is the Australian AV 20 produced by the Amalgamated Wireless Valve Co. The resonant cavities in the AV 20 are slightly different from those of most other magnetrons in that they are made by brazing vanes to the inside of a copper cylinder.

The magnetron anode is normally fitted with fins for air cooling and is operated at ground potential with a high voltage negative pulse applied to the cathode. The magnetic field is applied in the direction of the cathode axis and is invariably supplied by a permanent magnet. The output coupling loop is brought out to a suitable connector or, as in the case of the AV 20, to a probe which projects into a waveguide in the transmitter.

Some magnetrons have built in permanent magnets; these are called *packaged* magnetrons.

Magnetic flux densities range from 1,000 gauss for 50 cm. wavelength to 5,000 gauss for 1.2 cm. whilst anode voltages of 12 to 30 Kv (peak) are employed.

Tunable Magnetrons.

Most radar magnetrons have fixed tuning although a more recent tendency has been towards tunable types. Bell Laboratories in the U.S.A. undertook a programme of developing tunable magnetrons for the 20-45 cm. range and about four types have been produced. The principle employed was variation in the capacitance between the resonator system and the tuning member which was supported on an adjustable diaphragm. A tunable magnetron is illustrated in Figure 13.

The circuit into which a magnetron delivers power has a very marked effect on the frequency and power output of the tube, and the behaviour of any particular magnetron under specified output impedance conditions is a big factor in determining its merit as an oscillator for any application.

C.W. Magnetrons.

Tunable C.W. tubes have been produced in England and America in recent years. These tubes operate at much lower anode voltages and currents than pulsed magnetrons and it was necessary to use small anode and cathode diameters than for pulsed tubes.

For example, a 10 cm. C.W. magnetron had an anode bore of 0.22in. with 16 radial vanes forming the cavities; 1500 volts and a field strength of 1800 gauss were used. A power output of about 60 watts was obtained. An untuned 10 cm. C.W. magnetron has been produced which will deliver 500 watts at 60 per cent. efficiency.

In conclusion, it may be pointed out that the development of the magnetron has been international, that the pulsed magnetron was brought to a high level of development during World War II and that future work will probably be centred on the production of more efficient C.W. magnetrons.

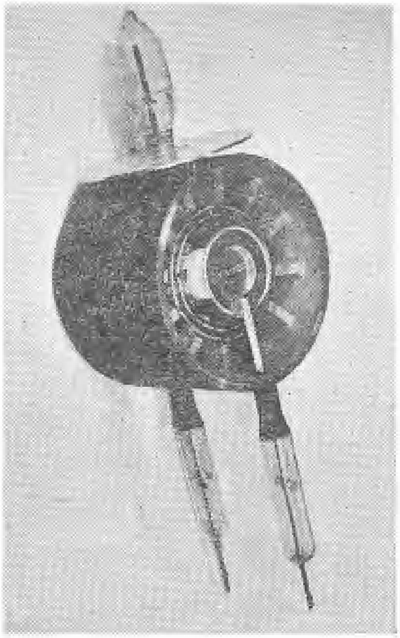


Fig. 12.—A 25 cm type AV20 Australian made radar magnetron. Note "strapping" of anode segments.

1. N. F. Alekseev & D. D. Malairov.—Proc. I. R. E. 32 136 (1944).

2. H. A. Boot & J. J. Randall, J.I.E.E. 43 Pt. 111A. 928 (1946).

3. G. R. Kilgore.—Proc. I.R.E. v. 24, p. p. 1140 (1936) or "Radio at U.H.F." by R.C.A.

4. E. G. Linder.—Proc. I.R.E. 27 732 (1939).

5. J. B. Fisk, H.D. Hagstrum & P. L. Hartman, B.S.J.J. 25, 167 (1946).

BOOKS

High Frequency Thermionic Tubes—Harvey.

Principles of Radar—M.I.T. Radar School Staff.

A Textbook of Radar.—Staff of Radiophysics Laboratory.

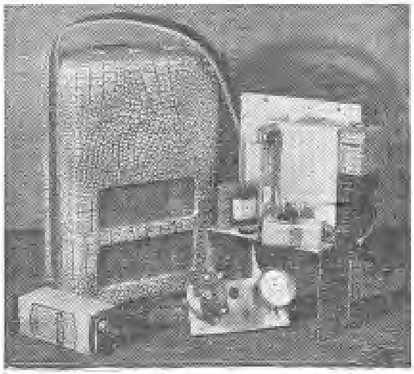
(To be continued.)

SOME REPRESENTATIVE RADAR MAGNETRONS PRODUCED IN ENGLAND, U.S.A. AND AUSTRALIA

Type	Maker	Wave Length Cm.	Magnetic Field Gauss	Peak Anode Current amps	Peak Voltage Volts	Peak Power Kilo-watts	Efficiency %
725A	W.E.	3.2	5500	10	12	40	30-40
CV355	English	3	5500	23	22	200	50
HK7	Raytheon	10	2000	40	30	750	60-65
CV76	S.T.C.	10	2300	40	25	400	50-60
AV16	A.W.V.	Australian equivalent of CV76					
4J51 (tunable)	W.E.	32	1100	20	20	400	35
AV20	A.W.V.	25	1100	35	30	600	60

Around The Industry

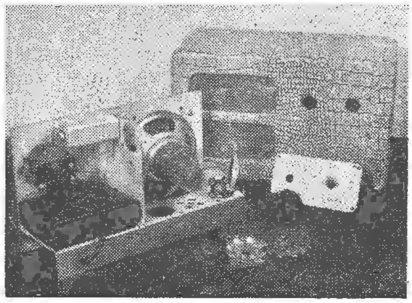
"RADIO SCIENCE" KITSETS NOW AVAILABLE



Miniminor Portable Kitset.

Advice has been received from the FN Radio and Electronic Co. that complete kitsets for the Miniminor Portable and Miniminor AC Mantel, recently described in this magazine are now available for immediate delivery.

In addition to the full kits, complete stocks of the special chassis and cabinets are now being held, and if required can be purchased separately .Further details as to price, etc., can be obtained by calling or writing to this firm at 265 Military Road, Cremorne.



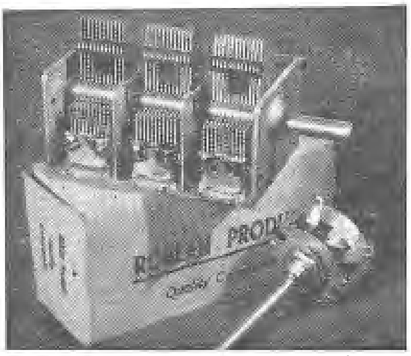
Miniminor AC Mantel Receiver Kit.

NEW MIDGET TUNING CONDENSER

The recently introduced range of ROBLAN tuning condensers has now been augmented by the addition of a midget three gang condenser. This latest release should find a ready application in small receivers where the addition of an RF stage is warranted.

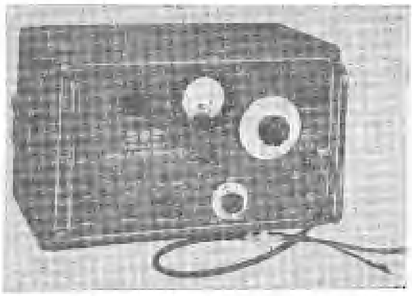
The sample received from the manufacturers compared very favourably with similar imported types, and some idea of the relative size can be obtained from the accompanying photograph. The type number is RMG 3, the maximum and minimum tuning capacities are 370 and 9 mmf respectively, and it will track with "H" gang coils and dials.

These condensers are manufactured by Robertson and Lansley and supplies are now readily available through most radio stores, the price being approximately 25/-. The local agents for the products are Electronic Industries Imports.



The new Roblan three gang tuning condenser.

A.W.A. FM SIGNAL GENERATOR



Latest addition to the AWA range of test equipment is an FM, I.F. Signal and Sweep Generator. This instrument is designed to provide a calibrated signal of a fixed frequency for use in designing and testing FM receivers of both the broadcast and communication types.

It combines the functions of a sweep generator for visual alignment of the I.F. and Detector stages and a low distortion signal generator for measurement of overall performance of the receiver from the converter to the audio output stage.

Two models are available, type A51920 with a 10.7 Mc. range with calibrated trimmer variation from 9.9 to 11.5 Mc. and type 1A51920 with a 2 Mc. range with calibrated trimmer variation from 1.96 to 2.04 Mc. The centre frequency can be checked against the internal crystal marker and adjusted to an accuracy of $\pm$ 0.01%. The calibrated vernier dial is then accurate to $\pm$0.2% except at the extreme ends of the calibration.

Both models are supplied in a grey wrinkle metal case, measuring 16 x 10 x 11 inches and weighs approx. 42 lb. Further details of this equipment can be obtained by writing to Amalgamated Wireless (A/sia.) Ltd., 47 York Street, Sydney.

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CONNISEUR CRYSTAL PICKUP

The Australian release of the Conniseur crystal pickup should be of interest to all amplifier and recording enthusiasts. Of a new, robust design, as well as pleasing appearance, these pickups have been designed to ensure the utmost in fidelity consistent low tracking error and minimum record wear.

The solid cast arm is free from any mechanical resonance effects, and this is counterbalanced and pivoted from a ball bearing support, reducing the tracking weight to one ounce at the needle point. The virtually unbreakable crystal unit is housed in this tone arm, and the crystal housing is of a special design to prevent damage due to dropping on records as well as being hermetically sealed against moisture effects.

The frequency response is from 20 to 10,000 cps, with a voltage output of 1.6 volts. The impedance is 265,000 ohms, whilst the distortion is reduced to less than one per cent. for the total harmonic and inter-modulation distortion.

Four different models are available, depending upon the particular application of the pickup, and details of these are contained in the technical bulletin issued by manufacturers. Readers requiring this information are requested to write direct Kelman Industries, Box 40, Hawthorn E.2, Melbourne.

SERVICE DATA SHEET

A.W.A. RADIOLA MODELS 609-T, 707-C & 803-G

ELECTRICAL SPECIFICATIONS

FREQUENCY RANGES:

(1) 1500-550 k.c.
(2) 4.0-1.5 Mc.
(3) 9.7-3.6 Mc.
(4) 12.0-9.4 Mc.
(5) 15.0-11.7 Mc.
(6) 19.0-15.0 Mc.
(7) 22.3-17.7 Mc.

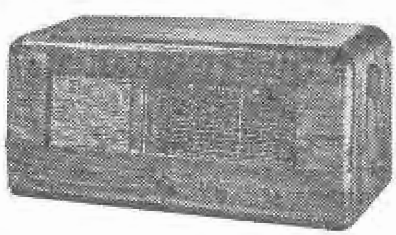
INTERMEDIATE FREQUENCY: 455 kc.

POWER SUPPLY:
200-260 v AC 50-60 cps.

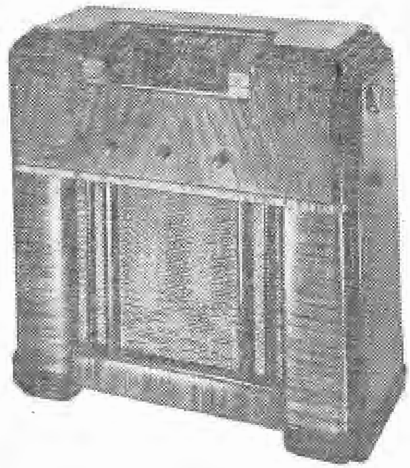
VALVES:
RF Amplifier 6U7G
Converter 6J8G
IF Amplifier 6U7G
Det. AVC and 6G8G/
AF Amplifier 6B8G
Power Amplifier 6V6GT
Rectifier 5Y3GT

LOUDSPEAKER:
7 inch, 1100 ohm FC. V. Coil Impedance 3 ohms, or
12 inch, 1500 ohm FC V Coil Impedance 12.5 ohms.

POWER OUTPUT: 4.2 watts.



609-T

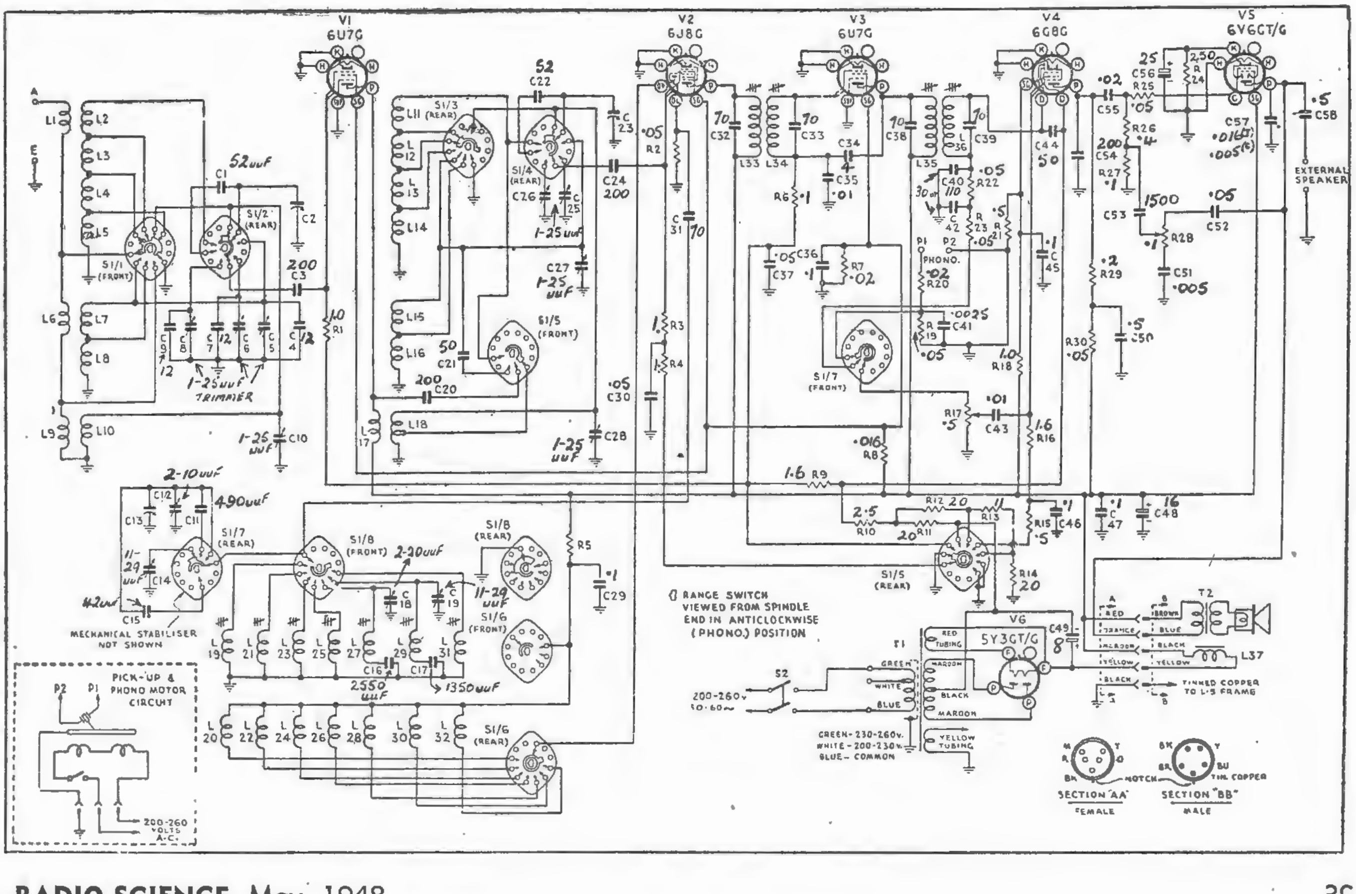


707-C

SOCKET VOLTAGES AND CURRENTS

Valve	Control Grid to Chassis Volts.	Cathode to Chassis Volts.	Screen Grid to Chassis Volts.	Plate to Chassis Volts.	Plate Current mA.	Heater Volts.
6U7G R.F. Amp., M.W.	-3.9*	0	95	255	7.0	6.3
S.W.	-3.5*	0	95	255	7.0	—
6J8G Converter, M.W.	-3.9*	0	95	255	0.8	6.3
S.W.	-4.5*	0	95	255	0.6-0.8	—
Oscillator, M.W.	—	—	—	150	5.0	—
S.W.	—	—	—	150	5.0	—
6U7G I.F. Amp., M.W.	-3.9*	0	95	255	7.0	6.3
S.W.	-3.5*	0	95	255	7.0	—
6G8G/6B8G Detector ..	-1.5*	0	30*	125*	0.5	6.3
6V6GT/G Output	0	12.5	255	245	44.0	6.3
5Y3GT/G Rectifier	700/350 V., 80 mA.			Total Current Drain		

Measured with receiver connected to 240 volts A.C. supply. Volume Control at maximum. No signal input. *Cannot be measured with ordinary voltmeter.



ALIGNMENT PROCEDURE

When using a signal generator or modulated oscillator with the tuning of the receiver fixed, two frequencies can be tuned from the test instrument, one 0.92 Mc/s higher in frequency than the other. In all cases the desired frequency is the lower of the two.

Perform the alignment in the proper order as shown in the chart, starting from No. 1 and following all operations across, then No. 2, etc.

Keep the volume control set in the maximum clockwise position and regulate the output of the test instrument so that a minimum signal is introduced to the receiver to give a standard indication on the output meter. This will avoid AVC action and overloading.

ALIGNMENT TABLE.

Alignment Order.	Test Ins. Connect to Receiver.	Frequency Setting.	Band Setting.	Calibration Scale Setting.	Circuit to Adjust.	Adjustment Symbol.	Adjust to Obtain.
1	6J8G Cap.*	455 kc.	Broadcast	0°	2nd I.F Trans.	Core L36	Max. Peak
2	6J8G Cap.*	455 kc.	Broadcast	0°	2nd I.F. Trans.	Core L35	Max. Peak
3	6J8G Cap.*	455 kc.	Broadcast	0°	Ist I.F. Trans.	Core L34	Max. Peak
4	6J8G Cap.*	455 kc	Broadcast	0°	Ist I.F. Trans.	Core L33	Max. Peak
Re-check 1, 2, 3, and 4.							
5	Aerial	600 kc.	Broadcast	19°	Oscillator†	Core L31	Calibration
6	Aerial	1500 kc.	Broadcast	168°	Oscillator	C14	Calibration
7	Aerial	1450 kc.	Broadcast	158°	Radio Frequency	C28	Max. Peak
8	Aerial	1450 kc.	Broadcast	158°	Aerial	C10	Max. Peak
Re-check 5, 6, 7, and 8							
9	Aerial	17.8 Mc.	22.3-17.7 Mc	18°	Oscillator	Core L19	Calibration
10	Aerial	17.8 Mc.	22.3-17.7 Mc	18°	Radio Frequency†	C26	Max Peak
11	Aerial	17.8 Mc.	22.3-17.7 Mc	18°	Aerial	C8	Max. Peak
12	Aerial	21.0 Mc.	22.3-17.7 Mc	149°	Oscillator	C12	Calibration
13	Aerial	15.2 Mc.	19.0-15.0 Mc	27°	Oscillator	Core L21	Calibration
14	Aerial	11.8 Mc.	15.0-11.7 Mc	25°	Oscillator	Core L23	Calibration
15	Aerial	11.8 Mc.	15.0-11.7 Mc	25°	Radio Frequency†	C25	Max. Peak
16	Aerial	11.8 Mc.	15.0-11.7 Mc	25°	Aerial	C6	Max. Peak
17	Aerial	9.5 Mc.	12.0-9.4 Mc	24°	Oscillator	Core L25	Calibration
18	Aerial	9.0 Mc.	9.7-3.6 Mc	156°	Oscillator	C18	Calibration
19	Aerial	9.0 Mc	9.7-3.6 Mc	156°	Radio Frequency†	C27	Max. Peak
20	Aerial	9.0 Mc.	9.7-3.6 Mc	156°	Aerial	C5	Max. Peak
21	Aerial	4.0 Mc	9.7-3.6 Mc	19°	Oscillator	Core L27	Calibration
Re-check 18, 19, 20 & 21							
22	Aerial	1.6 Mc.	4.0-1.5 Mc	15°	Oscillator	Core L29	Calibration
23	Aerial	3.7 Mc	4.0-1.5 Mc	153°	Oscillator	C19	Max. Peak
Re-check 22 and 23							

Finally, re-check broadcast band. This is necessary only if the setting of C12 has been altered

† Rock the tuning control back and forth through the signal.

* With grid clip connected. A 0.001 uF capacitor should be connected in series with the "high" side of the test instrument

The column headed "Calibration Scale Setting" refers to the 180° scale on the ganged tuning capacitor drive drum. In taking readings on this scale, read from the right-hand edge of the pointer, that is, the edge nearest the rear of the chassis. Check the setting of the drum before taking readings. The zero mark should be opposite the pointer with the tuning capacitor fully closed

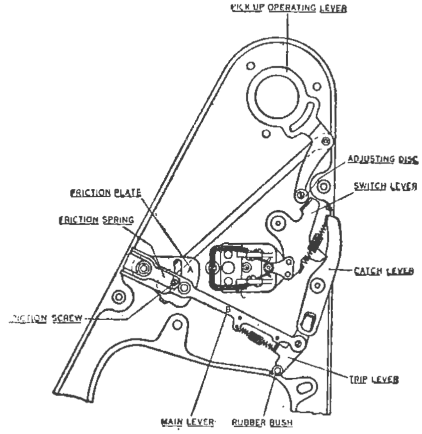


DIAGRAM OF AUTO-SWITCH FITTED TO TYPE "E" RADIOGRAM UNIT

PHONO. MOTOR STOP ADJUSTMENT

The patent stop and switch is fully automatic. If stop fails to operate at finish of record, there is probably insufficient friction between lever A and lever B. This may be rectified by turning the friction screw in an anti-clockwise direction. If there is still insufficient friction it may be that oil is present on the felt friction pad. If so, remove the pad and wash it in petrol to remove the oil.

When the stop operates early, i.e., before needle reaches the end of the record, the trouble is either due to excessive friction or to rubber bush on the trip lever being worn. Friction can be reduced by turning the friction screw clockwise.

As this adjustment is very sensitive, the screw should not be turned more than a quarter of a turn at a time. Excessive friction may cause a knocking sound to be heard in the loudspeaker and undue wear on the records.

When the rubber brush is worn this may be turned around on its pin to expose a new face to the striker.

CHASSIS REMOVAL AND REPLACEMENT

(1) Turn the Phono-range switch to the 22.3-17.7 Mc position and then remove the three control knobs from the front of the cabinet.

To remove the two knobs at the side of the cabinet, proceed as follows:

Table Model:
The knobs pull straight off. Do not loosen the set screw in the lower knob.

Console Model:
The knobs are not removed but the spindles to which they are attached are parted at the couplings within the cabinet.

(2) Disconnect the dial pointer from the drive cord, first unscrewing the thumb nut, and disconnect the cable from the loudspeaker.

(3) Disconnect the Bowden cable which actuates the band indicator on the dial scale. The cable is connected to the dial assembly at two points—the sheath to the top left-hand corner of the dial assembly (viewed from the rear), and the core to the band indicator. Loosen the thumb screws at these points and free the cable from the assembly.

(4) The chassis is held in the cabinet by four bolts. Remove these and withdraw the chassis from the cabinet.

(5) Replacing the chassis in the cabinet is a direct reversal of the above instructions, but care must be taken to connect the dial pointer to the drive cord as follows:

(a) Turn the tuning control to bring the ganged capacitor plates into full mesh.

(b) Connect the dial pointer to the drive cord with the pointer in a position opposite the setting mark on the dial scale which is approx. 5/16in. to the right of the 550 kc. calibration point.

SIMPLE SHORT WAVE CALIBRATION ADJUSTMENT

The short wave calibration may be adjusted slightly, without removing the chassis from the cabinet for full alignment, by adjusting four cores, L19, L21, L23 and L25 after a station of known frequency is received.

The correct procedure is as follows:

(1) Set the dial pointer so that calibration is correct on the medium wave band.

(2) To adjust the calibration of the 22.3-17.7 Mc. band, tune in the known station, and to shift the pointer position to the left turn L19 clockwise or vice-versa until the station can be tuned in at its assigned frequency.

(3) The adjustments for the 19.0-15.0, 15.0-11.7 and 12.0-9.4 Mc. bands are similar, using L21, L23, and L25 respectively.

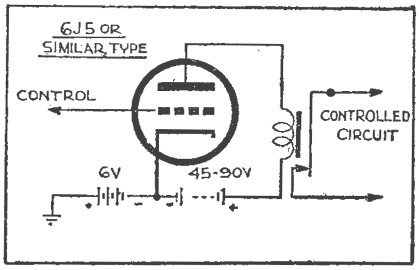
FOR THE EXPERIMENTER

By A. H. NICHOLLS, VK2NI

Sensitive Relay

The 6J5 or similar triode valve can be connected up to provide a sensitive relay control. The plate voltage is not critical and should be adjusted to the value which gives best operation.

The relay is actuated by touching the control, whilst still standing on the ground. This means that the unit can be wired to window catches, door knobs, etc., to make a sensitive burglar alarm.

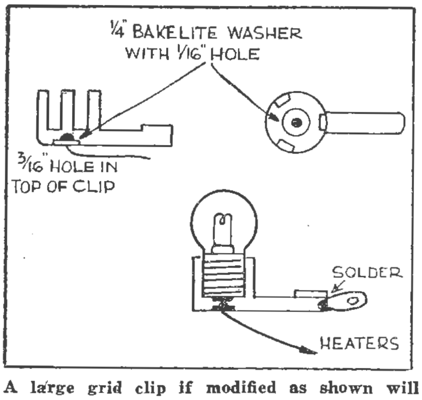


A 6J5 or similar triode is suitable for actuating the relay in this circuit.

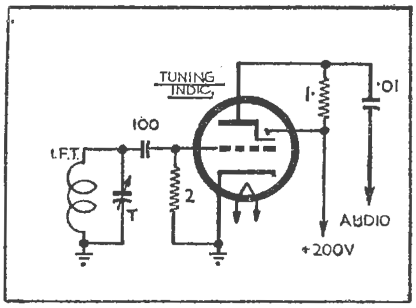
Homemade Pilot Light Socket

A handy pilot light socket can be made up from the large type of grid clip shown in the drawing. A 3/16 inch hole is drilled in the top of the clip for the filament lead. A bakelite washer, $\frac{1}{4}$ inch in diameter, and having a 1/16 inch hole is cused to prevent short circuits. The filament lead is then threaded through this, and soldered to form a "knob," ensuring positive contact with the base of the lamp.

It will be probably necessary to slightly bend the tips inwards to allow a firm clamping of the pilot lamp screw bulb.



A large grid clip if modified as shown will make a useful pilot lamp socket.

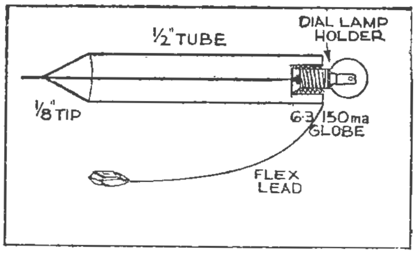


Here is the method of connecting a tuning indicator valve for use as a combined detector and signal indicator.

Dual Use for Magic Eye

Many uses have been made of the versatile "magic eye" valves in the past, and here is one application which should interest many experimenters. The types 6E5, 6G5, EM1, etc., can be connected as shown in the diagram to make a suitable detector and yet still operate as a signal indicator.

The valve can be mounted in the usual manner on the front panel of the receiver, but care should be taken to avoid overlong leads, especially those from the second I.F.T. and to the audio output.



This diagram gives full details for constructing a handy continuity tester.

Low Resistance Continuity Tester

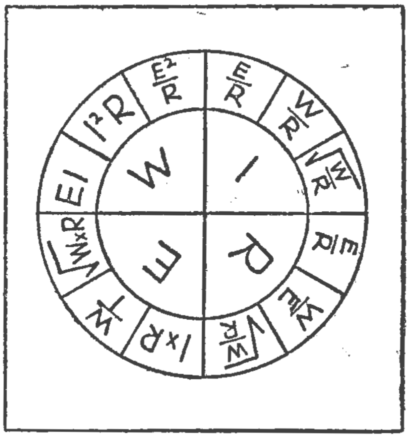
A simple continuity tester can be made up by fitting a dial lamp holder in an $\frac{1}{2}$ inch piece of tubing. One connection is taken direct to metal tip, and the other to the heater voltage via the flexible lead and clip.

By clipping this on to the heaters in a receiver the continuity of coils, IF's, electrolytics, speaker fields, output transformers, etc., can be easily and readily checked.

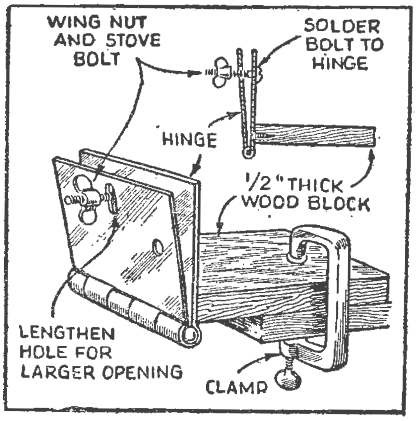
Ohm's Law Reference Card

Here is a handy device to keep by your side when doing any circuit calculations involving Ohm's Law. Draw out a circle on a piece of cardboard approx. 3" in diameter, and inside this transcribe another circle about $\frac{3}{4}$" smaller.

Divide the circles into four quadrants by drawing two lines at right angles through the centre point, and then subdivide each quadrant into three sections as shown. This enables three different formulae to be written in for the I (Amps), R (Resistance), E (Volts) and W (Power) calculations.



Ohm's Law calculations can be simplified by the use of this card.



A SIMPLE VYCE

A makeshift vyce can be fashioned from an old hinge about 3 inches long. This is mounted on a piece of $\frac{1}{2}$-inch wood with flat head wood screws. A machine screw and wing nut then completes the assembly and this handy vyce will be found useful for all kinds of small work.

NEW 2UW TRANSMITTER

Technical details of the new aerial mast and transmitter recently erected at Homebush Bay by Station 2UW, Sydney.

The new transmitting station and aerial mast situated at Homebush Bay, and recently put into operation by Station 2UW should result in improved reception of that station in many localities.

Mast Details.

The all steel, guyed mast used as a vertical radiator is 472 feet high, which corresponds to a wavelength of 0.53, and is of a triangular cross section construction. The mast base and guy anchorages are set on wooden piles driven approximately 28 feet into the ground and situated in the salt water swamp. The associated transmitter house is built on high ground at a distance of 730 feet from the mast.

A full half wave ground system occupying some 15 acres was laid using 120 radials, each 450 feet long and buried to a depth of 8 inches. The area on which the ground mat is laid is tidal for a large part of the year, with the average ground level only slightly above the high water level of Homebush Bay. This results in the area being covered with up to 18 inches of water during Spring tides.

A view of the 472 feet high all-steel mast, now being used on all transmissions by 2UW.

Because of this the aerial is fed via a 100 ohm concentric cable run in a duct 4 feet above ground level as also are the mast lighting and telephone circuits to the mast. This level is approximately 2 feet above the highest tide ever recorded by the Sydney Harbour Trust, and should take care of all likely contingencies.

The mast has been designed to withstand a wind velocity of 80 m.p.h. at ground level with an increase of 1 per cent. for each 100 feet rise above the ground level. Two sets of guys, 4½ inches in circumference, are at the 369 feet level, and these are anchored 240 feet from the base. The lower set of three guys (each 3 inches in circumference) is at the 185 feet level and are anchored 160 feet from the base of the mast.

Transmitter Equipment.

The transmitter used is a 1,000 watt Class B modulated type and this equipment is divided into six main sections—Speech input console, Speech input amplifier rack cabinet, Voltage regulator rack cabinet, RF filter unit, Transmission line change-over unit, and the main transmitter.

Speech Input console is on centrally situated control table and provides line attenuation, volume indicator, aerial current meter, etc., giving the technician on duty full control of normal equipment; together with emergency use of local microphone and/or pick-up circuits.

Speech Input Amplifier rack cabinet is 7 feet high and contains line equaliser programme amplifiers, limiting amplifier, programme failure alarm amplifier, monitoring amplifier and rectifiers, together with a jack field for isolating any particular amplifier as required.

Voltage regulator rack cabinet. This matches the speech rack in size and houses distributing AC circuits and hand voltage regulator, together with switching arrangement to bring automatic voltage regulator into circuit.

The radio frequency filter unit mounts at rear of transmitter and serves to remove spurious radiations which would otherwise be radiated due to cross modulation from nearby transmitters.

Transmission Line change over unit provides interlocked method of switching output of either of 2 transmitters to the main transmission line. Line arc over relay device also installed to shut down transmitter momentarily in event of lightning flash, causing arc across line.

TRANSMITTER PERFORMANCE FIGURES

AUDIO FREQUENCY RESPONSE.

C.P.S.	100% Modulation
30	1 db
50	0.3
100	0
400	0
600	0
800	0
1000	0
2000	0
3000	0
4000	0
5000	0
6000	0
7000	0
8000	0
9000	0
10000	0.5
11000	-0.5
12000	-3.7

The above test was taken with feedback of 18 db measured at 1000 c/s.

AUDIO DISTORTION. PERCENTAGE.

Frequency	100% Modulation
50	3.4
100	1.2
400	1.5
1000	2.1
5000	3.3
7500	4.0

CARRIER NOISE.

Below 100% Modulation. Frequencies, 250 cycles and lower equal 63 DB. Frequencies above 250 cycles equals 75 DB.

SHORT WAVE LISTENER

Conducted by Ted Whiting

SUNSPOTS AFFECT RECEPTION CONDITIONS

Extremely erratic reception has been evident on all bands during the past weeks, and although many of our favourite stations have suffered the ravages of the Sunspot disturbances, many signals are heard for brief periods which do not normally appear at these times. This sporadic reception is a feature of such disturbances, and the Short Wave listener should at all times be on the alert for such signals.

There is no evidence at present that this disturbance will end in the immediate future, and no doubt in the coming weeks we will receive many interesting logs from our readers.

South Americans

We are now approaching the time of the year when signals from the Central and South Americas are to be heard at ever increasing level, and would suggest our readers pay particular attention to the frequencies around 9000kc and those in fact down to 6000 kc. The former is a useful band in the afternoons. On Sunday stations from those countries are heard until closing at 4 p.m., and in some cases until as late at 5 p.m.

A few suggestions would be COBC 9363 kc; COCX 9270kc; COBQ 9236kc; COBZ 9026kc; COKG 8955kc; COCQ 8825kc; COJK 8725kc; COCO 8696kc; COCH 9437 kc; all located in Cuba; HI2G 9223kc in Dominican Republic, and that consistent XEWW 9500 kc, together with XEFT 9548kc, XETT 9557kc, XEYU 9606 kc; XERQ 9615kc, XEBT 9625kc, XEQQ 9680 kc, located in Mexico. We would be pleased to hear your reports on any of these stations, and in addition attractive ards are received from many of these stations.

DX Session

We would again remind readers of the weekly DX Session heard from Radio Australia at 3.25 p.m. Sundays, the 25 metre band transmission being excellent, and in which some fine information is broadcast. All times given are GMT.

We are indebted to Graham Hutchings, DX Editor of Radio Australia, for the following details. We are giving the times in Australian EST.

VPO3, Barbadoes 10605kc, is heard rather infrequently until closing at 7.45 a.m. with broadcasts of topical sporting events such as Cricket and Races. The closing announcement states that VPO3 opens at 12.35 a.m. Sunday EST.

Jerusalem is heard now on 6075kc until closing at 7 a.m., the 7220kc frequency not now being in service. It is worthy to mention that some reorganisation in the Forces Broadcasting Service in Palestine has taken place, and as far as is now known the 7220kc frequency is the only one heard here at the time of writing.

READERS' REPORTS

Radio Australia

Mr. Rooke, Manly, N.S.W., informs us that in a recent announcement over a news session, a new Short Wave station is being constructed at Perth, the power 10Kw. This will be used in service to Northern Australia as a supplement to the present 2Kw outlet.

OLR2A, Prague, is heard at 6 a.m. on 6010kc, news in French at 6.15 a.m. and news in English at 6.45 a.m. and 8.45 a.m. OLR2A fades at about 7 a.m. in these parts.

HCJB, "The Voice of the Andes" heard well at Manly operating on 12455kc, 9970-kc and 15110kc. At the time they were participating in a special DX programme from 4 p.m. until 10 p.m. New verification cards are being issued by this station.

FZI, Brazzaville carries English news regularly at 2.45 a.m., 6.45 a.m., 8.15 a.m., 10 a.m., 2.30 p.m. and 10.15 p.m., frequencies in all cases is 11970kc and 9440kc.

Vatican City, HVJ, heard at the same location at Midnight on 15095kc in English. The suggestion it that another frequency of 9660kc is also used in parallel.

New Zealand Report

Mr. Fox, Dunedin, reports some good ones—reception in N.Z. being the S.W. listener's dream. Mr. Fox has logged over 800 stations and has verification cards from some 500 of these. Among his loggings are CS2ML Portugal, which is now operating with 50 kw; Radio Douala, 7950 kc, heard well at 3 a.m.; LLG, Oslo, Norway, 9610kc, 2.30 p.m.-3.30 p.m., with news at 3 p.m. LKQ, 11735kc, is heard in parallel with LLG, but suffers from American interference at this time. Incidentally, these stations are also heard at 9.30 p.m.

OIX2 9495kc is heard broadcasting a church service at 4 p.m. Sunday, and OIX4 15190kc is good when not under interference from VLA6 at the same time. The location of these stations is, of course, Finland.

HCJB Ecquador has been testing on 5995kc until 2 p.m., using a power of 500 watts—no chance of hearing this one in Australia at this time.

Radio Tetuan, EA9AH 6067kc, opens at 3.30 p.m. Mr. Fox reports that signals are weak to fair.

Mr. Penhall of Merrylands sends in a list of stations heard on a two valve receiver, all on the speaker. These include HCJB Ecquador, 12455 kc, closing at 3.50 p.m. and on 9958kc at 9.50 p.m.; CKCS, Sackville, 15320kc, at 7.30 a.m.; OCT2, 9740kc, fair signal at 7.30 a.m.; Radio Nacional de Espana, 9369kc, 6.30 a.m.; YV1RX, Venezuela, 4800kc, at midnight; YV5RM, 4970kc; FZI, Brazzaville, 11970 kc, 6.45 a.m.; CR7BV, 4870kc, prior to 6 a.m. Very nice work.

LISTEN FOR THESE STATIONS

Belgian Congo

Radio Congolia, OQ2RC, 6010kc, is now on the air from 3 a.m.-4.30 a.m. carrying local programmes. Reports are requested and should be addressed to P.O. Box 63, Leopoldville, Belgian Congo. OQ2RC, 15,325kc. is apparently in parallel with the former mentioned frequency and no doubt reports will be appreciated on this outlet also.

Moscow

News and comment can be heard from Moscow in their English transmission opening at 10.45 p.m. daily. This transmission is carried on no fewer than seven outlets operating on the announced frequencies of 6160kc, 7200kc, 9540kc, 9570kc, 11720kc, 15170kc, and 17770kc. All outlets are heard at quite good level, no doubt, owing to the higher power in use. Many transmissions from Russia are to be heard, but owing to the frequent changes made by the Russian authorities, we hesitate to mention them in these notes.

Latin Americans

From San Paulo, Brazil, ZYB8 is fair listening at 8.15 p.m. on their frequency of 11765kc. This transmission is heard daily, and in some locations may suffer from interference from Eastern stations. This station verifies with an attractive card. The address is ZYB8, P.O. Box 252, San Paulo, Brazil.

CE1190, Valpairaiso, Chile, on 11900kc is audible at 9.30 p.m. after KWID closes. This reception is, however, brief at present, as the transmission fades out shortly after. Next month this transmission should be heard at increased level.

From Mr. Cushen, Invercargill, N.Z., comes the news that HI2T, Cuidad, Trujillo, Dominican Republic, is heard on 9740kc until 3 p.m. daily at good level. The frequency of this one has been changed from 11900kc. HI2T has also been heard opening just prior to 10 p.m. at fair level.

Munich

The American Short Wave Station at Munich has announced the following schedules and frequencies, most of which are to be heard in this country and which will be heard at excellent level in the coming winter:

6170kc	4 a.m.-5 a.m.
7250kc	2.15 a.m.-3.15 a.m., 5.15 a.m.-8 a.m.
9540kc	9.15 p.m.-8 a.m.
11870kc	2.15 a.m.-8 a.m.
15150kc	3.30 a.m.-5 a.m.

Asiatics

XURA, Taipeh, Formosa, has reverted to the former channel of 7220kc after being heard on 6150kc. The schedule is 7.30 p.m.-12.15 a.m. For those interested in the lower frequencies, XURA also operates on 670kc, 750kc, 1020kc, and 1190kc. The 750kc transmission is one of 100Kw and operates from 8.30 p.m. until 12.40 a.m.

Voice of Free Indonesia is heard on 11855kc at from 9 p.m., carrying a programme consisting of Western-type music and news bulletins in Indonesian — very good signal at most times.

The Macassar station so frequently heard has changed frequency from 11000 kc to 10842 kc, operating at the same times and the call is YHN.

Radio S.E.A.C.

The station of South East Asia Command, Kandy, Ceylon, is heard with a fine signal on opening at 6 a.m. Indian Time, 10.30 a.m. our time, the announcer, Geoffrey Ellis, stating that transmission is taking place on 17730kc, 15120kc, 9520kc, 6075kc and 3390kc. SEAC closes on Monday at 2.15 a.m. and other days at 3 a.m. The two former frequencies are very good in the forenoon, 9520kc is fine in the afternoon and the latter two at night.

All India Radio Schedules

The Summer schedule for All India Radio, Madras is 7260kc, Monday to Saturday 11.30 a.m.-1.30 p.m., Sunday 11.30 a.m.-2 p.m.; 9590kc Monday to Friday 5 p.m.-7.30 p.m., 8.30 p.m.-9.30 p.m., Saturday 5.30 p.m.-7.30 p.m., Sunday 5.30 p.m.-9.30 p.m.; 4920kc Daily 10 p.m.-1 a.m.

Austrian Heard

Further loggings from Mr. Cushen and the DX Bulletin, to whom we are much indebted, states that KOFA, Salzburg, is a good one on 7220kc, from 4 p.m. daily. This "Blue Danube Network" station, operated by the Armed Forces Radio Service, is much improved since the Jerusalem station on the same frequency closed. News is heard at 4.30 p.m.

Norway

LLG, Oslo, Norway, is outstanding in the new transmission. Using a power of 100kw, LLG is heard with musical programme from 4.30 p.m.-5 p.m., followed by the time signal, news, and a devotional broadcast, the station closing at 5.30 p.m.

Damascus

One of Mr. Cushen's latest verifications is from Damascus which states that the station is only a temporary one using 500 watts. Three powerful transmitters are under construction and should be in operation in the near future. No doubt this portends an extension of the service which in the meantime is 3 p.m.-5 p.m., 10 p.m.-11 p.m. and 2 a.m.-6 a.m. All programmes are conducted in Arabic and the General Director, Post Telephones and Telegraphs, Damascus, Syria will appreciate reports on the emissions.

Swedish DX Session

Radiojanst conducts a regular DX session from Sweden, which is very interesting. The transmission for Australia is heard at 5.45 p.m. Saturday over SBO 6067kc and SBT 15155kc, for Europe on Sunday 1 a.m. on SDB2 10780kc and SBT 15155kc, and finally for North America on SBU 9535kc and SDB2 10780kc. Reports on this transmission will be welcomed by Radiojanst, Kingsgaten 8, Stockholm, Sweden.

Rhodesia

ZQP, Lusaka, Northern Rhodesia operating on 9710kc is on the following schedule 1 a.m.-3 a.m. daily, with English programmes on Wednesday and Sunday. The Sunday schedule is 7 p.m.-8.30 p.m., 1.30 a.m.-2.30 a.m. on 7820kc and 3940kc in addition.

Antartica

Another rare station mentioned in Graham Hutchings' bulletin concerns LQX, Guna Is., South Shetlands, no doubt the station of the Argentine expedition which was recently so much in the news. LQX was heard at 3 a.m. on 1233kc in contact with Buenos Aires, and from Deception Island a further transmitter was in use with the call LQX2 on 14800kc and heard at 4 a.m.

New Danish Stations

The Danish authorities are establishing Short Wave stations which, is is tentatively announced, will be in service on April 1st, broadcasts to the East will take place on 13 and 30 metres and to South Americas on 30 and 40 metres. No times or frequencies are yet available.

Monte Carlo on 6075kc, which has been heard in this country, is to increase power to 20kw in the near future.

NEWS OF THE AMATEUR BANDS

Of practical interest to those breaking into the new 144 Mcs band is the letter received from VK2VW. An AR301 Disposals VHF receiver has been modified for this band, among other alterations being the alteration of the IF channel to a frequency of 6 Mcs. In addition, VK2VW gives details of the beam he has erected for the purpose. It is a 4 element array consisting of a folded dipole, two directors and a reflector. The dimensions are as follows; Front Director $35\frac{1}{2}$ inches; Second Director $34\frac{1}{2}$ inches; Folded Dipole $34\frac{7}{8}$ inches; Reflector, $33\frac{1}{4}$ inches. Both sides of the folded dipole are of the same diameter, the spacing in this element being one inch. This is fed with 75 ohm coaxial Cable.

The spacing between elements; 1st and 2nd Directors 16 inches; Dipole to Reflector $13\frac{3}{8}$ inches.

We would be pleased to hear of your success with this array, Vaughan.

14 Mcs Activity

The 14 Mcs band has almost returned to its old form, a few days during the past month being the only ones clouded over by conditions due to the sun spot activity, many countries being heard for the most part at good strength. During the early morning Europeans have been breaking through very nicely, among them G8IG, G6XR, G8DG, GM8MN, with a fair smattering of F's, SM's and I's. Good contacts have been heard from time to time, one excellent one between VK2AGU, VK2NO, VK2AGW, VK2XG, VK2CM and G8IG and later with G6XR. On this occasion all signals were at good level, VK2NO being especially pleased with the new aerial he was testing.

American signals have been coming in through the forenoon, while later in the afternoon reception has been more or less normal. More Europeans are heard from about 5 p.m., but during the Contest week-ends, conditions for European signals were difficult.

After the usual fade out at 6 p.m. the band comes to life at 10.30 p.m., and among the stations logged at this post between that time and midnight are OK4AM, A1YJ, TG9RV, CT1PM, CE1AI, CT1SQ, YV5AY, VR3A, RV2, CE3CE, LU9AT, ON4AR, ZD1BD, VR2AP, LA8C, LA3Q, VQ8AE, VQ8AD, PK3WG, ET3AF, XZ2MM, LU2BL, XE2AM, LU6AJ, VS2-AL,, VS2AO, ZC6AM, CN8AB, PAONG, ZM6AF, and one which does not look so good to us, QY2AM, working at C7.

Ten

Very little listening has been done on 28 Mcs of late, but on those few occasions on which the converter has been warmed up it has appeared as though reception has been normal. Many Americans and Canadians have been heard at excellent strength and many of the local amateurs are taking advantage of the conditions. About 5 p.m. a few South Africans have been heard but not at good level in our case.

One point comes to mind, in that both on Ten and Twenty many local contacts are heard in progress often to the detriment of the reception of good DX signals. Quite a few amateurs have taken advantage of the allocation of the 50-54 Mcs band and use this convenient frequency for their cross-town contacts. While there are still a few operating on this band it seems a pity that more do not take advantage of the band and thus to some extent relieve the congestion on the DX Bands. The equipment is quite simple, and with an efficient aerial system low power will get results.

Forty

Unfortunately the 7 Mcs band is not sufficiently wide to accommodate all the stations which work thereon. Many of the chaps who are doing a very good job with stabilised VFO's, but as usual there are always the few who spoil anything. However despite the interference which can be avoided, there is always some which is quite unintentional and many fine contacts are made. Quite a few networks have been organised, during which some very fine operating is performed.

Eighty

Some rumours of DX on 3.5 Mcs, none heard here as yet, the only stations logged being VK2, VK3, VK4, VK5 and many ZL signals. Conditions are definitely on the improve however, and when the static has subsided no doubt some of this elusive DX will be heard.

Few City amateurs use this band owing to the prevalence of B.C. interference, but the country boys are doing a good job there. For cross country work, and even interstate contacts, the 3.5 Mcs band takes some beating in the autumn and winter.

MARINE RADIO

An interesting letter has been received from Mr. R. T. Neal, Wanganui, N.Z., in which he recounts some of his interesting experiences in receiving and reporting Marine Radio stations. For the past two years Mr. Neal has been reporting these stations, and whilst most of the reception is on CW, frequencies are allotted for phone transmissions on 2012kc and 2045 kc. Over 30 stations have been verified on the former frequency, the latter being use mostly by trawler and base stations. Many readers have receivers which will cover this band, and any queries and reports will be welcomed both by ourselves and Mr. Neal. Address your queries to my address and I will send them to Mr. Neal in bulk.

CLUB NEWS

SHORT WAVE LEAGUE OF W.A.

Secretary, Mr. F. R. Matthews,
24 Midgley Street,
Rivervale, W.A.

The Short Wave League of W.A. is always interested to hear from enthusiasts and regular monthly meetings are held at the office of Hale's Reporters, Second Floor, South British Chambers, Barrack Street, Perth.

The cost of Life membership is 5/- for those outside the metropolitan area of Perth and for those residing within its limits 6/-, and the official organ of the League, "Radio Listening Post" is supplied at a cost of 6/- per annum.

This is an excellent publication and is a must for the ardent DX-er. Interested readers may apply direct to the Secretary or to Box P1179, G.P.O., Perth, W.A.

N.S.W. RADIO DX LEAGUE

Meetings of the above club are held every Thursday at 520 Woodville Road, Guildford at 8 p.m. All interested are requested to contact the organiser, Mr. B. Penhall, 2 Brady Street, Merrylands either personally or by letter, or at the meetings.

HURSTVILLE DISTRICT AMATEUR RADIO CLUB

C.W.A. Rooms,
378 Forest Road,
Hurstville.
President: F. Tregurtha.
Secretary: C. Coyle.

With the re-issue of the Club's Call Sign VK2MZ, all members are busily engaged in the construction of the new transmitter. It is hoped to have this in operation in the near future, when all old friends will be contacted once again.

The last Field Day, which was held at National Park proved very successful, and during the day 10 contacts were made. Plans are now being made to hold another Field Day, and the date of this will be announced as soon as finalised.

The Club meets on the 1st, 3rd and 4th Tuesday of each month at the C.W.A. Rooms, 378 Forest Road, Hurstville. All persons interested in radio are invited to attend at the club rooms, and can be assured of a warm welcome. Any further information can be obtained by contacting the Secretary, C. Coyle, 84 Carlton Crescent, Kogarah Bay.

MULTIPLE TRACK RADAR RANGE

(Continued from page 14.)

the high-frequency counterpart of Loran, and uses frequencies in the vicinity of 80 Mc. Each combination of a slave station with the master provides a series of hyperbolic tracks, and the use of several slave stations results in a lattice of intersecting tracks. This lattice extends over a very wide area, and provides a "blanket" navigational coverage of that area. A typical Gee lattice is shown in Figure 4.

As has been mentioned, Gee was first developed as a military navigational aid, in connection with the blind bombing of Europe. However, because of the extensive coverage of a Gee system, and because of its well-proven performance, wide familiarity with its techniques, and the existence of much Gee equipment, it is under serious consideration in Europe as a system of track guidance for civil aircraft. Gee tracks are in no way dependent on the laying down of overlapping radiation diagrams or on any other technique involving the comparison of signal *intensities*. Gee is a pulse system, and the delineation of its tracks depends only on the comparison of the *time of transmission* of pulses from the master and slave stations.

Pulse System Advantages.

Now it is easy to distinguish in the aircraft between direct pulses and those due to reflection from obstacles (these always arrive after the direct pulse). One can be sure, therefore, of always using the direct pulses, and since we are concerned only with the *time of transmission* of these, variations in their intensity are of no importance. Pulse systems of track guidance are, therefore, free from those serious disadvantages due to reflections and variations in signal intensity which, as we have seen, are inherent in radio ranges. This point cannot be emphasized too strongly.

The disadvantage of Gee for civil aviation is that it does not lend itself readily to the provision of tracks radiating omnidirectionally from an airport, a characteristic which we have pointed out to be increasingly desirable. The basic Gee pattern is a lattice; to convert this into radial track information requires a rather elaborate automatic computer in the aircraft. This difficulty may prevent Gee coming into general use as a track system for civil aviation.

The "Omni" Range

The so-called *Omni* range, developed under the guidance of the U.S.A. Civil Aeronautics Authority, follows upon work done in America on 2- and 4-course ranges to operate in the V.H.F. band (199-150Mc). It is a continuous wave system. The principal idea underlying the development of the Omni range is the provision of a system of tracks radiating omni-directionally from an airport or other site.

The Omni range is based on a rather ingenious principle in which two aerial systems are used at the range station. Aerials spaced a small distance apart are used in one system to radiate a modulated C.W. signal in such a way that the *phase* of the modulation received at a distance is proportional to the *bearing* of the receiving point from the station. The second aerial also radiates a modulated C.W. signal, but the phase of this modulation is the same on all bearings, and provides a reference phase. By measuring in the aircraft the difference between the phases of the modulations of the two signals an indication of bearing from the station is obtained. This measurement is done automatically and the information presented to the pilot on a meter.

The Omni range should, therefore, be well capable of meeting the requirement for numerous radial tracks. Unfortunately the necessary comparison of modulation phases in the aircraft involves the comparison of signal intensities, and therefore, as we have already seen, is subject to all the difficulties arising from the existence of reflected waves. Being a C.W. and not a pulse system it is impossible to distinguish between direct and reflected signals. The Omni range consequently tends to suffer from those disadvantages of bent and split tracks which we have already discussed in connection with equi-signal ranges. Satisfactory siting of stations may be difficult, and testing of each site lengthy and expensive.

Australian Multiple Track Radar Range (M.T.R.)

The Australian Multiple Track Range (M.T.R.) is a development from the war-time Gee system. It employs, however, a master station and only one slave station, and the separation between master and slave is much less than in the case of Gee. The resultant hyperbolic tracks are very nearly straight and radial at distances from the station exceeding 10 miles. M.T.R. operates at a frequency of about 200 Mc.

Being a pulse system, M.T.R. is quite free from reflection effects and siting difficulties for the reasons discussed in connection with Gee, and it is capable of high accuracy. Also, the tracks, as has been mentioned, are very nearly radial; they can be seen in Figure 5. The disadvantages of M.T.R. in its present form are that there are two regions about 180° apart, where no tracks are obtained; these areas can be seen in Figure 5. Also, from the administrative viewpoint, it is less convenient to operate two stations (usually about 10 miles apart) than one which can be situated right at the airport. However, there are probably no insuperable difficulties in overcoming these defects.

Choice For International Use

At the 1946 meeting of I.C.A.O., already mentioned, the Omni range was selected for standardisation, for the time being, as an international track guidance system. The particular category defined by I.C.A.O. into which fall those track systems we have described (and also the system of distance measurement) is known as *Short Range Aids to Navigation.*

However, I.C.A.O. at the same time recommended that intensive development to improve track guidance systems should be proceeded with. These recommendations, it should be pointed out, leave each member country free to pursue its own policy regarding navigational systems for internal use.

(To be continued.)

QUIZ ANSWERS

A.1. (c) If you answered (b) you would be partly right. A vertical antenna has a "no-signal" area immediately above it, and this fact is used by pilots to ascertain their exact position when homing on broadcast stations using the radio compass.
A.2. (b). **A.3. (a).**
A.4. (c). This is the term applied to the resistors in such circuits.
A.5. (b).
A.6. (c) and (d). The value (c) is the minimum and (d) the maximum accepted value.
A.7. (c).
A.8. (c) The answer (a) is partly right since there are two experimental FM stations at present operating.
A.9. (a). **A.10. (f).**
A.11. (c) and (e). **A.12. (b).**
A.13. (c). This feat was accomplished in 1901 and the signal transmitted between Poldhu, Cornwall and St. Johns, Newfoundland, a distance of 2100 miles.
A.14. (b). Caustic soda is found in the Edison alkaline cell, and (d) sulphuric acid is found in the lead cell.
A.15. (c).

IS THIS A RECORD?

As expected, the recent description of the converted radar receiver to tune in the experimental FM station has created no small amount of interest.

One of our readers, Mr. Wild of Manly, recently informed Mr. C. Slade, of Slade's Radio Pty. Ltd. that he made the necessary alterations and additions, including the installation of the aerial in SIX hours and is very happy with the results.

We would appreciate hearing from any reader who has built up this receiver, and not yet written in, giving details of results obtained with it, etc.

Technical BOOK REVIEW

UNDERSTANDING MICROWAVES.

By Victor J. Young. Published by John F. Rider, Publishing Inc. Stiff cover. 385 pages. Price approximately 48/- plus postage.

The title of this book "Understanding Microwaves" is actually synonomous with the aims of the Author—that is, to disseminate knowledge of microwave techniques to the reader having a non-mathematical background.

To enable the book to be widely read, the subject has been presented without resort to complicated mathematics, yet in no way has the accuracy of text been sacrificed. Where mathematical explanations are necessary they have, for the most part, been relegated to footnotes at the end of each chapter thus providing the serious student with additional material.

The book comprises a total of eleven chapters and covers in a clear, understandable fashion, such topics as Ultra High Frequency Concept, Stationary Charges and Magnetostatics, Alternating Currents and Lumped Constants, Transmission Lines, Wave Guides, Resonant Cavities, Microwave Oscillators, Radar and Communication, Antennas and Poyntings Vector and Maxwell's Equations. The inclusion of this latter chapter in an elementary text book is rather unique and whilst in some respects necessarily incomplete, it is extremely important in view of most text explanations being based on Electrostatic and Electromagnetic fields.

Of particular interest are the Microwave terms and theorems presented in Section 2. These definitions will undoubtedly be of great value to all having any interest in this branch of radio development.

Whilst it is not claimed that this book will give the reader a complete knowledge of Microwaves, it is possible for the engineer and layman alike to obtain from it a sound working knowledge of this somewhat complex subject.

REFERENCE DATA FOR RADIO ENGINEERS.

(Second Edition). Published by Federal Telephones and Radio Corp. Stiff cover. 322 pages plus index. Price approximately 18/- plus postage.

Whilst following the general arrangement of the first edition, this new publication has been greatly expanded by the edition of several new chapters, as well as a subject index.

In all, it contains some 322 pages of tabulated information and data, subdivided into sixteen main chapters. To provide the reader with more complete information than that available in the first edition, the new chapters added are those dealing with Transformers and Room Acoustics. This latter chapter should be of interest to all sound engineers, some of the topics covered being: Governing factors of good acoustics, Computation of reverbration time, and Electric power levels for public address equipment.

In addition to general engineering tables, there are sections on audio and radio design, valves and rectifiers, R.F. transmission lines, radio propagation and noise measurement, wave guides and resonators (including formulas of both rectangular and cylindrical types). A comprehensive section on mathematical tables, etc., all add to the value and usefulness of this book.

Although the text is quite up to date, one point to be noted is that American units are used throughout. Since in some cases these are not indentical with the British counterparts, it will be necessary before use to apply correction factors to some of the numerical data.

In conclusion this book contains a wide range of valuable information and is a publication which should find a ready place on every radio engineer's desk.

RADIO ENGINEER'S POCKET BOOK.

By F. J. Camm. Published by George Newnes Ltd. Stiff cover, 144 pages. Price, approx. 5/6d., plus postage.

This vest pocket book has been produced to meet the needs of all those engaged in various branches of radio. In addition to containing the usual comprehensive list of formulae, and general radio tables, much other interesting information is included. The very complete index is fully cross-referenced and this will enable the user to readily trace any information he requires.

Actually, this book may be considered as an "In the pocket" reference library for the radio technician and as such should find ready acceptance by those who require on the spot availability of such information.

★All copies from Angus & Robertson Ltd., 89 Castlereagh St., Sydney.

The Mail Bag

TECHNICAL QUERY SERVICE

Readers are invited to send in any technical problems either dealing with our circuits or of a general nature, and an earnest endeavour will be made to assist you through the medium of these columns. For convenience, keep all letters to the point, with questions set out in a logical order, as space is rather limited.

All technical enquiries will be dealt with in strict rotation and the replies will be published in the first available issue of the magazine. Address all letters to RADIO SCIENCE, Box 5047, G.P.O. SYDNEY, and mark the envelope "Mailbag".

N.A.E. (Bathurst, N.S.W.) enquires about the One Valve Receiver and the Miniminor A.C. Mantel described in recent issues of RADIO SCIENCE.

A.—Full constructional details, including the parts list, of these two receivers were given in the February and March issues respectively. Copies of these are still available and can be obtained by forwarding one shilling for each issue required.

L.B. (R.A.A.F., Toowoomba, Q'ld.) sends in several suggestions for the magazine.

A.—Thanks for the letter, L.B. Although paper restrictions have some effect on the production, you can rest assured that the changes you suggest will be made as soon as possible. Your offer of the technical data is appreciated, and should the occasion arise we will certainly take advantage of the offer.

C.A.R. (East Bankstown) is interested in all phases of radio, especially in connection with VHF and UHF techniques, and hopes the present series of articles on these subjects will be continued.

A.—Yes, the various Radar and UHF articles will continue for some time yet, as they are very popular with most readers. It is our policy, as far as possible, to publicise Australian developments in this particular sphere, as we feel sure this will create more interest than merely re-hashing some overseas report. The chassis drawings will be included, where practicable with every receiver description, so as to enable all interested to build their own chassis. Thanks for the appreciative remarks and good wishes.

C.C. (Flemington, Vic.) asks for further information regarding the Fremodyne FM circuit described in the March issue of RADIO SCIENCE.

A.—This particular article was based on an overseas report and is the only information we have regarding it. Since it is a Hazeltine patented circuit, no details of the tuning condensers or coils were included. The dual triode used is the 12AT7, a type not obtainable in this country. We might mention the larger FM receiver detailed in the same issue will tune in the Melbourne FM station as it operates on approximately the same frequency as the Sydney station.

J.M.S. (New Plymouth, N.Z.) forwards a subscription, and includes a list of the type of articles which interest him.

A.—Thanks for the subscription and suggestions. The present Radar navigation aids series should interest you, and this is the first time they have appeared in any radio journal. The C.R. Oscilloscope articles are at present under consideration and it is hoped to publish something along the lines you suggest in the near future.

A.A.C. (Hurstville South, N.S.W.) requests some additional information regarding the Signal Tracer described in the April issue

A.—This particular unit was built up using the complete kit supplied by the FN Radio and Electronic Co., but they will probably be able to supply the meter separately. The load impedance for the speaker transformer should be 5000 ohms.

E.S. (Sofala, via Bathurst) agrees with T.A.W.'s request in the last issue and suggests that a large vibrator amplifier would be popular with many country readers.

A.—Yes, E.S., we also agree with you on this point. It is hoped to feature such a unit in a future issue, but at the moment cannot say when this will be.

G.P. (Kurralta Park, S.A.) writes in an interesting letter and suggests we devote more space to the beginner.

A.—Thanks for the letter and suggestions. Unfortunately, due to space limitations we have not been able to include very much for the beginner in the recent issues. However, we think the small battery receiver described in this issue should interest you. This type of article, together with suitable technical articles will be presented for the beginner from time to time. The diameter of the formers used in the one valve receiver should be 1¼in. diameter.

E. W. C. (Heidelberg, Victoria) has written in strong terms regarding historical inaccuracies contained in the last UHF Techniques article. Chief among his criticism is a rebuke to the remarks concerning Popov and Marconi, that Nicholls and Tear should have mentioned, and then goes on to give further evidence of other experimenters in the field.

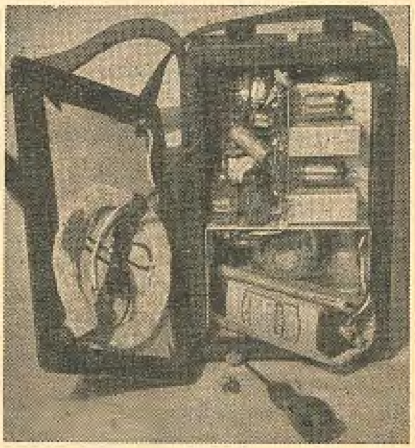
A.—Thanks for the letter and criticism, E.W.C. Your letter was forwarded to Mr. Edwardes for comment and here is his reply: In reply to Mr. E.W.C., I would like to point out that he has confused the term "wireless" with "radio communication". The article on UHF Techniques specifically mentioned the latter. Regarding the acceptance by scientists of the view that Popov preceded Marconi, I would refer him to the results of a scientific investigation on the subject by Professor V. A. Bailey and Dr. K. Landecker, presented in the Australian Journal of Science, Vol. 9, No. 4, February, 1946, page 126. The claim that others "invented" radio communication are also dealt with in that article. I admit the work of Nicholls and Tear should have been mentioned in the history of UHF, but Mr. E.W.C.'s reference to them as "artists" is inexcuseable.

MINIMINOR PERSONAL PORTABLE

If you intend building this receiver, here are details of an alternative arrangement for the "A" battery. In place of the two standard U2 torch cells a single X71 type cell is now used.

The size of this cell is such that when wrapped with a single layer of corrugated cardboard, it will fit securely at the bottom of the cabinet, being held in position by the speaker magnet. The screw terminals fitted very effectively solve the battery clip problem and also enable easy replacement of the cell.

With intermittent use, a life of approx. 12 hours could be expected from this cell, and this compares more than favourably with the U2 type of cell.



A photograph of the Portable with the new battery in position.