RADIO SCIENCE

Vol. 1.—No. 6. Registered at the G.P.O., Sydney, for transmission by post as a periodical. JULY, 1948

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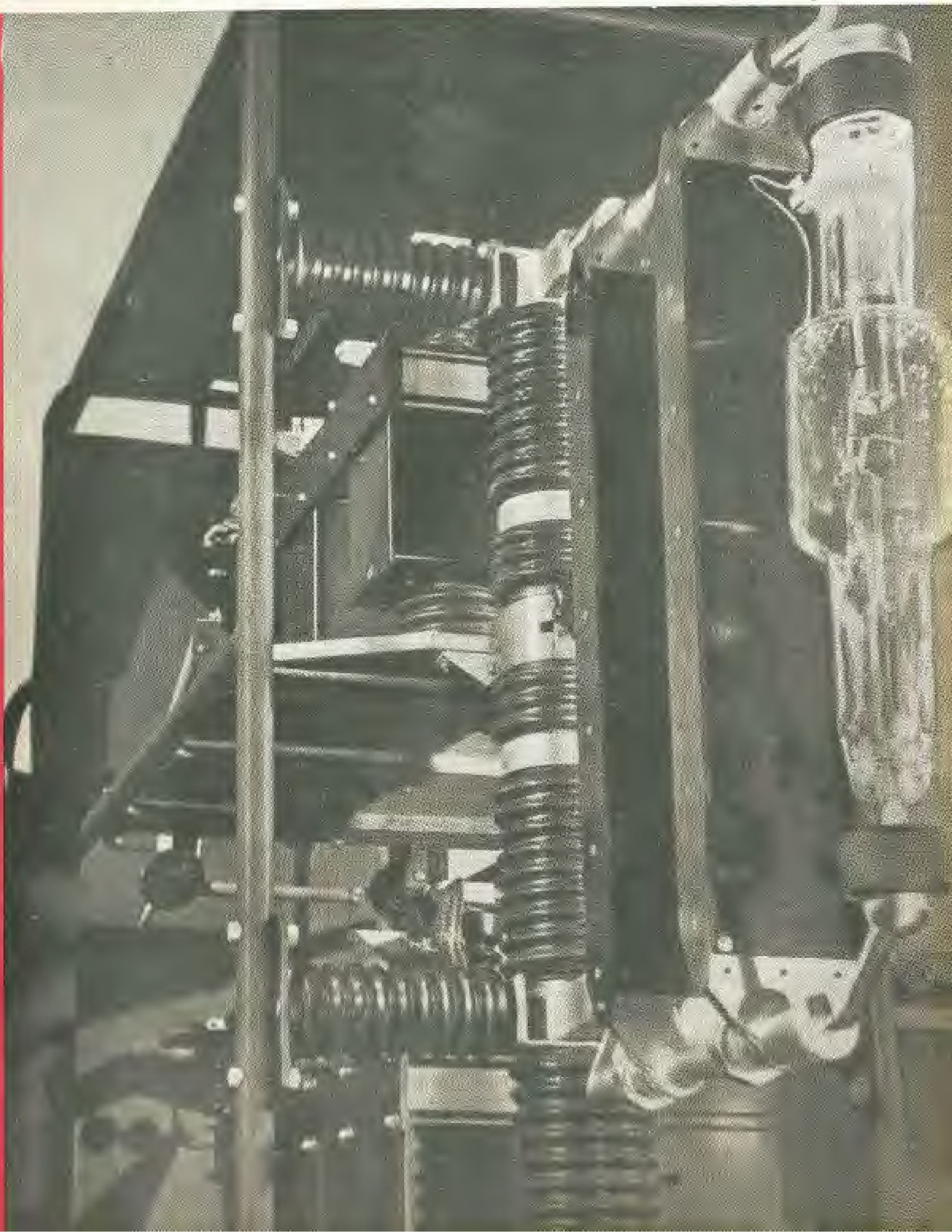

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By M. G. SCROGGIE, B.Sc., M.I.E.E. (Eng.)

No. 2: Mullard TWIN TRIODE ECC32

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Ideally, the signal anode currents would be equal and opposite, so would cancel out in R_c. In practice they must be sufficiently unequal for their *difference* to give enough voltage drop in R_c to drive V2 oppositely to V1. To minimize this inequality, R_c should be large—of the same order as R_{a1} and R_{a2}—and the voltage gain per stage also large. With the ECC32, for example, the difference in outputs need be only about 5%; and this, if not negligible, can be corrected by making $R_{a1} < R_{a2}$.

A feature of this circuit is that if one wants to mix another signal in the balanced output, without coupling the two signal sources, the grid of V2 is available for doing so.

It is obvious, too, that by coupling the anode of V2 to the grid of V1 it can be made to generate sustained oscillations, of a type depending on the couplings. If a 2-phase output is not needed, R_{a1} can be short-circuited. A very stable constant-frequency oscillator, using an untapped inductor, may be based on this arrangement, which is easily seen to be an earthed-grid triode driven by a cathode follower. Used as an amplifier, it is capable of covering a very wide frequency band.

The following are a few references to details of the foregoing schemes:

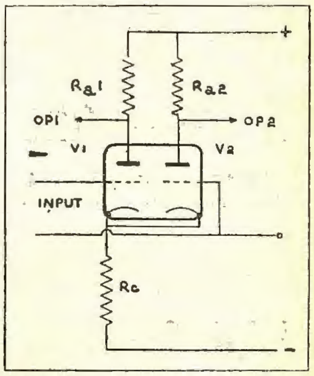
"Cathode-Coupled Push-Pull Amplifiers," O. S. Puckle; *Electronic Engineering*, July, 1943.

"The Cathode-Coupled Double-Triode Stage," Emrys Williams; *Electronic Engineering*, May, 1944.

"Cathode - Coupled Oscillators," F. Butler; *Wireless Engineer*, 1944.

"Cathode-Coupled Wide-Band Amplifiers," G. C. Sziklai and A. C. Shroeder, *Proc. I.R.E.*, Oct., 1945.

"Self-Balancing Phase Inverters," M. S. Wheeler, *Proc. I.R.E.*, Feb., 1946.



BASIC CATHODE-COUPLED CIRCUIT

Mullard

This is the second of a series written by M. G. Scroggie, B.Sc., M.I.E.E. (Eng.), the well-known English Consulting Radio Engineer. Reprints for schools and technical colleges may be obtained free of charge from the address below. Technical Data Sheets on the ECC32 and other valves are also available.

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e d i t o r i a l.

Two-Way Radio

Considerable interest has been created by the recent announcement from the Postmaster General's Department to the effect that licenses would be issued permitting the installation of two-way mobile communication systems.

A two-way radio system is generally understood to refer to—"radio telephone voice communications between stationary or moving radio stations, or a combination of both." A typical example is the system at present being used by the Police Department, which enables cruising patrol cars to receive or reply to messages transmitted by the main fixed transmitter, thereby increasing their efficiency.

Probably one of the first public utilities to take advantage of this new proposal will be the taxi cab services and, it is understood, that even at this early date several companies are contemplating such two-way installations. By providing instant communication between a central booking office and individual cabs, the necessity of aimless cruising around the streets will be eliminated. Instead, after discharging a passenger the driver will simply call up for further instructions, and if necessary, can then be sent to the next nearest caller with a minimum waste of time to the ultimate benefit of all concerned.

By the same token, trucks, delivery vehicles and even passenger cars can be contacted whilst in motion and thereby report any change of route or other occurrence.

Generally, pre-war systems used A.M. equipment but it is now highly probable that this will be supplanted by the more modern F.M. equipment. Apart from requiring decreased operating power this latter system will provide users with the added advantages of improved signal to noise ratio, freedom from interference and maximum receiver sensitivity.

Whilst the thoughts of applications to this form of radio communication are not new, the actual application is and, consequently, in the initial stages of any installation there will be many local problems to overcome.

Although war-time experience in developing two-way systems should provide valuable data and assistance, it will be generally found that each installation will have to be considered as a separate entity and not merely installed according to a book of rules.

This may well be the commencement of a new communications "era" in this country in which the general public, as well as many public utilities, may be permitted to transmit and receive radio signals.

In This Issue

In view of the interest in two-way radio systems, the first of a series of authoritative articles dealing with such equipment is presented in this issue. Written by a practical engineer who has had wide experience in this particular field, these articles will be found most timely and informative.

On the constructional side, there is the T.R.F. Tuner, a unit which should appeal to all readers requiring a high fidelity reception. Incorporating an infinite impedance detector and an amplified A.V.C. system, the unit is capable of really excellent results and well worth adding to your favourite amplifier.

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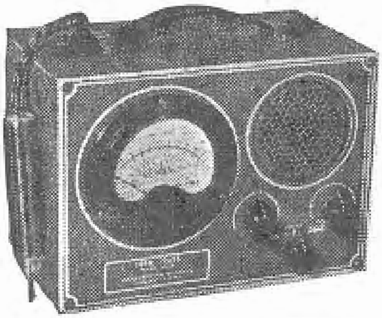

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OUR COVER: A close-up of the super internal action stopper used in high speed X-ray snapshots. Energy is stored slowly in the cabinet and discharged suddenly through the special tube in foreground. (See page 12.) Westinghouse Photo.

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Mobile Radiotelephone Communications

By A. G. BROWN

Engineering Sales Dept., Amalgamated Wireless (A/sia.) Ltd.

A brief review of the past and present developments in this field of telecommunications is given in two parts, with emphasis on the present application of frequency modulation.

In order to obtain the correct perspective in this view of radiotelephony as it applies to communication with road vehicles, it is well to first consider what has been achieved up to the present time by systems using amplitude modulation on medium and high frequencies.

Such services have been relatively few in number in Australia, and have mainly been operated by the police departments of the States, by ambulance organisations, State Forestry Departments, and by public utilities. In the latter group the electricity supply authorities have always been in the lead, apparently due to features of their activities which are particularly aided by radio communication, and due in some measure to electrical engineers being generally aware of the possibilities of such communication.

Fixed Tuning

For these services the usual practice has been to adapt standard car broadcast receivers by fixing the tuning and improving the efficiency of the coupling between aerial and first grid. The first-named modification, generally achieved by crystal control of the converter oscillator, removes the danger of the mobile receiver drifting out of tune and at the same time prevents the operators from listening to adjacent broadcasting channels.

This fixed-frequency operation permits the second-named modification whereby overall receiver performance can be somewhat improved. Conventional circuit design is used in the mobile transmitters, whose output carrier powers range from 5 to 10 watts. Crystal-controlled oscillators ensure stability of the carrier frequency.

Since the termination of war in 1945, the application of A.M. low-power apparatus in the medium-high frequencies has been encouraged by the large quantity of available ex-Service materials, and some commendable ingenuity has been displayed in adapting Service designs to civilian uses. However, the indifferent results obtained in some cases serve to underline the difference in technique between peace and war; the latter's specifically-trained operating personnel and wasteful maintenance practices cannot be called upon in peacetime.

Characteristics of the A.M. Systems.

Although it is intended to deal mainly with the new and rapidly-expanding application of frequency-modulation to mobile services, it is worth while, for the purpose of later comparison, to briefly review the more important characteristics of the A.M. systems.

Firstly, the central station transmitter and radiating systems have been generally similar to their counterparts in broadcasting, since the objective is the same: good coverage over as great an area as possible with the use of the ground wave. For this reason, carrier frequencies in the region 1500 kc to 2000 kc have been the usual choice, with T or vertical radiators. For transmission from the mobile stations back to the central station it has been common practice to employ frequencies as high as 30 Mc, duplex operation generally being achieved, meaning that simultaneous transmission and reception is possible.

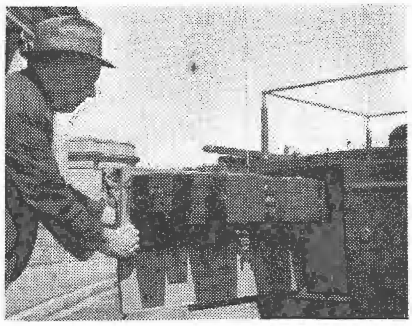
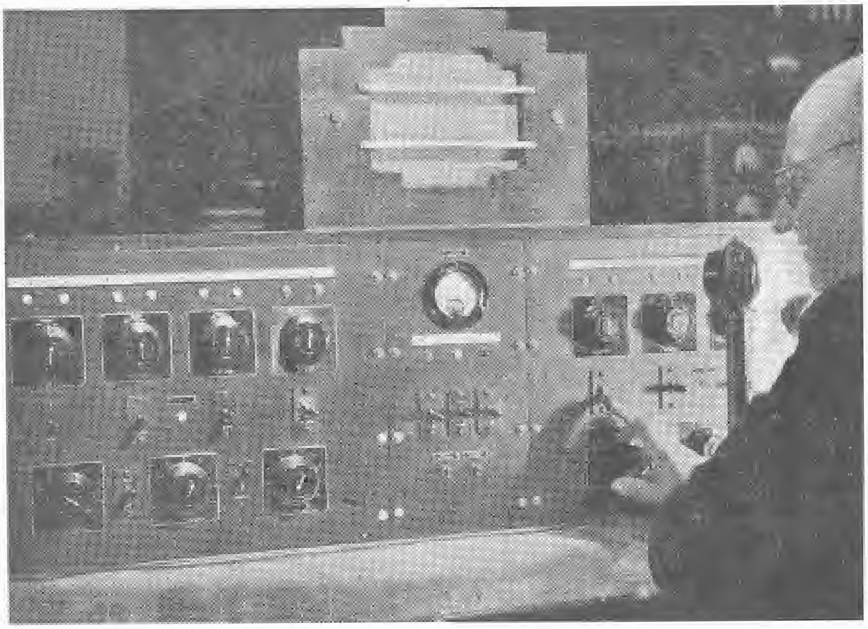


Fig. 1.—Vehicle aerials used on an A.M. H.F. radio installation; the horizontal "luggage rail" aerial is for transmission and the small vertical whip for reception.

In consequence of the use of these frequencies it has been found, as is to be expected, that the ionosphere is responsible at times for interference from other stations. During the winter season particularly it has been found that transmitters located hundreds of miles away, and operating on frequencies up to 10 kc removed, can cause annoying or serious jamming. At 31 Mc, police services have experienced consistent reception of signals emanating from North and South America; however, the relative weakness of

THE AUTHOR

A. G. BROWN graduated in Radio Engineering at the Marconi School of Wireless in 1936. He was engaged in the development and design of communications and military equipment with Amalgamated Wireless (A'sia.) Limited from 1937 to 1946. Since 1946 he has been attached to the Engineering Sales Department of the same organisation.



In use for the last ten years, the central control panel of the Sydney County Council's AM mobile radio system is shown above. The operator has control of the remotely situated main transmitter and of a number of pickup receivers. The system uses duplex operation.

these signals has enabled the local car transmission to over-ride them.

Owing to the short distances involved, fading has not been noted. It is unfortunate for electric supply authorities that atmospherics caused by thunderstorms in the summer months occur at times when reliable radio communication is especially desired. Noise arising in electrical plant and appliances is a far more serious and consistent hindrance to reception at the medium frequencies. Notoriously bad in this respect are electric arc welders, rotating machines with commutators, and tramways.

The ignition system of petrol-engine vehicles is a further source of severe noise interference of a somewhat different type; it is interesting that whereas it was once thought that ignition noise decreased at frequencies higher than about 30 Mc, it has been confirmed that substantial noise signals are produced by the average modern vehicle throughout the frequency spectrum and as high as 500 Mc. 1, 2, 3.

Aerial Design Problems

A major difficulty with medium/high frequency apparatus, when installed in road vehicles, is encountered when the aerial circuit is considered. For a practical design it is obvious that the aerial can only be a small fraction of a wavelength, and can only have a very low effective height. The loading coil or circuit employed to effectively couple the aerial to the transmitter must accordingly be devised from components of high Q value; i.e., losses must be kept at a low value. Even in good designs, the efficiency of power transfer from transmitter output to aerial is quite low in practice and there appears to be little scope for improvement.4.

A particular design is illustrated in Fig. 1, wherein a **"luggage rail"** type of transmitting aerial is shown for transmission on a frequency of 3190 kc. The support insulators which carry the horizontal tubular aerial are made of a semi-hard rubber moulded to shape. The vertical aerial is used for reception on 2130 kc, and it is interesting to note that duplex working is possible; i.e., transmission may take place during reception.

The design of effective muting circuits for the receivers of A.M. systems, to operate reliably at low threshold values of signal, has long been a problem confronting the design engineer. In the absence of this desirable refinement either the operators have been subjected to the extremely trying noise output of the receivers, or the system operates with the central station transmitting a carrier signal continuously. The latter practice has been commonly adopted, although wasteful as regards power consumption and valve life.

However, it has the advantage that the vehicle operator is always aware when he is in an area of good signal strength since, under such condition, the receiver gain is automatically reduced so that background noises are suppressed. It is clear that this protection fails when the vehicle is moving through an area of poor reception.

In conclusion, it is worth enumerating three advantages of A.M. systems: Firstly, by using carrier powers of 200 to 500 watts at the central transmitter, reasonably effective coverage may be achieved over quite large areas; for example, ranges up to 30 miles are possible. Secondly, the topography of the service area is of secondary importance; and, thirdly, the transmitters and receivers employ relatively simple, non-critical circuits.

V.H.F. Transmission Characteristics.

In passing now to consideration of the new F.M. mobile communication installations, it is necessary that the transmission characteristics of the high frequencies used for these services should first be reviewed.

The fact that, both in the United States of America and in this country, the application of frequency modulation has proceeded in step with the employment of V.H.F. technique, seems to have caused considerable confusion in the minds of tele-communications engineers and others; some of the claims made on behalf of frequency modulation may, in fact, be attributed to the properties of V.H.F. transmission. In the future it may be found unfortunate that A.M. systems operated in the V.H.F. bands have never been exploited in this country, due to the war of 1939-1945. Development in this direction has taken place in the United Kingdom and is referred to again later.

The propagation characteristics of transmission in the frequency range 30 to 300 megacycles (and higher) are now reasonably well defined for the purposes of communication engineers, and there are many references in the literature 5-14 which may be consulted. It may be stated immediately that the condition that clear **line-of-sight** should exist between the transmitting and receiving aerials for effective communication is definitely not a strict requirement. In the general case such a path produces a high degree of constancy of received signal field strength, the variation in meteorological conditions in the lower atmosphere having no practical significance at the frequencies now being employed for mobile services; i.e., 70-80 megacycles and 150-160 megacycles.

Such a case may be illustrated by the transmission from Station A to Station B

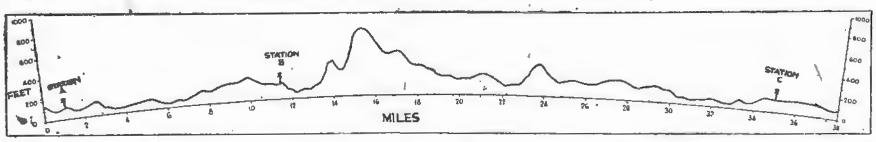


Fig. 2.—Typical profile of terrain. Station B. would be in continuous reliable communication with A, but transmission from the latter to Station C would be variable and dependent upon meteorological conditions.

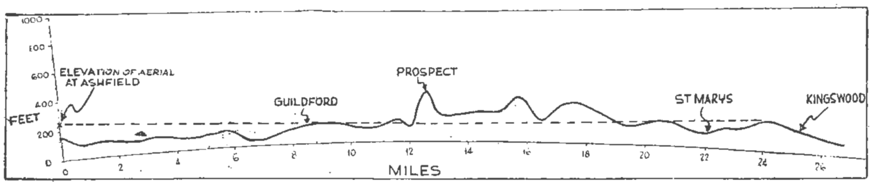


Fig. 3.—Profile of terrain used for prediction of transmission, Ashfield to Kingswood, Sydney.

in Fig. 2, in which a typical profile of terrain is portrayed. In this diagram the effect of the earth's curvature is allowed for in the usual manner. 15, 16.

Beyond the range of clear line-of-sight, and for much further distances, useful receiver signal strengths may be obtained, but it has been well established that considerable variations in reception occur, governed by refraction of the radio wave in the lower atmosphere. The thickness of the latter has been assessed as approximately 20 kilometres, as regards the effects on V.H.F. propagation. As the main factors controlling refraction are temperature variation vertically, and variation of water vapour content, there is a correlation between the beyond-horizon transmission and weather conditions prevailing along the transmission path. The concept of a *standard refraction* has been found useful as a reference in the analysis of long-distance V.H.F. propagation.

In Fig. 2 transmission from Station A to Station C would be dependent upon lower atmosphere refraction for the creation of downward curving of the wave path. Using this hypothesis it is natural to assume that the variations of received signal strength will increase as the range beyond the horizon increases, and this has repeatedly been found true in practice. For ranges greater than about twice the horizon distance, the very high frequencies become of little use for continuous commercial services.

Where V.H.F. communication is with a vehicle, the effective height of the aerial on the latter is low enough to justify taking the horizon distance as a first-order approximation of the reliable range, and height of the fixed station aerial relative to the surrounding country becomes the important factor. Accurate correlation of practical results with idealised propagation theory is difficult, and the anomalous results encountered, the interference patterns commonly found in built-up or wooded areas, and at distances beyond the horizon, all indicate the complexity of the wave pattern as it arrives at the receiving aerial.

Freedom from atmospherics which greatly trouble the low, medium and high frequencies, is an advantage of the very high frequencies which becomes more marked as the frequency is raised; at the present time it is not clear to what extent this fact has led to false claims on behalf of the F.M. technique. There is a relative decrease in the intensity of noises from electrical sources as the frequency is raised, although recent papers[3] show that vehicle ignition interference is a partial exception.

Such interference has been shown to exist at substantial level at frequencies as high as 500 megacycles, with wide variations between types of vehicle. A marked advantage of the very high frequencies is that the aerial dimensions reduce to the stage where it is entirely practicable to fit quarter-wave or half-wave resonant aerials to vehicles, and to devise very effective coupling circuits between these aerials and the equipment.

4.—Fixed Station Site Selection.

From the discussion in the preceding section, it is seen that the selection of the site for a fixed station which is to operate with mobile stations, is a matter requiring careful engineering attention. The general topography of the service area must be considered in relation to the requirements which the communication system aims to achieve, and in particular the disposition of roads (or water-ways, if a marine installation is being planned) and the distribution of population must be noted.

Height of the fixed or base station aerial above the average terrain altitude is the prime factor in obtaining reliable communication over a long range. The distance to the optical horizon is given by—

$$d = 1.23 \sqrt{h} \text{ miles},$$

where the height of the observer h is known in feet. For example, an aerial located 64 feet above an ideal plane earth would see the horizon at about 10 miles distance, whereas increasing its altitude to 144 feet, would place its horizon at 15 miles. As a first order approximation, the radio range would appear to be increased in the same ratio, but other factors have an important influence.

That the aerial height and not the radiated power from a base transmitter is the factor of more importance in determining range, may be seen from the expression for received field given by Peterson [15]:—

$$e = (.01052 \sqrt{W}\, h\, a\, F)/d^2 \text{ microvolts per meter.}$$

where W = watts radiated by transmitting half-wave dipole;
h & a = altitudes above reflecting surface, in feet.
F = frequency, in megacycles;
d = distance, in miles.

For a given height of aerial, frequency, and distance, it is seen that the field can only be doubled by quadrupling the power, whereas doubling the height of the transmitting aerial will produce the same result.

There is now sufficient information available [13, 14] to enable the transmission losses over a specified point-to-point path to be assessed with reasonable accuracy. Briefly, the procedure is to mark off the path on a contour map and to note the heights at suitable intervals, generally at each quarter mile. The readings are then marked down on a profile chart and the calculation proceeds, using the method of Bullington [14].

The chart usually incorporates the factor of earth curvature shown with sufficient accuracy by scaling down the earth's radius and exaggerating the height scale by the correct ratio. It may be presented in two ways, either by drawing a curved base line and a straight ray path, or alternatively by using a straight base line and drawing in the ray path with the correctly-chosen radius, concave upward. Fig. 3 is a typical example of the first method. Between the points Ashfield and Kingswood, satisfactory communication has been obtained, using F.M. transmitters and receivers of a high standard of performance.

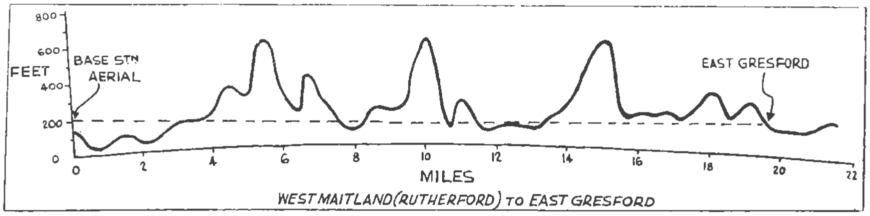


Fig. 4.—Terrain profile. Communication has been obtained between the points joined by dotted lines. See text.

Profile Chart

While the prediction of a few point-to-point transmission paths may be readily undertaken, it can rapidly become a laborious and tedious matter to forecast the service area which will be obtained by the central station of a mobile system; in the latter case the possible movements of the vehicles demand a consideration of the terrain along radials, possibly spaced 5 or 10 degrees apart. Furthermore, in hilly country it is common experience that rather anomalous results can be obtained, presumably arising from fortuitous reflections. Where complicated terrain is encountered, it is frequently more practicable to carry out an actual field survey to determine the effective coverage.

A typical case is illustrated by considering communication in the area north of West Maitland, N.S.W. From the best adjacent site available, the terrain for the first 5 to 9 miles is only slightly undulating. Beyond this the country suddenly becomes very hilly, with peaks rising to 1,000 feet and over, and Fig. 4 is a profile from which it would be deduced that transmission from West Maitland to East Gresford was not attainable. In actual fact, however, locations were found in this vicinity, where good two-way operation was obtained with a vehicle fitted with radio. Just beyond East Gresford are two peaks of 1,345 feet and 745 feet, respectively.

There are other empirical factors which influence the site of the base station. It is important that the aerial should surmount all local obstructions, even of a seemingly minor nature [17, 18], and that it should be well surrounded (for a radial distance of a few miles) by reasonably flat terrain of lower altitude. Sites fulfilling such requirements are not always easy to find, and since, in the majority of cases, the desirable site does not coincide with the location of the station control centre, it is inevitable that some system of remote control of the radio equipment must be provided. However, this is no real disadvantage, as it is easy to provide full control facilities together with speech transmission on one land line pair between the two locations.

(To be continued.)

The author is indebted to Amalgamated Wireless (Australasia), Limited, for permission to publish this paper.

With the installation of the many proposed mobile services, the scene depicted in this photograph will become commonplace.

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RADAR AIDS TO NAVIGATION

MULTIPLE TRACK RADAR RANGE

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

In the preceding articles the principles of hyperbolic navigation and ground station operation were discussed in some detail. In conclusion, the author now deals with the requirements of the air-borne equipment used in the M.T.R. system.

The function of the M.T.R. airborne equipment is to search for and receive the pulses radiated from the selected ground stations (master and slave), to measure automatically and continuously the difference in time of arrival of each two corresponding pulses, and to display the result in the form of a *track number* which, in conjunction with a prepared map, indicate to the pilot his bearing relative to the stations.

The equipment must also fulfil all the usual requirements for airborne use in civil aircraft, namely: lightness, compactness, reliability and ease of servicing.

Circuits and Mode of Operation.

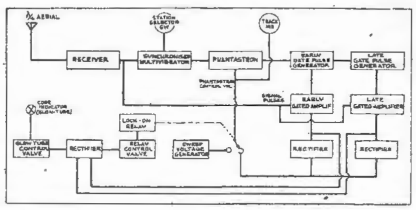
A block schematic diagram of the M.T.R. airborne equipment appears in Figure 1.

Receiver:

The receiver is a superheterodyne with one R.F. stage and four stages of I.F. amplification. The frequency of the received signals (pulses) is in the vicinity of 200 mc. The converter valve is of the twin-triode type, one section acting as local oscillator and the other as mixer.

The bandwidth of the receiver is about 3 mc; it is made intentionally wide to allow for drift of both the transmitter and local- oscillator frequencies as well as to preserve the pulse shape. The intermediate freqency is 30 mc.

A diode detector is used, followed by a stage of video-frequency amplification, which in turn is coupled to a cathode-follower stage, providing a low-impedance output which is convenient for transference of the signal to the next section of the equipment, known as the ranging unit.



Block schematic of MTR Airborne Equipment.

The receiver is illustrated in Figure 2. It is built as a separate unit to facilitate rapid servicing by replacement of the entire receiver should a fault develop therein. Also, because of the high gain and relatively high intermediate frequency used, careful assembly and wiring of the I.F. stages is necessary; this is a somewhat specialised job, and for this reason it is advantageous to construct the receiver as a separate unit.

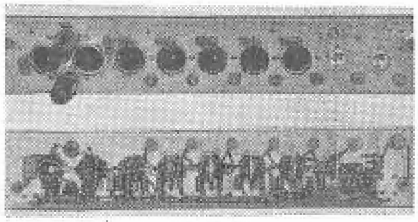
The tuning of the I.F. inductances is by means of eddy-current slugs. The valves used are all of the miniature type, principally the 6AK5.

Ranging Unit.

The manner in which the time difference between corresponding pulses is automatically measured is somewhat complicated. The master pulse always arrives first at the aircraft, followed by the slave pulse (special provision to ensure this is made in the ground stations). The pulses are fed to a multivibrator circuit and if the natural frequency of the latter is just below the rate at which the master pulses are received, the multivibrator becomes synchronised to the incoming pulses. Pulses are sent from the master station at twice the rate of the slave station; this enables the multivibrator to be synchronised to the master rather than the slave.

The purpose of this multivibrator stage is to discriminate between M.T.R. transmissions of different repetition frequencies; it can be seen that by changing the natural frequency of the multivibrator (by a switch on a control panel) and by allocating different repetition frequencies to the various M.T.R. systems in a given area, it is possible to select any desired system.

The output of the multivibrator, now assumed to be synchronised with the master pulses, is coupled to a delay-generating stage known as a *phantastron*. The action of this stage is such that on receipt of an impulse it goes through



Receiver used in the MTR Airborne equipment.

a cycle of operations at the end of which a new impulse is generated; that is to say, the stage produces a delayed pulse. The duration of the phantastron cycle, i.e., the delay, can be controlled by varying the voltage on the anode of the phantastron valve, so that we have a satisfactory way of producing a smoothly-variable delay.

The delayed pulse from the phantastron, after suitable shaping and amplification, is applied to the screen grid of a multi-element valve.

This valve is known as a *gated amplifier* and the applied pulse called a *gate pulse;* the reason for this term will appear shortly.

(Reference should be made to Figure 3, where the relevant waveforms are depicted).

To the signal grid of the gated amplifier is applied the output from the receiver, namely, the incoming master and slave pulses. It will be seen that if the delay of the phantastron is equal to the difference in arrival time of master and slave pulses, the pulses on the screen grid of the gated amplifier will coincide in time with the slave pulses so that conduction through the valve will occur, and output pulses be obtained. The slave pulses are said to pass through the gate, or be *gated,* under such circumstances.

Now, immediately on switching on the equipment, a saw-tooth sweep voltage produced in a normal resistance-capacitance circuit, is applied to the phantastron valve as a control voltage, and this has the effect of causing the generated delay to increase in value, commencing from practically zero delay, up to a certain maximum value. It will be seen that, under this *searching* condition, assuming slave pulses are being received, there will come an instant when the gate pulses coincide with the slave pulses.

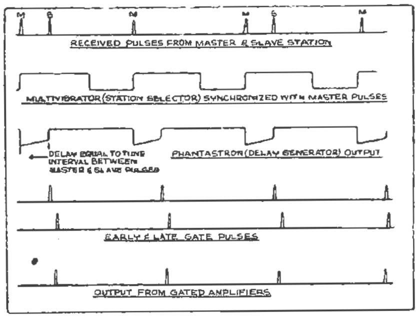
The gated amplifier then conducts, and its output, after rectification, is applied to a control valve having a relay in its anode circuit; this relay accordingly becomes energized. The relay is so arranged as to disconnect the sweeping control voltage from the phantastron, and the delay of the latter consequently stays fixed at the value which produces pulse coincidence in the gated amplifier; this coincidence, and the resultant relay action, is described as *lock-on* to the slave pulses.

"Lock On" Action

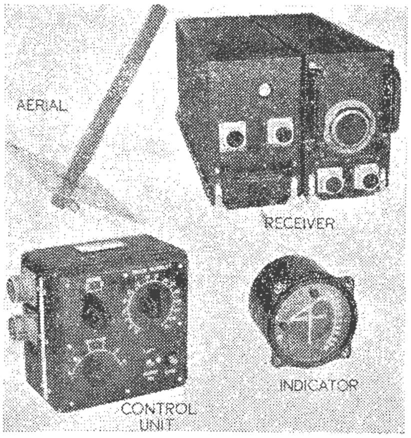
When lock-on has occurred, the value of control voltage on the phantastron is indicated on a meter. Since the control voltage is proportional to the generated delay, which in turn has been made equal by the action of the circuits to the time separation between master and slave pulses, the meter reading is a measure of the latter.

Now, it was explained in an earlier part of this article how by allocating definite values to the difference in arrival time of the master and slave pulses, a number of tracks were defined, and these could be drawn superimposed on a map of the area covered by the system. The tracks are usually numbered 1, 2, 3, . . . and represent increasing values in time-difference between pulses. It can be seen, therefore, that our meter, which indicates the time-difference between the pulses being received, can be calibrated in terms of track number, and this is in fact what is done. The pilot, by observing the indicated track number and making reference to his chart, can immediately establish his bearing from the stations.

It will by now probably have occurred to the reader that although the facility of locking-on to pulses has been described, no mention has been made of the method adopted to ensure that the



The various waveforms used in MTR system.



Various units of the MTR airborne equipment.

equipment stays locked-on during the flight of the aircraft, which may involve the crossing of tracks. To allow for this, further circuits are necessary. Instead of a single gate pulse being generated, two such pulses, one closely following the other are produced; these are known as the *early* and *late gate pulses.* (The mention of a second pulse was omitted from the preceding description for simplification, this pulse not being essential for the lock-on action.) Those are applied respectively to the screen grids of two separate gated amplifiers, called the *early* and *lated gated amplifiers.* The output of the receiver is connected in parallel to the signal grids of the two gated amplifiers.

General Operation

Now, assume that the circuits have gone through the searching process and have locked-on to the slave pulses in the manner previously described. The two gate pulses will then be coincident with the slave pulse. Suppose now that the aircraft flies a course such that it moves towards a track of a lower number. The time difference between the received pulses will be decreasing; i.e., the slave pulse can be regarded as moving towards the master pulse. The slave pulse will thus tend to coincide more completely with the early gate pulse, and will move out of coincidence with the late gate pulse.

As a consequence, conduction through the early gated amplifier will predominate. The output of this amplifier controls a diode circuit in such a way as to reduce the value of the control voltage on the phantastron; the delay of the latter is accordingly reduced, and consequently the gate pulses are moved until they coincide once again with the slave pulse.

Similarly, should the aircraft be moving towards a track of higher number, the slave pulse will tend to coincide only with the late gate pulse. Conduction throught the late gated amplifier will then predominate, and this amplifier controls a diode in such a way as to increase the phantastron control voltage. As a result the gate pulse will be moved until they both coincide with the slave pulse.

By the simultaneous action of the two gated amplifiers the gate pulses are made to straddle the slave pulse continuously, following it as it moves relative to the master pulse. At the same time, the phantastron control voltage is read continuously, appearing as an indication of track number on the pilot's meter.

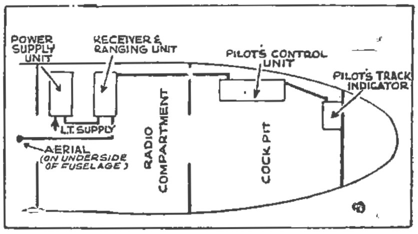
Track Indication

It is often the case that the pilot requires to fly the aircraft along a particular track. To allow this to be done easily and accurately an additional meter indication is provided. It takes the form of a centre-zero meter movement, so arranged that when the pilot adjusts a track selector switch for a particular track, the meter needle is central when the aircraft is on that track, but deviates to left or right as the aircraft departs from the track.

Navigation along a particular track is thus made quite simple, and the arrangement allows of considerable sensitivity; for example, a departure of 1 degree from the selected bearing can be readily observed.

The circuit used for the centre-zero indication is a form of bridge; the control voltage on the phantastron corresponding to the particular track selected is balanced by an equal voltage obtained from a potentiometer, and the centre-zero meter is connected between the two potential points. Consequently, no current flows through the meter when the aircraft is on the selected track, but any departure from the track causes a change in phantastron control voltage in the manner described previously, and current will flow in one direction or the other through the meter.

Both types of meter indication are combined in a single instrument, which can be seen in Figure 4. The *horizontal* needle indicated on the scale on the right-and side on which track the aircraft is located, while the *vertical* needle indicates departure to left or right of a selected track.



Typical equipment layout in an aircraft.

The output from the gated amplifiers, in addition to feeding the lock-on circuit in the way previously described, is applied after rectification to a control valve having a small glow-tube in its anode circuit.

When the equipment has locked-on to a pair of M.T.R. stations the stream of gated pulses causes this lamp to glow. Now it was described in an earlier part of this article how at the slave station the stream of transmitted pulses is interrupted periodically by a coding unit in such a way as to form a Morse code group characteristic of the particular station. The glow-lamp in the aircraft responds in accordance with this periodic interruption of the stream pulses, so that by observing the lamp one can identify the particular system to which the equipment has locked-on. This provides a check on the proper functioning of the station selector control.

Although the time-constants in the glow-lamp circuit must be sufficiently small to allow the lamp to respond to the coding, it is not desirable that the lock-on relay circuit should be affected by these periodic interruptions of the pulse stream. Accordingly, a relatively long time-constant is introduced into the relay circuit. This ensures that the equipment will remain locked-on during the coding periods and any other brief interruptions to the signal.

Equipment Details

The various units of the M.T.R. airborne equipment are shown in the photograph of Figure 4, and Figure 5 is a block schematic diagram of the arrangement of the units in the aircraft.

Two cases, identical in size, house respectively, the power supply and the receiver and tracking unit. The power supply is constructed separately both for ease of assembly and maintenance, and also to avoid excessive heating of the components in the receiver and ranging unit, particularly those which determine the accuracy and stability of the equipment. The power supply unit contains a H.T. dynamotor and associated voltage-regulator valves and potential dividers; the dynamotor is fed from the main L.T. supply of the aircraft, to which all the valve heaters of the equipment, in a series-parallel arrangement, are also directly connected.

The second case, in addition to housing the receiver already described, contains the tracking unit, which uses miniature valves and, so far as they are available or desirable, miniature components throughout.

A small and compact control unit houses an on-off switch, the station selector control, the track selector switch, and the code glow-lamp. It also contains a sense switch, which it is necessary to set in accordance with the general direction in which the aircraft is flying through the track system; when this is done the centre-zone indicator always indicates to the pilot the correct direction to fly in order to reach any given track.

The double-movement track indicator is mounted on the pilot's instrument panel in a position where it may be clearly seen. The control unit is located in the cockpit in a position convenient for operation either by the pilot or the co-pilot. The receiver and tracking unit and the power supply are mounted together in any convenient position in the aircraft.

The receiving aerial is a simple *spike*, one quarter-wavelength long, projecting usually from the underside of the aircraft, and connected to the receiver by coaxial cable.

The installed weight of the entire equipment, including cables, is about 35 lb.

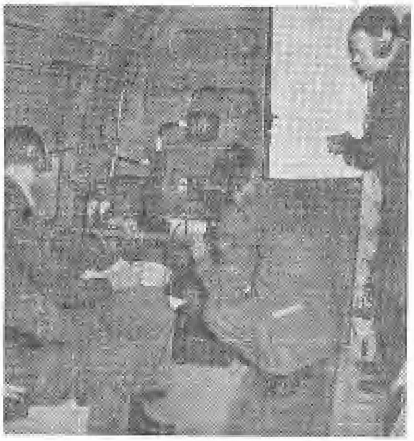
Test Equipment.

In addition to the routine test instruments, certain specialised pieces of equipment have been built to assist in the testing aand maintenance of the M.T.R. airborne equipment.

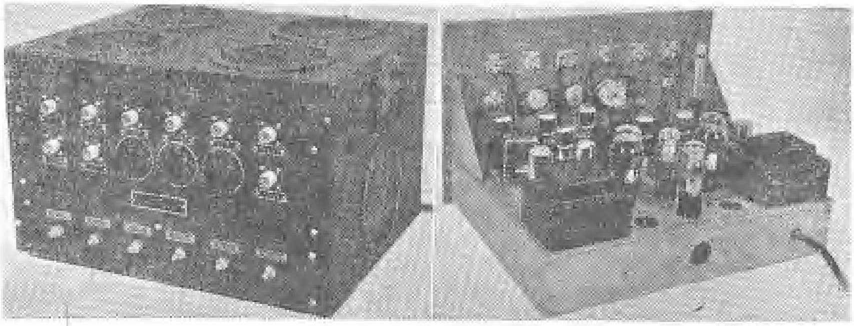
One important test is that of the ability of the equipment to lock-on to signals transmitted at any given repetition rate, and to reject signals of which the repetition rate differs appreciably from the given figure.

To make this test pulses are fed into the equipment from a pulse generator of which the frequency is determined by a stable resistance-capacitance oscillator; the frequency range over which lock-on occurs can be rapidly and accurately determined by this means.

The calibration of the R-C oscillator can be checked when desired against a specially-designed crystal calibrator unit.



The Canadian trials were carried in an RCAF Dakota.



Two views of the crystal calibrator—an important unit of the MTR test equipment.

In this unit the frequency of a 100 Kc crystal is successively divided down to audio frequencies, so that direct comparison with the R-C oscillator can be made. The crystal calibrator unit is illustrated in Figure 6.

Another important test on the M.T.R. airborne equipment is that of the accuracy of the track calibration. To carry this out pairs of pulses (simulating the master and slave pulses) having a closely-controlled time separation, corresponding to that for a particular track, are fed into the equipment and the track-number indication is observed. If necessary, a re-calibration can be made using this instrument. The method of obtaining pairs of pulses spaced by an accurately known time interval is interesting; the basis is once again the crystal calibrator unit. Outputs from this unit at 5 Kc and 40 Kc; these outputs are in the form of pulses, which will, therefore, recur at intervals of 200 and 25 microseconds respectively. By picking out particular pulses from each output a large range of stable pulse separations can be obtained.

Operational Trials of the Equipment.

In order to check the performance under airline conditions of engineered models of the M.T.R. equipment and also to determine the suitability of the design from the navigational point of view, installations of the equipment were made in civil aircraft in daily use and tests made under airline conditions over the Sydney-Melbourne air route for a period of about five months. A large number of flights were made. Particular attention was paid to studying the reliability of the equipment under these conditions, and to determining the average coverage area of M.T.R. ground installations. The reliability was found to be of a high order, the only troubles encountered being one or two component failures.

Under airline conditions it was found difficult to make satisfactory checks of the accuracy of track indication. Accordingly, some special flights were made for this purpose, and these were deliberately carried out over mountainous country, where reflected signals could be expected to be present; the flights, therefore, represented a reasonably severe test of the accuracy of the system. Under these circumstances, and within the narrow limits of experimental error, no discrepancy was observed between the tracks as delineated by the aircraft equipment and the theoretical tracks as drawn on maps.

Overseas Tests of the M.T.R. System.

In additon to the airline trials, M.T.R. equipments were sent to Canada in 1946 and very successfully demonstrated to a large number of delegates of the International Civil Aviation Organisation. Figure 7 shows the equipment set up for demonstration purposes in a Dakota aircraft of the Royal Canadian Air Force.

Subsequently, certain of this equipment was taken to England and used by the R.A.F. as part of an intensive development programme to study methods for the rapid landing of aircraft under instrument conditions. Again the equipment performed extremely well and played an important part in the rapid-landing procedures.

Present and Future Status of M.T.R.

It has been described in this series of articles on the M.T.R. system how in its present form it represents a thoroughly-tested equipment, accurate and free from siting difficulties.

Disadvantages in the M.T.R. system in its present form are the gaps in coverage where no track guidance is provided, and the necessity for two stations, some miles apart. The present trend in development aims at reducing or removing the gaps in coverage and at lessening the station separation considerably, so that both may be located within the airport boundaries, or at least in close proximity thereto.

When this development has been carried through the M.T.R. system will provide a very promising answer to the problem of providing reliable omnidirectional track guidance.

Millionth-of-a-Second—

X-Ray Snapshots

By DR. CHARLES M. SLACK L. F. EHRKE C. T. ZAVALES
Westinghouse Electric Corporation

The new ultra-high speed X-ray machine freezes for direct and leisurely examination all sorts of ultra-rapid action of machines, of impacts, and perhaps even of chemical reactions. It opens a wide door to an entirely new "world" of time in mechanical phenomena.

X-ray pictures of a golf ball as it is struck, a football and the foot that kicks it, a glass bulb as it is shattered by a missile, are spectacular, interesting, but perhaps not too important. They are indicative, however, of the capabilities of a new type of high-speed X-ray machine, which offers a prospect of major importance to every engineer concerned with machines in motion, impacts, vibrations, or other occurrences that are too fast for observation or are obscured from view of eyes or camera.

Furthermore, taking of such high-speed X-ray pictures does not necessitate highly specialised laboratory technique or complex, cumbersome laboratory apparatus. The new high-speed X-ray machine is a compact unit on wheels, with simple controls. It is actually simpler in its principle of operation than the conventional X-ray machine. It is a practical industrial tool. It is self-contained, requires no special source of power, and is suitable for either special or routine investigations.

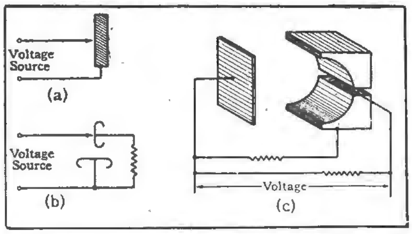


Fig. 1.—These successive steps led to the cathode construction that has proved effective in the high speed X-ray unit. The point-to-plane cathode of (a) is inconsistent in performance. That of (b) is much better, the emission first occurring at the point to plane but quickly breaking down into an arc. The series resistance is high enough to cause a stable, reliable discharge between the two planes. The cathode of (c) carries out the idea developed in (b) and provides by its cup shape, a means of focussing the electrons toward the anode.

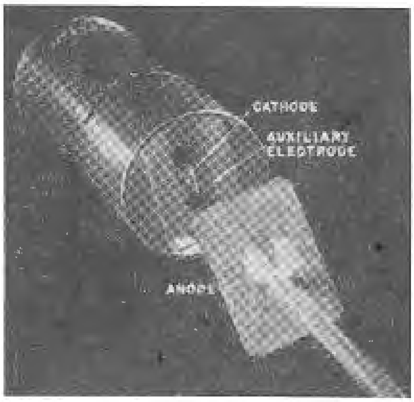


Fig. 2.—The practical form of the cathode and anode construction used in the high speed X-ray tube. The cathode is a sharp-edged paddle set in a slot in the trough-shaped auxiliary electrode, the shape of which provides a focussing cup.

Special Equipment

The high-speed X-ray is not an ordinary industrial X-ray machine "souped-up" for ultra-fast operation. That is impossible. The high-speed X-ray machine employs a tube using a new type of electron emitter, and is supplied with power from a stored-energy source, instead of drawing it from a power line as used.

In taking a radiograph, the time of exposure at any given voltage is determined by the intensity of the X-ray beam, which in turn is dependent on the magnitude of the current through the tube. For normal exposures, which range from a few seconds to perhaps minutes, in duration, the tube current is several milliamperes. To make a suitable exposure at one millionth of a second, a current a million times greater than the usual current, i.e., some thousands of amperes, must be passed through the tube. Currents of this magnitude cannot be obtained from a heated tungsten filament. Some other source of electrons is required.

The search for a new method of supplying such an inordinately large current led, curiously, to utilisation and encouragement of a phenomenon previously considered a weakness or defect in high-vacuum electronic tubes, and consequently was studiously avoided—that of random discharge. This emission abnormality had been previously thought to result from an increase in the gas pressure in the tube.

In a simple two-electrode tube filled with gas at or about atmospheric pressure, the voltage required to produce a discharge is large. As the pressure is reduced, the discharge voltage also decreases until a certain minimum is reached, after which further decrease in pressure causes the voltage to rise again. This is in accordance with Paschen's Law.

Gassy Tubes

As the high-vacuum portion of the curve is approached, the slope becomes extremely steep, leading to the expectation that the voltage should reach infinity at extremely low pressures. Furthermore, X-ray tubes were known to operate at higher and higher voltages as the vacuum improved. Reasoning along these lines, it has generally been concluded that when

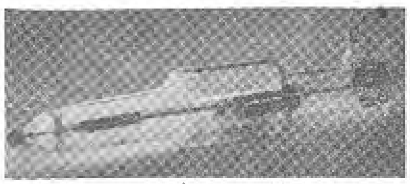


Fig. 3.—In this tube controlled bursts of extremely high emission currents produce X-ray radiation of such great intensity that exposures of one millionth of a second are possible.

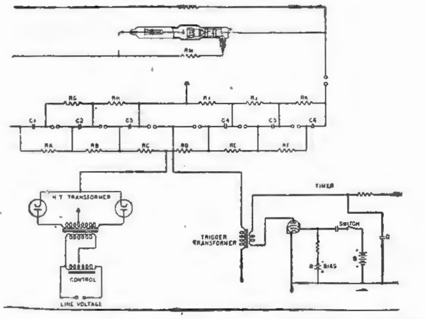


Fig. 4.—In this schematic circuit the physical components are arranged as in the actual set.

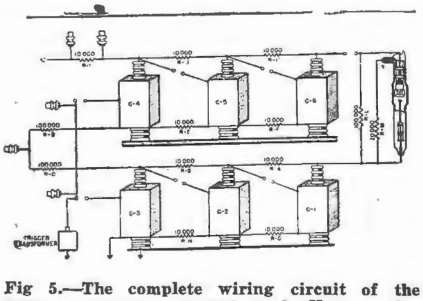


Fig 5.—The complete wiring circuit of the surge generator, control and X-ray tube.

is because the vacuum has become im-
a tube fails to withstand high voltage, it
paired. The tube is said to be *gassy*.

Physicists now recognise that irregularities in operation often occur in tubes having the highest of vacuums, and that gas is not responsible for the phenomenon. Illustrative of this, a deep therapy X-ray tube was provided with an ionization gauge and sealed off with a neon pressure of three microns. The tube operated satisfactorily for some hundreds of hours. When arc-overs, usually attributed to gas, did develop, the actual pressure as indicated by the ionisation gauge, instead of increasing, declined to 0.01 micron.

The erratic behaviour of tubes, referred to as gassy, is apparently not caused by the gas content of the tube, but by the emission of electrons under the influence of high electric fields that exist at points other than the heated cathode. Sharp corners and points on the tube parts tend to accentuate the voltage gradients; impurities or occluded gas tend to lower the work function of the surface and make it easier for the electrons to escape. Such bursts of electrons by cold emission occur at voltages far less than those calculated to be necessary for their production from pure metals. This phenomenon is not limited to X-ray tubes, but applies to all high-vacuum electronic tubes and is the cause of a large part of the irregularities in such tubes, particularly where the voltage rating is exceeded.

The magnitude of these bursts of electrons was surprisingly large, of the order of several amperes. Inasmuch as the effect was so large in tubes designed especially to avoid them, the possibility presented itself of increasing them by deliberate design to the point where some useful purpose might be served by the sudden flow of large amounts of current.

Early Trials

The first trial was made with a single-point tungsten cathode placed approximately one millimetre from a flat anode, Fig. 1 (a). With this arrangement several thousand amperes could be drawn from a condenser charged to 50,000 volts. Some X-rays were produced, but, in general, the behaviour was erratic. If the point was too close to the anode, an arc was formed that allowed such large currents to pass, that most of the energy was dissipated in the circuit rather than in the tube. As the wire was moved farther back, the peak current diminished and the production of X-rays increased, but the initiation of the discharge became uncontrollable, the tube often refusing to fire. Many shapes and types of material were tried, but the results were much the same in each case.

This difficulty was overcome by the introduction of a third electrode, Fig. 1 (b), spaced close to the cathode and connected to the anode through a high resistance. This electrode served to concentrate a high field at the cathode and initiate the discharge that is then forced by the voltage drop across the high resistance to transfer to the anode. As soon as this auxiliary electrode has performed its job of starting the discharge, it assumes a potential close to that of the cathode, and consequently, if shaped correctly, as in Fig. 1 (c), focusses the electrons on the desired region of the anode. By this arrangement currents of several thousand amperes essential to the production of intense X-ray outputs required for extremely fast radiography, are regularly obtained.

Valve Structure

The tube structure used is illustrated in Fig. 2. The tungsten point is replaced by a small rectangular piece of molybdenum, which acts as the cathode. The auxiliary cathode consists of the through-shaped block, which provides a focussing cup. The sharpened edges of the molybdenum cathodes are located close to the edge of the slot in the auxiliary electrode,

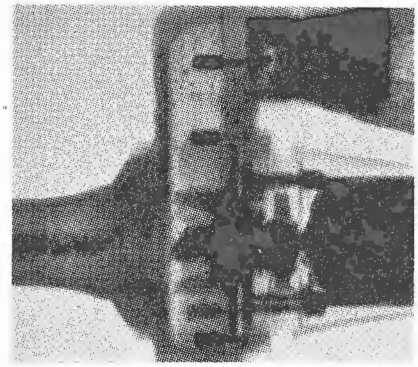


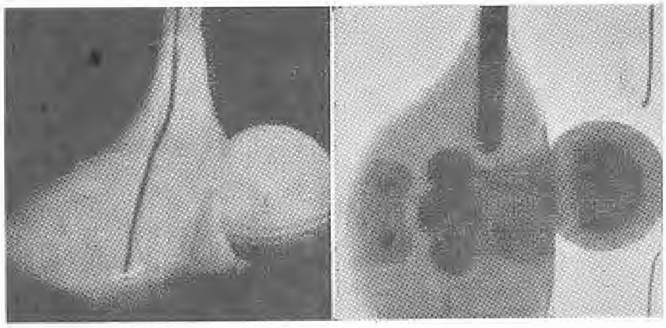
Fig. 6.—The behaviour of components in the interior of rapidly moving machinery can be studied as indicated by this high speed shadowgraph of a vacuum cleaner and dirt particles.

so that the high potential gradient thus obtained is sufficient to initiate a cold-emission discharge. The auxiliary electrode also acts to focus the electron beam so that an approximately rectangular focal spot is produced on the anode.

The target consists of a rectangular slab of tungsten 1 by $1\frac{1}{2}$ x $\frac{1}{8}$ inches thick. Tungsten is desirable because of its relatively high efficiency of X-ray production, as well as its high melting point and good heat conductivity. Although the exposure time is only one microsecond, a large amount of energy is put into the focal spot during this time. Theoretical considerations show that heat conduction plays the major role in dissipating the energy delivered to the focal spot area. Because the amount of heat conducted from this area depends on time and the difference in temperature, the heat-dissipating ability of a focal spot decreases as the exposure time decreases. Thus heat conduction would seem to be quite small for exposure times of one microsecond, such as are considered here. Fortunately, the heat dissipated varies with the square root of the exposure time.

Even calculated on this basis, focal spots far larger than those in use would be necessary to dissipate the energy without vaporisation of the target. However, in practice, while some vaporisation does occur within the small focal areas, several thousand exposures can be made before the deposit of metal on the glass becomes

Fig. 7. — While a high speed light-camera shows what the outside of a golf ball and club look like during impact, the high-speed X-ray picture shows the interior of ball and club.



heavy enough to interfere with the operation of the tube.

These conditions indicate that the focal spot (hence the obtainable definition) cannot be made as fine in a tube operating at these extremely short exposure times as in tubes operating in the conventional manner. However, adequate definition for most purposes is easily obtained and rather fine definition can be secured in one direction by taking the X-rays off the target at or near grazing incidence.

Development of these high currents in the X-ray tube, shown in Fig. 3, requires a large but brief rate of power flow. During the period of peak operation, the amount of power flowing to the tube is of the order of 600,000 killowatts. Its total duration, of course, need be but a few microseconds. Clearly, then, stored energy is demanded. This requirement is fulfilled by a surge generator, such as is commonly used for simulated lightning studies.

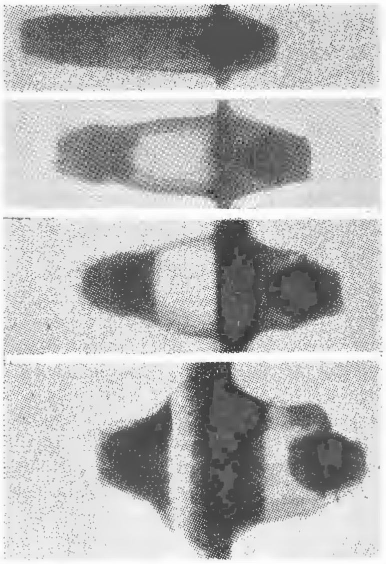


Fig. 8.—From high speed X-ray pictures like these ballistics experts learn many things about projectiles and armour plate.

Circuit Details

The surge generator, built to operate the high-speed X-ray tube, is shown in Fig. 5. Six 0.04 uf condensers are arranged in a Marx circuit substantially as illustrated in Figs. 4 and 5. The exceedingly rapid breakdown of the X-ray tube has permitted closer spacing of the condensers than is normally the case, so that a relatively compact design has been achieved. The condensers have been separated into two groups or levels of three each. Each of the condensers can be charged to a potential of 50 kv, thereby resulting in an output potential of 300 kv across the tube. A stabilising resistor is added across the X-ray tube to facilitate consistent firing. Without this resistor, the surge generator would be feeding into an unknown resistance because of the varying characteristics of the vacuum space within the tube, which is part of the circuit. The condensers are arranged to be charged in parallel through resistance high enough (10,000 ohms), that when they discharge in series through the sphere gaps, no appreciable loss of energy occurs in the resistors.

The first condenser is connected directly to the anode of the X-ray tube. C6 is connected to the cathode of the X-ray tube through a sphere gap. Condenser C3 is grounded and the cans of condensers C2 and C1 are connected to each other through series resistors. The metal cases of C4, C5 and C6 are connected together through resistors and connect to the positive input potential from the high-tension transformer. The three upper gaps are linked together and are adjustable by means of a special micrometer, operable from the front panel of the generator.

The lower two gaps are connected in like fashion, and can be adjusted by a similar micrometer mechanism. The gap on the condenser C3 is made non-adjustable and serves as the triggering gap for the surge generator; that is, the output of the trigger potential transformer is connected between this gap and ground. The high-tension cable is connected to the upper lead of condenser C3 and to the case of condenser C4. The connections between the input potential and the case of C4, and the insulated lead of C3, are made through 100,000 ohm resistors.

When the condensers have been fully charged and the unit is ready to fire, an impulse is sent from the timing unit through the primary of the triggering transformer. This pulse is supplied by condenser C in the timing unit, which, at the appropriate instant, is caused to discharge by removing the negative bias on the grid of thyratron. This is done by closing the switch that connects battery B to the grid of the thyraton.

Triggering Methods

Several means have been used to accomplish this break, such as a bullet cutting a wire and setting off the machine to radiograph itself, or a golf club breaking a swinging contact. In the timing unit furnished with the surge generator, the triggering can be done by either breaking or making a contact and the unit is provided with several resistances and capacities, so that the time interval between actuating the contact and firing the X-ray tube can be chosen to catch the desired phase of the action cycle.

The pulse delivered to the circuit by the secondary of the triggering transformer causes the gap between ground and condenser C3 to break down. When this gap breaks down, the voltage between the gap of condenser C4 and ground rises until the gap on condenser C4 breaks down. This results in immediate discharge of all condensers. The voltage applied across the X-ray tube is then equal to six times the charging voltage on the condensers.

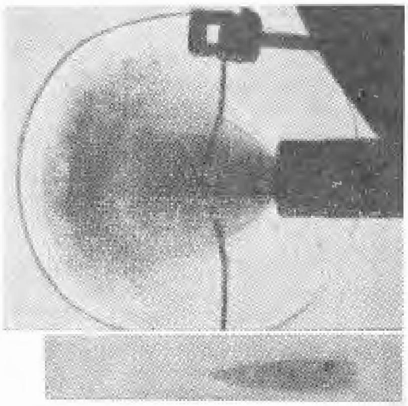


Fig. 9.—A light picture and a high-speed radiograph taken simultaneously of the nozzle blast and the projectile in the gun barrel gives engineers information not heretofore obtainable.

This high voltage is applied directly across the closely-spaced cathode and auxiliary electrode. Electrons are drawn from the cathode, and this initial discharge evolves into a metallic arc between the cathode and auxiliary electrodes that spreads out into the focussing cup and becomes a virtual cathode of apparently unlimited current-carrying capacity. Due to the action of resistance R-M, the discharge transfers to the anode with consequent production of X-rays.

Application of High-Speed Radiography.

The usefulness of the high-speed X-ray in ballistic studies is conspicuous. The engineers at the Frankford Arsenal Laboratory were quick to so use it. The equipment has been used by them to study what happens to a bullet when it strikes a piece of armour, and also what happens to the armour during penetration. Ordinary photographic methods, including high-speed photography, are handicapped because the actual penetration is obscured by luminous fragments thrown back at the time of impact. This difficulty is, of course, avoided in radiography.

(Continued on page 46.)

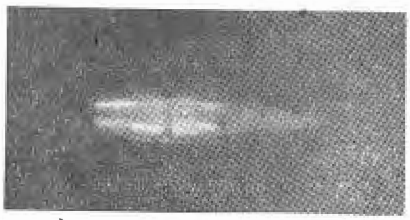


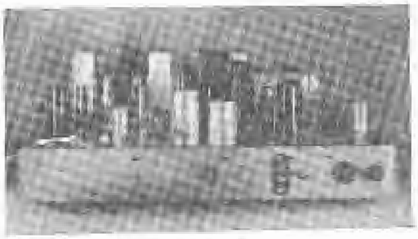
Fig. 10.—To take this light picture of a bullet in flight the X-ray tube was removed and the surge generator discharged across a gap to give an intense but extremely brief light.

A Technical Survey of Latest Overseas Developments

"INTER-CARRIER" TELEVISION SYSTEM

A recent development in the television field may be the means of making such entertainment available to many more homes in the future. The new system is known as the *Inter-carrier* system, and may point to the production of a less expensive type of television receiver.

A comparison between the conventional and "inter-carrier" systems is shown in Figure 1. The conventional receiver splits the IF into sound and video sections right at the mixer circuit. The IF carriers are then detected and amplified separately. In the case of the inter-carrier system, illustrated in the bottom diagram of Figure 1, the action is as follows:—



A receiver employing the new system.

(1) The incoming television signal is heterodyned as usual, producing sound and video IF carriers.

(2) The combination of sound and video IF carriers is amplified as a unit in the IF amplifier.

(3) The video signal is then detected and amplified as usual. It is then fed to the CR tube.

(4) The video IF carrier and the sound IF carrier *mix* at the second detector and produce 4.5 mc beat carrier. This beat carrier has the 25 kc FM deviation of the sound signal.

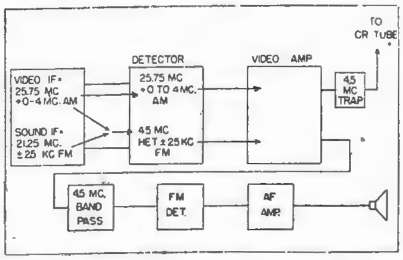


Fig. 2.—Operation of the "Intercarrier" television system.

(5) This 4.5 mc FM beat is amplified in the video amplifier. It is then detected in a discriminator and passed through the AF amplifier to the speaker. These operations are illustrated in Figure 2. The system thus eliminates the need for a sound IF channel and, in addition, the receiver is less affected by oscillator drift, since the sound frequencies will not normally move out of the wide video band pass.

As a result the system makes possible lower cost television receivers at only a slight sacrifice of resolution and adjacent channel rejection. It may therefore eventually be adopted for all cheaper television sets.

However, before this system can be fully employed commercially, it will be necessary to amend the present standards for television transmission to insure that the video carrier does not fall below a minimum value during transmission.

—Courtesy, "Radio Maintenance."

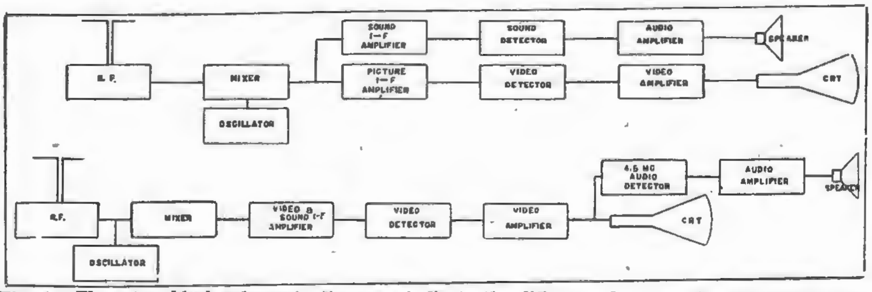
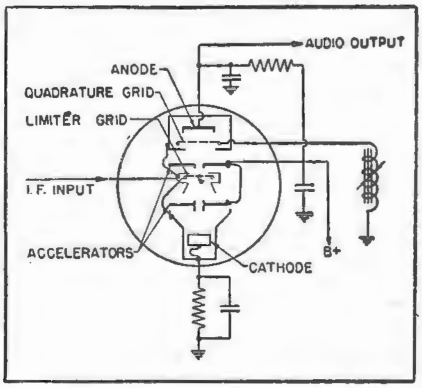


Fig. 1.—These two block schematic diagrams indicate the difference between the conventional and "Inter-carrier television system.

NEW FM DETECTOR TUBE

A new type of FM detector tube which affords instantaneous limiting and the use of a single circuit discriminator has been developed. Known as the *gated-beam limiter tube,* it has an additional grid which is tuned to the signal frequency and driven by space-charge coupling with audio output produced on the final anode.

In use an i-f signal, between one and perhaps 50 volts is applied to the limiter grid; for one half of each cycle, the electron beam is passed and projected upon the quadrature grid. The periodic variation of the space charge in front of this grid produces about 5 volts across the resonant circuit connected to it.



The Adler FM Detector Tube.

The quadrature grid clips the leading portion from each half-cycle pulse and passes on to the anode periodic pulses of about one-quarter cycle length. Modulation of the signal frequency affects the phase displacement between the half-cycle electron stream and the voltage produced on the quadrature grid; correspondingly, the length of the anode current pulses varies. Across the plate load resistor, a voltage drop appears which is proportional to this pulse length, and therefore a function of the original modulation.

The audio output so produced is about equivalent to the output from a Seeley-Foster discriminator. The required i-f input is similar to that needed for a grid-bias limiter.

—Courtesy "Service."

NEWSBRIEFS

According to recently published figures, there were, at the end of last year, 356 FM stations in operation in the U.S. The production of F.M. receivers last year accounted for seven per cent. of the industry's output. The figures were; AM sets, 16,324,002; FM, 1,175,104 and television, 178,571.

☆ ☆ ☆

Shortwave heating and blasts of dry air are now being used to kill the larva inside silkworm cocoons. This new method, it is claimed, produces a silk as tough and durable as synthetic fibres, as it avoids the intense heat usual with the older method.

☆ ☆ ☆

The FCC announces that at the end of 1947 there were 17 television stations operating in the United States. Permission has been granted for a further 55 to be constructed, and applications for another 84 were pending. The industry produced 178,571 television receivers, which was about one per cent. of its total output of sets.

☆ ☆ ☆

The world's longest phototelegraph circuit between London and Wellington was recently opened. All pictures are relayed via Colombo.

☆ ☆ ☆

Conventional tubes such as 6V6's were recently found capable of generating substantial powers on microwaves. The excessive transit time and grid conductance problems appear to have been overcome by a unique waveguide-tube system with the transit time between cathode and plate made to correspond to some multiple of 360 deg. phase shift.

☆ ☆ ☆

According to figures issued by the International Broadcasting Organisation there were 344 medium and long wave broadcasting stations operating in Europe at the end of last year.

☆ ☆ ☆

A radar system designed for the complete control of a port was recently installed at Douglas, Ise of Man. During summer months when there is normally heavy holiday traffic the port is subject to sudden fog, and the radar system will enable shipping to be worked safely in and out of the port under the most unfavourable weather conditions. The equipment operates on a wave-length of 3 cm., pulse width is 0.2 used with a peak power of 22-30 kW, and the recurrence frequency is 200 c/s. Three ranges are provided, the maximum being about 3 miles and the others 1.2 and 0.8 miles. On the shorter ranges the ship can be brought right into the harbour.

☆ ☆ ☆

Four new broadcasting stations have been opened in India during the past few months bringing the number of medium-wave stations operated by All-India Radio to nine. The new stations are:— Jullunder (1,333 kc), Cuttack (1,355 kc), Patna (1,131 kc) and Amritsar (1,305 kc).

☆ ☆ ☆

A radar proof container for air shipment of photoflash bulbs has been recently developed. This new container is intended to protect the bulbs from accidental ignition by radar, which can happen under certain conditions. The new canister resembles containers used to hold perishable food.

☆ ☆ ☆

Snowstorm—a type of television interference that produces streaking on the television screen and commonly produced by ignition interference has been found to be caused by the sun. Engineers of the BBC suspected the sun while they were tracing the cause of a brief but particularly violent snowstorm. A check with records of solar noises confirmed their suspicions.

☆ ☆ ☆

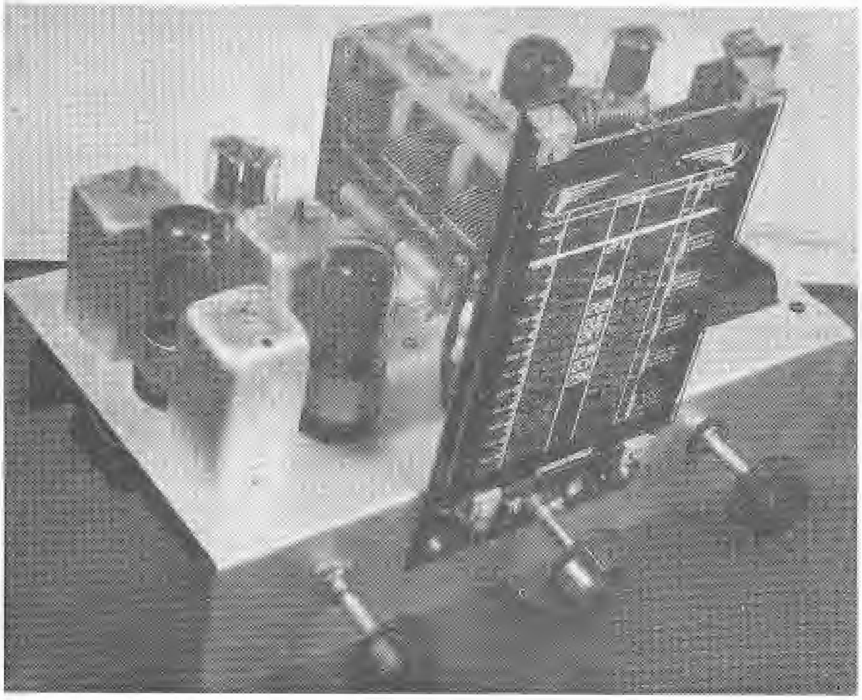
Two radar mirrors, about 25 feet in diameter are being used by the NBS to study cosmic and solar noise. Recent advances in design for very-high and ultra-high receivers, which practically eliminate internal set noise indicate that limiting factors will be those arising from natural phenomena. Atmospheric radio noise—like that from a lightning discharge ceases to be a major problem about 15 mc., but it is at this frequency that cosmic noise becomes noticeable as a low steady hiss. Even FM suffers from this interference. The giant reflectors will assist in the observation by intercepting and recording solar noise reaching the earth. Automatically controlled mirrors will be directed at the sun constantly throughout the day and will be used initially for the 480-500 megacycle band.

☆ ☆ ☆

One of the most ambitious projects yet suggested for extending the range of television has been announced in the U.S.A. It is proposed to erect a tower, 2,650 feet, over half a mile—high in the vicinity of New York, and to install at the top of a number of transmitters. The estimated coverage would extend over the whole of Long Island, most of New Jersey, and parts of Connecticut and Pennsylvania.

T.R.F. Tuning Unit

With Amplified A.V.C.



A front view of the completed tuner. The three controls are volume, tuning and switch.

SPECIAL FEATURES.

- ★ Can be used as Tuner or complete Receiver.
- ★ Infinite Impedance detector ensures minimum distortion.
- ★ Separate A.V.C. amplifier section.

This broadcast tuning unit should interest those who intend to construct, or already possess better than average equipment designed for pickup work and require a tuning unit capable of delivering a signal in keeping with their equipment.

As little mention is made of T.R.F. Receivers in these days of superheterodynes, the reader may well wonder the reason for describing such a tuner unit. Whilst at this stage it is not possible to deal with the *pros and cons* of such a question, the following brief remarks may be useful.

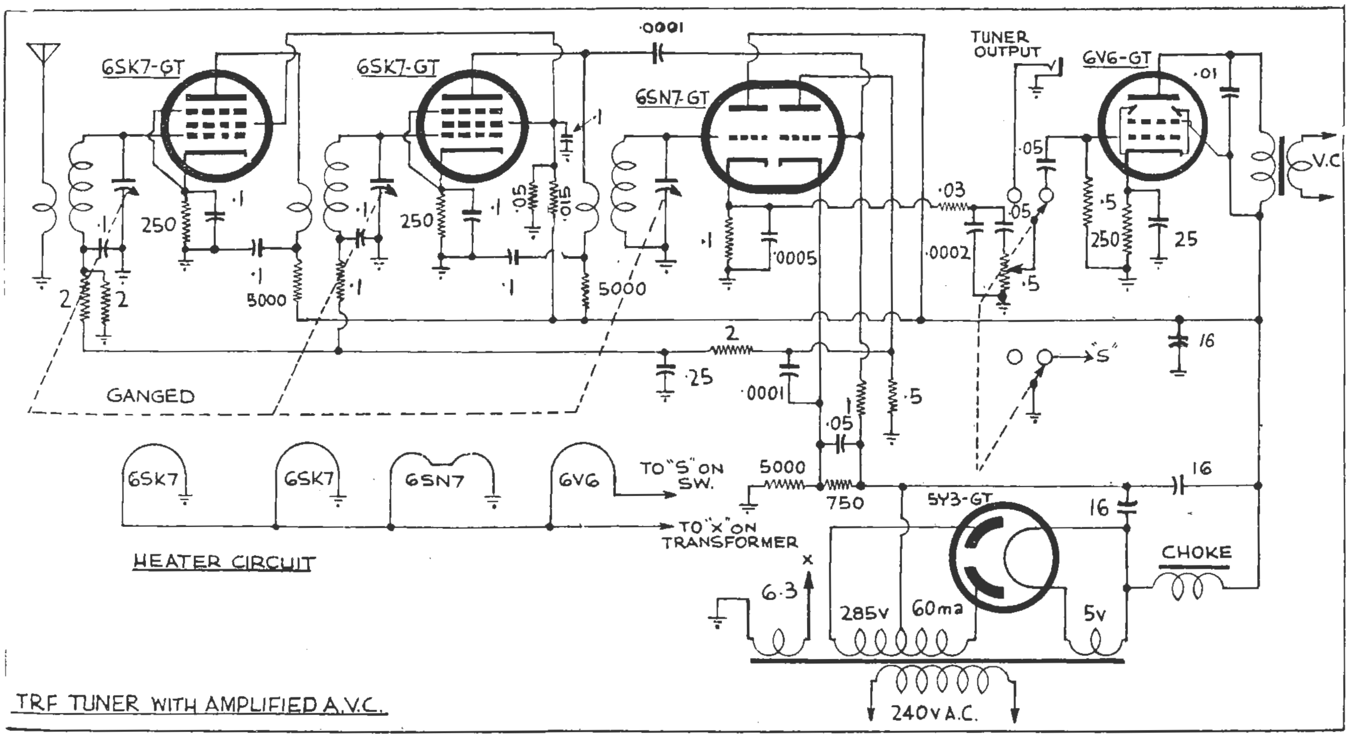
The average superhet. receiver now in general use has good sensitivity and selectivity. To achieve this at a low cost, usually a single stage of high gain I.F. amplification is used, and this necessitates the I.F. transformers being well designed and possessing a high "Q" (or magnification) factor.

Such a circuit, when properely aligned, has a sharp response curve, covering only a narrow frequency band. This resul s in the attenuation of those side bands carrying the high modulation frequencies with consequent lack of brilliance in the output signal.

On the other hand, the tuned circuits of T.R.F. type receivers have a much broader response, resulting in more of the modulation frequencies being passed without attenuation. In other words, the "frequency distortion" is less than the average superhetrodyne.

It should be mentioned that whilst it is possible to arrange for a superhetrodyne to have a *wide band pass,* this usually calls for special I.F. transformers, and alignment procedures, all of which add to the cost of the finished receiver. As a consequence the arrangement has not been used to any grea. extent in this country.

To gain this wide response in the T.R.F. receiver, it is necessary to sacrifice both gain and selectivity. Whilst both these factors have been overcome to some extent by the two tuned R.F. stages, and the use of modern iron core coils, the results will not be comparable to a superhet. receiver. However, in most localities you should be able to receive the main local stations and perhaps a few of the major interstate stations.



The circuit is quite straightforward and should present no difficulty. The main feature of the circuit is the 6SN7-GT used as the combined infinite impedance detector and AVC control.

The Circuit

The circuit uses the latest GT series of single-ended valves—two 6SK7-GT for the r-f amplifiers, a 6SN7-GT as combined detector and AVC control, a 6V6-GT output valve, and a 5Y3-GT rectifier. The r-f amplifiers, being variable-mu type valves, are AVC-controlled and, in the interests of stability, each is provided with a separate cathode bias system. A common screen voltage divider network is provided by means of the 0.015 and 0.05 meg resistor network.

A 6SN7-GT is a twin triode type, and in this case one section has been used as an infinite impedance detector and the second half as a biased triode AVC amplifier. As this valve is actually the feature of this circuit, it will be discussed in some detail further on in this article. The 6V6-GT and 5Y3-GT are both used in a standard manner and consequently call for little comment.

Output Valve Optional

At the outset is was decided to provide the tuner with a self-contained power supply, thus obviating any additional drain on the amplifier to which it was connected. With this view in mind it was considered desirable to slightly increase the cost and make the unit more versatile by adding an output valve. This arrangement, which is optional, works out very nicely, as it allows the main amplifier to be switched off when local programmes are only required at low volume, and consequently the listener is then provided with a complete low cost, but efficient TRF receiver.

For this change a two-pole, two-circuit switch is used and connected so that in one position the a-f output from the detector is fed to the output jack and thence to whatever amplifier unit is being used. Simultaneously the heater circuit for the 6V6-GT is opened, making this valve inoperative. In the position 2, the tuner output is taken direct to the grid of the 6V6-GT, and at the same time the heater circuit for this valve is completed and the unit functions as a normal TRF receiver.

In cases where it may be desirable to use this arrangement as a complete receiver, the output jack can be dispensed with and a 2-pole 2-circuit switch replaced with a 50,000-ohm potentiometer connected in series with a 0.05 mfd condenser to provide a tone control. This series combination is connected between the plate and screen of the 6V6-GT in place of the present 0.01 mfd condenser.

PARTS LIST

1 Chassis
1 3 gang tuning condenser
1 Power Transformer 60 ma., 285V HT, 6.3v @ 3 amps, 5v @ 2 amps
1 Aerial Coil, 2 R.F. Coils (iron core)
1 Filter Choke (6/60)
1 Tuning dial

RESISTORS

3 2 meg ½ watt
1 1 meg ½ watt
2 .5 meg ½ watt
2 .1 meg ½ watt
1 .05 meg 1 watt
1 .03 meg ½ watt
1 .015 meg 2 watt
2 5000 ohm ½ watt
1 5000 ohm 1 watt
1 750 ohm ½ watt
3 250 ohm ½ watt
1 .5 meg potentiometer

CONDENSERS

2 16 mfd Electrolytic 525v
1 8 mfd Electrolytic 525v
1 25 mfd Electrolytic
1 .25 mfd tubular condenser
7 .1 mfd tubulor condensers
3 .05 mfd tubular condensers
1 .01 mfd tubular condensers
1 .0005 mfd mica condensers
1 .0002 mfd mica
2 .0001 mfd mica

VALVES

2 6SK7-GT, 1 6SN7-GT, 1 6V6-GT, 1 5Y3-GT

SUNDRIES

6 octal sockets, 1 2 pole 2 position switch, 1 phone jack, 3 banana plugs and sockets, 3 knobs, anchor strips, nuts and bolts, solder lugs, grommet, hookup wire, etc.

Detector Circuit.

The problems of detection are many and complicated, and it is beyond the scope of this article to discuss them in any detail. At the present time, probably the most widely-used form of detection is the diode detector. High efficiency is possible with this circuit, providing there is a large input voltage, and if the RC circuit of the diode is not shunted to any appreciable extent, then large output with low distortion can be obtained.

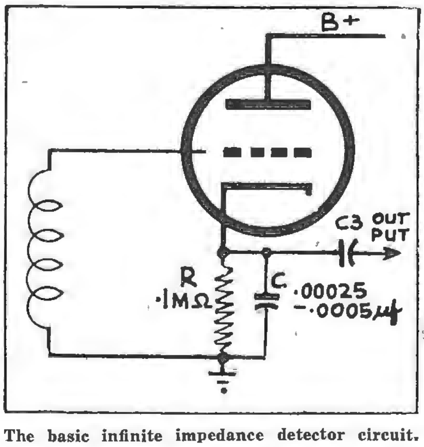
While the necessary high input voltage is usually obtainable under normal conditions, the elimination of the AC shunting on the diode load is not so readily overcome. This means that distortion is frequently introduced, especially with high percentages of modulation. Furthermore, considerable damping occurs on the tuned circuit supplying the diode, with consequent reduction in sensitivity and selectiity.

One means of eliminating these faults is by the use of a system commonly referred to as an *infinite impedance detector*—and which has been incorporated in this particular circuit. Possibly the only disadvantage with this form of detector is that there is no means for obtaining a negative AVC voltage, and despite the advantages to be gained by its use, this is possibly a factor which has prevented to its more widespread use.

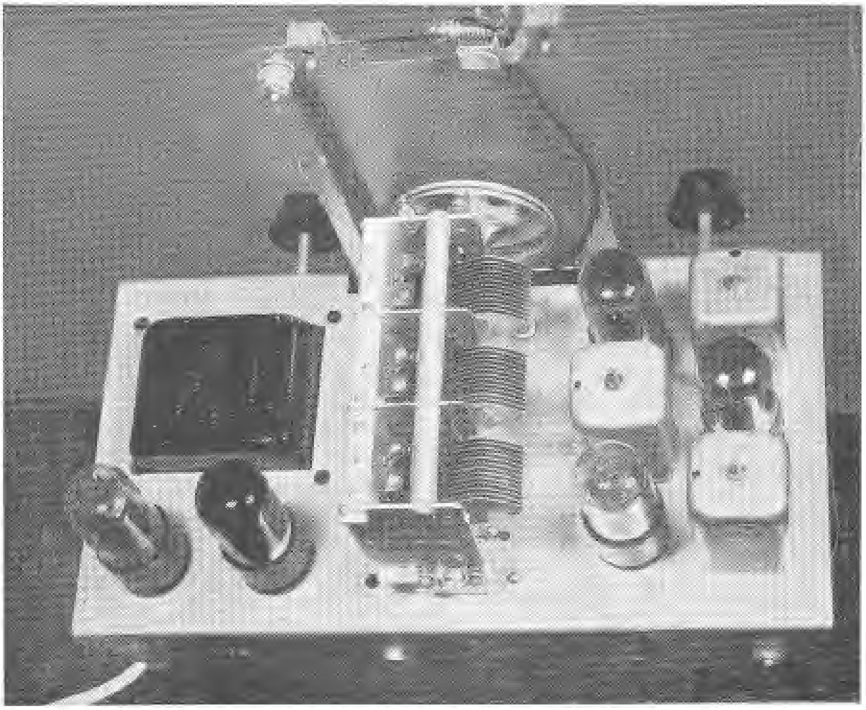
However, by using a twin triode, such as the 6SN7-GT, ECC-32, 6F8 and similar type, it is possible to use one triode section as the detector and the second half as an amplified AVC control, without the necessity of additional valves. This arrangement constitutes the circuit presented and has resulted in a tuner (or receiver) possessing excellent characteristics.

Mode of Operation.

The infinite impedance detector is almost perfectly linear and may be regarded as a plate or anode bend type of detector



The basic infinite impedance detector circuit.



This photograph clearly shows the chassis layout.

with negative feed-back. For clarity, this section of the circuit is shown in Figure 1, and its mode of operation is briefly as follows:——

The valve is self-biased to practically cut-off by the resistor R. This resistor is, in turn, shunted by the condenser C, whose value is such that it presents a very small impedance to the carrier and side-band frequencies, but a large impedance to the actual modulation frequencies.

When the r-f signal is applied to the grid, plate current increases on the positive half-cycles of the carrier and rectification results, as in the plate detector. Because of the high impedance offered by C to the modulation frequencies, the condenser C becomes charged to a value only slightly less than the amplitude of the modulation envelope. The effective bias on the valve is therefore varying in accordance with the instantaneous amplitude of the carrier, and increases as the carrier amplitude increases. This is, in effect, a type of negative feed-back which tends to straighten the characteristic curve of the valve, thus considerably reducing distortion.

For the distortion to be reduced to a minimum, a fairly large carrier voltage is desirable (about 10v) as in the case with conventional receivers. Although no gain is available from a valve being used as an infinite impedance detector—this being sacrificed to obtain low distortion—it will be found that the output is more than enough to load the 6V6-GT, and should be sufficient in most cases for driving any amplifier.

Since the circuit draws no power from the grid circuit, it presents an almost infinite input impedance to the tuned circuit feeding the grid. This fact is most desirable, as it enables the maximum sensitivity and selectivity to be maintained in this stage—a very important point in the case of TRF receivers.

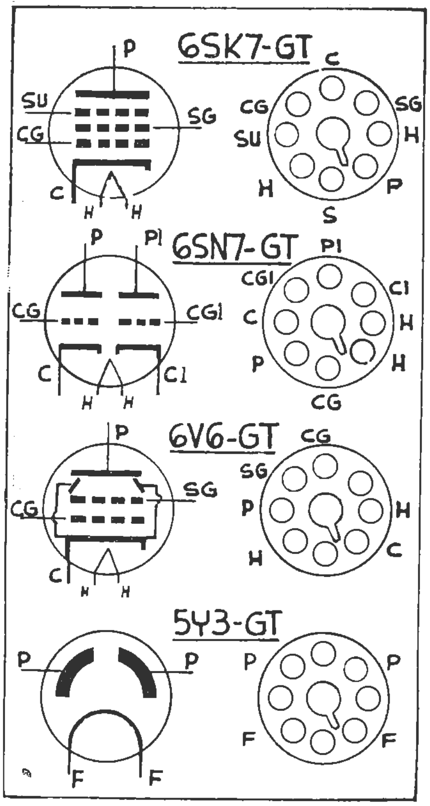
Automatic Volume Control.

To maintain the input signal to the detector at an optimum value, and yet prevent the signal from reaching such a magnitude that overloading occurs, it is both desirable and necessary to incorporate AVC in the circuit.

As previously pointed out, the infinite impedance detector has no provision for providing a negative voltage suitable for AVC application, and for this reason the twin triode 6SN7-GT has been used. In this circuit the problem is to obtain a voltage from the output of the AVC triode which is negative with respect to the grids of the controlled r-f stages. The most logical method of doing this is by a system of back-biasing, as shown in the schematic.

Varying A.V.C.

The voltage across the 750-ohm resistor is the bias on the AVC triode, and as such represents the delay voltage. With the values chosen, the output of the unit



Here are the valve socket connections. In each case the socket is viewed from the bottom.

can be maintained constant on all local stations. If desired, the two resistors—5,000 ohms and 750 ohms, can be replaced with a wire wound potentiometer of about 5,000 ohms, connecting the cathode return line from the 6SN7 AVC amplifier to the moving arm. This arrangement will then allow a great variation to be made in the AVC characteristics.

Due to the large voltages developed with powerful signals, it is desirable to apply only portion of the total available AVC voltage to the first RF stage. This is done by connecting the two 1-meg resistors in the form of a voltage divider network, as shown. With this arrangement, approximately half the AVC voltage is applied to this valve.

Output Valve and Power Supply

As the power amplifier valve is in no way dependent on the RF section, except for driving voltage, this stage can be considered as being independent of the rest of the circuit. Normal cathode bias is used, this giving approximately -12-volt bias for a plate and screen voltage of 250 volts.

The power supply is a conventional arrangement, using a 60 ma 285 v high-tension power transformer. Due to the back bias arrangement used, the actual voltage available on the RF plates is approximately 170 volts. However, it will be found that this lower plate voltage is no disadvantage, as ample gain is still available. In the case of using a dynamic speaker with a 2,500-ohm field coil, the field can replace the filter choke shown, and then it will be necessary to replace the transformer with one having a 385V secondary.

Layout and Construction.

To reduce the possibility of instability, the layout shown should be followed as closely as possible. This has been worked out to keep the plate and grid lead as short as possible. In this regard it is necessary to ensure the orientation of the coil lugs is correct, so as to enable these short leads to be accomplished. The aerial lead should be run along the edge of the chassis to prevent any pick-up from the second RF stage. The grid leads to the tuning gang should be kept direct and lie flat along the chassis.

To prevent any coupling between stages by common r-f earth leads, all appropriate r-f by-pass condensers should be returned to a common earth point. This includes the by-pass condensers in the decoupling network in the high-tension leads to the RF transformers. In some cases it may be found that the two 5,000-ohm decoupling resistors and associate condensers can be dispensed with, but this can only be reliably ascertained by experiment.

The construction is quite straightforward and should present little difficulty. Most of the details can be easily followed by referring to the photographs and, in addition, the complete chassis layout is given for those who may wish to duplicate to original unit.

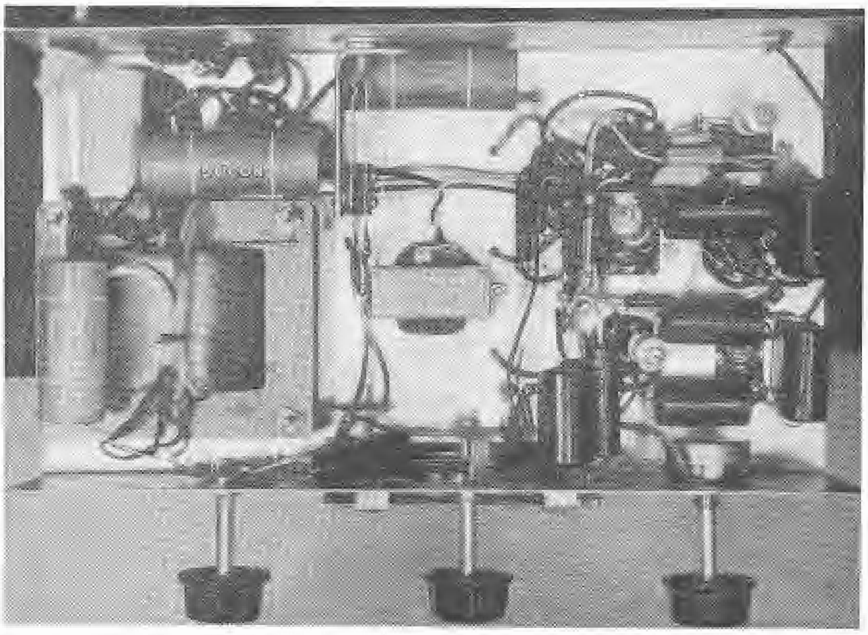
Alignment.

The alignment of this tuner should present no difficulty, and is carried out by adjusting the small trimmer condensers connected across the main gang sections.

Unscrew all trimmers to approximately a half-way position and tune in a station at the low frequency end of the band. Set the dial pointer to the correct station position on the dial and peak each stage by adjusting the iron cores in the coils.

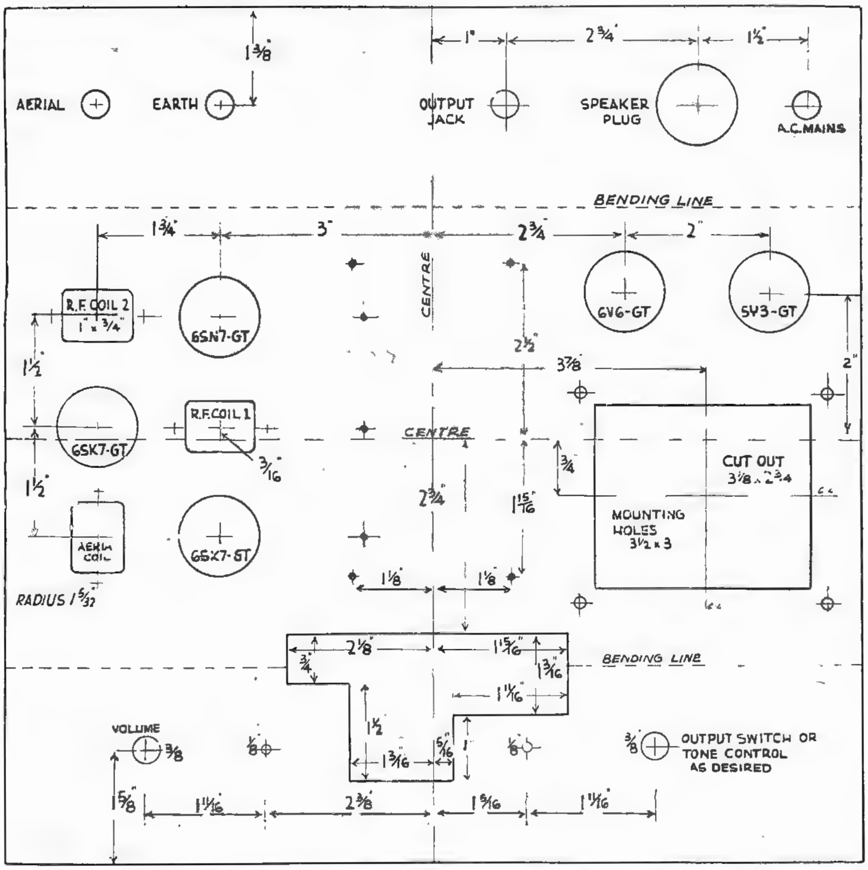
Next tune a station on the high frequency end of the band, check the dial calibrations and peak each trimmer condenser for maximum output. The stations should now fall in their correct position on the dial, providing the dial has been calibrated for the particular tuning condenser being used.

In conclusion, this tuner will be found to be an excellent adjunct to any amplifier system, as it possesses ample gain, selectivity and output on all local stations.



Use this underneath photograph as a guide to the component layout when wiring up.

★ CHASSIS DETAILS ★



This diagram gives the complete chassis details.

DID YOU MISS THESE ARTICLES?

FEBRUARY, 1948.
- Build the Miniminor Portable.
- Can you Read Circuit Diagrams?
- Low Cost Amplifier.
- The ABC of Frequency Modulation.
- Speaker Network Design Data.

MARCH, 1948.
- The Miniminor AC Mantel.
- UHF Techniques.
- Convert the AR-301 to FM.
- A Two-Valve Tuner Unit.
- An Abac for Designing Resistors.

APRIL, 1948.
- High Frequency Heating.
- Dual Purpose Amplifier.
- F.M. Antennas.
- A Versatile Signal Tracer.

Copies of the above issues are still available, and can be obtained by writing direct to the Subscription Department, Box 5047, G.P.O., Sydney. The price in each case is 1/-, post free.

ILLEGAL TRANSMITTERS

By ROTH JONES, VK3BG

In this special article, our Melbourne correspondent, who is an active amateur, discusses the problems as well as possible dangers arising from the indiscriminate sales of ex-service transmitting equipment.

Recently in Melbourne an unlicensed radio station transmitted political propaganda on the broadcast band. As to be expected, it caused quite a consternation; newspapers splashed the story on front pages and the Postmaster-General's Department set a trap for the *pirate.*

From the quality of the transmitter signal, there seemed little doubt that a former Service transmitter, purchased through the Disposals Commission, was being used. Although the Postmaster-General (Senator Cameron) was the first to criticise the *pirate,* his Government should never have allowed former Service transmitters to reach the hands of unlicensed people.

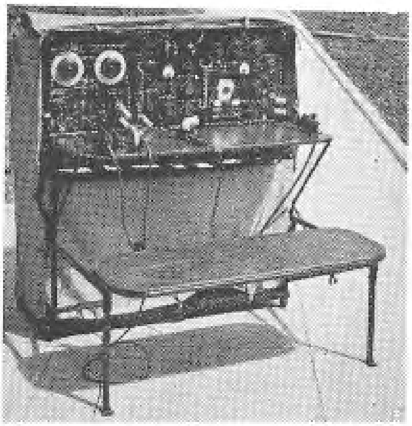
W.I.A. Protests

Despite strong protests from the Federal Executive of the Wireless Institute of Australia—supreme governing body of amateur radio in Australia—the Commonwealth Government allowed the sale of these transmitters to any person possessing the finance. No questions are asked when a purchase is made, and the name of the buyer is never taken. Once the transmitter leaves the Disposals Store, it has been "lost" from official record.

From the Government's point of view it was a quick cash turnover and a ready means of disposing of surplus equipment. This easy profit, however, might not be considered so easy should this country be again involved in war.

Throughout Australia's capital cities and many larger country towns, former Army and R.A.A.F. transmitters can be purchased from prices varying from £5 to £50. In some cases many have never been used, whilst others have seen little service—with the addition of a battery and an aerial, they are on the air.

One particular Army transmitter—at present selling for £12—needs only a 12 or 24-volt battery and an aerial, and it is on the air with 25 watts of C.W. or 12 watts of phone—sufficient power to be heard in any part of the world under favourable conditions. It can be carried like a suit case, and only weighs 30-lb. With little modification, it could be placed on the broadcast band and jam commercial and national stations.



A typical high power transmitter now being sold through Government disposal sources.

WARNING ! !

(In the Melbourne District Court on May 27 Ricardo Blackburn, 30, Redesdale-road, Ivanhoe, was fined £30 with £5/5/- costs and a £140 transmitter confiscated for jamming Melbourne commercial stations on May 2.)

What better set could there be for operation by an underground station during war-time? It could be stored quickly, yet would always be available for communication within the minimum of time.

Many of the sets also have a small five-valve superhetrodyne enclosed in the case. It operates from the same battery voltage and has excellent sensitivity and selectivity. This, too, is even more suited for under-ground work with the whole outfit self-contained in less than one cubic foot. Yours for £12 and no questions asked.

Others for sale—although only in a minority—are high-powered quarter-kilowatt transmitters previously used by the R.A.A.F. for point-to-point duty. These, too, could be a danger to the community in time of an emergency, were they in the wrong hands.

Many Purchases Legitimate

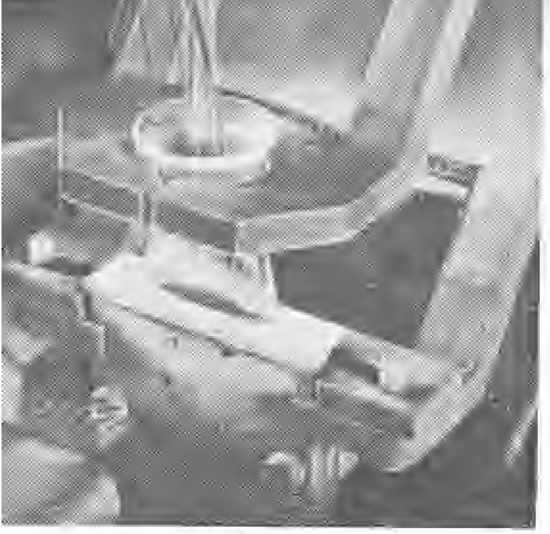
Although many of the equipment purchasers have been licensed radio amateurs who bought the gear through the Wireless Institute of Australia, a large number were young men, keen on radio, yet with no desire of ever sitting for the special examination necessary to gain the amateur radio licence. Some are known to be using equipment for communication amongst themselves on frequencies not always in the amateur bands. This in itself is illegal, offenders being liable for a £500 fine or five years' imprisonment.

Now that the equipment is privately-owned, the Government has no power to recall it, except possibly in an emergency. But even then it would not know where it was! There are many ways of facing the problem. Probably the most logical step would be for the Government to bring down legislation making it necessary for all owners of transmitting equipment to register their names with the P.M.G. Department.

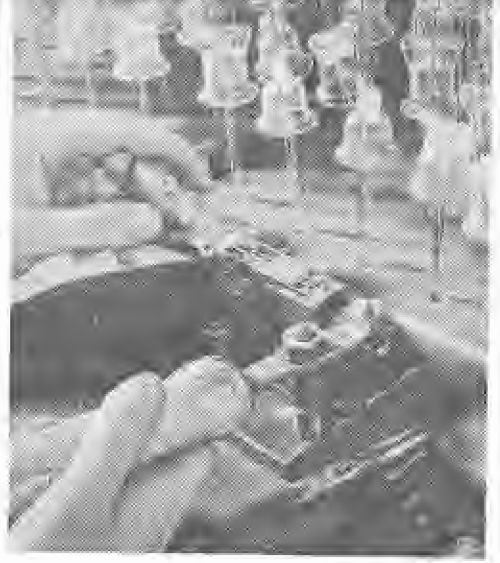
This same legislation could also make it law for disposals and other radio stores to obtain the name and address of all purchases of transmitting equipment. On routine visits radio inspectors could check this equipment to ensure it was not being used illegally. In time of a national emergency, it could easily be recalled, such as the P.M.G. did with all amateur radio gear in 1939-40.

IN THE AUGUST ISSUE.

Another exclusive amateur radio achievement from Roth Jones:—Amateur Radio's Bid for World Peace—K2UN's Challenge to the World.

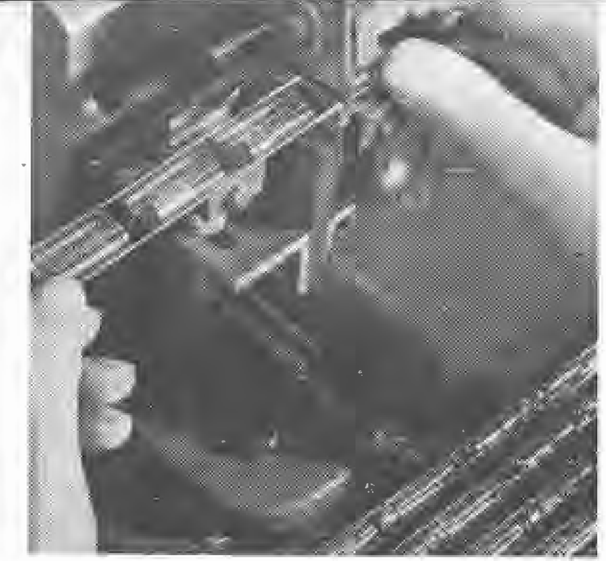


(A) A partially formed "foot" glows "white hot" between two gas jets during its journey around the machine.



(B) Bending the mounting wires to the correct shape.

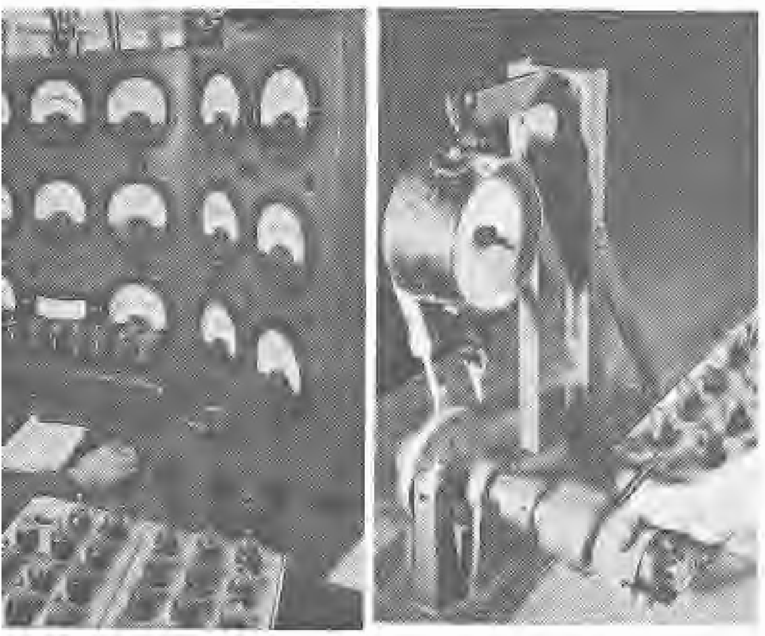
(C) A grid bar emerging from the "head" of the grid making machine.



(D) Cutting the grid bars to the correct length.

(E) Checking the circumference of a grid in a standard gauge.

(F) Spot welding the various elements into position.



(M) Two of the many laboratory tests. (a) checking the characteristics of the valves and (b) testing security of the base cement.

A MODERN MIRACLE

The manufacture of a valve involves such a complex series of operations that the basic processes of making and preparing bulbs, grids, anodes, mica discs, "feet", etc., are carried out concurrently. Some of these major operation are depicted in this series of photographs.

"Foot-making" is actually the fundamental step, as it is on this finished "foot" or valve flange, that the various electrodes are mounted prior to the ultimate "sealing-in" process. The "feet" are assembled mechanically from glass flanges, pieces of glass tubing and lengths of wire. (A).

After the wires have been sealed into the glass "feet" they are then bent to the correct angles to accommodate the various electrodes (B).

Simultaneously other components are being manufactured—one of the most interesting being that of grid construction. This is carried out by automatic machines (C) which form the grid spirals by continuously coiling wires of hairlike fineness around several heavier wire supports. After the grid bars have been removed from the machine they are subjected to various finishing processes for thorough cleansing, and are then cut to their correct length (D). Before being ready for mounting on the "feet", the grids undergo a formation process which forms the correct shape and then are tested for the slightest inaccuracy (E).

When the various elements have been formed they are then mounted in the correct order on the preformed "foot"—being held in position by spot welding (F).

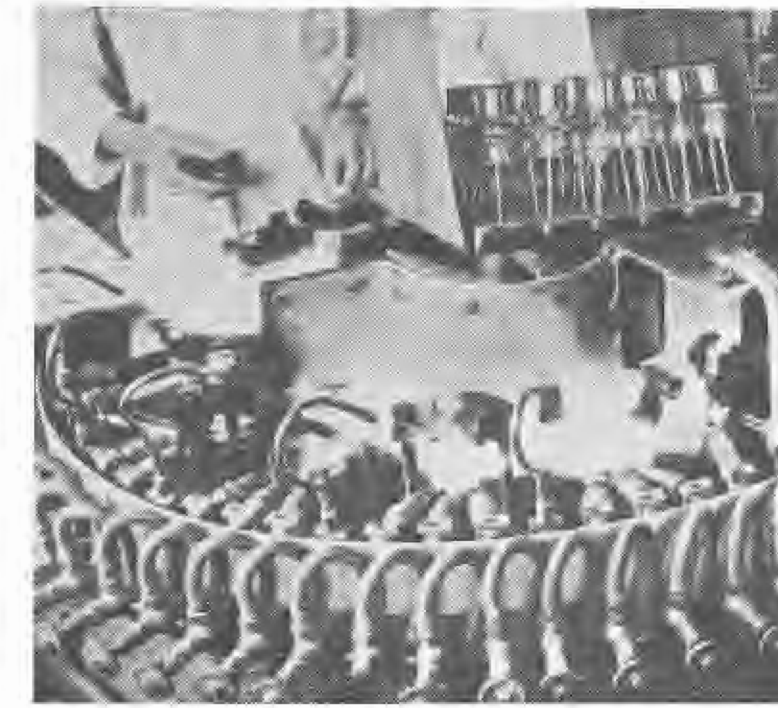
The next stage is the "sealing-in" process. Like that of "foot-making" this is carried out by means of a rotary machine which welds the bulb to the valve flange by means of gas jets (G & H). Each valve passes around the machine on its own revolving carrier so that the heat is evenly applied. At the last set of jets the superfluous glass is cut off and the flange and bulb are securely welded together.

The valve then passes on to the air-exhausting machine (I). This operates on the mercury pump principle and exhausts the air from the bulb through the tubular glass stem incorporated in the "foot-making" process. At the same time the machine carries out degassing of the metal parts of the valve by means of eddy currents and activation of the cathode. All residues of gas are thus expelled from the various electrodes—the heat eventually explodes the "getter" and this removes all traces of the gas from inside the valve.

Following the "sealing-in" process the next procedure is that of attaching the bases to the otherwise completed valves. A ring of cement is placed around the inside of the base, the various leads are inserted in their correct base pins, and then the cement is baked—to ensure the base adheres firmly to the bulb—by passing the valve through a series of thin gas jets incorporated in the rotary machine (K).

On completion the valves are then placed on an ageing rack for a fixed time to reduce gas and improve emission. After leaving the ageing rack the valves are complete in every respect as far as actual manufacture is concerned. They now undergo a series of tests up to 35—to ensure their characteristics and actual receiver performance are up to standard. In the typical testing line shown (L) tests for noise, emission, saturation, short circuits and insulation checks are carried out.

Photographs and technical data made available through courtesy Phillips Electrical Industries Ltd., Sydney.

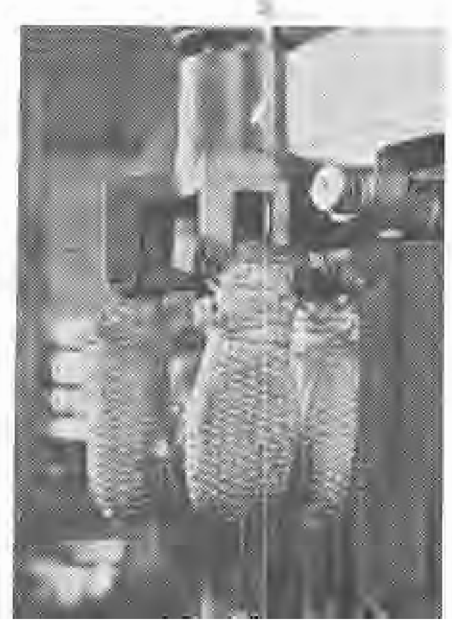


(G) The "sealing-in" machine.

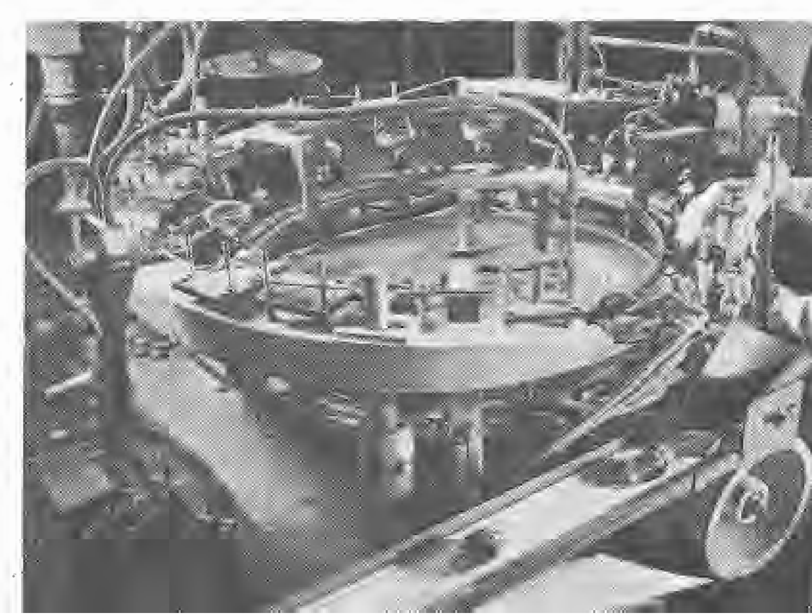
RADIO SCIENCE, July, 1948

(L) A typical testing line where many production checks are carried out.

(K) The capping mill where the base is baked onto the glass bulb.



(J) The mechanical hand which lifts the valves off the machine in (I) and places them on the conveyor belt.



(I) The "sealed-in" valves passing around the exhausting machine.

(H) A close-up of the "sealing-in" machine showing the valves passing through the gas jets.

RADIO SCIENCE QUIZ

This month's quiz is of a simpler nature than those previously set, and is mainly intended to test the "Beginners'" general radio knowledge. To obtain your score take ten points for each question correctly answered and only five points if half right.

As a guide to your ability use the following table:—

90% or over	Excellent
75% or over	Very Good
60% or over	Average
50% or under . . .	Poor

Q.1.—In these days of power blackouts, our first question is in somewhat of a topical vein. The term "foot-candles" is the name given to—

(a) Torches carried by the famed Olympic runners.
(b) Units for expressing the brightness of illumination.
(c) Marked candles burned in olden days to measure the passing of time.

Q.2.—Whilst on the subject of lighting, no doubt most readers have seen the photoflood type of lamps used in photographic studios, etc. These lamps have a very high light output rating which is due to—

(a) Mercury vapour in the bulb.
(b) An exceedingly high vacuum produced by mercury pump.
(c) Overloading the filament.

Q.3.—Horseshoe magnets bring back memories of school days, when they were used to attract any nearby metal objects. However, did you know the "like" poles of a magnet will—

(a) Attract each other.
(b) Repel each other.
(c) Neither will attract or repel.

Q.4.—A galvanometer can be converted into a useful ammeter by the simple expedient of adding a—

(a) 1.5v battery.
(b) Condenser.
(c) Shunt.
(d) Buzzer.

Q.5.—Undoubtedly you must have heard of the terms "positive" and "negative" in connection with electricity. Another name for the negatively charged terminal is the—

(a) Anode.
(b) Pentode.
(c) Cathode.
(d) Nematode.

Q.6.—If you have been a recent reader of this magazine, you should have little trouble with the next question. A "geiger-counter" is—

(a) The special refrigerated type counter seen in delicatessen stores.
(b) Indicates the number of revolutions per minute of a rotating shaft.
(c) Measures radiations such as those emitted by radium.
(d) Is a photo-electric cell used to count the number of visitors to exhibitions.

Q.7.—This question may set a few readers thinking although we don't think it will fool very many. A "commutator" is—

(a) A form of electronic accelerator which converts base metals into gold.
(b) A person who signs the reprieve for a condemned criminal.
(c) Transmits electric current between moving and stationary parts of a dynamo and motor.
(d) A person making daily trips between the city and suburbs.

Q.8.—Now for some easy ones to help you gain those few extra points. There are many forms of electricity and the type which reverses its direction many times per second is usually called—

(a) Static electricity.
(b) Alternating current.
(c) Direct current.

Q.9.—Increasing the diameter of an electric wire will—

(a) Increase the resistance in the circuit.
(b) Decrease the resistance in the circuit.
(c) Have no effect on the resistance.

Q.10.—When making soldered connections it is generally advisable to use some form of flux. This flux is necessary because it—

(a) Protects the parts from oxidation.
(b) Lowers the melting point of the solder.
(c) Provides a material that will conduct electricity across the finished joint.

Q.11.—Often a technical article refers to the "grid leak" in a certain piece of equipment. The grid leak is—

(a) Caused by a short circuit which should be located and eliminated.
(b) Used to maintain the grid voltage at the desired average value.
(c) Due to faulty valve construction which allows the electrons to flow in the grid circuit.

Q.12.—Ohm's Law is probably among the most widely used laws these days. This law—

(a) Refers to housing ballots.
(b) Shows the effect of pressure upon the volume of gas.
(c) Sums up in a simple formula the relationship between electric voltage, current and resistance in a circuit.
(d) Refers to the emission factor in valves.

Q.13.—Copper is generally used for electric wires because it is one of the best—

(a) Insulators.
(b) Dielectric.
(c) Conductors.
(d) Shock absorbers.

Q.14.—Passing an electric current through the ground is one of the modern methods employed in—

(a) Making it rain.
(b) Prospecting for minerals.
(c) Guarding citrus orchards from the effects of frost.

Q.15.—No doubt most readers have at some time or another changed or re-wired a "blown" fuse in a house installation. Household fuses are usually rated according to—

(a) Their useful life.
(b) Candle power.
(c) Current rating.
(d) Heat of fusion.

(For answers see page 48.)

TELEVISION STUDIO LIGHTING

Although broadcast television has not yet become established in Australia, the information in this article is an indication of the overseas activity in this comparatively new phase of electronics. It is felt that the details will be of considerable interest to those with an eye to the future in this field.

The quality of a television recording in the studio depends to a high degree upon the lighting in the studio, or rather upon the illumination of the scene to be recorded.

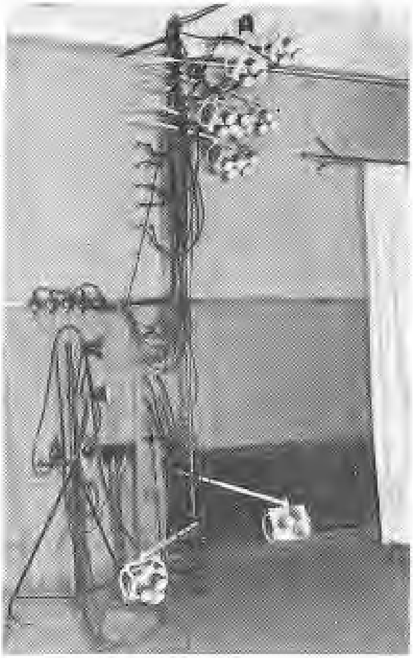
The nature and composition of the light in the television studio is thus of paramount importance. It must be determined, therefore, what colours (or wave-lengths) of the whole of the light spectrum have to be considered particularly for television purposes. The important thing to bear in mind is that the scene in the studio is not recorded by the human eye, but by the eye of the camera.

Eye versus Camera

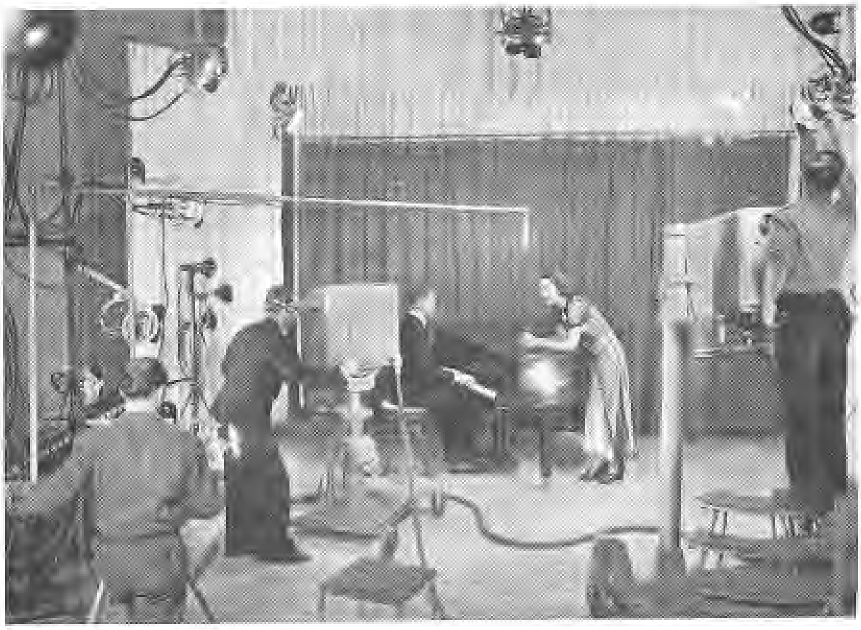
The television camera contains an iconoscope and the sensitivity of the camera is very different from the sensitivity of the eye. While the human eye has a maximum sensitivity for the recording of rays from the yellow-green range of the spectrum, and is very much less sensitive to other colours, the inconoscope prefers a completely different part of the light spectrum. Not what the human eye requires, but what the iconoscope requires with regard to the spectral composition is the important thing for television work.

Before we go deeper into the subject of the particular spectral composition required by the iconoscope, we will say something in general about the illumination of the television studio. It is known that the light and dark patches of the image recorded are converted into electrical impulses, which are further intensified and dealt with in the transmitting apparatus. The greater the amount of light falling on the mosaic screen of the iconoscope, the less the signal has to be intensified. Apart from a good optical system, the first requirement is a large quantity of light coming from the scene. To produce a very bright image on the mosaic screen of the iconoscope, the illumination level of the scene should be at least 500ft. candles and can be up to 1,000-ft. candles, or even more, for the sake of the reflection conditions of the colours of the skin, dresses and scenery.

The second factor is that this large quantity of light impinging on the iconoscope must also be of a special spectral composition.



A battery of water cooled super-high pressure mercury lamps used for illuminating the television studio whilst recording.



A typical studio scene, showing the application of the mercury lamps.

It has been found that for best results illumination for television recording should consist mostly of light from the blue end of the spectrum and radiations from the long-wave part of the ultra-violet range. It does not really matter that the scene thus illuminated gives the human eye the impression of unnatural colours, for—as we have observed already—it is not the human eye which is important here, it is the light sensitivity of the television camera.

Thus it can easily be understood that it is wrong to use incandescent light for the illumination of the television studio. If we look at the composition of incadescent light in connection with the sensitivity of the iconoscope, we find that it does not fulfil requirements, because it contains a good deal of red, but very little blue.

(Continued on page 46.)

A-F AMPLIFIER SERVICING

Sound systems have found such wide application in recent years that the maintenance and repair of this equipment has become a distinct occupation.

Modern amplifiers approximate radio receivers in the number of their circuits and the increasing difficulty with which faulty operation is diagnosed and localised in them. Since, in order to be profitable, an amplifier test must be performed as quickly and completely as possible, and the diagnosis must be precise. The test must be made according to a well-organised, time-saving plan.

This article will describe a procedure for the routine inspection of audio amplifiers in maintenance and trouble shooting. Some of the methods included have been borrowed from laboratory practice, others are common to radio servicing. The steps given below have been selected to disclose most amplifier troubles. The arrangement of tests and their sequence are believed logical for complete diagnosis of amplifier performance, whether trouble is present or not.

Recommended Tests

By sufficient rehearsal of the operation, the sound serviceman should acquire considerable dexterity in the speedy analysis of amplifier operation. The data he collects from the series of tests should enable him to recondition an amplifier completely or appraise its performance. The following are the recommended tests in the order in which they should be made:—

1. **Tube Check.**
2. **A.F. Signal Tracing.**
3. **Static Voltage and Current Measurements.**
4. **Gain Measurement.**
5. **Frequency Response Check.**
6. **Distortion Check.**
7. **Check for Feed-back.**
8. **Impedance Measurement.**
9. **Power Output Measurement.**
10. **Hum and Noise Level Checks.**

The **tube check** (1) is preferably one which gives an indication of some dynamic characteristic (such as trans-conductance or amplification factor), rather than emission. **A.F. Signal tracing** (2) consists of following the progress of an audio signal through the various amplifier stages, noting amplification, reduction, or distortion of the signal in the stages. The **static voltages and currents** (3) are measured at appropriate circuit points, generally directly at the tube socket terminals. A rectifier-type a.c. voltmeter is satisfactory for indicating the heater voltages, but an electronic d.c. voltmeter or potentiometer-type indicator is mandatory for plate and screen voltages. Most of the high-resistance non-electronic meters are totally useless for measurements in resistance-coupled amplifier circuits. The operations numbered from 4 to 10 in the list will now be discussed in detail.

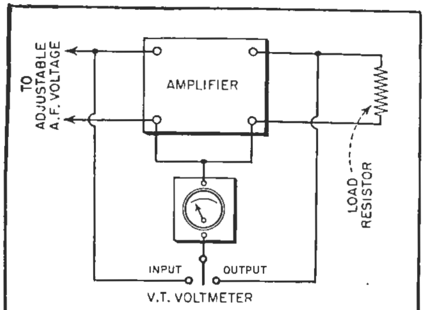


FIG. 1

Gain.

Gain measurements reveal the actual amplification obtained in the entire amplifier or in any of its stages. Both voltage gain and power gain are measurable and are of importance to sound engineers. However, voltage gain is of commonest concern and is generally implied by use of the single word, gain.

Both voltage and power gain are determined by the increase in output signal over input signal. In procedure, the ratio of output voltage or power to input voltage or power is discovered by measurement. There is no name unit for gain, this characteristic being expressed simply as the quotient indicated by the voltage or power ratio. For example, a gain of 10 (or 10 times) corresponds to the ratio 10 : 1, and indicates the amount of amplification in any case where the output voltage or power is ten times the input value. Since this is regardless of the actual magnitudes of the input and output signals, gain is seen to be a relative characteristic.

Determining Voltage Gain

To determine the overall voltage gain of an amplifier, an a.f. voltage is applied to the input terminals of the amplifier and successive readings taken of the voltage impressed across the input circuit and the output voltage developed across the terminating resistance or impedance. Voltage measurements are made with a vacuum-tube voltmeter in a circuit similar to those of Figures 1 and 2. The ratio of the two voltages is the overall gain. However, most amplifier manufacturers state overall gain as the number of decibels corresponding to this ratio.

It is advisable to make overall gain measurements with all volume controls set at maximum volume and to adjust the voltage of the input signal to deliver an output voltage corresponding to the rated amplifier output power. The proper output voltage may be determined from the equation:

$$E = \sqrt{PR} \quad \ldots\ldots \quad (1)$$

where E is required e.m.f. (volts)
P the rated undistorted output power (watts)
R the load resistance or impedance (ohms)

An alternative method of measuring overall gain is shown in Figure 2. The source of audio-frequency test voltage is properly terminated and then connected to the amplifier input through a standard *gain set*. The amplifier is suitably terminated by a non-inductive load resistor of appropriate wattage, and a vacuum-tube voltmeter is arranged to give successive indications of input and output voltages.

The tap on the load resistor enables the operator to select for output indication an a.f. voltage within the full-scale range of the vacuum-tube voltmeter, while full power output is supplied to the load. This is an advantage since the amplifier will be operated at full output during the measurements without slamming the meter.

With the voltmeter in the input position, the a.f. voltage is adjusted to a value necessary to give full power output by means of the gain control in the oscillator. The meter is then switched to the output circuit and the gain set adjusted to restore the meter reading to this reference level. The gain may then

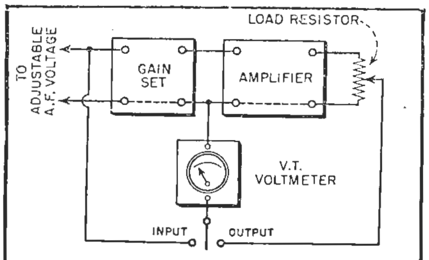


FIG. 2

be read directly from the dials of the gain set.

Frequency Response Checking.

The frequency response of the entire amplifier, of any one or combination of its stages, or of its transformers is studied by observing the output voltage magnitude as the frequency of a constant-level input signal voltage is varied. Values of a.f. output voltage are plotted against frequency to give a responsive curve. In frequency response checks, the input signal voltage must be delivered by a good variable-frequency oscillator with low-distortion output, and a vacuum-tube voltmeter or calibrated oscilloscope employed as the indicator.

It is customary to make response tests at as many points in the range, 30 to 10,000 cycles per second, as practicable. The frequency response of good PA amplifiers is such that the output voltage- (or output db) input frequency curve does not deviate from a straight line by more than plus or minus 2 db between 30 and 10,000 cycles per second. Amplifiers for broadcast, laboratory, and high-fidelity applications show even better response.

When checking the overall frequency response of an amplifier, it is recommended that the input signal voltage be maintained at the proper level required to produce maximum undistorted power output, and that gain controls be set for maximum volume. The tone control must be set at the mid-range or "mellow" position.

Single stages or any combination of stages may be checked for frequency response in the same manner, except that the constant voltage-variable frequency input signal is fed into the input circuit of the particular stage under investigation and the indicating instrument connected to its output circuit. Single-stage frequency response runs are invaluable in tracing the cause of overall response deficiencies.

Distortion Checks.

The entire amplifier or each stage may be checked at various settings of gain controls and at various input-voltage frequencies for the presence of distortion. This test logically should follow the response run.

An input signal of very low harmonic content is supplied to the amplifier or stage under test by a high-grade oscillator, and distortion checked by observing the steady tube currents for fluctuations, or by an inspection of the output signal waveform.

When the simple qualitative check is employed, the cathode current in a single stage is the most satisfactory to examine. The d.c. component of cathode current in a class-A amplifier stage should, under normal operating conditions, show no fluctuation when the input signal is applied. Distortion is betrayed by a change in the value of current indicated by a d.c. milliammeter upon introduction of the input signal.

Each amplifier stage may thus be examined for distortion, the test advancing from input to output sections of the amplifier and distortion localized within one stage circuit.

Class "A" Only

The foregoing simple distortion test is useful only in class-A voltage amplifiers and others in which the cathode current does normally change with the input signal. It is obvious that this method would be of no value in class-B and class-AB systems in which the total cathode current swings widely under dynamic conditions.

The output waveform is inspected for excessive harmonic content (distortion) by means of a distortion meter or wave analyzer, a low-distortion a.f. signal or normal voltage being applied to the amplifier or stage input. These instruments will indicate directly the actual percentage of each harmonic present in the output signal from each stage, values which may be compared with the tube charts or amplifier manufacturer's guarantee.

Tests For Feed-back.

Regenerative feedback is often quite perplexing to the amplifier serviceman, since it may not cause the amplifier to oscillate at an audible frequency, but nevertheless is present in sufficient quantity to cause serious distortion.

When regeneration is suspected, each stage should be examined for its presence by means of grid current or cathode voltage measurements. The presence of grid current in any class of amplifier receiving no input signal is a certain indication of feedback.

Each stage should be examined separately, progressing from input to output circuits of the amplifier. The presence of feed back over several stages, rather than in a single one, may be verified by opening the connection between a stage in which abnormal no-excitation d.c. voltages or currents have been discovered and the stages immediately preceding and following. Currents or voltages should fall to normal values when the contributing stages are thus uncoupled. Likewise, abnormal currents and voltages will not be found in the isolated stages.

Audible feedback in a previously efficient amplifier generally arises in one stage. In developmental units, it is most often due to unwise layout. In the first case, the a.f. voltage generated is passed along to each succeeding stage and into the loudspeaker. The offending stage is readily located if, in the absence of an input signal the output of each stage—from input to output ends of the amplifier—is inspected with a vacuum-tube voltmeter or sensitive headphones. The first stage delivering a howl to the headphones or deflecting the meter is the one in which the audible feedback originates.

Determination of Impedance.

An investigation of the impedance of transformer windings logically will follow the discovery of distortion, although the impedance of an output transformer will be under surveillance when the loudspeaker signal is low. It may also be desirable to check an unknown transformer for secondary impedance when matching speakers to a strange amplifier.

Figure 3 shows a simple method of measuring the impedance of a transformer winding. The unused winding is connected to its usual circuit points or to an equivalent resistor, Rl. The winding under test is connected in series with a variable resistor, Rt, and a source of 400-cycle controllable a.f. voltage. Rt is a wire-wound rheostat or a laboratory decade box. A vacuum-tube voltmeter is arranged with a s.p.d.t. switch to measure successively the a.f. voltage drops across the resistor and winding.

In making the test, Rt is adjusted until its voltage drop is identical with that of the transformer winding. Its resistance at this setting then equals the impedance of the winding. The input voltage level

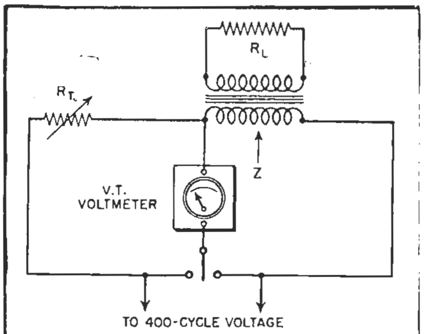


FIG. 3

is adjusted for a good, readable deflection of the meter.

The value of Rt at "balance" may be determined by means of a good ohmmeter or, for more accurate purposes, by means of a resistance bridge.

Bridge Measurement

The impedance of a transformer winding (with the other winding appropriately loaded) might be found also by measuring its inductance upon a suitable bridge for the purpose, measuring its resistance, and calculating from the equation:

$$Z = \sqrt{R^2 + (2\pi fL)^2} \quad . \; . \; . \; . \quad (2)$$

where Z is required impedance (ohms)
R the resistance (ohms)
f the frequency of the bridge voltage (c.p.s.)
L the measured inductance (henries)

If the turns ratio of a transformer has been determined previously, the impedance ratio or the separate impedances may be found with the aid of the following formulae:

$$\frac{N_S}{N_P} = \sqrt{\frac{Z_S}{Z_P}}, \quad \frac{Z_S}{Z_P} = \frac{N_S^2}{N_P^2}, \quad Z_S = \frac{Z_P N_S^2}{N_P^2},$$

$$\text{and} \quad Z_P = \frac{Z_S N_P^2}{N_S^2}$$

where N_P is the number of primary turns
N_S the number of secondary turns
Z_P the primary impedance, and
Z_S the secondary impedance or impedance of the load.

The turns ratio may be determined by applying a known alternating voltage across one winding and measuring the induced voltage across the other. The ratio of the two voltages will then correspond to the turns ratio.

Tube manufacturers state in their tables the values of load impedance (or load resistance) recommended for maximum undistorted power output. This load value is matched to the power-tube plate impedance by means of a transformer of proper turns ratio, as indicated above.

Rapid Method

A rapid method for determining the impedance of an output transformer secondary of an amplifier in operation consists in adjusting a standard *output power meter* for maximum deflection and reading the impedance from the meter dials. The power meter is connected simply to the output transformer terminals, a 400-cycle signal voltage introduced into the input circuit of the operating amplifier. The meter-range switch is set to accommodate the maximum amplifier power output, and the meter input impedance is adjusted for maximum deflection of the indicating instrument. The reading of the impedance dial at this setting is the impedance of the output transformer secondary.

Power Output Measurements.

The audio output watts may be measured with the audio-frequency output power meter or determined from voltage or current readings taken in a properly terminated output circuit.

Several models of non-electronic output power meters are now commercially available for a.f. measurements. The following ranges are provided by three of the currently advertised models: (A) 2.5 to 20,000 ohms input impedance in forty steps of a single rotary switch; indicating instrument reads full-scale ranges from 0.5 milliwatt to 5 watts in four ranges with a midscale accuracy of 5 per cent. (B) 2.5 to 20,000 ohms input impedance in forty steps of a single rotary switch; indicating instrument reads full-scale values of 0.1 milliwatt to 50 watts in twenty ranges with a midscale accuracy of 2 per cent. (C) 2.5 to 20,000 ohms input impedance in forty steps divided between a 10-position ohms selector switch and a 4-position ohms multiplier switch; indicating instrument reads full-scale values from 0.1 milliwatt to 5 watts in four ranges with an accuracy stated by the manufacturer as variable with frequency.

Since the output power meter presents to the amplifier under test a load impedance of widely adjustable value, this instrument may be connected directly to the amplifier output terminals without introducing any further load or matching device, provided the input impedance of the meter is set to the value of amplifier output impedance. If the latter is not known, the meter impedance may be adjusted for maximum deflection of the indicating instrument with the amplifier passing a 400-cycle signal, whereupon the output impedance may be read from the dials.

Direct Readings

Advantages of the output power meter are that its wattage readings are direct, requiring no calculations or conversions, and its input circuit may be closely matched to the amplifier output circuit.

By the voltmeter or ammeter method, output power levels are calculated from voltage or current values measured in a terminating circuit of proper resistance or impedance. This method is illustrated in Figure 4. Circuit A is that for the indication of a.f. power output in terms of voltage; Circuit B for power indications in terms of current readings. In both examples, the load resistor, R, terminates the amplifier output. Its resistance must accordingly be equal to the rated output impedance of the amplifier and its wattage must be sufficient to withstand the maximum power output.

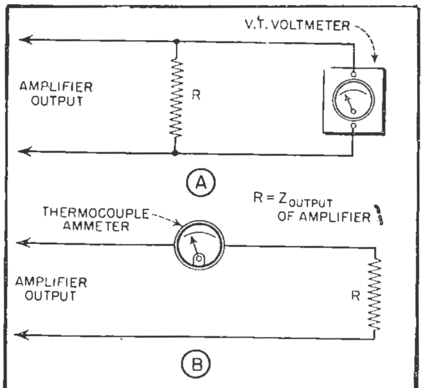


FIG. 4

The a.c. voltmeter used in Figure 4-A must have good accuracy at the test frequency. It is strongly recommended that a vacuum-tube voltmeter be used in this position.

The amplifier power output is determined, in the voltmeter method, by means of the equation:

$$P = \frac{E^2}{R} \quad \ldots\ldots \quad (3)$$

where P is the audio output (watts)
E the meter reading (volts)
R the load resistance (ohms)

Alternatively, the value of the a.f. current flowing through the load resistor may be measured, as in Figure 4-B, and this value employed in a calculation of the a.f. power:

$$P = I^2R \quad \ldots\ldots \quad (4)$$

where P is the audio output (watts)
I the meter reading (amperes)
R the load resistance (ohms)

For best results, the current instrument should be a thermocouple type am meter or milliammeter. As a substitute for this type of current meter, a vacuum-tube voltmeter may be employed in connection with a suitable shunt for reading the current in terms of the voltage drop across the shunt.

Hum and Noise Level.

Inherent hum and noise level of an amplifier or isolated stage may be quantitatively analysed by means of a vacuum-tube voltmeter of sufficient sensitivity or a standard output power meter.

Any output voltage present when the signal voltage is removed, and not due to feedback, may be attributed to hum and noise components. If the one is known to be present in the absence of the other, it may be identified by a simple headphone and speaker listening test.

The simple vacuum-tube voltmeter or output meter will indicate the total magnitude of hum and noise components and will not differentiate between the two nor separately evaluate them. To determine the amplitude of each component, it is necessary to select that component from the total. This operation is best performed by a wave analyzer, which is in principle a highly selective vacuum-tube voltmeter which may be tuned successively to the fundamental hum frequency and each of its harmonics. It will generally be necessary to measure only the fundamental, second, third, and fourth harmonic amplitudes with the wave analyzer.

Sound equipment manufacturers usually express the hum or noise level as a number of decibels below maximum output, and the experimenter may, if he desires, convert his measured values into these units.

After the hum level has been accounted for, the remainder of the no-signal output voltage may be attributed to noise. A certain amount of this arises from thermal agitation in the input stage. However, coupling capacitors in resistance-coupled stages should be inspected for low dielectric resistance, with a good megger, when the noise level appears excessive. A good coupling capacitor should show a dielectric resistance equal to 500 times the value of the grid resistor used in the succeeding stage.

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FOR THE EXPERIMENTER

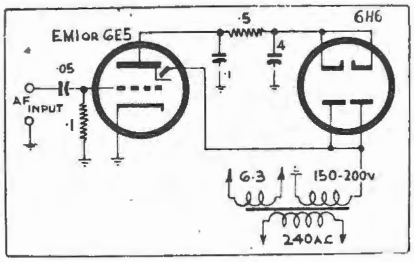
By A G. NICHOLLS (VK2NI)

Calibrator for Sweep Generator and A.F. Oscillator.

A simple circuit using a "magic eye" and very small power supply, and which is suitable for calibrating sweep generators and a-f oscillators, is shown in the accompanying diagram. The magic eye indicator valve actually does the work of a cathode ray tube, but does not require the high voltage to operate it.

The oscillator to be calibrated is fed into the grid of the tuning indicator, whilst the a-c voltage is applied to the target. The fluorescent screen is illuminated only for the positive half-cycles, and thus an accurate time base is established for calibration. At fundamental or even harmonics of the oscillation, the shadow on the screen stands still. At frequencies other than harmonics the shadow flutters.

This unit is useful up to 10 kc. if care is taken with the construction and layout.

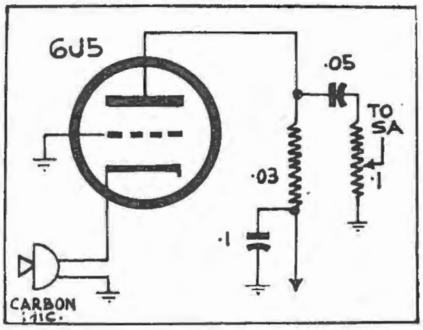


High Voltage Warning Blinker.

In the interests of safety some form of warning for the high voltage supply should be fitted to every transmitter. While indicator lights are useful, the steady light can be easily overlooked, and in this respect a blinker lamp is much more effective of indicating that the high voltage supply is on.

A simple form of Neon blinker can be wired up as shown, using a ¼-watt Neon lamp. The value of resistor shown is about right for a 1,200-volt supply, and will produce a blinking rate of one flash per second. If you have difficulty in obtaining this high resistance, then three 10-meg units can be wired in series.

The value of the resistance can be adjusted according to the voltage of the power supply and the desired flash rate. If the Neon glows steadily, the resistance is too low, and this should be a guide as to the correct value.



Carbon Microphone Input.

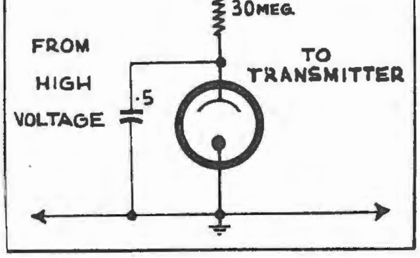
A simple hum-free method of connecting a carbon micophone to a pre-amplifier is shown in the accompanying diagram. This system utilises the current flow through the valve for its excitation.

Due to the extremely low grid impedance, the hum pick-up is negligible. The gain, of course, from the stage is less than unity, but the arrangement will still be found quite suitable for most speech amplifiers.

Increasing Audio Output from SCR-522.

Most users of the very efficient "522" on 144 mc. have changed the 12J5 output valve to a 12A6, or similar type, to increase the audio output. Another change for the better may be obtained by connecting a .01 mfd 600-volt condenser from the centre arm of the gain control potentiometer, after disconnecting the lead already soldered to it.

The other side of the condenser is connected straight to the grid cap of the 12C8 and earthed with a .5 meg ½-watt resistor. This by-passing the first audio microphone transformer, and it will also be found that the hum level has decreased considerably.



U.H.F. Techniques

By

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

Transmission lines or "feeders" perform the same function at U.H.F. as they do in low frequency power distribution systems—that is the transfer of power from one unit of a system to another.

Various forms of transmission lines are used in practice. The configuration and size of line for any application depends upon the frequency employed and the power to be transferred. The simple open wire feeder is satisfactory for the lower quencies of the U.H.F. spectrum whilst co-axial lines are adopted for higher frequencies. Waveguides are ideal for microwaves and their use is essential at very short wavelengths. If wavelengths are reduced beyond their present limit some new form of feeder will probably be needed.

Although transmission lines vary in form, the fundamental concepts and theory are applicable to all lines. From this fundamental theory, the properties which render transmission lines suitable for the above applications are derived.

For many transmission line problems the field concept is used; that is, instead of referring to voltages and currents, the electric and magnetic fields between conductors are examined. Maxwell's field equations are then employed. However, much of the theory can be built up from the ideas of conventional transmission lines.*

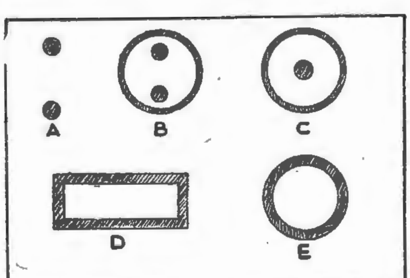


Fig. 1.—Cross sections of various types of transmission lines
(a) Two wire line
(b) Shielded pair line
(c) Co-axial line
(d) Waveguide (Rectangular)
(e) Waveguide (Circular)

* An introduction to the concepts involved in transmission line theory was given in an article on "F.M. Transmission Lines," in "Radio Science"—(May, 1948, page 30).

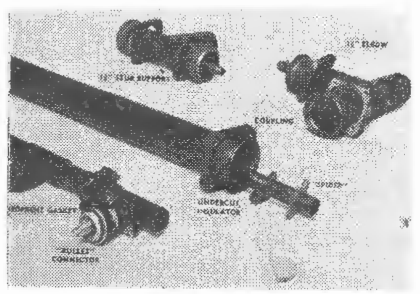


Fig. 2.—Co-axial line components. Couplings, insulators, stub supports, and elbows.

A transmission line may be defined as one or more lengths of conducting material, the configuration of the cross section of which may take various forms. The different cross sections employed are shown in figure 1. In practice the material has a high conductivity in order to reduce losses unless attenuation is purposely required. Copper or silver plated brass are ideal materials.

All transmission lines except waveguides require an insulating support between the conductors. At U.H.F. this is made of low loss material.

Transmission Line Quantities.

A transmission line is specified electrically in terms of its characteristic impedance, propagation constant and power handling capacity.

PART 5
TRANSMISSION LINES

The *characteristic impedance,* usually denoted by the symbol Zo is equal to $\sqrt{R + jwL/G + jwC}$ where R, L, G and C are the resistance, inductance, conductance and capitance per unit length respectively. $Zo = \sqrt{L/C}$ for a loss free line.

Two Wire Lines.

The two wire open line (figure 1a) consists of two parallel conductors, usually of circular cross section, separated by insulators. The spacing of the conductors is between 5 and 20 times the diameter of the wires, whilst the insulating material may be in the form of intermittent spacers of low loss material such as polystyrene or trolitul or continuous flexible polythene.

Open wire lines are not employed at frequencies above approximately 200 Mc/s as radiation losses then become excessive. In order to reduce radiation the spacing of the wires must be as small as possible.

The characteristic impedance of a two-wire line is $276 \log 10 \frac{2D}{d}$.

where D equals spacing of conductor centres, and

d equals diameter of conductors.

Thus a line consisting of two wires ¼in. in diameter spaced 2in. apart has a characteristic impedance of 330 ohms.

Two-wire lines have the advantage of being balanced for r-f with respect to earth and therefore may be connected to an aerial in a simple manner.

The shielded pair line (figure 1b) does not radiate and maintains the balanced feature although the characteristic impedance is lower than the open wire line. However, connections with shielded pair lines are complicated and this type

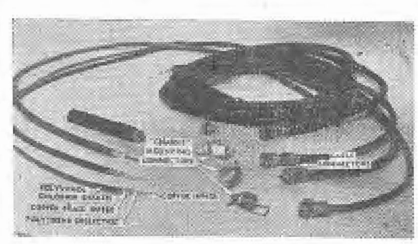


Fig. 3.—Typical polythene U.H.F. cables with connectors.

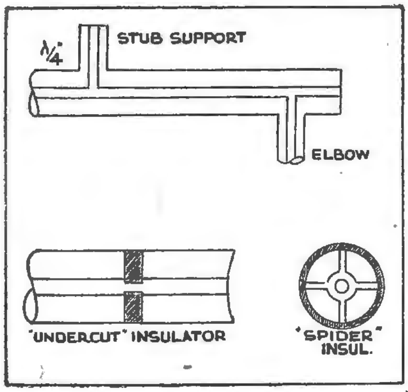


Fig. 4.—Various types of insulators are used in U.H.F. lines.

of feeder is not used extensively in practice.

Co-axial Lines.

The co-axial transmission line (figure 1c) is the most convenient form of shielded feeder at U.H.F. It consists of two concentric cylinders separated by a dielectric of either solid material or air with occasional solid spacers. The outer conductor is *earthed* for r-f and acts as a shield, preventing radiation. However, in a co-axial line the voltages on the two conductors are unbalanced with respect to earth. When a co-axial line is connected to elements constituting a balanced system such as a dipole or a two wire-line it is necessary to employ a *balance to unbalance* transformer to prevent radiation from the outside of the feeder.

Connections to units contained in metal cases can be made easily with co-axial lines. In making such connections it is essential that the outer conductor be well bonded to the case. If there is a high resistance or merely a capacity connection a voltage could develop between the outer conductor and the case.

Joints between different sections of a co-axial line must be well made to prevent loss and radiation. In high power applications, sparking will occur unless good contact exists between sections. In practice, extensive use is made of spring contacts and suitable flanged joints using standardised parts are employed in co-axial line installations.

Flanged couplings of one type used in 1$\frac{5}{8}$in. and 1$\frac{7}{8}$in. air spaced co-axial lines are illustrated in figure 2. These couplings are made weatherproof by means of a neoprene gasket in a groove surrounding the metallic contact of the outer conductor. The ends of the inner conductors are fitted with split *bullet* contacts which couple into a plain tube and on the mating piece. The characteristic impedance of a co-axial line is $Z_o = 138 \log_{10} \frac{b}{a}$ where $\frac{b}{a}$ is the ratio of the outer to inner diameter.

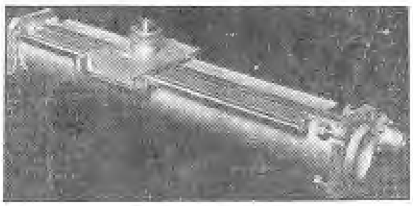


Fig. 5.—A standing wave indicator suitable for use at 1200 Mc/s.

For minimum losses the ratio of diameters should be about 3.6 with a corresponding of 77 ohms.

The co-axial construction is particularly adaptable to flexible cables. Several types of cable are illustrated in Fig. 3. Polythene forms a suitable flexible dielectric. The inner conductor may consist of either a single or stranded copper wire whilst copper braid is an ideal outer conductor. A wide range of such cables is produced commercially today overseas. Characteristic impedances range from 47 ohms to over 100 ohms. Variations in size correspond to different power handling capacities.

Losses.

Losses in polythene cables are naturally greater than those in air dielectric lines and are greater at higher frequencies. For example at 3,000 Mc/s a typical figure for loss is I db per yard.

Special connectors have been developed for the various types of cable. A few of these are illustrated in Fig. 3 with the corresponding *chassis* type of mating connector suitable for use on shielded units. Impedance and power handling capacity as well as mechanical stability are important considerations in connectors. The simple *Amphenol* type connectors have excellent impedance properties even at 3,000 Mc/s and are ideal for laboratory use but are unsatisfactory for permanent installations particularly in outdoor applications.

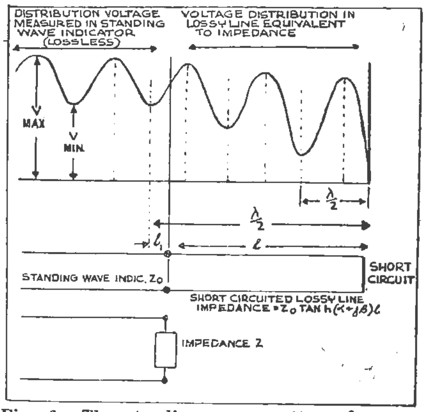


Fig. 6.—The standing wave pattern for any impedance which may be considered equivalent to a short circuited lossy line.

In air-spaced co-axial lines when dielectric spacers are used they are made either in the form of *spiders* or let into the inner and/or outer conductors as indicated in Fig. 4 in order to reduce *reflection* effects. Fig. 4 contains examples of these two types of insulators. The undercutting compensates for the presence of the dielectric and is aimed at maintaining a constant characteristic impedance.

Metal Insulators.

At high power the use of dielectric insulators becomes impracticable because of the high stress which would be developed in the dielectric. This would result in sparking and destruction of the insulators. The solution to this problem lies in the use of *metal insulators.* These are quarter wave length short circuited stub lines shunted across the main line at appropriate intervals as illustrated in Fig. 4. Because the input impedance of a short circuited quarter wave line is very high these stubs have negligible shunting effect on the transmission line.

Impedance and Matching.

In both transmission line theory and practice the concept of impedance is one of the fundamentals. In the development of r-f components impedance calculations and measurements are extremely important.

The input impedance of a transmission line depends upon the terminating or *load* impedance, the characteristic impedance, line length, and wave length. For the maximum transfer of power from the transmission line to load the latter should have an impedance of the feeder. In this condition the load is said to be *matched* to the line.

If the load is not matched energy is considered to be *reflected* from the load. This reflection may be overcome by an impedance transformer which provides reflections in the opposite phase and of appropriate amplitude to cancel out the original reflection. This impedance transformer is analogous to the transformer between the loudspeaker and output valve of an audio power amplifier.

The mathematical expression for the input impedance of a line is:—

$$Z_{in} = Z_o \frac{Z_o \tanh \delta l + Z_L}{Z_o + Z_L \tanh \delta l}$$

where Z_{in} equals input impedance
Z_L equals load impedance
δ equals propagation constant
l equals length of line

Returning to the question of reflection and impedance matching, let us consider impedance measurements. Reflection or mismatch is characterised by the presence of standing waves in the transmission line. The magnitude and position of these standing waves are related directly to the load impedance. Measurements of these quantities constitute impedance measurements at U.H.F. Having calculated the load impedance from this data suitable matching transformers may be designed.

Standing Waves.

Standing waves may be measured in the transmission line itself or in an accurately made line connected to the load. This special line which should be at least one wavelength long is known as a standing wave detector or indicator. It is provided with a sliding probe to measure the relative voltage distribution along its length. In the co-axial line type a slot is provided in the outer conductor to allow a small probe mounted on a sliding carriage to project a short distance into the electric field inside the line. (See Fig. 5.)

For standing wave measurements the system is usually fed from a C.W. source and the signal from the probe is led to a suitable detector such as a U.H.F. crystal and micro-ammeter or a field strength receiver. Crystal detectors are simple and non frequency selective but are not suitable for high standing wave ratios.

The impedance is determined from the standing wave ratio (denoted by S = maximum voltage divided by minimum voltage) and the distance of the standing wave minimum from the reference point.

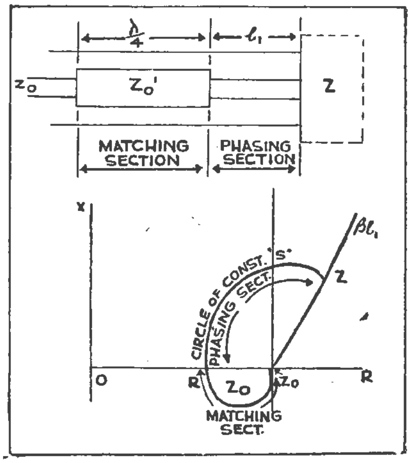


Fig. 8.—Quarter wave matching transformer with corresponding circle diagram.

A mathematical transformation performed with the aid of an impedance chart or circle diagram is used for this purpose.

Theory of Standing Waves.

The theory of this process may be explained by considering the impedance being measured as equivalent to a short circuited lossy transmission line. This is

Consider the equivalent line system fed from a suitable source (see Fig. 8). The effect produced can be pictured as a forward wave, travelling towards the short circuited end being reflected and producing a backward wave. The combination of these two waves results in a standing wave system, i.e., a series of maximum and minimum voltage points along the line. These are analogous to the nodes and antinodes of standing wave systems in organ pipes. The minima occur at points half a wave length apart starting from the short circuited end. However, since the section of line which is equivalent to the impedance is lossy (i.e., has attenuation) the amplitude of the wave is reduced as it travels along this line and back. The result is that the amplitude of the standing wave pattern diminishes from a short circuit to the opposite end in the manner of a damped oscillation as indicated in Fig. 6.

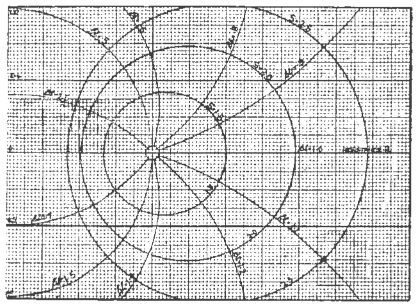


Fig. 7.—Circle diagram or impedance chart used for converting standing wave measurements to impedances.

Circle Diagram.

In order to evaluate the impedance from tan h (δ + jB)L a circle diagram such as Fig. 7 is used. This has been derived from the Kennelly chart.

The chart consists of a rectangular co-ordinate system representing Resistance horizontally and Reactance vertically, together with two sets of circles from which corresponding values of tan h (δ + jB)L may be read. The smaller circles correspond to constant values of δL and therefore constant values of "S" as marked, whilst points corresponding to constant values of Bl lie on the larger circles.

The values of R and X can be read off the axes for the values of "S" and "L" determined from standing wave measurements. On the chart impedances are *normalised* in terms of the characteristic impedance, i.e., 1.0 represents Zo ohms.

Alternatively the standing wave ratio and length of equivalent line can be determined for any impedance. This reverse procedure is employed in the problem of matching transformer design.

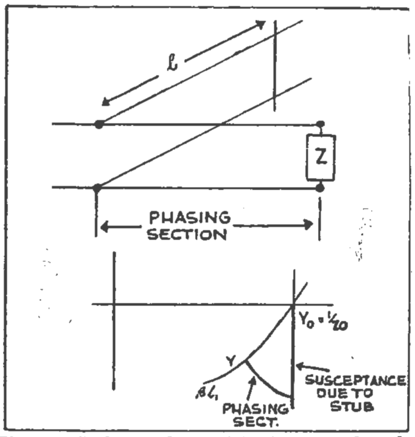


Fig. 9.—Stub matching. (a) Diagram of stub. (b) Equivalent circle diagram.

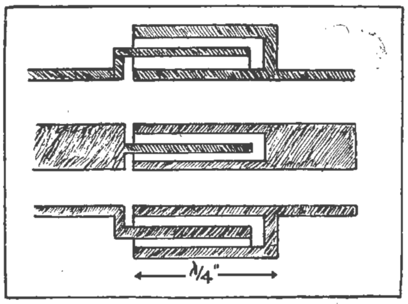


Fig. 11.—Diagram of a rotating joint for co-axial line.

Matching Transformers.

Matching transformers for low radio frequencies consist of lumped reactances in the form of inductances and condensers. For U.H.F. transmission lines, aerials and other components, low loss line type elements are used as matching transformers. Sections of transmission lines form reactances which may be used as either series or shunt elements. Variations in the magnitude of the reactance and the position of insertion in the transmission line are available for matching adjustment.

The operation of transmission line type matching transformers may be understood by reference to the circle diagram of Fig. 7. The problem resolves itself into doing things which will move the point on the chart representing the load impedance (OR admittance) to the point representing Zo the characteristic impedance of the feeder. This is achieved by moving around circles of constant "S" and up or down vertical lines. The former is equivalent to moving back along the feeder whilst the latter represents the addition of shunt reactances.

Quarter Wave Transformer.

A form of matching employing a series element is the quarter wave transformer. This comprises a section of transmission line a quarter of a wave length long of a different characteristic impedance as depicted in Fig. 8a. In Fig. 8b the mechanism of this device is illustrated. The length of the *phasing* section is represented by the path Z-R while the semicircle R-Zo corresponds to the quarter wave section of characteristic impedance Zo. The magnitude of Zo' is $\sqrt{\text{Zo R}}$.

If R is less than Zo, Zo' will be less than Zo and the inner conductor would be enlarged as in Fig. 8a if a co-axial line were used. If R is greater than o an undercut section is necessary. The choice of R depends upon the particular application.

Stub Matching.

Matching can be achieved by stubs., i.e., short lines *shunted* across the main line as indicated in Fig. 9. Since they are shunt elements it is more convenient to plot admittances on the diagram. The resultant of two parallel admittances is obtained by simple addition, whereas with impedances the process is more complicated. The change to admittances is very simple on the chart; it consists of

(Continued on page 48.)

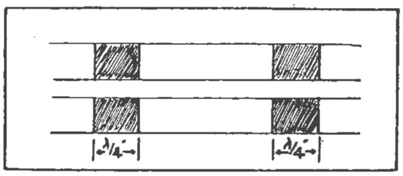
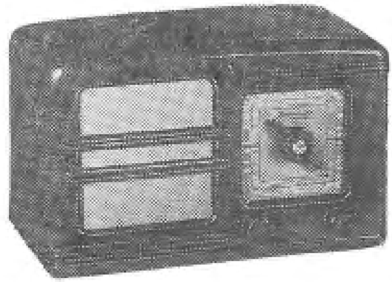


Fig. 10.—Dielectric Slug matching transformer.

SERVICE DATA SHEET

HOTPOINT BANDMASTER MODEL G64-MEX

For all alignment operations, connect the "low" side of the signal generator to the receiver chassis, and keep the generator output as low as possible to avoid AVC action. Keep the volume control in the maximum clockwise position. The two RF alignment points, 600 kc. and 1500 kc. are marked on the right and left hand edges of the glass dial scale.



ALIGNMENT TABLE.

Order	Connect "high" side of generator to:	Tune generator to:	Tune receiver to:	Adjust for maximum peak output
1‡	6A8G*	455 Kc/s	540 Kc/s	L8 Core
2	6A8G*	455 Kc/s	540 Kc/s	L7 Core
3	6A8G*	455 Kc/s	540 Kc/s	L6 Core
4	6A8G*	455 Kc/s	540 Kc/s	L5 Core
Repeat the above adjustments until the maximum output is obtained.				
5	Aerial lead	600 Kc/s	600 Kc/s	L.F. Osc. Core Adj. (L4)†
6	Aerial lead	1500 Kc/s	1500 Kc/s	H.F. Osc. Adj. (C5)
7	Aerial lead	1500 Kc/s	1500 Kc/s	H.F. Aer. Adj. (C2)
Repeat adjustments 5, 6 and 7				

‡ Before I.F. alignment is possible, a capacity lead connected to the plate of the 6G8G must be twisted until it lies alongside the electrolytic capacitor C7. Upon completion of I.F. alignment, move the capacity lead back as far as possible towards the 1st I.F. without causing oscillation. At this point, no further adjustment of the I.F.'s must be made.

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

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

ELECTRICAL SPECIFICATIONS.

Frequency Range: 540-1600 kc.

Intermediate Frequency: 455 kc.

Power Supply: 4.0 volt Accumulator Synchronous Vibrator

Valve Complement:

1R5—Converter

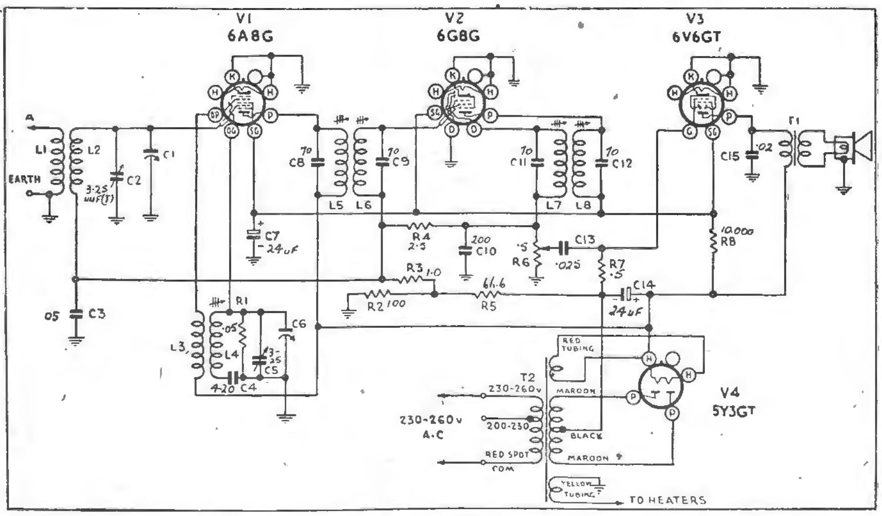
1T4—I.F. Amplifier

1S5—Detector, AVC and AF amplifier

3V4—Power Amplifier

Valves.	Cathode to Chassis Volts.	Screen Grid to Chassis Volts.	Anode to Chassis Volts.	Anode Current mA.	Bias Volts.	Heater Volts.
6A8G Converter	0	100	210	3.5	-3	6.3
	-		210	5.0	-	-
6G8G I.F.Amp., Detector, A.V.C.	0	100	100	4.0	-3	6.3
6V 6GT Output	0	100	200	14.0	-5	6.3
5Y3GT Rectifier	210		190A.C.			5.0

Total H.T. Current—35 mA.
Measured at 240 volts A.C. supply. No signal input. Volume control maximum clockwise. Voltmeter 1000 ohms per volt; measurements taken on highest scale giving accurate readable deflection.



Winding.	D.C. Resistance in Ohms.
Aerial Coil—	
Primary	30
Secondary	4
Oscillator Coil—	
Primary	1.5
Secondary	6.0
I.F. Transformer Windings	8
Loudspeaker Input Transformer (T1)	
Primary	525 or 430
Secondary	*
Power Transformer (T2)	
Primary	60
Secondary	350

The above readings were taken on a standard chassis, but substitution of materials during manufacture may cause variations and it should not be assumed that a component is faulty if a slighty different reading is obtained.

*Less than 1 ohm.

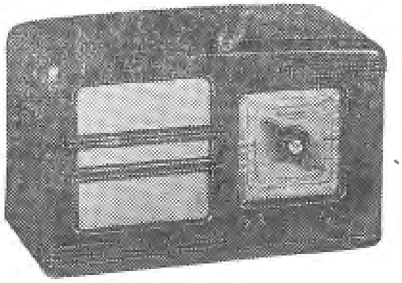
SERVICE DATA SHEET

HOTPOINT BANDMASTER — MODEL G64-MVX

ELECTRICAL SPECIFICATIONS:

Frequency Range: 540-1600 kc.
Intermediate Frequency: 455 kc.
Power Supply: 200-260 volts
Loudspeaker: 5", VC impedance 3 ohms

Valve Complement:
6A8G—Converter
6G8G—IF Amplifier, 2nd Detector and A.V.C.
6V6-GT—Power Amplifier
5Y3-GT—Rectifier



For all alignment operations, connect the "low" side of the signal generator to the receiver chassis, and keep the generator output as low as possible to avoid A.V.C. action. Also, keep the volume control in the maximum clockwise position. The two R.F. alignment points, 600 kc. and 1500 kc. are marked on the right and left hand edges of the glass dial scale.

ALIGNMENT TABLE

Order.	Connect "high" side of Generator to:	Tune Generator to:	Tune Receiver Dial to:	Adjust for Maximum Peak Output.
1	1R5 Grid*	455 Kc.	Below 550 Kc.†	Core L9
2	1R5 Grid*	455 Kc.	Below 550 Kc.†	Core L8
3	1R5 Grid*	455 Kc.	Below 550 Kc.†	Core L7
4	1R5 Grid*	455 Kc.	Below 550 Kc.†	Core L6
	Repeat the above adjustments until the maximum output is obtained.			
5	Aerial Terminal	600 Kc.	.6 Mc. Mark	LF Osc.Adj. (L5Core)‡
6	Aerial Terminal	1500 Kc.	1.5 Mc. Mark	HF Osc.Adj. (C7)
7	Aerial Terminal	1500 Kc.	1.5 Mc. Mark	HF Aer.Adj. (C4)
	Repeat adjustments 5, 6 and 7.			

*With grid clip connected. A .001 uF capacitor should be connected in series with the "high side of the test instrument.
†Ganged tuning capacitor fully closed.
‡Rock the Tuning Control back and forth through the signal and reset the dial pointer to the .6 Mc mark, if necessary, by turning it in the required direction whilst holding the tuning control knob.

SOCKET VOLTAGES.

Valve.	Bias Volts	Screen Grid to Chassis Volts	Anode to Chassis Volts	mA Current Anode	Heater Volts
1R5 Converter	0	45	45	0.5	1.3-1.4
1T4 I.F. Amplifier	0	45	85	2.7	1.3-1.4
1S5 Det., A.V.C., A.F. Amplifier	0	25*	20*	0.07	1.3-1-4
3V4 Output	*-6.5	85	90	8.5	1.3-1.4

Total battery current—0.8 Amp.
Measured with no signal input. Volume Control Battery Switch maximum clockwise.
*These readings may vary depending on the resistance of the voltmeter used.

Resetting the Dial Pointer.

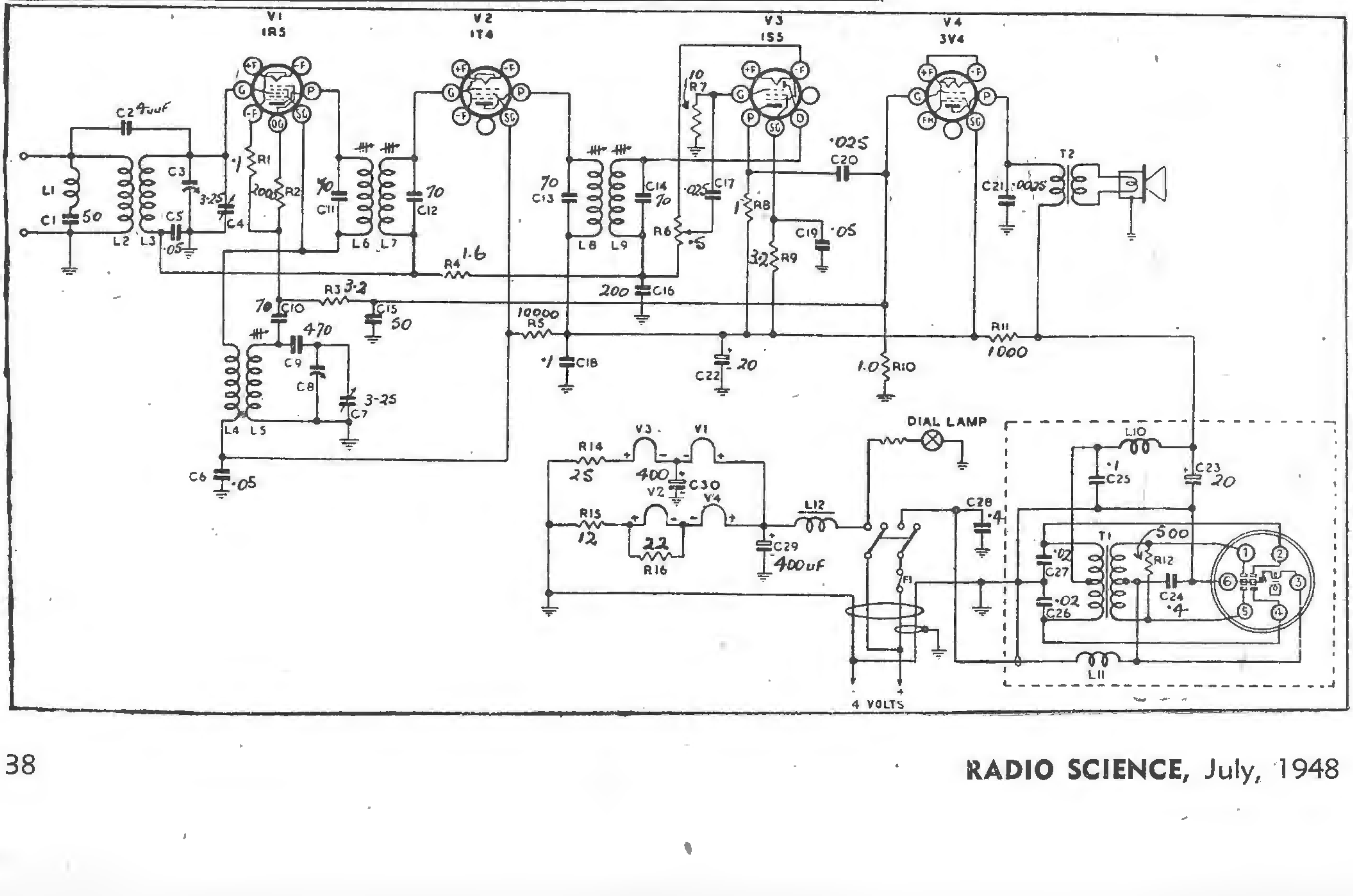
Should the pointer become displaced it can be reset as follows:

(1) First turn the tuning control knob clockwise until the pointer stops turning.

(2) Then, whilst holding the tuning control firmly, turn the pointer with the other hand to bring it to a horizontal position.

(3) Next tune a known local station and note any inaccuracy of the pointer in relation to the station.

(4) Finally, again holding the tuning control firmly, turn the pointer sufficiently to correct the error.



For your note book

A page of radio servicing hints and notes of practical value to the radio serviceman and technician.

"Rejuvenating" Valves

Frequently it will be found that apparently worn out valves often show new signs of life after having been relegated to the spare-parts shelf for a period of time. This *self healing* process can also be speeded up by subjecting the valves to the effect of heat.

The simplest method of reactivating such valves, whose only defect is low electron emission, is to place them in a tray or shallow pan and bake them for four to five hours in an oven that is kept between 350 to 400 degrees F. Then allow the valves to slowly cool in the oven to prevent any glass cracks and retest when cold. It may be found that some valves will not show any noticeable improvement until they have been in operation for a few hours.

This process is only applicable to the oxide coated type of cathode and can be applied successfully only once to any valve.

Straightening Records

Warped phonograph records in your collection can be often straightened by the even heat of an infra red lamp. Place the disc on the turntable or a felt covered level surface and let the beam play over it for about five minutes. When warm the record will usually level out by itself, but in some cases gentle pressure may be required. Ensure that the heating is not excessive, otherwise the record may be damaged.

Prevent Burnt Fingers

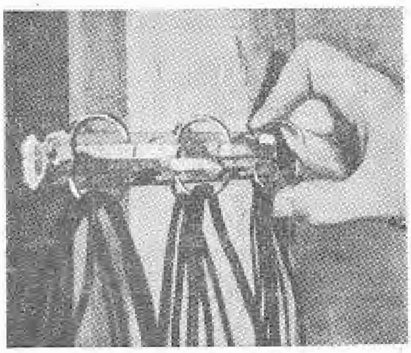
Burned fingers are sometimes the result when tubes that have become uncomfortably hot are removed or switched around. This applies generally to all rectifiers, power amplifiers as well as most metal valves which dissipate enough watts to be painful to touch. A pair of rubber finger tips generally available from many stationery stores will protect the fingers against this heat as well as provide a sure grip on the valve.

Miniature Vise.

Frequently when soldering leads and small components, it is difficult to hold them in position and still manipulate the iron. A handy vise which will solve this problem can be made by stretching a strong rubber band across the handles of a pair of pliers. The pliers may be laid on the bench, with the leads, etc., being soldered placed in their jaws. They will then be held there securely by the pressure of the rubber band.

Test Lead Holder.

A metal clip binder of the type illustrated and taken from a worn out notebook may be used as a convenient test lead holder. The clips can be sprung open to insert or remove the wires. When in a closed position leads are prevented from slipping over other wires and falling to the floor as frequently happens with other holders.



High Hum Level.

When a set has a high hum level even though the power supply filter condensers are satisfactory, examine the coupling condenser to the grid of the first a-f valve. An open or very low capacitance here will result in hum even though there is a signal getting through.

Distortion and noisy output usually indicates a bad plate coupling condenser. A quick test for a positive voltage reading on the grid side of the capacitor will usually be sufficient to verify this fact.

Removing Insulation.

An easy method of removing the insulation from Litz and other fine wires such as are frequently found on pickup heads and headphones, is by-passing the end of the wire slowly through a match flame. This will char the insulation sufficiently to permit it to be pulled off, but care should be taken otherwise the fine wires may char or melt. In the case of ordinary hook-up wire, a handy insulation stripper can be made up from a metal photograph clip. Simply place the wire between the jaws of the clip, press them tightly together and pull the wire out fully stripped.

Speaker Connections

Screw lug connections to loud-speakers usually have to be disconnected when the set is removed from the cabinet for servicing. To make sure that the wires are replaced properly, tie loose knots in the cord ends. The wire with one knot connects to first terminal, that with the two knots to the second terminal and so on for all the wires.

Heat Aids Soldering

When soldering the seams of a chassis using a small soldering iron that cannot supply enough heat, preheating the chassis may help solve the problem. Clean and clamp the joints, apply a good flux and place the unit in an oven or over a burner. The warm metal requires less heat from a soldering iron than if left in the cold state.

Frayed Loop Ends

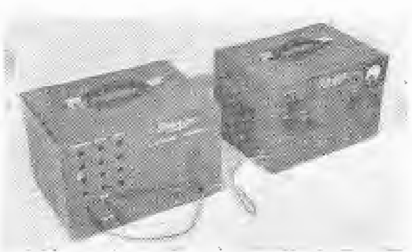
In some portable receivers it will be found that the "lead in" wire from the loop aerial has only a thin layer of cotton insulation, which after a period of time often becomes frayed or unravelled, from the wire. This results in the bare wire fouling other parts whenever the set is moved with a usual noticeable noise or decrease in signal strength. This fault can be easily remedied by slipping a piece of insulated tubing of the correct size over the wire.

Around The Industry

PORTABLE GEIGER-MULLER COUNTER

From the Electrotechnic Engineering Company comes details of a portable Geiger-Muller counter now being produced by that company.

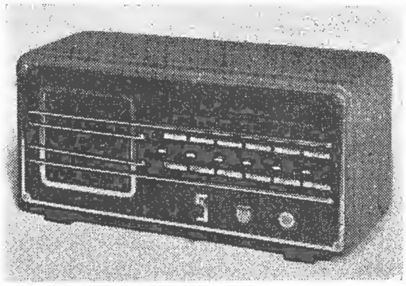
The design of the instrument is such that it is quite suitable for Alpha, Beta, Cosmic, Gamma and X radiation detection and classification. Provision is made to operate either of two Geiger-Muller tubes — one fitted internally and the other externally in a small cylinder. This latter tube can be fitted to a handle enabling it to be carried just above the ground under which conditions even a very small specimen of radio-active substance may be detected. The output of the amplifier is registered on a meter mounted on the front panel, or by means of a pair of headphones.



The instrument is of rugged construction and contained in an aluminium case measuring $11\frac{1}{8}$ x $7\frac{1}{2}$ x $8\frac{3}{8}$ finished in grey with white inlaid lettering. Complete with batteries the unit weighs some $23\frac{1}{2}$ pounds.

Further information on this equipment can be obtained by writing to the manufacturers — Electrotechnic Engineering, Edgerton St., Lidcombe, N.S.W.

"PHILIPHONE" I.C. UNIT



"Philiphone" Desk Control Unit.

Of interest to all business executives, factory owners, etc., is the recently introduced Philiphone Intercommunication Unit. Attractively finished in brown crackle, this small and unobtrusive unit will provide, at the flick of a switch, instant contact with the most remote department.

The standard Philiphone has provision for 13 stations, which is generally adequate for most needs. However, in cases where more lines are necessary, then an additional panel of 12 stations can be readily added when required. For confidential use a special ear-piece is provided, and this automatically cuts out the speaker when it is lifted off the hook.

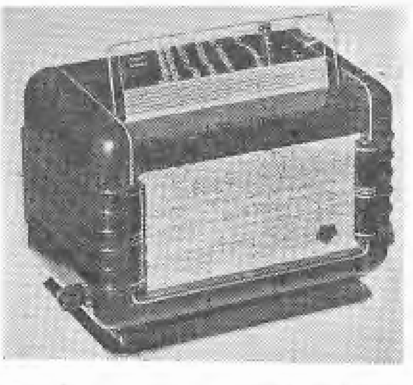
The complete desk unit measures $12\frac{1}{2}$ x 6 x $6\frac{1}{2}$, operates from the 240 volt mains, and is fitted with a volume adjustment. Full particulars can be obtained from a Philips distributor, or by writing direct to the manufacturers—Philips Electrical Industries Pty. Ltd., Clarence St., Sydney.

NEW MULLARD RECEIVER

Details of the first of the new Mullard "Thousand" series of receivers incorporating the exclusive "Eye-line" tuning were recently released. This is the model MAS 1000, a compact A.C. broadcast mantel receiver.

Housed in an attractively designed bakalite cabinet, this new receiver uses an ECH35 converter, EBF35 combined IF amplifier and detector, 6V6GT power output and a 5Y3GT rectifier. The circuit incorporates screen grid regeneration and an inbuilt power switch, which features, in conjunction with high quality performance, should make this a very popular receiver.

The list price is £18/18/- in walnut colour cabinet, whilst other colours are obtainable at 10/6 extra. These prices are slightly higher in Northern Queensland. Further particulars can be obtained from any Mullard Distributor or by writing direct to Mullard-Australia Pty Ltd., Box 2118, G.P.O., Sydney.



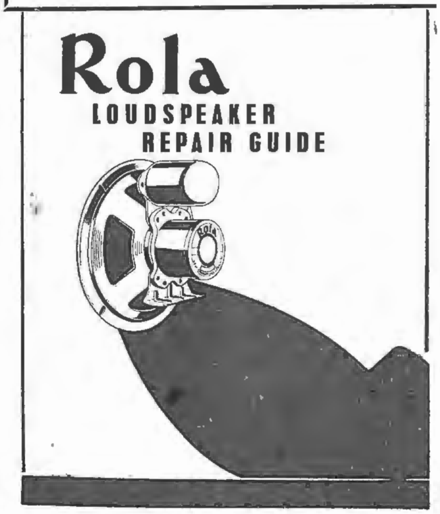
Mullard Mantel Receiver Model MAS 1000.

ROLA REPLACEMENT GUIDE

The Rola Loudspeaker Replacement Guide, recently published by the Rola Company (Australia) Pty. Ltd., has been produced with the object of helping the radio dealer, the serviceman and the general public select the modern loudspeaker types suitable to replace non-repairable obsolete models which may have broken down.

Not only does this booklet list the complete range of Electro and Permagnet types made by the Rola Company, but it also indicates whether the obsolete types can be economically repaired. When this is impracticable the modern type loudspeaker which can be used as a replacement is listed.

This attractively produced booklet can be obtained from the Rola distributors in all States or direct from the Rola Company (Aust.) Pty. Ltd., The Boulevarde, Richmond, Victoria.



TRANS-TASMAN DIARY

By J. R. FOX

RECEPTION CONDITIONS

With the approach of winter, short-wave reception in New Zealand is showing signs of producing some excellent catches during daylight hours. Over the past month there has been a general improvement in conditions. The powerful South Americans are to be heard most of the day, while the lower power stations can be heard in the latter part of the afternoon.

Broadcast band conditions have been far from good. The North American stations have been very weak, Australians are building up in strength, while the Asians are on the improve. On the other hand, late Europeans have been reported to as late as 7.30 a.m. However, by the time that this issue is printed, these stations will have disappeared until the September equinox.

Within the next few weeks signals will peak and DX-ers should maintain a careful watch for new stations.

KZCA Salzburg.

In a verification to Mr. John Stenhouse, the American Armed Forces Radio Service Station at Salzburg, Austria, advised him that they have changed their call sign from KOFA to KZCA. This alteration took place on July 1, 1947. KZCA is a member of the Blue Danube Network of the A.F.R.S., and operates on 1104 Kilocycles, 1000 watts, while a short-wave outlet is heard on 7220 kilocycles with a power of 350 watts. Other stations of the Blue Danube Network are WOFA, at Vienna, on 1068 kilocycles, 1000 watts, and KOFA, at Linz, 629 kilocycles, 1000 watts.

HOXA Verifies.

It was indeed a surprise to receive a long-awaited reply from HOXA. It will be remembered that this station began operation in October, 1946, and at that time heard very well in this country. To my knowledge, this is the first verification from Radio Centro Americana received by a New Zealand DX-er. My verification arrived after a follow-up report had been sent by registered mail. The letter was signed by Jose Adolfo Hazera, General Manager of Radio Centro Americana, Apartado Postal 1335, Panama, Republic of Panama.

Canada Relays U.N. Radio.

The United Nations Radio at Lake Success is now being relayed through stations of the International Service of the Canadian Broadcasting Corporation. On the air at 3 p.m. daily, except Mondays, the programme is directed to Australia, New Zealand and the South Pacific over stations CKNC, 17820 kilocycles, 16.84 metres; and CKCS 15320 kilocycles, 19.58 metres.

The new United Nations amateur station at Lake Success was officially opened on May 17. The call sign is K2UN and has been heard on 20 metres.

WAVELENGTH CONFERENCE

According to a cablegram report from Canberra, the Australian Government has set up a sub-committee of Cabinet to devise methods of overcoming possible interference to Australian broadcast stations when the new New Zealand transmitters take the air with increasing power. One suggestion has been that Commonwealth stations should also be permitted to increase their power.

Such a move has its disadvantages, since for years, some high-powered Australians have caused interference to our stations. Listeners residing out of the district where a local station is situated, and desiring to hear a programme from other stations, sometimes face severe heterodyning from these stations across the Tasman.

It is hoped that as a result of the Conference between representatives of the Australian and New Zealand Governments held on March 10, at Melbourne, that a satisfactory allocation of frequencies has been arranged. In a statement to "Radio Science," the New Zealand Minister-in-Charge of Broadcasting (the Hon. F. Jones), stated that the results were still confidential and a statement would be issued simultaneously by both Governments.

UNLESS OTHERWISE STATED ALL TIMES ARE NEW ZEALAND STANDARD TIME. 12 HOURS AHEAD OF G.M.T. 2 HOURS AHEAD OF E.A.S.T.

Free Radios.

A new radio programme which has been heard over the ZB network during recent weeks was "Posers, Penalties and Profits." Compered by Selwyn Toogood, the programme was similar to the famous American show, "Truth and Consequences." For giving the correct answer or paying the penalty, a competitor would receive anything from a travelling bag to a £130 radio gramophone.

This was the first programme of its kind to be held in New Zealand, and whilst not quite up to the standard of "Truth and Consequences," it was an enjoyable break from the usual type of entertainment broadcast in the Dominion.

New Zealand readers are invited to contribute any items concerning radio, broadcasting, DX-ing and amateur radio activities for inclusion in this section. All letters should be forwarded direct to: Mr. J. F. FOX, 41 Bird Street, St. Kilda, Dunedin, S.2. N.Z.

N.Z. Short-wave Service.

No date can yet be given by the New Zealand Broadcasting Service for the opening of the new short-wave transmission.

According to advice received from Professor James Shelley, Director of N.Z.B.S., Stations ZL2, 9540 Kilocycles; ZL3, 11780 kilocycles, are to be used. It is possible that further test transmissions will take place. These will, however, be restricted to very short periods. DX-ers will be interested to know that special verification cards are in the course of preparation. It is hoped that they will be of a brighter and better design than the plain pink cards at present being used by the Broadcasting Service.

New Aeradio Station.

A new aeradio station will soon be opened for regular service to aircraft. The location is on the peninsula at Kaikoura, South Island. Communication facilities, navigational aid and a homing beacon will provide aircraft with a more reliable service between the North and South Islands. A land line link will be established with Flying Control Centre in Wellington and Harewood air station. A 180ft. steel lattice antenna tower will be used for the transmitting aerials and homing beacon.

ON THE BROADCAST BAND

TEST CRICKET AND DX-ING

The presence of numerous Australian stations on the air with extended schedules will no doubt give Test cricket enthusiasts the opportunity to try a little DX during pauses in play, or the tea adjournment.

The A.B.C. (interstate network and all regionals) will be on the air till stumps are drawn at 3.30 a.m. during each Test, whilst several commercial stations have arranged to remain on the air much later than their normal closing time, with descriptions and score services. As these notes are written, the first Test has not commenced, thus we are unable to speak from experience, but would suggest looking for such overseas stations as: KCMB Honolulu, Hawaii, 590kc, with its Japanese programme around 1.30 a.m.; KZBU, Ceub, P.I., 1250kc, may also be heard at many locations free from interference from stations taking the Test programmes.

Try also at tea adjournment (1.30 a.m.) for Singapore, 570kc (further details below), which should also be on a clear channel, and one may be able to catch a few minutes programme from VUD, Delhi, India 886kc, after stumps, as it is possible that some Indian stations may broadcast short periods of main matches.

Then, shortly after 3.30 a.m., several New Zealand stations begin testing prior to commencing their morning session at 4 o'clock. Try IZB Auckland, 1070kc; 4ZB Dunedin, 1310kc; 1YA Auckland, 650-kc; 3YA Christchurch, 720kc, and listen for others. Although unconfirmed as yet, it is likely that WLKS, 1470kc, the BCOF station in Kure, Japan, may also take Test broadcasts, and this should provide DX-ers with a good opportunity to log this.

By
ROY HALLETT

"RADIO MALAYA" BROADCASTING SERVICES

The following items of information gathered from the columns of a recent issue of the magazine "Radio Malaya News" make interesting reading, as they provide a clear picture of the service provided by "Radio Malaya" for local listeners. As most of these transmitters may be logged in this country during coming weeks, we take pleasure in passing this information on to our readers of this page.

Singapore, operating on 570kc. is on the air daily till signing off after a five-minute news summary at 1.35 a.m. A.E.S.T. except Sunday (Saturday night of course in Malaya) when it leaves the air at 2.5 a.m. This outlet has been heard in South Australia as early as 10.45 p.m. EST (10.15 p.m. in that State). This channel is not occupied at present by an Australian station, and is clear after 2YA Wellington N.Z. closes down at 9.30 p.m.

Singapore is also heard in this country on 1333kc. although we have no information concerning this from our Malayan source. This outlet is possibly used for programmes in Asiatic languages, as most programmes on 570kc. are in English.

Penang, 1280kc. leaves the air daily except Sunday at 1.30 a.m. and their Saturday night programme continues till 11.30 p.m. Malaya time, 2 a.m. here, Sundays.

Malacca, 1073kc. not heard a great deal I think in this country, closes down daily at 1.35 a.m. after news.

Seremban, 1023kc. relays Singapore from 12-b/n till closing 1.30 a.m. week-days, 2 o a.m. Sundays.

Kuala Lumpur, 1013kc. operates daily till the end of the short news summary beginning at 1.30 a.m. except Sundays, when it continues for an additional thirty-minutes.

All of the above stations take the news from Singapore at 12-m/n.

Recorded music (classical, dance, etc.) and BBC transcriptions are among the main features presented by "Radio Malaya" stations. When reporting reception of any of the above address your envelopes to "Radio Malaya," c/o the City in which the station you heard is located, e.g., "The Director, Radio Malaya, Kuala Lumpur, Malaya."

We offer our many thanks to Margaret Ballingall, Singapore, for her valued co-operation re the above information.

STATION CHANGES

An airmail letter from Art Cushen, Invercargill, N.Z., reached us just before going to press informing us that from September 1st, all N.Z. stations except five, will operate on new frequencies. At the same time five new transmitters are scheduled to commence operation. Full details of the new frequencies will either appear in these columns or those contributed by Mr. J. Fox before the change takes place.

As the result of this big change across the Tasman, many Australian stations will also alter frequencies on the same day. We have to thank Mr. Gaven Kelly for supplying the following information he was able to obtain from A.F.C.B.S. during his holiday in Melbourne.

Commercial stations scheduled to change frequencies on September 1st are as follows. Their new frequency is shown, while present channel is listed in brackets:—

4BH 1390kc. (1380kc.); 4KQ 690kc. (650kc.); 5DN 970kc. (960kc.); 5RM 830kc. 2GN and 4MK 1380kc. (1390kc.); 2DU and (810kc.); 2BH 650kc. (790kc.); 3HA 1000kc. 7BU 1250kc. (660kc.); 3BO and 4AY 960kc. (1010kc.); 7EX 4MB 4CA 1010kc. (1000kc.); (970kc.).

National Stations will change as follows:—

4QL 540kc. (690kc.); 3GI 560kc. (830kc.); 4QR 590kc. (940kc.); 2NA 1510 kc. (820kc.); 4QB 910kc. (660kc.); 4RK 940kc. (910kc.); 7ZR 940kc. (1160kc.); 42G 790kc. (800kc.); 6WN 800kc. (790kc.).

READERS' REPORTS

Mr. Rex Gillett reports in his DX column in the South Australian publication, "Radio Call," his hearing the call "Radio Pakistan" on 1167kc. the frequency on which we have been accustomed to hearing All India Radio's outlet at Dacca. It is uncertain whether or not this is a new transmitter, or merely the former A.I.R. gear operating on behalf of the Pakistan Government. A news bulletin in English is broadcast from this station at 1.30 a.m.

In a letter to this page, Mr. Gillett refers to four new outlets brought into use by All India Radio. A 5kw. transmitter has been installed at Patna, on 1131kc, at Cuttack, a 1kw. unit is operating on 1355kc. while two lower powered units are at Amartisar, 1305kc.

With a power of only 50 watts, and Jullundur, with only 250 watts on 1333kc. It is unlikely that the last mentioned units will be heard in Australia, particularly as the latter operates on the same channel as Singapore, mentioned elsewhere on this page.

Fair signals from VUD Delhi, 886kc. VUT Trichinopoly, 758kc. VUW Lucknow, 1022kc. VUL Lahore, 1086kc. VUP Pashawar, 629kc. VUB Bombay, 1231kc. perhaps VUM Madras, 1420kc. VUC Calcutta, 810kc., around 1 to 3 a.m. during the next few months. These stations present generally Indian native-type programmes, with occasional English language features.

Mr. Art Cushen writes suggesting the identity of the station operating on the 1500-1600kc. band heard by our Victorian friend, Mr. Norman Harper, may be the powerful XERF, operating with 100kw. on 1570kc. from a transmitter at Piedras Negras, Mexico, while requesting listeners to address mail to them at Del Rio, Texas, U.S.A. XERF is heard by our two friends around 8.30 p.m. with Hillbilly programmes, while Mr. Cushen hears the station open with a Mexican programme at 8 p.m. and in English at 8.30 p.m.

This reporter also informs us that XEMC Mexico City, broadcasting Mexican language programmes on 1590kc. is now on an all-night schedule, and advises also good reception from such stations as—WCKY Cincinatti, Ohio, 1530kc. also an all-nighter (this one must not be confused with KFBK, Sacramento Calif. also 1530kc. likely to be heard around 9 p.m.) WKBW, 1520kc. Buffalo, N.Y. another all-nighter, WLAC, 1510kc. Nashville, Tenn. heard opening 8 p.m. KOMA 1520kc. Oklahoma City, Okla. opens 9 p.m.

SHORT WAVE LISTENER

Conducted by Ted Whiting

B.B.C. SPORTS BROADCASTS

It is a well-known fact that the B.B.C. has made a speciality of outside broadcasts. This year will be an exceptional one in this branch of broadcasting, as it is proposed to give a full coverage to the series of cricket Tests at present in progress, as well as to the Olympic Games, which will commence shortly. The immensity of this task is immediately evident from the following extracts, taken from **"London Calling"**:—

"The B.B.C. is equipping a radio centre at Wembley, consisting of eight studios, 20 recording channels, and a control room capable of passing 32 simultaneous broadcasts to the European trunk line exchange of the Post Office or to the B.B.C.'s own transmitters. In addition the television headquarters will also be located at Wembley.

"To provide good broadcasting facilities for the great radio organisations of the world is a large undertaking. The installation of land lines is a major operation, for high quality circuits are needed all the way from the commentators microphone to the transmitter, and each commentator must have a return circuit for taking his cue.

Electrical equipment is also needed for each microphone to amplify the commentators voice, to mix it appropriately with the various crowd effects that the listener wants to hear. These facilities are being installed at some 30 places in and around London, with positions for commentators.

"In Wembley Stadium, where the athletics will take place, there will be 32 commentators positions."

Many languages will be used to give the maximum coverage to the 50 countries which will be represented at the Games. No doubt a schedule of transmitters will come to hand in the near future, but we think little alteration will be made to the schedules now in force.

As regards the cricket Tests, commentaries on these games will be heard on GSV, 17810kc; GSH, 21470kc; and GSJ, 21530kc, with SEAC also taking the broadcasts which are to be made from 8.15 p.m.-9 p.m.; 9.30 p.m.-10 p.m.; 10.15 p.m.-10.30 p.m.; 2.30 a.m.-3 a.m.; 3.15 a.m.- 3.30 a.m. Other transmitters will probably be put into service, dependent on conditions prevailing at the time; complete announcements will be made on any such changes.

READERS' REPORTS

An outstanding list of loggings has been received from that well-known DX enthusiast, Mr. R. Gillett, Prospect, S.A. Knowing that the list will be of interest to readers we publish it in its entirety.

SYRIA: Beruit has an English transmission from 1 a.m., but reception is marred by severe interference. The Beruit frequency is 8036kc.

BRAZIL: ZYB8, Sao Paulo on 6095kc. has been heard strongly at 7.15 a.m. with a variety programme in Portuguese.

SOUTH AFRICA: Pietermaritzburg has been noticed on its channel of 4855kc. recently, closing at 7.45 a.m. This was heard on a Sunday, but normal close down is at 7.5 a.m. The next day this station was back on 4878kc., where it has been operating for some considerable time.

ITALY: Radio Italiana broadcasts a special service in English for listeners in South Africa from 7.10 a.m.-7.20 a.m. after which both transmitters, on 6085kc. and 11810kc., close down.

FRANCE: Paris is logged on separate occasions on 6220kc. and 6170kc. until sign off at 8 a.m. Transmissions do not appear to be regular, the latter frequency producing a very fine signal. At a later hour the 10230kc. channel was also heard.

CELEBES: Macassar has been heard opening on 9550kc. at 8 a.m. with fine signals.

SUMATRA: "Here is Radio Sumatra, Medan" was announced in Dutch on 7210kc. at 11 p.m., following a programme of recorded music, the pre-war call was YDX.

JAVA: An Indonesian station on about 3260kc. heard at 11.20 p.m. is possibly Sourabaya. Bandoeng on 3015kc. is also heard at the same time.

GREECE: Athens leaves the air at 7.30 a.m., following a foreign language feature on 7295kc.

MOZAMBIQUE: Lourenco Marques announces that from May 1st they are operating from 7 p.m.-1 a.m. on 31 metres, presumably 9650kc., and from 1 a.m.-7 a.m. on 60 and 85 metres, 4925kc. and 3490kc.

U.S.S.R.: At 7.30 a.m. the following Moscow channels have been heard on the 30 metre band, 8910kc. with music, 9760kc., 9720kc. and 9710kc. in German language transmission and 9750kc. with music.

NEWFOUNDLAND: A station was heard at 8 a.m. which is thought to he VONH. The time, frequency of 5970kc. and Canadian type of speech check, but local noise prevented positive identification. This station gave a news bulletin at 8.15 a.m. lasting 15 minutes, male and female announcers being used.

NEW CALEDONIA: Noumea has been heard at 8.30 p.m. on 6000kc., but despite a good strength signal the quality appeared to be mushy.

VATICAN CITY: HVJ on 5970kc. heard at 7.30 a.m. on Saturday in a French broadcast, from 8 a.m. the transmission is carried out in Italian.

SWITZERLAND: Berne on 15305kc. concludes an English broadcast to South Africa at 6.45 a.m., the level is very good.

PRAGUE is now using 9550kc. again for its broadcast, concluding at 8 a.m., English being used during the last 15 minutes.

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Loggings received from Mr. A. T. Cushen, Invercargill, N.Z., are also of interest, many of the stations mentioned being received here in Australia.

SOUTH AFRICA: Johannesburg on 4800kc. is operating from 6.45 p.m.-8.30 p.m. and 6.20 a.m.-11.5 a.m., heard here at 5 a.m. only fair strength.

GOLD COAST: ZOY, Accra is fair in news on 4900kc. at 7.45 a.m., close at 8 a.m.

CHINA: XHSR, 5948kc., Honan-Shantung Broadcasting Station relays XNCR until 2 a.m., local programme follows to sign off at 3.30 a.m.

HAITI: HH2S, Port au Prince opens at 1.30 a.m. but interference is bad, opening announcements are in French and Spanish.

PALESTINE: Forces Broadcasting Station was operating on 6075kc. from Jerusalem, 2.30 p.m.-4.30 p.m. and 6 p.m.-7 a.m.

GERMANY: A.F.R.S. stations have closed down, now broadcasting as Radio Munich on 6080kc. from 3 p.m.-2 a.m., 8 a.m.-9 a.m., and Voice of America relays at 2 a.m.-8 a.m.

PORTUGAL: CS2WD, Lisbon opens at 5.30 a.m. but reception is poor owing to interference from Berne on 6165kc.

GUATEMALA: Radio Marimba, 6220kc. and Radio Libre, 6385kc. both have good signals on Sunday to 4 p.m. A new station opening at 9.58 p.m. on 6380kc., thought to be located in Guatemala City is badly interfered with.

HONDURAS: HRQ, San Pedro Sula, is a new one operating on 6125kc. at noon, but not likely to be heard in Australia at this time. Other Latin Americans heard in N.Z. are YSHQ, San Salvador, 6150kc., 11 a.m.-2 p.m.; HC4FS, "La Voz de Esmareldes," Cuidad Esmareldes, Ecuador on 4560kc. 11 a.m.-2 p.m.; YSOP, San Salvador, 5200kc. 11 a.m.-noon; YV1RG, Cabimas, Venezuela, 6150kc. 10 a.m.-noon; YV6RK, El Tigre, Venezuela, 3330kc. 9 a.m.-12.30 p.m.; YV9RA, San Fernando de Apure, Venezuela, 4820kc., 10 a.m.-12.30 p.m.; HCQRX, Quito, moved recently from 6000kc. to 4925ks.

AFGHANISTAN: The new Afghan Radio is on the air daily until 3.30 a.m. on 6760kc.

CUBA: COCX, "La Emisora del Pueblo," Mil Diez, Reina 314, Havana, Cuba, is one of the best Cubans, closes 3 p.m. daily, calls mentioned on closing are CMX, COCX, CMKM, CMJF, CMKX.

MEXICO: ZETT, Mexico City, is received on 9550kc. at fair level 3 p.m.-4 p.m. ZEBT, from the same location carries a news broadcast in English at 1.45 p.m. on 9625kc. Good signal.

CHINA: Schedules to hand for XGOY, Chungking are, 7.55 p.m.-9.30 p.m. on 15170kc. to Australia and New Zealand; 9.35 p.m.-11.35 p.m. on 6140kc. and 7153kc. to East Asia and the South Seas; 11.45 p.m.-2 a.m. on 6140kc. and 7153kc. to North America and Europe; 2 a.m.- 3a.m. on 6140kc. and 7153kc. to Europe, North America and the South Sea.

LISTEN FOR THESE STATIONS

Athens is still being heard at quite good level in the early morning, the station announces, "This is the Athens Broadcasting Station" and is heard at the commencement of its transmission at 2 a.m. on 7295kc., when news is read in English until 2.15 a.m. This is followed by a broadcast in French.

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Radio Algeria, Algeria is heard in French on 9570kc., having moved there recently from 11835kc. This station is heard at good level from 5.30 a.m.-8.30 a.m.

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Listeners on the 13 metre band have no doubt heard the transmissions from PCJ, "The Happy Station," Hilversum, Holland. With Eddie Startz at the helm this is always an interesting station to listen to, and the signals are really good. This transmission is heard at 8.45 a.m.-10.45 p.m. on 21480kc. The station is anxious to receive reports which should be addressed to Radio Netherlands, P.O. Box 137, Hilversum, Holland.

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Radio Monte-Carlo advises that the station has been operating on 6035kc. since 5/3/48, using a power of 25 Kw. Present transmissions are made at 4.30 p.m.-6 p.m., 9.0 p.m.-11.0 p.m., 4.0 a.m.-8.15 a.m. Another similar transmitter is on order and will be operated on the 25 or 31 metre bands. Reports on the transmissions are welcomed and should be addressed to Administration-Direction, 16 Boulevarde Prine, Charlotte, Monte Carlo, Monaco.

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TIPG is heard on 9620kc. despite the interference from KZFM at about 10 p.m. This is quite the most consistent of all Latin Americans on the bands. The location is San Jose, Costa Rica.

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COCX, Havana, on 9270kc. is another consistent station heard nightly at 10 p.m. at very good strength and carrying the customary type of programme. Another one from Cuba is COKG, Santiago de Cuba, on 8955kc. heard at slightly less strength at the same time. Further transmitters operating from Cuba are COHI 6465kc., COCQ 8850kc., COCO 8700kc., and COCM 9830kc.

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ZYB8, Sao Paulo, Brazil, is heard regularly in the mornings at 7 a.m. on 11765kc., quite a good signal when conditions are favourable.

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An interesting station was heard at this location, in FO8AA, Papeete, Tahiti. At the time of reception traffic was in progress at 1.38 p.m. and the signal was quite fair despite interference from other stations and from local sources. We believe this station has a regular schedule on this frequency on Saturdays but it is rarely heard here. Look for FO8AA on 6,980kc.

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LRY, Radio Belgrano, Buenos Aires is heard opening at 7.58 p.m. at very good level. The announcement made makes mention of LR3, the broadcast band call and also LR1 which is also in relay. Good reception can be had from LRY till 8.50 p.m., when a Russian station blankets LRY out.

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YV5RY 4275kc. and YV5RM 4970ks., Caracas, Venezuela, are heard through the interference on that band at 9.15 p.m. soon after opening. No doubt reports on any stations on this band will be well received as the stations are intended for purely local reception, the nature of the country in which they are located dictating this choice of frequency. While the two stations mentioned are the outstanding ones there are many others to be heard. Any readers reports on these bands will be welcome.

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The schedule for Munich on 7250kc. is 2.15 a.m.-3.15 a.m. and 5.15 a.m.-8 a.m., signal fair but a little harsh about this frequency.

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TAP, Ankara, Turkey, has an English transmission from 3.45 a.m. daily which includes a news cast. On Monday at 7.30 a.m. the familiar **"Post Bag"** session is heard in which calls are made to those who have reported the station. On Tuesday and Friday at the same time a special broadcast is made to England while on alternate Wednesdays at 7.30 a.m. there is a transmission to USA. TAP operates on 9465kc. and is a good reliable signal here.

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YHN, Jokjakarta is another good one at 9 p.m. on the new frequency of 10840kc., news, etc., being the main items.

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VPO3, Bridgetown, Barbadoes Is. is heard on 10605kc. carrying a broadcast of a race meeting, on closing at 7.45 a.m. the announcement is made that further transmissions would be made on Saturdays at 12.45 p.m.

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SEAC, Ceylon, is still operating the same frequencies as formerly, 15120kc., 9520kc., 6070kc. and 3397kc., which may be heard daily. A further frequency of 17730ks. is also used carrying a separate programme, this one will possibly be used in the relay of the BBC programmes in the near future. A 9915kc. transmission has been reported, but as yet has not been heard.

SEAC, 21620kc. is heard regularly at 10 p.m. on this newer frequency. Reports are welcomed by the station.

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XGOY, Chungking, 15170kc., is a good one on this frequency at 8.30 p.m. in transmission to Australia.

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OQ2AA, Leopoldville, Belgian Congo, can be heard on 15175kc. at 6.30 p.m.-8.45 p.m. with a fair signal. Reports from all States on this station.

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On 11850kc. the Norwegian station LLD is heard at 11 a.m.-12 noon, but has been hit badly by interference and poor conditions of late.

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XEEP, Mexico City, Mexico, "Radio Education" can be located on 6155kc. at Midnight, only fair signal at this location.

A new station located in Afgranistan is heard at 3.30 a.m. on 7960kc., reported to us originally from W.A.

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From British Honduras, ZIK2 on 10598kc., located at Belize is on the air from 4.30 a.m.-4.38 a.m. This one will be a good catch as the station only operates at low power.

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All India Radio is heard in six English transmissions daily and are heard at good level throughout. The schedule is as follows:—

1.30 p.m.: 21510kc., 17830kc., 15290kc., 15190, 15160, 11870kc.

3.30 p.m.: 21510kc., 17830kc., 15190kc., 15160kc., 11870kc.

4.30 p.m.: 21510kc., 17830kc., 15290kc., 15190kc., 15160kc., 11870kc.

8 p.m.: 21510kc., 15290kc., 15160kc., 11870kc.

9.30 p.m.: 21510kc., 17830kc., 15190kc., 11870kc.

12.30 a.m.: 15160kc., 11870kc., 9590kc., 6068kc.

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VPO8, Barbardoes, 19055kc. is heard handling traffic at 7 a.m., but we doubt that a report will be received on this one. This transmitter may be used at odd times carrying programme material.

The Damascus station operating on 12000kc. was being heard at 3 p.m.-4 p.m., but of recent weeks has not been heard on a regular schedule owing to current events in that part of the world.

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CBRX, 6160kc., located at Vancouver is heard again at 2.15 a.m., good card from this station.

An interesting point, although not concerning a short wave station, is that the United Nations are soon to operate a transmitter from Geneva, Switzerland, which is intended to provide a coverage of the whole of Europe. This is to be assigned to 1200 metres and will use a power of 1000 Kw. Use may be made of frequencies on the Short Wave bands in the future, these will be well worth looking for.

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KZFM, Manilla, now on 11840kc. is the usual good signal heard from the Philippine stations at night. From 8 p.m. the usual good programmes are heard and prove quite interesting at times.

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Canadian Summer schedules are as follows: To Europe: 11 p.m.-8 a.m. CKNC 1782kc.; 11 p.m.-1.45 a.m. CKCK 15190kc.; 1.45 a.m.-8 a.m. CKCS 15320kc. To the Carribean Area in English: 9.20 a.m.-10.30 a.m. CKNG 17820kc. and CKCX 15190kc. To Latin America: 10.30 a.m.-11 a.m. in Portuguese on Tuesday, in Spanish from 11 a.m.-12 p.m. CKNC 17830kc. and CKCK 15190kc. To Canadian Arctic in English on Sunday only from 2.10 p.m.-3 p.m. on CKLO 9630kc. and CKOB 6090kc. To Australia and New Zealand: 6.45 p.m.-8.30 p.m. on Sunday on CHOL 11720kc. and CHLS 9610kc.

Club Notes and News

ST. GEORGE RADIO CLUB

1a Market St.,
Rockdale, N.S.W.
President: E. Brown (A.M.I.R.E.).
Secretary: D. Boyd.

The St. George Radio Club, originally but an idea in the minds of a few local hams, has grown rapidly and now embraces such activities as weekly code classes, exam quiz's, corrections and advice plus equipment demonstrations. The club is also fortunate in having the services of a large panel of lecturers who deliver numerous talks on radio and electronic subjects.

An attractive adjunct to the frequent field days is the follow-up picture night, when participants are afforded the opportunity of seeing themselves and the highlights of the day in colour movies. This and the extensive film library are made available by the courtesy of Mr. E. Jones, the Vice-President.

A steadily increasing membership attests to the success of this club, and all interested parties are invited to attend at the above address any Tuesday or Friday evenings at approximately 8 p.m. Further information may be secured from the Hon. Secretary, LX3403 or LX2012.

HURSTVILLE DISTRICT AMATEUR RADIO CLUB

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

In May, a Lecture on The Practical Construction of a Practical C.R.O. was given by VK2AWW, with particular regard to Ham application. This Lecture will be elaborated upon, it is hoped, in August. Circuit Diagrams on which the Lecture will be based, for a useful and inexpensive instrument, will be issued to all attending.

The programme for the Club's activities for the month of July is as follows:—

Tuesday, 6th July.—General Meeting.

Tuesday, 13th July.—Morse Practice, Transmitter Construction.

Tuesday, 20th July.—Morse Practice, Instructional Night. Basic Principles Serial No. 1.

Tuesday, 27th July.—Morse Practice, Quiz Night on Radio Definitions.

On the Sunday, 18th July, the Club will hold a Field Day at Carr's Park, and will be transmitting on 40 and 6-metre bands, using the Club's call sign, VK2MZ, and would be pleased to hear from Hams who hear us on the air.

We invite any person interested to attend at the Club Rooms on any night that the Club meets.

GLADESVILLE AND DISTRICT EXPERIMENTAL RADIO CLUB

Rear 117 Victoria Road,
Gladesville.

Operating on 144 Mc., the club held a very successful field day on 13th June, 1948. It has been the object of this club to use UHF to its full advantage, as nearly all its members are operating on these bands. On this occasion it was arranged for six parties to proceed to high points around Sydney and outlying parts and from there endeavour to communicate with the other parties and local stations.

Stations were sent to Beacon Hill, Brookvale, Pretty Point, Prospect, Waterfall, Engadine and Bringelly. These were operating by 11 a.m., and 100 per cent. communications then ensued.

A broken feeder at Brookvale put this station off the air for quite some time, but repairs were effected and in the afternoon they were on again. All stations that were operating were contacted by the Prospect station, led by W.I.A. UHF Officer Charles Fryar, VK2NP. Other leading UHF amateurs were in charge of the other parties: Brookvale, George (Mick) Bamford, VK2AGB; Waterfall, Wal. Webster, VK2EW; Bringelly, Horrie Lapthorne, VK2HL.

Weather conditions were far from favourable and extreme conditions were reported from all points, particularly Prospect, who were operating from an exposed hillside and were continually showered with rain, sunshine and high winds. The gear was supplied by the club members and all operated from car storage batteries. Beam antennae and dipoles were used. To create interest a form of point score was arranged and some quite good scores were returned.

At dusk all parties QRT and returned to Sydney.

It has been the policy of this club to run field days, which have proved a great success in keeping interest alive within the club. In addition, lectures on radio and allied subjects are given by club members each month and also any club business is dealt with on one meeting night each month, thereby giving more time for instruction, lectures, etc.

All members are now looking forward to our next field day, which will be held late in August, and it is hoped to use 288 Mcs. as the working band.

EXPERIMENTAL RADIO SOCIETY OF N.S.W.

Melody Hall,
George St., Burwood.

Following the successful reunion, a meeting was held, at which the election of officers for the ensuing year took place.

R. A. Blades, VK2VP, was re-elected President; B. Taylor, Secretary; O. R. Pearce, VK2IV, Vice-President; C. E. Whiting, Publicity Officer; W. Jennings, QSL Officer; H. Ackling, Treasurer; A. I. K. Clarke, Librarian.

Intending members are assured of a warm welcome at the meetings of the Society held in Melody Hall on alternate Thursdays at 8 p.m., the meetings for July being on the 1st, 15th and 29th of the month.

NEWS OF THE AMATEUR BANDS

Recent modifications having been made to the Amateur Frequencies, we feel that the complete list of these frequencies may be of interest to those who listen to these bands.

As at 20/5/48 these allocations are:—

3500kc.-3800kc. 80 Metre band.
7000kc.-7200kc. 40 Metre band.
14,000kc.-14,400kc. 20 Metre band.
26,960kc.-27,230kc. 11 Metre band.
28,00kc.-30,000kc. 10 Metre band.
50M/c-54 M/c. 6 Metre band.
144 M/c-148 M/c.
288 M/c-296 M/c.
576 M/c-585 M/c.
5650 M/c-5850 M/c.
1345 M/c-1425 M/c.
2300 M/c-2450 M/c.
10,000 M/c-10,500 M/c.
21,000 M/c-22,000 M/c.
30,000 M/c and all frequencies upwards.

The extension of the 11 metre band will be very welcome and no doubt good contacts will be made on these frequencies. Much speculation is being made on the potentialities of the 21,000kc.-21,450kc. allocation which is to be ratified next year. Undoubtedly the opening of this band to Amateur Communication will to some extent relieve the congestion on the 14000kc. allocation. The bands from 50 M/c offer experimental work of great interest, both 50 M/c and 144 M/c are now receiving the attention of many amateurs, and good work is being done in the form of local contacts, with in the case of the 50 M/c band an occasional opening of the band to VK3, 4 and 5 and more infrequency to ZL. In the U.S.A. there appears to be a large amount of activity on the VHF bands, the latest issue of "QST" listing the record contacts for their various frequencies, which in some cases are different to those allocations made in Australia.

The figures for 144 M/c are 660 miles; 235 M/c, 210 miles; 420 M/s, 186 miles; 1215 M/c, 12½ miles; 2300 M/c, 66 moles; 3300 M/c, 150 miles; 5250 M/c, 31 miles; 10,000 M/c, 7.65 miles; and 21,000 M/c, 800 feet.

It will be interesting indeed to learn how the achievements of the Australian amateurs compares with those over the Pacific. General conditions over the past month have been rather poor, on 7 M/c in particular conditions have been very variable. At night, this band has at times faded right out for contacts up to 300 miles or so, the interstate boys at this time being received at excellent level.

Much DX is being worked on both 14 and 28 M/c with conditions much as related in these columns last month, the usual countries being evident in most logs. Conditions on 3.5 M/c are very good and many signals are to be heard on the band at night, consisting of interstate and ZL signals; American CW is also reported at around 10 p.m.

A very interesting contact was heard recently from VK2ARC/ Mobile while in flight between Sydney and Melbourne. The signals were nearly perfect on 'phone throughout the trip. The 136 foot aerial with an effective height of some 7000 feet doing a fine job. VK2ARC/Mobile was using a Type 3 Mk2, a low power rig which has given him some very fine results.

X-RAY SNAPSHOTS

(Continued from page 14.)

High-speed X-ray pictures have been taken of armour-piercing bullets during the actual penetration. Two mutually perpendicular high-speed X-ray pictures, taken in sequence of a .30 calibre armour-piercing bullet penetrating a small two-hy-two-inch piece of ½-inch thick armour, are shown in Fig 8.

The first of the high-speed X-ray pictures was taken when the core of the bullet had penetrated ⅜in. into the yielding armour plate. The jacket, which cannot penetrate the armour, has telescoped forward on itself and exposed the base to the core. The second high-speed X-ray picture was taken of the same bullet approximately 20 microseconds after the first picture. The core of the bullet has penetrated the armour, and its tip is projecting through the back. Part of the armour pushed out by the penetration can be seen. The jacket of the bullet has continued to telescope on itself and even more of the base of the core is in evidence.

Other high-speed X-ray pictures taken during this study showed the flow of the jacket material and the breaking up of the core as the bullets penetrated the armour.

Ballistic Studies

The high-speed X-ray equipment is pre-eminently fitted to study the bullet motion and behaviour inside a gun barrel. No other means is available for taking a picture of a bullet as it passes down the bore of the gun. When a bullet is fired in a gun barrel, the blast that accompanies each shot reaches the muzzle before the bullet does. A spark shadowgraph of the blast which precedes the bullet exit is shown in Fig. 9. (This spark shadowgraph was taken at the instant the silvered glass rod placed at the muzzle of the gun was broken. The location of the bullet, still several inches from the muzzle, was determined by means of a simultaneous high-speed X-ray picture shown. Previous methods of determining the location of the bullet at any instant in the gun barrel, such as by strain gauges, have proved to be inaccurate.

The high-speed X-ray equipment has been used to observe the realignment of component parts inside the bullet when it is fired. A stationary X-ray picture was taken of the bullet in question. The bullet is then fired and a high-speed X-ray picture is taken of this same bullet in flight. A comparison of the two X-ray pictures reveals any shift of the component parts that has taken place. This procedure can be used, for example, to study the motion of the component parts of valves during their operation.

A series of high-speed X-ray pictures has been taken of a 20 mm, high-explosive shell passing through steel plate. It was necessary to place a steel plate ¼in. thick over the X-ray film-holder in order to protect it from the force of the explosion and the flying fragments. A new protection plate was required after every shot. Despite the fact that all the pictures were taken through ¼in. of steel, the details of the explosion are clearly evident. One of the amazing things revealed by this study is the immense swelling of the shell to almost twice normal diameter before it finally bursts open.

The high-speed X-ray equipment has one use for which it was designed. It can be readily adapted to serve as the light source for high-speed *flash* photography. A wire spark gap is substituted for the X-ray tube on the surge generator. The short duration, high intensity spark resulting from the discharge of the surge generator can be used to take a millionth of a second photograph of any moving object. A picture of a .50 calibre bullet in free flight taken in a millionth of a second is shown in Fig. 10. The light from the spark discharge of the surge generator was used as illumination.

Future Uses

The applications of this equipment have primarily been confined to the field of ballistics, simply because of the tremendous interest in this subject during the war, and the high-speed is so well adapted to this purpose. Many applications exist in other mechanical-engineering fields. The requirements for a suitable application are: (1) A desire to study parts in motion; (2) a condition where high-speed light photography is not adequate, either because the parts to be studied are not visible, or because of the of the danger of mechanical damage to an unprotected camera.

Consider the severe problem of the blades in both steam and gas turbines. Under the stresses imposed by the high-speed and thrust of the expanding vapours, the condition under rotation may be very different from that existing at rest. Further, the blades are necessarily enclosed in a heavy metal case. The operation of turbine blading becomes a problem susceptible to study by the high-speed X-ray unit.

Valve action for reciprocating engines, compressors, and similar machines can be observed in normal operation by this X-ray unit. Deformation in butterfly valves in one case caused a shift in the timing of one machine that impaired the operation. Just how the valves were acting could be determined by the X-ray.

Extension of the applications of this unit must come in the post-war period when more of these units become available. This extension will be in those applications that satisfy the two fundamental requirements.

The new uses will be in those fields of engineering when parts are moving rapidly and cannot be "seen" by the conventional camera using a light source.

TELEVISION STUDIO LIGHTING

(Continued from page 27.)

The requirements of illumination for the iconoscope can be met by the use of a super high-pressure Mercury Discharge lamp. The emission from the mercury lamp is bluish and contains an appreciable percentage of near-ultra-violet radiations. It corresponds, therefore, with the sensitivity of the iconoscope.

Another point of utmost importance for the application of mercury lamps in television studios is that they radiate very little heat. With stage lighting, heat radiations can cause considerable difficulty due to their effect on the actors. When the lighting system consists of incandescent or carbon arc lamps, the illumination level is limited by the heat which the actors can stand. Some relief can be afforded by good ventilation, but the heat rays remain annoying, as all those who have ever acted in front of a film or television camera will bear out. Mercury lamps may be water-cooled, and thus the heating effect is, to a considerable extent, eliminated.

Ultra Violet Rays

As mercury light contains ultra-violet rays, to which the iconoscope is very sensitive, it has also the advantage that the actors are less troubled by the light. Yet another advantage is that mercury lamps need less energy than incandescent lamps, with the result that their use means less current consumption.

The most suitable type of mercury lamp is that with the highest possible luminous efficiency. Thus the Philora water-cooled Mercury lamp, with an efficiency of 60 lumens per watt, provides the ideal answer to the choice of a light source for the television stage. As a means of comparison, the luminous efficiency of the incandescent lamp does not exceed 15 lumens per watt and, of course, the emission from it is not at all suitable for the task involved.

The main lighting system of the Philips television studio consists of 42 lamps, type SP500, with a total load of 42 x 500 watt = 21 Kw. The lamps are mounted in 14 groups of three lamps each. The additional lighting consists of 5 lamps, type SP, 1,000 d.c. The total illumination level at the back of the television studio is about 700ft. candles, a value closely approaching sunlight conditions.

Data courtesy Philips Electrical Industries Ltd.

The Mail Bag

A.D. (Five Dock, N.S.W.) enjoys reading each issue of RADIO SCIENCE and would like to see the description of a five valve dual wave mantel receiver.

A.—Thanks for the suggestion, and no doubt a receiver of this type will be featured in some future issue of the magazine. However, at the moment we cannot say just when this will be. There have been so few requests for the underneath wiring diagrams, that it has been decided space normally necessary for these can be put to better use in some other manner.

A.L. (Semaphore, S.A.) was interested in the photographs of Bunnerong Power House and mentions that it is very similar to the Osborne Power House in Adelaide.

A.—Your letter was quite interesting, A.L., especially the remarks about the similarity of the two power houses. The suggestion in your earlier letter re the Short Wave Station List will be forwarded along to the SW correspondent, Mr. Whiting, for comment. If the idea is feasible it may be possible then to include the list in one issue.

K.J.McL. (Heyfield, Vict.) sends in a two year subscription and suggests that we describe the construction of an inexpensive amplifier suitable for operation from either the AC mains or a vibrator.

A.—Thanks for the subscription and suggestion. An amplifier of the type you mention was fully detailed in the April, 1948, issue of RADIO SCIENCE. As this issue was included among those requested no doubt by now you will have seen the circuit, and probably have it under construction. The short wave coils for a one valve receiver can be readily wound. If you could let us have further details of the circuit you have in mind, we will endeavour to assist you through these columns.

M.A.G. (E. Brunswick, Vict.) forwards a subscription and is particularly interested in reading about FM activitites and wire recorders.

A.—Thanks for the subscription, M.A.G. This has been attended to by the department concerned. The February issue of RADIO SCIENCE contained a general article dealing with FM theory and no doubt this will interest you. To date nothing has been published in any issue dealing with Wire Recorders, mainly because of lack of suitable equipment and materials in this country. However, it might be possible to include some data on overseas trends in this field, at a later date.

C.G. (Balladoran) writes in an interesting letter and suggests among other things that we include some articles on basic radio theory that would be of value to the beginner.

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".

A.—Yes, C.G., we realise the importance of catering for the needs of our many younger readers and agree that the inclusion of articles as you suggest would be welcomed by many. Several other readers have forwarded similar suggestions and from all these letters we hope to be able to draw up a series that will have some practical as well as theoretical value to the reader. Although there is a certain amount of heat dissipated by valves, we have found this is not particularly excessive in the case of the Miniminor Mantel and unlikely to cause any speaker troubles. The issue requested has been forwarded along and we hope that future copies will he received satisfactorily from your newsagent.

R.H.G. (Burwood, N.S.W.) suggests we publish details of a five valve AC operated superhet, incorporating an RF stage.

A.—There are no immediate plans for describing such a set as you mention. We might add that the May, 1948, issue of RADIO SCIENCE contained full constructional details of a Seven Valve receiver and this incorporated an RF stage. Possibly this circuit may interest you or if necessary it could be amended to suit your requirements. We regret the error in the Ohm's Law card, and tihs matter has heen brought to our notice by many other readers.

B.J.G. (East Oakleigh, Vict.) is interested in short wave reception and would like to know the meaning of the abbreviated terms used by amateurs.

A.—In this limited space it is not possible to list all these abbreviations and suggest you refer to either the Radio Handbook or the ARRL handbook for the various meanings. If you have not a copy of these publications, you should be able to see one at the Melbourne Public Library. We have no idea if there is a DX club in your vicinity.

Possibly some other reader may be able to help. If so, write in, giving particulars and we will pass on the details.

W.P. (Woollahra) forwards some suggestions for consideration and possible inclusion in future issues of RADIO SCIENCE.

A.—Thanks for the letter and suggestions, W.P. The idea of including a series of articles describing the Sydney broadcast stations is quite feasible, although we wonder whether it would be as popular as you mention. Actually our Broadcast Band DX correspondent, Mr. Hallett, has mentioned this matter previously, but to date nothing has been done mainly because of space commitments. Efforts have been made to try and induce amateurs to send in photographs of their stations, together with equipment, details, etc., but apparently the majority are simply not interested in the idea.

H.A.O. (Hawthorn, Vict.) suggests that we describe in a future issue of RADIO SCIENCE the construction of a large radiogram.

A.—Many thanks for the letter and suggestion. This will be kept in mind, and when suitable gramophone motors as well as cabinets are readily obtainable we will endeavour to run something along the lines you suggest. The copy of the first issue has been forwarded and no doubt by now you will have received it.

B.C. (Adelaide, S.A.) writes in an appreciative letter and asks for an early issue of RADIO SCIENCE.

A.—The issue requested has been forwarded along. We appreciate your remarks about the magazine and are pleased to know you find much to interest you.

L.F.D. (West End, Brisbane) requests some of the earlier issues and says: "In passing I should like to congratulate you on an excellent publication. You seem to have gathered an impressive array of talent to contribute articles and I sincerely hope the present quality will be sustained."

A.—Your letter is appreciated and the issues required have been forwarded along to you. You may rest assured that the future copies of RADIO SCIENCE will maintain or even better the present standard. Your suggestion re the defining of radio terms is quite interesting and as soon as space permits will endeavour to include this as a feature. Undoubtedly many other readers will also find it as a means of brushing up their knowledge.

A.K. (Strathfield) would like to see some articles published dealing with Test Instruments and Laboratory measurements.

A.—Thanks for the letter, A.K. The issues requested have been forwarded along. Due to lack of space it is impossible to include all the articles we would like, but no doubt we will eventually get around to the ones you mention. Possibly the "A-F Amplifier Servicing" article in this issue will interest you.

U.H.F. TECHNIQUES

(Continued from page 36.)

moving half way around one of the constant "S" circles (i.e., through one quadrant). This is because the admittance is the same as the impedance quarter-wave further down the line. Thus Y is the admittance corresponding to the impedance Z in Fig. 9b.

Stub matches have the advantage over quarter wave transformers of being more easily adjustable. A stub of variable length can be made with the aid of a spring contact plunger.

For experimental work universal matching transformers capable of a wide range of adjustment are desirable. Two stub transformers with two variable stubs spaced an eighth wave-length apart are used for this purpose.

A simple type of matching transformer consists of two quarter-wave dielectric slugs, as indicated in Figure 10. The dielectric has the effect of increasing the characteristic impedance because of the increased capacity, so that the slugs act as quarter-wave transformers. By adjusting the position of the slugs in the line and the distance between them, impedances with standing wave ratios less than k2 may be matched. The dielectric must be of low loss. At 10 centimetres wavelength, polystyrene with a dielectric constant of 24 is satisfactory. The length of the slugs is shorter than quarter-wave in air because of the dielectric.

Where axial rotation of one section of transmission line relative to another is required, a *rotating joint* is employed. An example of this is in the connection of a feeder to a continuously rotating aerial as in a radar.

In two-wire lines slip rings are satisfactory, but with co-axial lines some form of non-contacting joint is desirable to eliminate wear and consequent losses which would occur in a spring contact joint. Figure 11 illustrates the principle employed in a rotating joint. The sections of line forming the joint overlap, to form quarter-wave lines open-circuited at one end. The impedances between the gaps in the conductors of the line are thus very low and practically equivalent to short circuits. To prevent radiation which might occur at high powers, a double choke is usually employed on the outer conductor. Mechanised support is usually provided by ball bearings.

The techniques described above are just a few of the many employed in transmission lines at U.H.F. In a following article wave guides will be dealt with, together with some of the applications of transmission lines in U.H.F. measuring techniques.

BIBLIOGRAPHY

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Sterba and Feldman—P.I.R.E. V. 20, *No.* 7, *July,* 1932.

Ragazzini—Electrical Engineering V. 62, *April,* 1943.

ANSWERS TO QUIZ.

A.1.—(b) One "foot candle" is the degree of illumination received from a source of one candle at a distanec of one foot. The illumination in foot candles may be found by dividing the candle power of the source by the square of the distance in feet from the source.

A.2.—(b).

A.3.—(b).

A.4.—(c) The term "shunt" is usually applied to one of the current paths in a parallel circuit.

A.5.—(c).

A.6.—(c) Such units are now being widely used in the detection and location of radioactive substances for use in atomic research.

A.6.7.—(c).

A.8.(b).

A.9.—(b) The resistance of a conductor varies inversely with its cross sectional area. That is to say if the area of a conductor is doubled the resistance will be halved.

A.10.—(a) The action of the flux is to clean the oxide from the work and leave the surfaces clean enough for the hot solder to adhere securely to the metal.

A.11.—(b) Usually a high resistance unit connected between the grid terminal and some part of the filament circuit.

A.12.—(c) The basic relationship is: Current equals Voltage divided Resistance. If any two factors are known the third or unknown can be readily calculated.

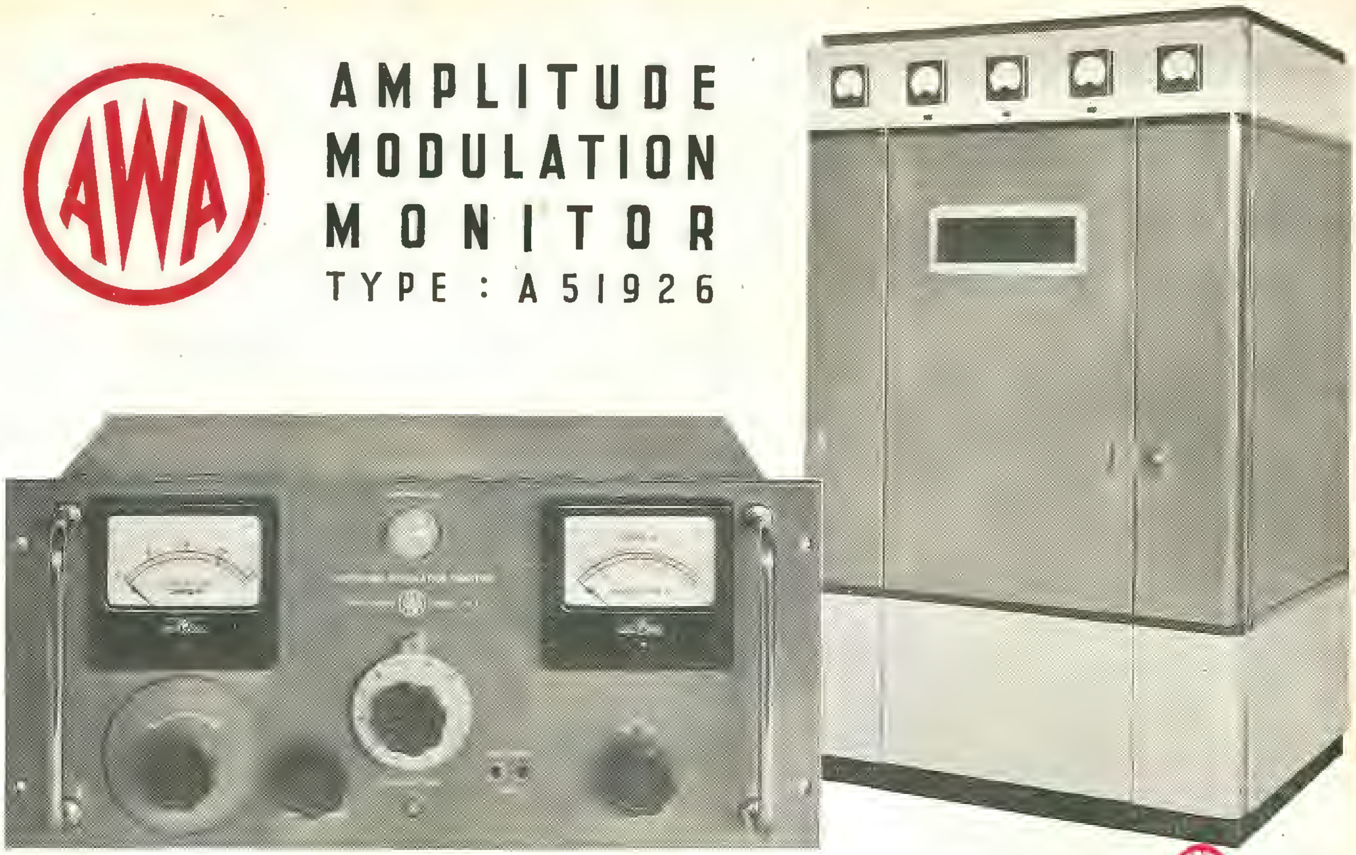
A.13.—(c).

A.14.—(b)

A.15.—(c).

AMPLITUDE MODULATION MONITOR

TYPE : A 51926



This new instrument, the latest in our already extensive range, has been designed to provide all the facilities necessary to monitor the output of amplititude modulated transmitters.

Simple and quick in operation, this instrument includes a fast meter ensuring accurate measurement of the instantaneous depth of modulation for either positive or negative peaks. A warning lamp is provided which flashes when the depth of modulation exceeds a predetermined level.

SPECIFICATIONS

Meter Range (Modulation percentages)	——	up to 110% positive peaks up to 100% negative peaks
Accuracy, Overall (30-15000 c/s)	——	± 4% full scale
Carrier Frequency Range	——	0.5 to 7.5 mc/s 3.0 to 50 mc/s (Coils normally supplied for one band only)
Input Impedance	——	80 ohms (broadcast range) (Slightly higher for high frequencies)
Input Power	——	0.6 watts required (broadcast range)
Distortion	——	Negligible below 90% modulation
Power Supply Required	——	220-260 volts 40-60 cycles AC
Consumption	——	60 watts
Mounting	——	Portable or Rack Mounting
Dimensions (Rack Mounting)	——	Panel size 19" x 8¾"

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