RADIO SCIENCE

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NEW FIVE VALVE MANTEL RECEIVER

PRINTED CIRCUIT TECHNIQUES — Pt. 1

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RADIO — ELECTRONICS — F.M. — TELEVISION

Valves and their applications

THE EF42 IN THE OUTPUT STAGE OF A WIDE-BAND OSCILLOGRAPH AMPLIFIER

In the design of a high-gain amplifier for a C.R. oscillograph it is usually necessary to consider the output stages first, as the major frequency limitations usually occur at this point.

A C.R. tube presents a largely capacitative load to the preceding stage, which must therefore have a low anode load resistance, while the voltage swing required for full deflection of the beam entails a high maximum current.

When an ECR35 tube operating at 1.2 kV is used, a total signal of 180 V (peak to peak) must be provided on the most sensitive plates (allowing, say, 25% over-deflection), and if this is derived from two EF42's in push-pull, each must give 90V.

With a 250V H.T. line, the EF42 will give this signal swing across a 5K Ω anode load resistance provided that a little non-linearity can be tolerated at the lower limit of current. This is quite permissible, as over-deflection has been allowed for. The bias resistor necessary for this condition is 180 Ω.

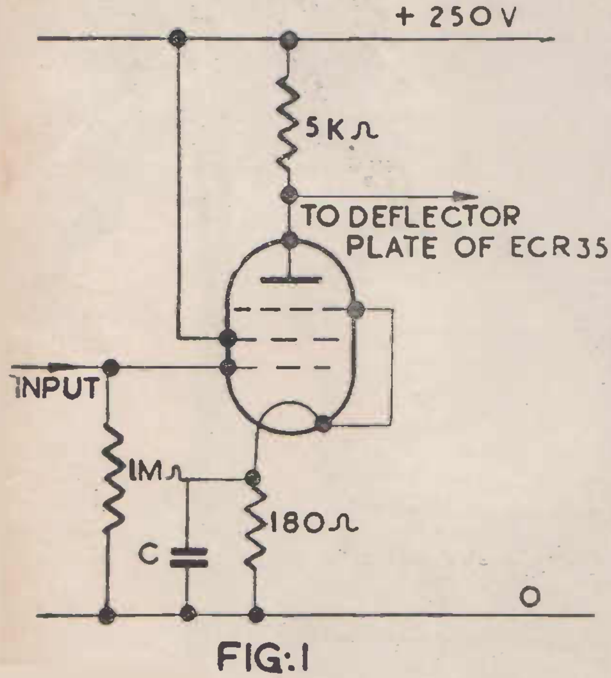
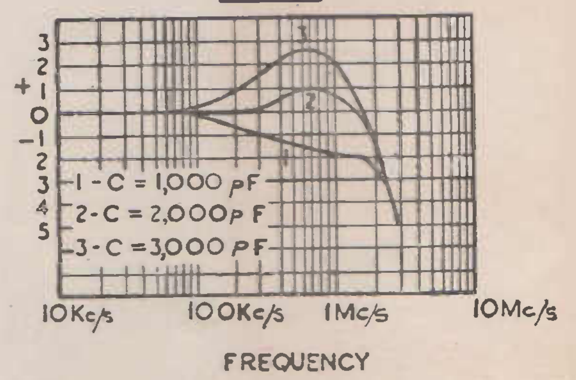


FIG:1

FIG:2



This amplifier-C.R. tube combination has a frequency response falling by rather more than 3db at 1 Mc/s., but this may be improved by compensation. One of the most convenient methods of doing this is to arrange that negative feedback shall appear in the amplifier at low frequencies, while at high frequencies the full amplification shall be used. This can be carried out in a variety of ways, but the most convenient and economical in components is that in which the existing cathode resistor is partially by-passed by a small capacitor. The circuit of the amplifier then becomes that shown in Fig. 1, while Fig. 2 indicates the freqnency responses that can be obtained when three different values of cathode by-pass capacitors (C) are used. It must be remarked, however, that at high frequencies the full sweep available at low frequencies will not be obtained from the valve owing to the current swing limitation.

The transient response of the amplifier—usually a more important feature where oscillographs are concerned—is such that a square wave with a rise-time of 0.2 μs is reproduced with an "overshoot" of 0%, 10% or 20% when the cathode capacitor is 1,000 pF, 2,000 pF or 3,000pF respectively.

On this basis, a capacitor of 1,500 pF would probably be satisfactory in most cases, but if the preceding amplifier stages were found to limit the response severely, up to 2,000pF could be used, as such rapidly rising transients would never reach the output stages. The amplifier gives a voltage gain of 15 times when used under these conditions. *Reprints of this report for Schools and Technical Colleges can be obtained free of charge from the address below.*

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editorial.

Printed Circuit Techniques

In this issue RADIO SCIENCE is proud to present the first of an authoritative series of articles on Printed Circuit Techniques compiled from data made available by the National Bureau of Standards, U.S.A. To date very little information on this highly important subject has been published in this country, and we feel sure these articles will be read with considerable interest by all radio technicians.

As most readers are aware, the whole electronic field was developed at a very rapid rate during the war years, and one of the major results of this intensive research programme was the practical production of the printed electronic circuit. This was first introduced into mass production during the early part of 1945 for use in the tiny radio proximity fuse, which proved invaluable in many types of explosive shells. So successful was the technique and method of production that there now seems little doubt that the coming years will see a major change in the construction of many types of radio equipment.

Since the introduction of FM and TV receivers overseas, receiver design has tended to become more complex with its consequent multiplicity of wires and soldered connections. With mass production methods, the more complex a unit becomes the more difficult it is to control both from an economic and servicing point of view, and because of this, it now appears certain that large sections of wiring in these receivers will be replaced eventually by these printed sub-assemblies.

In general, a typical unit consists of a solid sheet of insulating material upon which is printed connecting wires, capacitators, inductors and resistance units. The actual method of application to the base material depends largely on the particular techniques used, but in general, the units can be either printed, sprayed or electroplated to the surface. Apart from the question of space and economy, the main advantage of these printed circuits is that the actual labor on the receiver can be reduced to an absolute minimum, with the resultant reduction of selling price. In place of the usual myriad of wires and their necessary soldered connections, these can now be replaced by a small prefabricated unit, equivalent to one or more stages and which may only require one or two connections into the receiver to make it fully operative.

Advances have taken place in the technique in England, where the major section of a radio receiver is now being made by a robot machine. Known as the Electronic Circuit Making Equipment, it is a spray milling technique designed for the manufacture of chassis panels for a small AC-DC broadcast receiver. In operation a plate is fed into an automatic machine which sandblasts both sides, sprays the surface with zinc, mills the surfaces to remove surplus metal, tests the resultant circuit, sprays on graphite resistors through stencils, inserts valve sockets and other small hardware, tests the unit again, and then applies a protective coating over the panel. This is carried out at the rate of a 7-inch panel each 20 seconds without the need of any human intervention, after which the valves, loudspeaker, electrolytic condensers, are attached in the conventional manner.

Although the Printed Circuit has not yet been applied on a large scale in home receivers in the U.S.A., there is now a gradual trend to a more widespread use of this revolutionary technique, and only the future will reveal the extent to which these printed circuits will be utilised.

RADIO SCIENCE

For the Advancement of Radio and Electronic Knowledge

Vol. 2, No. 7 JULY, 1949

EDITORIAL CONTENTS

OUR COVER: Televising a surgical operation at Leiden, Holland. In this demonstration the operation was televised to some 200 medical practitioners and students in an adjoining section of the hospital.
(Photograph courtesy Phillips Electrical Industries).

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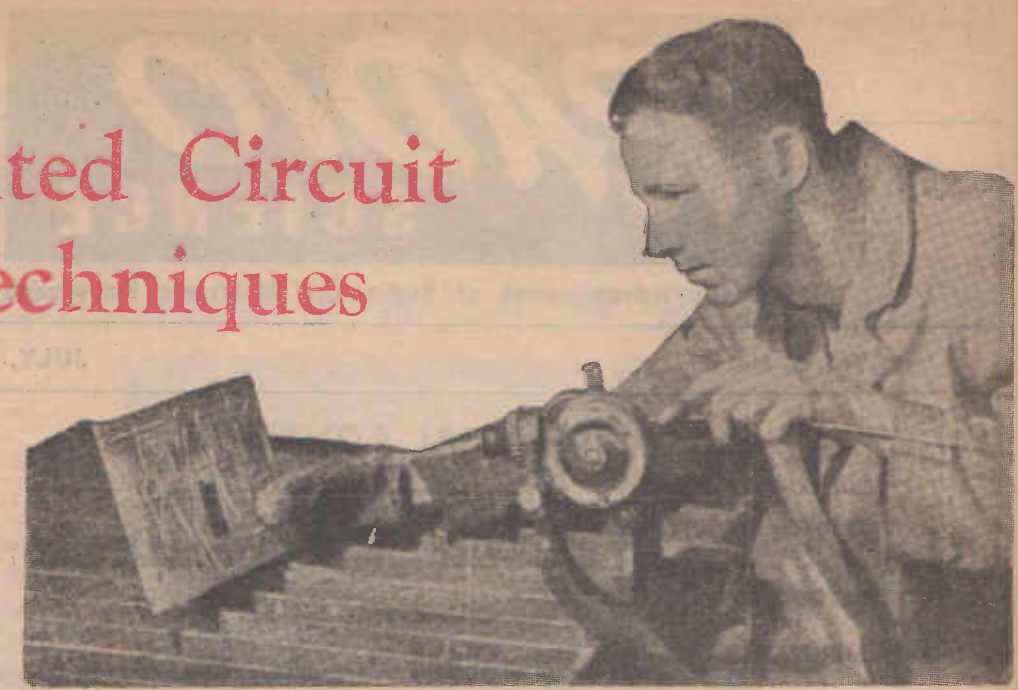
Printed Circuit Techniques



One method of producing a circuit design is by spraying the metal directly on to the insulating surface as shown in this photograph.

Printed electronic circuits are no longer in the experimental stage. Introduced into mass production early in 1945 in the tiny radio proximity fuze for mortar shells, printed circuits are now the subject of intense interest of manufacturers and research laboratories. Proposed applications include radios, hearing aids, television sets, electronic measuring and control equipment, personal radiotelephones, radar, and countless other devices.

The first mass production of complete printed circuits as they are known today, was set up at the plant of Globe-Union, Incorporated, at Milwaukee, Wis., and a subsidiary plant at Lowell, Mass. Facilities were provided for daily production of over 5000 printed electronic subassemblies for the mortar fuze shown in figure 1. The plate on which a complex electronic circuit was printed by the stencilled-screen process, can be seen.

Other printing processes, such as spraying and stamping, have reached the production lines, and today we find many manufacturers in mass production of whole radio sets or subassemblies by one or other of the printed circuit techniques.

Printed Circuits have now emerged from purely laboratory experiments to become one of the most practical new ideas of mass production of electronic devices in several decades. This and the articles to follow have been compiled from the NBS Circular 468 by Dr. Cledo Brunetti and Roger W. Curtis, and are now published through the courtesy of the National Bureau of Standards, U.S.A. These articles represent the first general treatise on the subject to be published in this country, and we feel sure they will be read with interest by every technician.

Size Reduction

The principal physical effect of printing circuits is to reduce electronic circuit wiring essentially to two dimensions. The effect is enhanced where it is possible to employ subminiature tubes and compact associated components. A properly designed printed circuit offers size reduction comparable to the best of standard miniature electronics practice and in certain cases affords a degree of miniaturisation unobtainable by other means. Just how much space saving may be realised depends on the application.

Standard electronic components are now available in such miniature size that complete amplifiers may be built into volumes of less than 1 in ^{3}, using standard methods. This, is exemplified in modern hearing aid designs. The greater part of the volume of a hearing aid, for example, is occuplied by the microphone, transformers, batteries, earphones, etc. The actual wiring occupies a small fraction of the total volume, hence even if the wiring were eliminated completely, it would not represent a substantial further reduction in the total volume of the unit.

By providing thinner base materials [1] or better by applying the wiring to an insulated outer or inner surface already present in the assembly such as, for example, the tubes themselves or part of the plastic cabinet, a significant reduction in volume occupied by the wiring may be had. The development of truly diminutive electronic devices now awaits only the availability of smaller microphones, transformers, speakers, batteries, etc.

Although size reduction is the factor that has attracted the most attention, there are other equal or more important advantages to be gained from the use of the techniques. Uniformity of promotion, reduction of assembly and inspection time and costs, and reduction of line rejects make the processes attractive, even in applications where size if not important.

Wiring Costly

In present assembly-line practices, wiring represents one of the larger items of production cost. Wires must be cut to length, bent into shape, twisted together or around soldering lugs, and individually soldered or connected. As there are over 100 soldering operations in even the small radio sets, the cost of labour and materials for soldering alone represents an important item. In a television set the number of soldering operations is nearer 500 The new wiring pro-

(1. Ceramic plates 0.01in. thick have been produced by mass production techniques.)

cesses eliminate as much as 60 per cent of the soldering needed for conventional circuits. A single operator on a production line may turn out thousands of plates each day.

Certain types of electronic circuits adapt themselves better to the printing technique than others. Standard amplifier circuits are readily printed as are T pads, and similar attenuating circuits and in general, any electronic configuration that does not have included within it large transformers and similarly unusually bulky items. Even in this case, the printed wiring may be arranged with useful eyelets or sockets to which the larger components are attached in the same manner as the tubes.

Main Processes

Although it would be beyond the scope of any single paper to attempt to cover thoroughly all the possible methods and processes, an effort has been made to present a reasonable complete treatment of the more important ones. They fall in six main classifications: *painting, spraying, chemical deposition, vacuum processes, die-stamping* and *dusting*.

Some of the processes are new, some have been used for years, others have not been applied to production of electronic circuits, but are included because they point the way to new techniques.

All are methods of reproducing a circuit design upon a surface and as such fall under the general classification of printing[2] processes. Electronic circuits produced by any of these methods will be called printed electronic circuits. The processes differ mainly in the manner in which the conductors[3] are produced. Resistors and capacitors are applied by methods that in general may be used interchangeably with any of the processes.

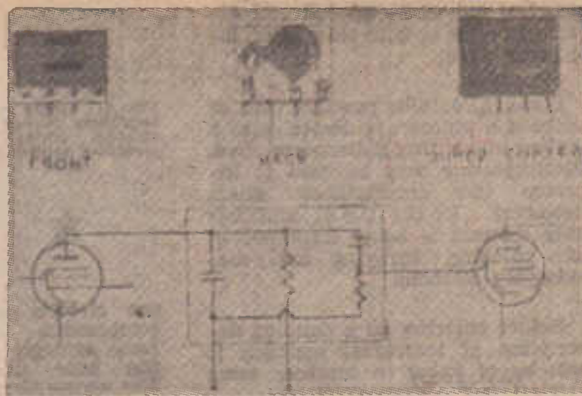


Fig. 4. Printed interstage coupling unit made by the stencilled screen process.

Painting. Metallic paints for conductors, inductors and shields are made by mixing a metal powder with a liquid binder to hold the particles together and a solvent to control the viscosity.

Spraying. Molten metal or paint is sprayed onto an insulating surface with a spray gun. In some processes, metals in the form of wire, powder or solutions are supplied to the gun. In some processes, metals in the form of wire, powder or solutions are supplied to the gun and sprayed directly on the surfaces through stencils to form the conductors and to fasten in place resistors, capacitors and other electronic components that have previously been placed in depressions on the surface.

Chemical deposition. A metallic solution, such as silver for example, is prepared by adding ammonium hydroxide to a solution of silver nitrate. A reducing agent is used to precipitate metallic silver on the insulating surface. A stencil is employed to define the circuit.

Vacuum Processes. The coating metal is made up in the form of a cathode or placed in a container in an evacuated chamber opposite the plate on which the pattern is to appear. Raising the metal to proper temperature distills it onto the plate through a suitable stencil to define the circuit. Resistors as well as conductors are made this way.

(2. Printing is defined in the dictionary as "the act of reproducing a design upon a surface by any process.")

(3. The term "conductors" herein is used to denote the leads or that part of the circuit wiring which connects the electronic components such as the resistors, inductors, etc.)

TABLE 1 — Composition of Paints.

Constituent	Function	APPLICATIONS: Conductors	APPLICATIONS: Resistors
Pigment	Conducting material.	Powdered silver Silver oxide Silver nitrate Powdered copper	Carbon black Colloidal graphite Flake graphite
Binder	Holds pigment together and binds it to plate.	Linseed oil Cottonseed oil Castor oil Resin Lacquer—for refractory base plates. Lead borate Lead silicate Ethyl silicate	Phenol-aldehyde resins Melamine aldehyde Vinylite resins Silicone resins Styrene resins Methacrylate resins.
Solvent	Dissolves binder if in solid form and adjusts viscosity of mixture.	Chlorinated solvents Alcohols Aromatics Ketones Acetates	Chlorinated solvents Alcohols Aromatics Ketones Acetates
Reducing Agent	Converts metallic salt to pure metal at low temperature.	Formaldehyde Hydrazine sulfate Hydrazine hydrate	
Filler	Increases electrical resistance by separating pigment particles.		Powered mica Mineralite Asbestos dust (iron free)
Protective coating	Protection against abrasion and atmospheric conditions.		Phenolic lacquers Silicone resins Vinylite lacquers Melamine formaldehyde lacquers.

Die-Stamping. Circuit wiring is punched out of metal foil and attached to one or both sides of an insulating panel.

Dusting. Metallic powders with or without a binder are dusted onto a surface in a wiring pattern and fired. Electroplating may be used to increase the conductance where necessary. In the U.S.A. considerable interest is being displayed in the painting, spraying and die-stamping methods.

Before entering on a detailed description of individual methods it will be of value to consider some general facts. Not all the components of an electronic circuit may be printed. The practice is adaptable to conductors, resistors, capacitors, inductors, shields, and antennas. By printing the circuit on a base plate of high dielectric constant one may print the capacitors, wiring and inductors all in a single operation. The capacitors in this case may be made up by silvering equal areas on opposite sides of the plate.

This practice is applicable to uses where high capacity between leads and components may be tolerated, such as in phase shift networks comprising only resistor and capacitor elements. It is desirable that the circuits and components adhere strongly to the base plate. The wiring should be of low resistance and of sufficient size to carry large currents without appreciable heating. The resistors and other printed components should be stable under rated electrical loads and should show a minimum ageing effect. The complete printed circuit should withstand fairly severe temperature and humidity exposures, rough handling and mechanical abuse.

The six main classifications of printed circuits will now be discussed in detail.

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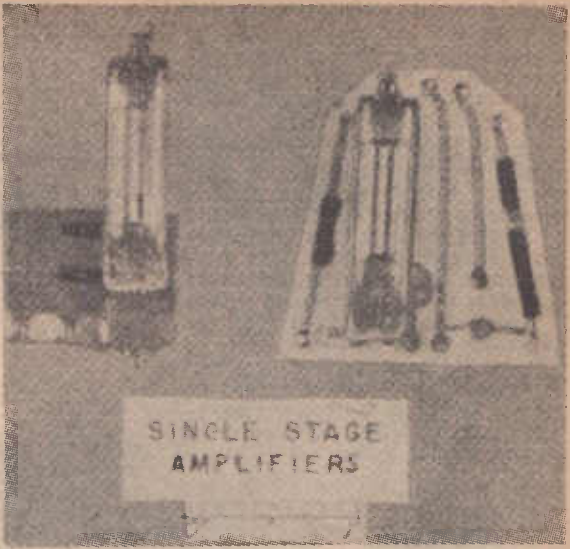

Fig. 5. Single stage amplifiers printed on steatite plates by stencilled screen process.

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2. PAINTING

This process is now well adapted to the production of printed circuits. Paints for resistors may be made up as well as conductor paints. Suitable metallic paints have been developed for use on most types of surfaces from glass to plastics.

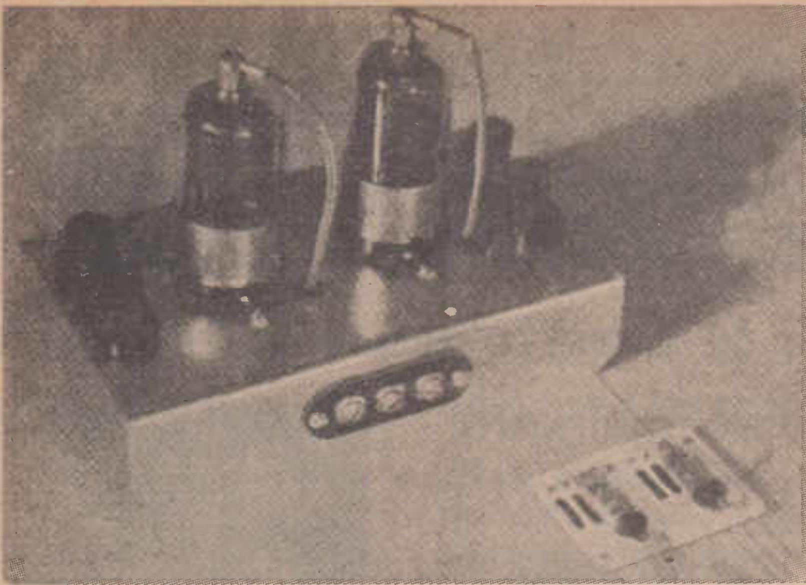


Fig. 2. Comparison of two-stage voltage amplifier printed on a ceramic plate (lower right) with equivalent amplifier constructed according to present-day radio practice.

In those applications in which the base material may be raised to elevated temperatures, the paint may be fired on to the surface with excellent adhesion. For materials such as plastics which cannot be raised to high temperatures, satisfactory results are obtained, although the adhesion of the paints is considerably less than is obtained by firing. Printing the conductors is the easiest part of the operation. Printing resistors is a more difficult problem, especially where it is necessary to hold them within close tolerances.

The painting of conductors in general follows the practice used in pottery manufacture of burning metal oxides containing ceramic fluxes on to hard insulating surfaces. Although it would appear to be a brief step from the pottery methods to those now used in painting electronic circuits, a considerable amount of research has gone into developing paints of sufficiently high conductances and adhesion that may be applied in a practicable way. :

1.—PAINTS

A.—Constituents

Paints for printed circuits are made up of selected combinations of constituents, examples of which are included in table 1.

(a) Pigment.

The pigment is the conducting material for the circuit wiring. For the leads, powdered silver, silver oxide, silver nitrate or organic combinations of silver are generally used. Silver has proven to be a most practicable metal for this purpose. Not only is it highly conductive, but silver films are easily produced. Copper or noble metal powders or salts may also be used effectively. Though salts of other metals might be employed, some form corrosion products that have such high resistance as to make them useless.

The cost of the silver is usually a small item; in fact the relatively small amount required makes the cost of the actual silver paint no more than of copper required for ordinary wiring. One ounce of silver is sufficient to paint as many as 125 average two-stage amplifier sections. Sheet silver, such as that used in the production of Edison cells, properly ground, is an excellent pigment for conductor paints. Flake silver in small particles works very well on most surfaces.

The pigment for resistors is usually carbon black, colloidal graphite, or a *"flake"* type of microcrystalline graphite. Carbon black and colloidal graphite appear better for screen painting and spraying. Flake graphite is used only for brush painting.

Lampblack has been tried, but the more common types available apparently do not have the proper physical properties to produce reasonable values of resistances. One of the theories advanced is that the configuration of the pigment particles must be such that they overlap or bridge one another in the finished resistor. It is an empirical fact that the shape and size of the pigment particles do play an important part in the resultant electrical properties of the circuit.

(b) Binder.

The binder is the constituent that holds the pigment together so that it may be painted on the surface, and also serves to bind the pigment to the plate. A resin is used that can be easily dissolved. Satisfactory synthetic resins are the phenolics dissolved in acetone or silicones dissolved in chlorinated hydrocarbons.

Where the paints are applied to surfaces that are not entirely rigid, the vinylite resins provide needed flexibility. For certain plastics, nitrocellulose or ethyl cellulose lacquers provide quick drying action at low temperatures. The phenolic resins are usually used to bond resistance paint. They yield excellent stability in respect to changes in temperatures. Lead borate, lead silicate, sodium borosilicate and similar fluxes[4] are recommended as binders for ceramics and glass. Although a stronger bond to the surface is had by firing, the use of ethyl silicate as a binder for silver oxide on glass and steatite without firing produced a satisfactory bond.

(Continued on page 39)

(4. The Term Flux is used to designate a Binder and not a Cleansing Agent).

TABLE 2 — Conductor Paint Formulas
(All percentages are by weight)

Base Plate Material	Ceramics	Glass	Thermosetting type plastics	Thermoplastic type plastics
	*450 deg. to 800 deg. C.	*450 deg. to 650 deg. C.	*25 deg. to 175 deg. C.	*25 deg. to 75 deg. C.
Pigment	Finely ground silver powder 65 per cent.	Finely ground silver powder 65 per cent.	Finely ground silver powder [illegible] per cent.	Finely ground silver powder 70 per cent.
Binder	Cellulose resin in, 13 per cent. + finely divided low softening point class 12 per cent.	Cellulose resin 13 per cent. + finely divided low softening point class, 12 per cent.	Cellulose resin Methacrylate resin Phenolic resins, 20 per cent.	Methacrylate resin, Polystyrene resin 20 per cent.
Solvent	Acetates or Cellosolve derivatives 10 per cent.	Acetates or Cellosolve derivatives 10 cent.	Acetates, Ketones or Cellosolve derivatives, 10 per cent.	Ketones, Benzene Toluene or Ethylene - dichloride 10 per cent.

*Processing temperature.

INTERNATIONAL RADIO DIGEST

A TECHNICAL SURVEY OF LATEST OVERSEAS DEVELOPMENTS

ELECTRONIC SWITCHING EQUIPMENT

Details of new switching equipment which enables a long distance call to be made as easily and as quickly as a local call.

Electronic switching equipment in New York and Chicago long-distance centres makes it possible for a long-distance operator to put through calls to distant telephones directly, without the aid of other operators en route. Plans are now being made to extend this new method of operator toll dialling throughout the United States and Canada so that a single operator will be able to dial a number anywhere in the nation just as easily as a subscriber dials a local call in his own city.

At present, operator toll dialling networks enable operators to dial calls straight through to the distant telephone in some 300 cities, and approximately 10 per cent. of long-distance calls are handled by this means. This figure will be greatly increased as new automatic switching centres are established.

The system is based on the development of electronic devices which determine and arrange the routing of calls, taking over where the human hand and brains were once essential. The equipment can select possible routes between distant cities, direct switching operations at intermediate points along a route, and complete connections automatically in a matter of seconds.

Long-distance calls now go through in about two minutes on the average. When the new system is more widely installed and all the circuits now planned are in service, the average speed of all long-distance calls is expected to be about one minute.

An operator using the 10-button key set which comprises the dialling system.

Method of Operation

In operation the operator will usually be able to complete any toll call by dialling a maximum of 10 digits—the six digits of the area and office codes and the four digits of the called telephone number. In calling distant cities, the operator does not actually dial the numbers. Instead a 10-button key set is used which operates about twice as fast as an ordinary dial. For each punch of a key, a tone pulse is sent out above the voice channels to the switching centre.

Each tone pulse is a combination of two different audible frequencies which are sorted out and classified by the brains in the switching equipment which then interprets their meaning. This switching equipment also provides the electronic hands which assume much of the complex switching operation.

Six frequencies spaced 200 cycles apart from 700 to 1700 inclusive are employed. Two of these frequencies are used for each pulse and each pulse represents one digit. The equipment practically never makes the tones audible to the calling party.

Courtesy Electronics.

This diagram shows how the system operates.

MULTIPLE TAPE RECORDER

A recently developed machine which can produce up to 48 hours of recorded music, on tape per hour by transferring the sound from a master tape to eight reels simultaneously without any perceptible loss of quality

The multiple recorder mass-produces recording on 600 or 1200 ft. lengths of tape, makes either single or double track recordings, and can turn out copies designed to run at speech 3¾, 7½, 15 or 30 inches per second. It can be adjusted by switch control for recording on reels of different lengths, and for different speeds.

It is also possible to make copies at a rate much greater than the basic playing speed. Copies to be run at 7½ inches per second can be made in half the actual playing time by doubling the process speed of master and copy tapes in synchronism, or copies to be run at 3¾ inches per second can be processed at three or four times their playing speed.

Double Pattern Tape

By recording two patterns instead of a single pattern on the tape, the playing time on a particular reel can be doubled. Double-pattern tape has two-parallel sound tracks, one track playing on the forward direction and the other on the reverse. Both forward and reverse patterns can be recorded simultaneously by the multiple recorder, so that double pattern sound tape, with twice the playing capacity of the single-track tape, can be mass produced at the same rate.

An idea of the production rate is gained from the following: Using multiple recording, reels having 600 feet of tape, double pattern and a playing speed of 3¾ inches per second can be turned out at the rate of 48 per hour, each reel having a full hour's playing time. Reels with 1200 feet of tape, double pattern and a playing speed of 7½ inches per second can be produced 32 per hour, with each reel having an hour of transcribed material.

Circuits and Controls

The electronic system provides complete dual channel amplification, equalisation and bias from a dual track master or two single track masters to 16 record heads operating simultaneously for dual track copies. Pre-amplifiers designed for 3000 times voltage gain and low noise assure good dynamic range.

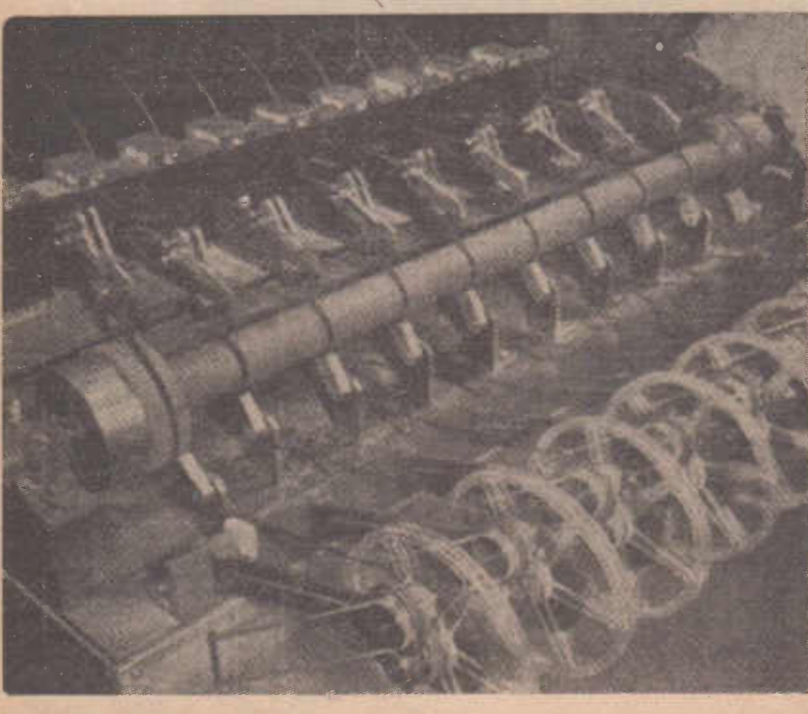
The equaliser system provides normal compensations to fit different tape speeds and heads, selectable by a switch. Additional flexible equalisation is available for modifying the frequency characteristic of the copy. Record amplifiers of low noise level and high power capability permit operation on the low portion of the inter-modulation distortion curve to maintain a large recording current dynamic range.

To prevent bias beats, a common bias oscillator is used, with separate amplifier for each channel (eight record heads per channel). Individual adjustment is provided for each head to maintain low distortion independent of record-head tolerances. A high bias frequency is used to reduce distortion. The magnitude of bias is adjusted in accordance with the tape speed and the wave form of the basis is controlled for medium distortion of recorded signal and minimum tape noise.

DC power for the entire electronic system is regulated to less than .0001 per cent. ripple and voltage fluctuation noise and the pre-amplifier supply is filtered to the same degree. No regulation of power for the drive motor is necessary for copy work.

As a result of this highly integrated mechanical and electrical design, faithfulness of reproduction in the multiple recorded tapes can be held to such a high degree that they are virtually indistinguishable from the master.

Courtesy FM-TV.



New Phosphor for Mercury Lamp

The discovery of a new phosphor which transforms the invisible radiation into visible red light and at the same time withstands the high heat in the tube has been announced by the Westinghouse Electric Co. This new material makes the light from the mercury-vapour tube eight times richer in red than from the tubes of clear glass. As a result people under it now look natural instead of assuming the pale and sickly look with the previous type tubes.

The material is a high-temperature phosphor, which is used to powder the inner glass wall of the mercury-vapour lamp. This fluorescent coating transforms the invisible ultraviolet rays into pure red light which, added to the bluish-white light from the mercury vapour, gives illumination under which persons and objects appear more nearly in their true colours.

Radar Detects Sandbanks

A radar sandbank detector is now being used to assist in the removal of sand bars on Lake Erie, U.S.A. The areas to be dredged are usually marked in advance by drum buoys.

For the radar application, a rod extending five feet into the air with a crossed screen on its top has been attached to the buoys. This screen is picked up on the radar installed aboard the dredge.

MINIMANTEL "5"

A new mantel receiver design which is capable of better than average performance. Using the latest miniature valves and components, this is the ideal second set for the home.

by

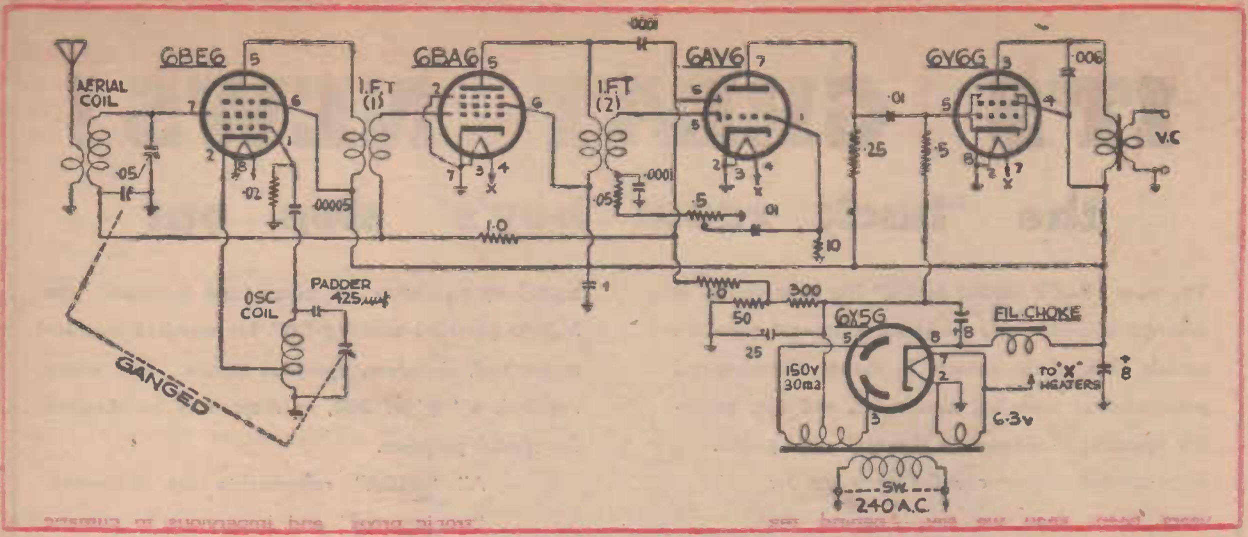
E. BINNS, A.M.I.R.E

With tne coming of the winter months, radio from an entertainment point of view plays a more important part in our lives. Whilst most people have the radio in their lounge room, it is not always convenient to be there to listen to the favourite programme, and under such conditions a "second" set becomes a necessity.

Consequently it was with these thoughts in mind that the small set described was designed and constructed. In commencing the design several general requirements were considered, such as the necessity for a logical layout and neat appearance, as well as simplicity of circuit and construction features in order that the whole receiver could be easily duplicated by the radio enthusiast.

By using miniature type valves and coils, the overall chassis dimensions have been kept down to 6½in. x 6¼in. x 1in. This is housed in an attractive cabinet measuring 6½in. x 6¼in. x 5½in., and being fitted with a carrying handle, makes it very convenient to carry the receiver around from room to room as desired. In fact we think you will find this an ideal set for use in the kitchen, bedroom, or sunroom, as the high gain circuit will permit easy reception of local and Interstate stations with only a short length of wire for an aerial.

The circuit is a five valve superheterodyne and comprises a converter, IF amplifier, combined sec-



Although requiring five valves, the receiver is not complicated and should not prove difficult for the constructor. Back bias is used, thus enabling all cathodes, except the 6BE6 to be earthed. The numerals around each valve diagram indicate the socket connections.

ond detector, AVC control and first audio amplifier, an output stage and a rectifier. Although a loop aerial could have been used in place of the aerial coil, it was found that the results obtained with the latter more than outweighed any disadvantage of having a trailing aerial wire.

6BE6 Converter

The converter used is a 6BE6, one of the new 6.3 volt miniature types designed for use in FM equipment. As this type differs both in construction and operation from the usual pentagrid converter, and in view of its limited use to date in home receivers, the following details on its operation should be of interest to all radio enthusiasts.

This valve differs from the pentagrid type in that it has no electrode to function as an oscillator plate, its construction being similar to the well-known 1R5 battery converter. The grid nearest the cathode is the oscillator grid, and inner grid oscillator injection is employed. Because of this lack of an oscillator plate element, it will be noticed that the oscillator circuit differs from the more conventional arrangement in that a single tapped coil is employed.

In effect a Hartley type oscillator using cathode circuit feedback is necessary, with the cathode of the 6BE6 being connected to the tapping on the coil. The entire coil is tuned by means of the tuning condenser, and it should be noted that the padder condenser cannot be connected in its usual position on the low side of the coil. It is necessary to provide a DC path for the cathode return to B minus and consequently this condenser must now be connected in series with the main tuning condenser as shown on the schematic diagram. The usual grid condenser and grid resistor complete the circuit, and the value of the grid resistor, 20,000 ohms, is lower than that normally found in converter circuits.

Second Detector

The IF amplifier is a 6BA6, another miniature type, and as the connections here are quite standard, they call for little comment. The second detector is a 6AV6, and as this is a duo-diode triode, it serves as combined detector, AVC control and first audio amplifier. Delayed AVC is used, this being applied to the IF amplifier and converter stages by means of a simple series circuit. The small delay voltage is obtained from the 50 ohm resistor connected in the back bias system. This delay voltage is sufficient to provide the correct grid bias for these two valves.

The diode load consists of the .05 meg resistor and .5 meg volume control connected in series. The audio output is taken to the grid of the 6AV6 via the .01 mfd condenser. The bias for this valve is provided by the 10 meg resistor connected from the grid to earth.

A 6V6GT is used in the output stage, mainly because the 6AQ6, which is the miniature equivalent, is not yet readily available. However, if you should be able to obtain a 6AQ6 it can be used in the circuit simply by changing the octal socket to a 7-pin miniature type. The circuit constants, as shown, will remain unchanged.

PARTS LIST

1 Chassis 6x6x1 inch.
1 2-Gang Tuning Condenser (midget type).
1 Aerial, 1 Osc. Coil (for 6BE6).
2 I.F.T..'s 455 kc.
1 Power Transformer 150v HT at 30 ma, 6.3v at 3 amps.
1 Filter Choke

CONDENSERS

1 25 mfd Electrolytic 40v.
2 8 mfd Electrolytic 525v.
1 .1 mfd Tubular 400v.
1 .05 mfd Tubular 400v.
2 .01 mfd Tubular 600v.
1 .006 mfd Mica.
1 .000425 mfd Mica.
2 .0001 mfd Mica.
1 .00005 mfd Mica.

RESISTORS

1 10 meg ½ watt.
2 1.0 meg ½ watt.
1 .5 meg ½ watt.
1 .25 meg ½ watt.
1 .05 meg ½ watt.
1 .02 meg ½ watt.
1 300 ohm 3 watt ww.
1 50 ohm 3 watt ww.
1 .5 meg potentiometer with switch.

SPEAKER—3-inch matched to 6V6GT.
VALVES—1 6BE6, 1 6BA6, 1 6V6GT, 1 6X5GT.
SUNDRIES—3 7-pin miniature sockets, 2 octal sockets, terminal strip, 2 knobs, hookup wire, shielded wire, nuts and bolts, etc.

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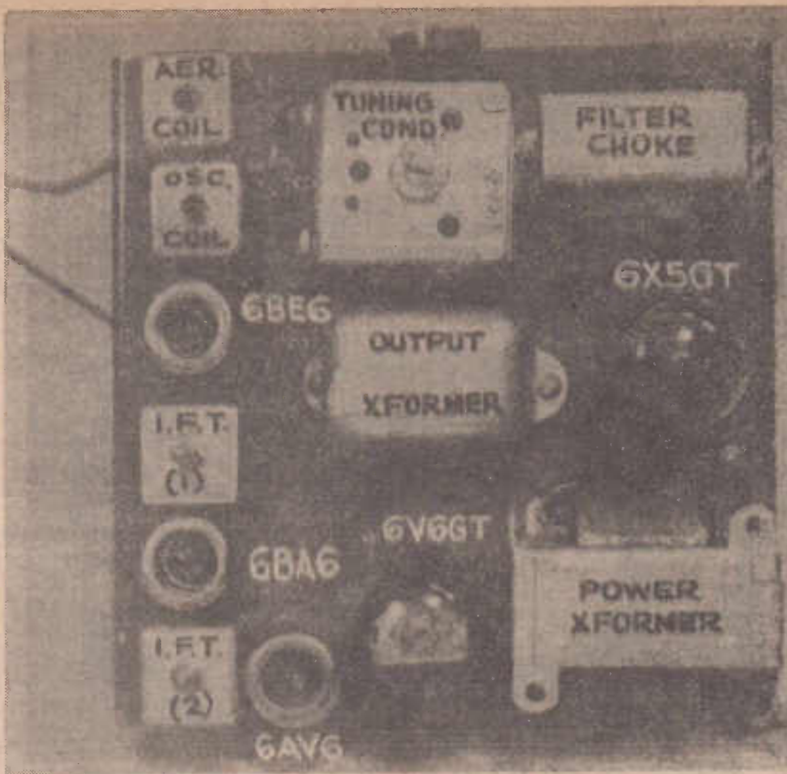
Power Supply

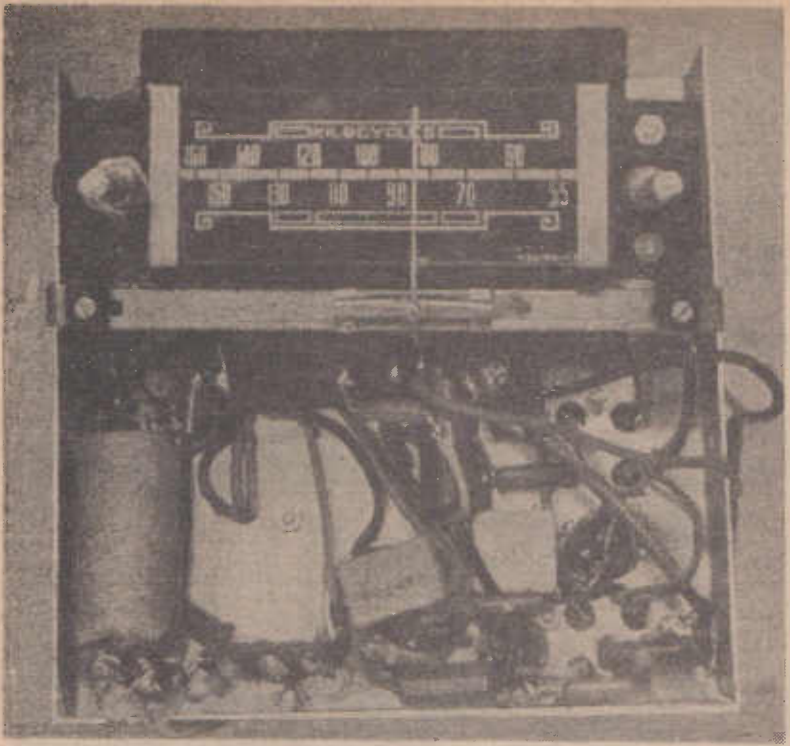
The power supply is conventional and consists of a 30 ma 150v HT power transformer and 6X5GT rectifier. Once again, if you can obtain a 6X4, which is miniature equivalent of the 6X5GT, then it can be used in the circuit without any alterations other than a socket change. Adequate filtering is provided by the two 8 mfd condensers and the 30 ma filter choke, and it should be noted that as a back bias system is used, the first filter condenser negative lead should be returned to the high tension centre tap and not to earth.

Back Bias Used

By using the back bias system, all cathodes with the exception of the 6BE6 can be connected directly to earth, thus simplifying connections and saving on components. The grid bias for the output stage is obtained by the voltage drop across the 50 and 300 ohm resistors since the .5 meg grid resistor is connected to the HT centre tap.



This top chassis view shows the location of the various components.



This underchassis view shows how the parts are fitted in. Note that a space has been left clear immediately below the left hand side of the dial so that the speaker can be fitted in.

The coils and I.F.T.'s are standard types. In the original receiver the recently released Vega miniature types were used, and these gave satisfactory results. Being iron cored, they will be found to provide ample circuit gain without any tendency to instability. One aerial, and one oscillator coil will be required and the latter should be the special type designed for use with the 6BE6. As pointed out this consists of a single winding, having a cathode tap provided, and consequently the usual oscillator coil will not be suitable.

Constructional Details

The construction of the receiver should not be difficult provided a logical sequence is followed for mounting and wiring up the components. The actual location of the main parts can be seen from the labelled top chassis photograph. The two coils, IFT's and valves are mounted around the one side and back edge of the chassis. The tuning condenser is bolted direct to the chassis, with the spindle passing through to the underneath of the chassis, and immediately behind this is the output transformer. The rectifier is mounted between the filter choke and power transformer on one side of the chassis.

In mounting the coils and valve sockets, make sure these are positioned so that all leads can be kept as short as possible. This precaution is essential to prevent any possibility of feedback between the circuits and especially grid and plate leads.

Light tinned copper wire is used for earth leads. One side of the heater circuit is earthed and connected with any other socket pins to be earthed to the one point right at the valve socket. The remaining heater connections are wired up in parallel.

Short Leads Essential

All bypass condensers and resistors should be wired in with leads cut as short as possible, so that the connections can be made right on to the socket or coil. In grouping the components care should be taken to leave a clear space as shown in the photograph so that the 3-inch permag. speaker can be slipped into place. This is screwed direct to the inside front of the cabinet, after checking that it will not foul any HT or other leads when the set is placed in the cabinet.

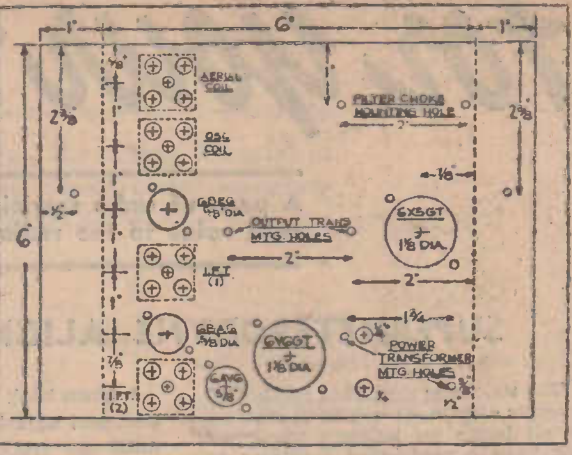
The dial used is the new Efco MSL 48, and this is fitted in place after all the components have been wired in. It is held in position by turning the two mounting brackets backwards and bolting these to the sides of the chassis. Before bolting in place remove the dial drum holding screw so that this drum can be slipped into position on the gang spindle. Lock nuts should be placed under the dial brackets to prevent them from working loose.

The volume control is mounted directly in the hole provided at one of the dial plates as shown. The audio leads to this are made with shielded wire, earthing the outer metal braid. The control of is one of the miniature types having a dp switch, and as this breaks the AC input leads, i-f provides a convenient ON-OFF switch.

Check Wiring:

After wiring the receiver it is best to make a few simple tests before attempting to place it in operation. Make a careful inspection of the wiring, checking it against the circuit diagram, and make sure no loose pieces of solder or wire are left in the chassis to cause possible shorts. Plug in all valves with the exception of the rectifier, and switch on. If the heater circuit is correct all valves should light up within a few seconds. Next insert the rectifier, watching for any signs of overheating or sparks which may be due to a short circuit, etc. If all is in order, then a humming sound will be heard from the speaker and the set will sound alive. By tuning across the band it may be possible to hear some stations before the set is aligned.

CHASSIS DETAILS



This drawing shows the layout used in the original receiver.

Alignment Procedure

Once the receiver is functioning correctly the next step is to align the tuned circuits. For this purpose make sure that a trimmer condenser is mounted across each section of the tuning gang. As the dial used is only frequency calibrated and does not show actual station markings, it is only necessary to ensure that the stations are received in approximately their correct positions.

Tune in a station at the high frequency end of the band, and adjust the aerial trimmer for maximum output, using the oscillator trimmer to position the station as necessary. As a fixed padder is used, there is no low frequency adjustment other than to peak the aerial coil for maximum output. After this the IFT's can also be checked for maximum output by moving the cores one way or the other, but care should be taken to ensure these are not misaligned.

Photo-Multiplier Telescope

Photo-multiplier telescope is the name applied to an invention which allows people to view an astronomical scene at the same time.

A television camera tube replaces the ordinary eyepiece of the teelscope, sending the image through amplifiers and an opticad system to an 8-inch square viewing screen. The image is increased in brilliance as well as size and the definition of the projected picture is as high as the telescope and atmospheric conditions permit.

Not an improvement on standard telescopes, the instrument is designed only to bring the image of ordinary telescopes to the view of many observers. It could be used with existing large telescopes.

WANTED . . . TECHNICAL ARTICLES

YOU can be an author, a man of distinction, if you heed these words. As the policy of this magazine is to provide a coverage of the radio and electronic fields, articles of a suitable nature dealing with any phase of these topics will always be considered for publication in this journal.

All you need do is to write about 2000 to 2500 words dealing with some item of interest or describe equipment you may have constructed, and which should be of interest to our readers. Whilst we prefer double spaced typewritten copy, this is not absolutely essential providing your ideas are sound. Just send the copy along, and if necessary we will decipher your writing and rework it into readable English. Put in any sketches and diagrams required, and these will be drawn up by our own draughtsman.

All manuscripts should be forwarded to the Editor, Box 5047, G.P.O., Sydney, and payment will be made for all accepted material on publication.

For your note book

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

SUPERHETERODYNE ALIGNMENT

The following simplified method of receiver alignment will be of interest to all home set builders who may not have a modulated oscillator to carry out this work. The method has been tested thoroughly and providing care is taken with the adjustments, little difficulty should be experienced in getting the various tuned circuits on to their correct frequencies.

In cases where the receiver has a variable padder adjustment, another receiver will be required to determine the oscillator frequency, but if a fixed padder is used, and consequently no low frequency adjustment is necessary, then only a screwdriver will be needed to make the necessary adjustments.

Since the adjustments for both types of receivers is more or less the same, with only slight amendments, the full procedure for adjusting the receiver with a variable padder will be detailed first. This is as follows:

1. First tune in the receiver to a station near the low frequency end of the dial. Place another receiver near the one being aligned and tune it to a station HIGHER in frequency by the amount of the intermediate frequency. For instance, if a station of 600 kc is used, and the i-f frequency of the receiver is 455 kc, then the second receiver should be tuned into a station at 1055 kc.

2. Now adjust the padder condenser of the set being aligned until a beat note from the oscillator is heard in the second radio with as low a pitch as possible. Without changing the tuning control, adjust the i-f trimmers until the 600 kc station is being received at good strength.

3. Next tune the receiver being aligned to a station at the high frequency end of the band, and adjust the oscillator trimmer to bring the station in at its correct position as shown on the tuning dial. Adjust any r-f or aerial trimmers for maximum output.

4. Turn back to the low frequency end, and adjust the variable padder until the station is received at its correct place on the dial.

Where a receiver being aligned has a fixed padder in place of the variable condenser, it is not necessary to use the second set as mentioned in step 1 and 2. For maximum results it may be necessary to carry out the adjustments once or twice to ensure that the tracking is correct.

Microphonic Valves

Frequently in battery receivers it will be found that mircophonism will develop in one or more of the valves. This is especially noticeable in personal portable receivers where the valve may be located close to the speaker.

The trouble can sometimes be overcome by wrapping the valve with several layers of cellulose tape now readily available, or by winding several rubber bands around the valve. If this does not help it might be necessary to remove the rivets or small bolts that fasten the valve socket to the chassis, and permit the socket to dangle on its leads. This will then mechanically insulate the valve from the speaker's vibrations, and possibly clear up the trouble.

Removing Control Knobs

When a control knob is hard to remove from its shaft do not attempt to pry it off with a screwdriver as this may only slip and ruin the cabinet finish or even break the edges of the knob. Simply wind a piece of heavy twine once around the shaft at the back of the knob, and then pull the ends of the cord outwards. It will be found that this will remove the knob without any damage.

Soldering Iron Hint

Here is a hint that will do away with the necessity for continually keeping the soldering iron tinned. Remove the copper tip and heat it with a blow lamp to the temperature at which silver solder will melt, and then flow silver solder all over the tip, thus, in effect, plating it. When the tip is cool replace in the iron.

It will now be found that the soldering iron should never require tinning fluxing, or filling since the temperatures ordinarily needed for soldering will not melt the silver solder.

Basic Electricity and Magnetism

In this article, the eighth of a series, the author discusses in some detail capacitor theory and calculations, including those for series and parallel networks.

We have seen how the action of a capacitor in an electrical circuit is similar to the action of the body springs of a motor car. (Part VI).* It was also stressed that the dimensions and nature of the dielectric used between the conductors constituting the plates of the capacitor were the factors which determined the use to which the capacitor was placed and the life we could expect from it.

Since the action of the dielectric is to store energy in the form of strain energy it is important to be able to calculate the amount of energy that can be stored. It is easy to derive an expression which will enable us to calculate the amount of stored energy.

Simple Circuit

Let us consider the circuit shown in Figure 8-1 wherein a capacitance C, is charged by a battery of E volts when the switch S, is closed. The initial p.d. between the plates of the capacitor is O volts, and the final potential between the plates will be E volts. During the time that the capacitor is being charged, any quantity of charge Q, will be transferred from one plate to the other. In effecting this transfer of charge the battery must obviously force positive charges against the gradually accumulating positive charges on the plate connected to the positive terminal of the battery. The battery does work in charging the capacitor.

The work done by the battery can be expressed in terms of the average potential between the plates of the capacitor and the amount of charge it forces against this potential difference.

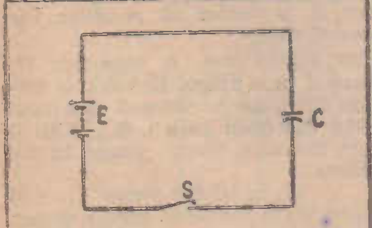


Fig. 1. The amount of stored energy in C, due to the action of battery E can be readily calculated.

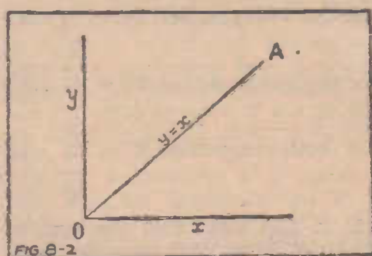


Fig. 2. Graphs can be used to solve complex mathematical problems. The vertical line is called the "ordinate" and the horizontal line the "abscissa."

This idea is in accordance with the expression we derived in Part V of this series when developing the idea of potential difference. In Part V we derived the equation,

Work = E.Q. joules.

where E is in volts, and Q is in coulombs.

By
A. L. THORRINGTON, A.S.T.C.

In the case of the capacitor, the initial potential is zero, or O volts, while the final potential is E volts. The *average* potential of the capacitor during the charging time is thus,

$$\text{Average potential of capacitor} = \frac{O + E}{2}$$

$$= \frac{E}{2} \text{ volts.} \qquad \ldots 8.1$$

Also, the charge transferred by the battery is Q coulombs, so that the work done by the battery in charging the capacitor is,

$$\text{Work done by battery} = \frac{Q \times E}{2} \text{ joules} \qquad \ldots 8.2$$

But, since $C = \dfrac{Q}{E}$

Then $Q = CE \qquad \ldots 8.3$

and substituting this value for Q in 8.2 we get,

$$\text{Work done by battery} = \frac{CE \times E}{2}$$

$$= \frac{CE^2}{2} \text{ joules} \qquad \ldots 8.4$$

Graphical Solutions

Graphs are useful in helping us visualise the significance of a mathematical expression but perhaps their greatest utility is that we can often use them to solve complicated mathematical expressions.

A graph is simply a picture of the way in which two quantities, such as x and y, vary with respect to each other. The simplest case is when y = x. To construct the graph, we mark off equal distances along a vertical line, as shown in Figure 8-2, and designate each point with values for y. The horizontal line is marked off in equal distances and given values for x. The vertical line is called *ordinate*, and the horizontal line is called the *abscissa*.

Since, in this case, y = x, then, for every value of x, there is an equal value for y. Putting points where these values intersect on the graph, and joining them we get the straight line OA. The equation of this line is said to be, y = x, simply because the line was graphed by using this equation.

In Figure 8-3, q is used instead of x, and e has been substituted for y. Since, by equation 8.3. Q = CE, and C is *constant*, we get the straight line OB. Now, the product

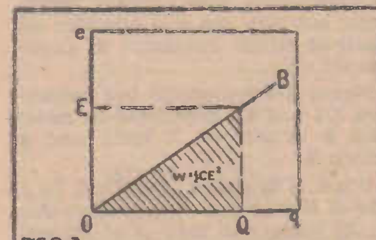


Fig. 3. The method of showing graphically the work done in charging capacitor C in Fig. 1.

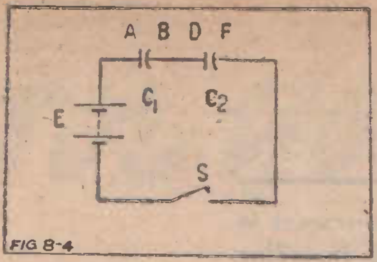


Fig. 4. When capacitors are connected in series, the total capacitance in the circuit is less than the capacitance of any individual unit.

of e (or quantity represented by the ordinate), and q, (or quantity represented by the abscissa) is equal to work done. That is, work done = eq.

But inspection of the graph shows that *graphically*, the product of eq represents the area enclosed by the lines Oe and Oq.

When the capacitor in Figure 8-1 is charged to some potential E, its charge is some quantity Q. These values are shown on the graph in Figure 8-3. The work done in this case is EQ, or the area under the curve OB. This is clearly a triangle, so that the work done in charging C in Figure 8-1 is ½EQ, which is exactly the same as equation 8.2.

A Numerical Example

The significance of equation 8.4 is perhaps, better appreciated if we substitute numerical values for C and E. If C is 2 microfarards (mfd), and E is 1000 volts, the work, W, done is,

$$W = \frac{2}{10^6} \times \frac{(1000)^2}{2}$$
$$= 1 \text{ joule.}$$
$$= 0.7375 \text{ ft. lbs.}$$

That is, to produce a potential difference of 1000 volts across the plates of a 2 mfd. capacitor, the charging source does nearly ¾ of a foot pound of work. This is amount of energy stored in the dielectric in the form of strain energy.

Capacitors in Series

An electrical network often consists of a number of capacitors in series and parallel. The practical network must also contain resistance, but now we will consider an idealised circuit consisting of capacitance only.

Figure 8-4 represents two capacitors, C1 and C2 connected in series with a battery of E volts, and a switch S.

When S is closed there will be a flow of charge from the positive side of the battery to plate A of C1 and a corresponding and equal flow of charge from plate D of C2 to the negative terminal of the battery. Similarly, charges must flow from plate B of C1 to plate F of C2, and the quantity of charge transferred between B and F *must be equal* to the amount transferred around that part of the circuit containing the battery. It follows that the charge Q, transferred to each capacitor *is the same.*

The total charge given the system is Q units. If the charge of each capacitor is the same then the p.d. across each capacitor must depend on its capacitance. Let the final p.d. across C1 be E1 and the final p.d. across C2 be E2. The p.d. across both capacitors is obviously E volts, and this is the p.d. across the total capacitance, C, of the circuit.

For the 1st capacitor, $E_1 = \frac{Q}{C}$ ..8.5

For the 2nd capacitor, $E_2 = \frac{Q}{C_2}$ ..8.6

For both capacitors, $E = \frac{Q}{C}$ ..8.7

It is also clear that the sum of the p.d.s across each capacitor must be equal to the battery potential E, that is,

that $E = E_1 + E_2$ ...8.8

When we substitute equations 8.5, 8.6, and 8.7 for corresponding values in 8.8, we get,

$$\frac{Q}{C} = \frac{Q}{C_1} + \frac{Q}{C_2} \quad ...8.9$$

and when we divide each term by Q, we finally have,

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \quad ...8.10$$

or expressed in perhaps a more familiar form,

$$C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}} \quad ...8.11$$

It is clear from this final expression, that the total capacitance of capacitors in series is *less* than the capacitance of any individual capacitor.

Equations 8.10 and 8.11 are true for any number of capacitors in series.

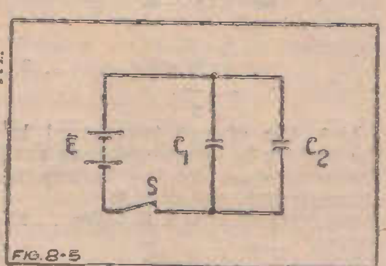


Fig. 5. In the case of capacitors in parallel the total capacitance in the circuit is equal to the sum of the individual capacitors.

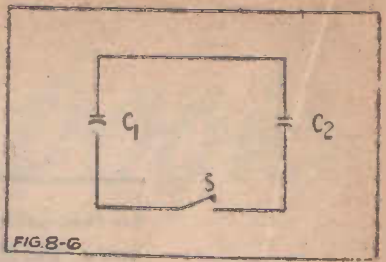


Fig. 6. When switch S is closed a transfer of energy will take place between the charged and uncharged capacitors.

Capacitors in Parallel

Figure 8-5 shows two capacitors, C_1 and C_2 connected in parallel across a battery of E volts, and a switch S. When S is closed in this case, the final potential across each capacitor will be the same, but the amount of charge transferred will depend on the individual capacitance of each capacitor.

Let the charge of C_1 be Q_1 and the charge of C_2 be Q_2. Then we have

$Q_1 = EC_1$ ...8.12

$Q_2 = EC_2$ .. 8.13

$Q = EC$ ...8.14

where Q is the total charge and C is the total capacitance of the circuit. Also, the charges of each capacitor must equal the total charge transferred by the battery. Hence, $Q = Q_1 + Q_2$ ...8.15

Substituting in a similar manner to the previous case, we get

$$EC = EC_1 + EC_2$$

and dividing each term by E, we have

$$C = C_1 + C_2 \quad ...8.16$$

so that the total capacitance of a circuit consisting of capacitors in parallel is equal to the sum of the individual capacitances.

As with the series case, Equation 8.16 is true for any number of capacitors in parallel.

Transfer of Energy in Idealised Circuits Containing Capitance Only

Many electrical circuits contain systems wherein a transfer of energy occurs between two or more capacitors. This is especially true of radio transmission and reception networks. Before citing a practical case it is better to consider the *general* case.

In Figure 8-4, a capacitor C_1 charged to a p.d. of E_1 volts, is isolated from an *uncharged* capacitor, C_2 by the open switch, S. With S open the *total* energy stored in the system is

$W_t = \frac{1}{2}C_1E_1^2$ joules ...8.17

where W_t is the total energy stored.

Equation 8.17 may be written in another form; one which is more convenient for the particular case we are discussing. Remembering that $Q = CE$, we may write 8.17 as,

$$W_t = \frac{\frac{1}{2}Q^2}{C} \quad \ldots 8.18$$

When S is closed, a transfer of charge occurs between C_1 and C_2, and the total capacitance of the system is

$C_t = C_1 + C_2$ (From equation 8.16) and the amount of energy in the system with these altered conditions is W_n where W_n is the new energy value. And

$$W_n = \frac{\frac{1}{2}Q^2}{C_1 + C_2} = \frac{\frac{1}{2}Q^2}{C_t} \quad \ldots 8.19$$

Now, since $C_1 + C_2$ must be *greater* than C_1 alone, the energy W_n must be *less* than the original energy, W_t. We can find the ratio of the new energy to the original energy by dividing equation 8.19 by 8.18, and when we do this we get,

$$\frac{Wn}{W_t} = \frac{C_1}{C_1 + C_2} \quad \ldots 8.20$$

or

$$Wn = \frac{W_t(C_1)}{(C_1 + C_2)} \quad \ldots 8.21$$

If $C_1 = C_2$, equation 8.21 can be written,

$$Wn = \frac{W_t(C_1)}{C_1 + C_2} = \tfrac{1}{2} W_t$$

so that the new amount of energy is only *half* the original amount stored in the system.

A Specific Case

A familiar and simple case is that of a tuned circuit connected between the grid and cathode of a thermionic valve as shown in Figure 8-7. Since a definite capacitance, Cgk exists between the grid and cathode of the valve, we have, neglecting the inductance, the same conditions as illustrated graphically in Figure 8-6. This is verified by comparing Figures 8-6 and 8-8 in which the equivalent circuit of Figure 8-7 has been drawn. In Figure 8-8, C_1 is denoted by C, and C_2 is indicated by Cgk.

When the tuning capacitor C is subjected to an alternating p.d. (as it is in practice), it continually charges and discharges at the same rate, or frequency as the p.d. With every altenation of p.d. there is energy transfer between C and cgk.

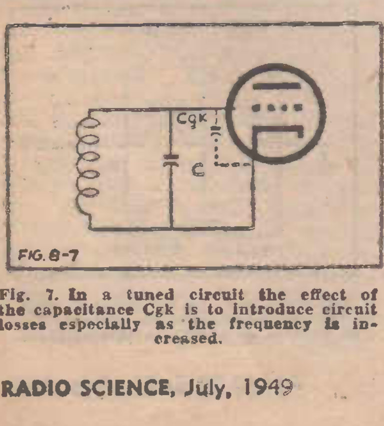


Fig. 7. In a tuned circuit the effect of the capacitance Cgk is to introduce circuit losses especially as the frequency is increased.

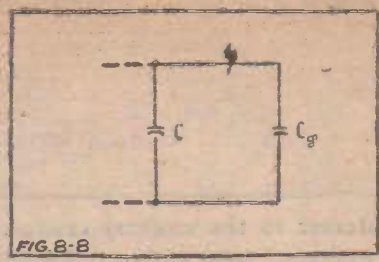


Fig. 8. This equivalent circuit of Fig. 7 clearly shows the effect of Cgk.

and each time energy is transferred, a definite amount is lost to the system. Increasing the frequency increases the rate at which energy is transferred, and, hence, the rate at which it is lost from the system. The rate of energy loss is nearly proportional to the frequency of the p.d. The amount of energy lost per cycle is in the ratio of C/C + Cgk.

If the capacitance C is equal to Cgk, and the energy stored in C during each cycle is W_t, then the energy lost per cycle is $\frac{1}{2}W_t$ joules, and should the frequency be 1,000,000 cps, the energy lost per second is theoretically 10^6 ($\frac{1}{2}W_t$) joules. Obviously, increasing the frequency must increase the amount of energy lost per second.

Graphical Representation of the Tuned Circuit Case

Figure 8-9 represents the dissipation on energy in the case of the tuned circuit and thermionic valve. In the Figure, OC, represents the capacitance of the tuning capacitor, Cgk represents the capacitance of the grid-cathode elements of the valve, E_t is the initial p.d. across C, and En is the common (and final) p.d. across C and Cgk when the latter is charged.

The quantity of charge, Q, originally displaced across C must be the same after charging Cgk as when Cgk was uncharged, and this is indicated graphically by the identical distances, "Q" marked off along the abscissa of the graph. The shaded area under the line OC represents the original energy stored in C; the shaded area under the line OCgk is charged. It is obvious by inspection of the Figure that Wt is greater than the final amount of energy, Wn.

This abstract analysis of the conditions under which a tuned circuit operates when connected between the grid and cathode of a valve makes it clear why the capacitance between the grid and cathode of a valve should be as small as possible if we desire to keep energy loss to a minimum.

The Aerial-Earth Case

If the tuned circuit is connected between the aerial and earth of a radio transmitting system, we have the same conditions we have just discussed. The aerial is equivalent to the grid and the earth is equivalent to the cathode. Due to the capacitance between the aerial and earth, energy must be lost to the system during each cycle of the alternating p.d. impressed across the tuning capacitor C.

The Physical Significance of this Analysis

We have emphasised that this analysis is abstract. It indicates, *mathematically*, that whenever a capacitor, or a system of capacitors, charges other capacitors, *some of the original energy* stored in the charged capacitors is lost. Now, this loss has nothing whatsoever to do with the physical conditions of the circuit or circuits because the physical conditions under when the energy is transferred have not been included in our hypothesis, so that our analysis is purely theoretical and is not about physical things at all.

The loss is *not entirely due to the resistance* of the circuit, although we know all circuits must contain resistance, neither can it be entirely due to losses in the dielectric separating the plates of our capacitors, because neither resistance nor dielectrics have been even mentioned in our enquiry. Practical circuits also contain inductance, but we deliberately neglected the inductance from the start.

It is a fundamental law of nature that any system of exclusively stored energies—similar to the one we have analysed—*can only function in a way to run down.* This is why inventors of perpetual motion machines will go crazy if they persist with their activities; they are not at conflict with the physicist, nor the mathematician, nor the capitalist, they are fighting a one man battle with the universe. Natural laws make the phenomenon of perpetual motion impossible.

This not only applies to electricity. Take hydraulics as an example. Here we find that the total energy

(Continued on Page 38).

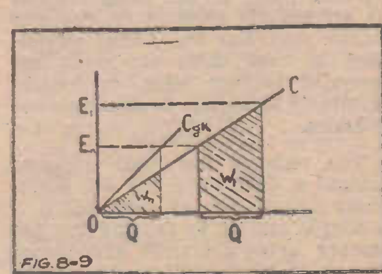


Fig. 9. A graphical representation of the tuned circuit showing the necessity for keeping interelectrode capacitances to a minimum.

FOR THE COUNTRYMAN ! !

32 VOLT FARM RADIO

Of particular interest to the country reader, this five valve receiver can be operated from either a 32 volt lighting plant or other 12 volt source. Using modern components it is capable of excellent results.

by

A. J. GARDINER

Assoc. I.R.E.

The receiver to be described may be considered to be the answer to the countryman's set problem if he is fortunate enough to possess a home lighting plant. The 12-volt version draws 2 amps from the supply, whilst the current drain of the 32-volt receiver is slightly over one amp. This small amount of current would make little difference to the drain on the lighting plant, and consequently the receiver is much more economical to operate than an ordinary dry battery or six-volt vibrator radio.

Input Voltage Values

The input voltage is not critical, and can vary over fairly wide limits without affecting the results or being detrimental to the valves or vibrator cartridge. The 12-volt supply can vary from 10 to 16 volts, whilst the 32-volt supply can vary from 26 to 36 volts, which means that the receiver can be operated even whilst the batteries of the plant are being charged. This statement is based on practical experience with several receivers of this type over a period of some three years.

The output and tonal quality will be found to compare more than favourably with an AC receiver of the same size, and it will deliver between two and three watts of audio power to the speaker, on either radio or gramophone pickup. It can be plugged into the home lighting plant in the same manner as an electric receiver on the city mains, and has the added advantage in that there are no messy corroded battery clips or battery terminals to handle or cause service troubles.

The receiver has been designed around a dual wave coil kit, but if short waves are not required, it is a simple matter to procure the necessary broadcast coils and ignore the short wave section. As can be seen from the schematic diagram of the circuit, the receiver consists of a 6U7G, r-f amplifier, 6A8G, converter, another 6U7G, i-f amplifier, 6B8G combined second detector and first audio amplifier, and a 6V6GT, output valve. This valve is operated with sufficient negative feedback to round off the treble response—the simple connection of a 2 meg resistor from the plate of the 6B8G to the plate of the 6V6GT supplying the necessary feedback. A treble cut tone control is provided and this consists of a .05 meg potentiometer and a .05 mfd condenser wired in series between the plate and screen of the 6V6GT.

Heater Connections

It will be noticed that all valves are of the 6.3v type and for 32-volt operation the heaters are connected in series. As all valves draw 0.3 amp heater current, except the 6V6GT which requires 0.45 amp., it is necessary to wire a 160 ohm 5-watt resistor in parallel with the other four valves to carry this 0.15 amp extra current. The dial lamps are 6.3v, 0.3 amp types, and are connected in series with a 60 ohm 10-watt resistor to allow them to work in series with the home lighting supply.

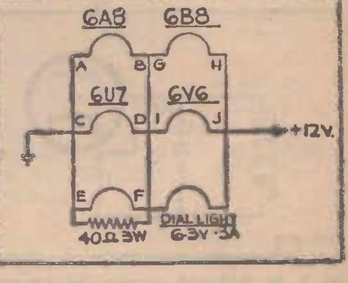
In the case of the 12-volt operation, the valves have to be wired in a series-parallel arrangement, and this is detailed in the small diagram. As can be seen only one 6.3v, 0.3 amp dial lamp is used and a 40 ohm 3-watt resistor is required to ensure the correct current and voltage balance of the network.

In the interests of economy, the output voltage from the vibrator is limited to 200-volt 50 ma. This high tension voltage is more than sufficient for the receiver, especially when using a modern 7-inch or larger permagnetic speaker. Because of this lower high tension voltage, the screen dropping resistor for the 6U7G and the 6A8G valves is slightly lower than usual, being 15,000 ohms, whilst the oscillator plate resistor is 10,000 ohms.

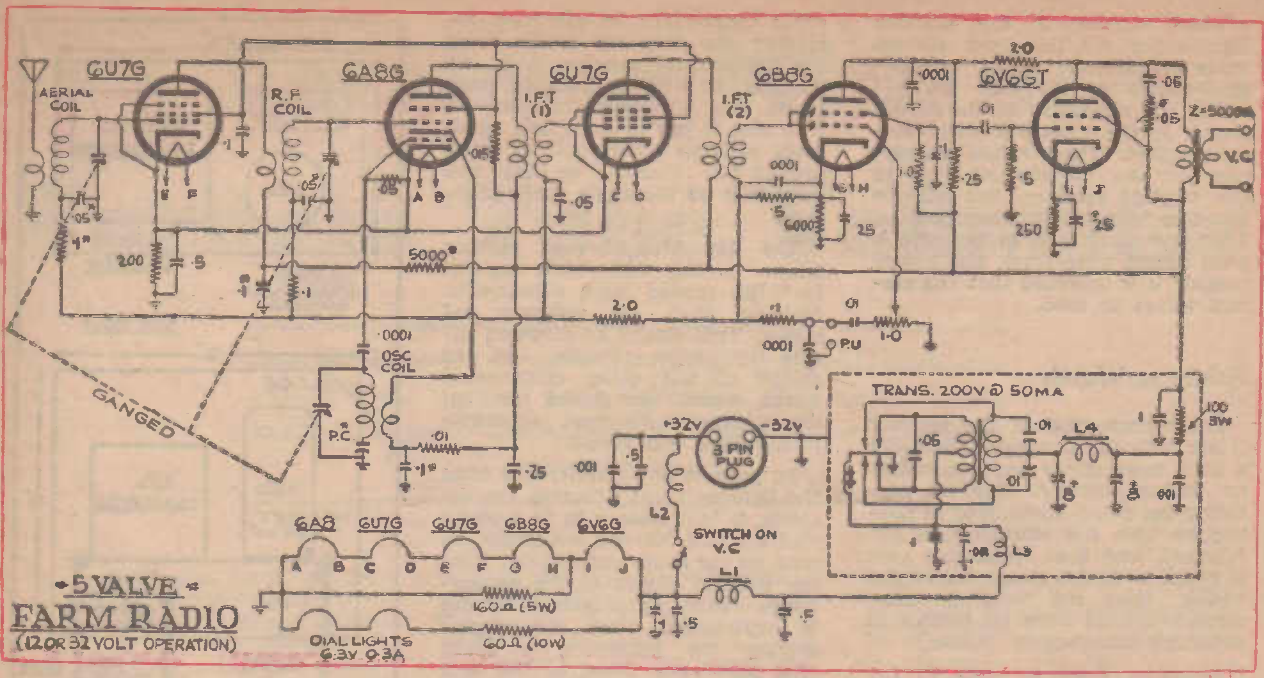
The actual vibrator transformer used will depend on the input supply voltage, but in general it will be found that suitable units can be obtained with either a 12, 24 or 32-volt primary to give the requisite high tension voltage. In the original receivers, the 32-volt vibrator cartridge used vas obtained from disposal equipment and consequently some difficulty may be experienced in obtaining this type. However, the 24-volt standard type unit can be used with a suitable transformer, the only circuit change necessary being to wire a 16 ohm 5-watt resistor in series with the lead from L2 to L4.

Vibrator Unit

The vibrator unit is made up on a base plate measuring 5½in. x 4in. and then fitted into a metal can 6in. x 4½in. x 6in. high, being held in place by the four long corner bolts. The whole unit is then mounted on the receiver chassis over the place usually taken by the power transformer and rectifier—if an AC chassis is used as in the



If the receiver is to be operated from a 12 volt source, the valve heaters should be rewired as shown in this diagram.



The complete circuit for operation from a 32 volt supply, such as a home lighting plant. The components marked with an asterisk may be included in some coil units, and should be checked on. If a 24 volt vibrator cartridge is used, then a 16 ohm 5 watt resistor should be connected between L1 and L3.

original receiver, and four rubber grommets are fitted on the chassis to take the four bolts protruding from the bottom of the vibrator case.

This is to insulate the vibrator unit from the receiver chassis and have a one point earth connection between the two. This precaution is necessary since it assists in keeping the vibrator hash to a minimum, and the connection is made with a piece of copper braiding to the earth bus bar. The incoming negative lead from the home lighting mains should also be connected to this point.

Another wise precaution is to mount the 6-pin vibrator socket on small rubber grommets, as otherwise the mechanical vibration of the vibrator reed will be transmitted to the receiver chassis and be heard as an annoying hum. However, do not make the connecting wires to the socket too short or too rigid, otherwise the vibrator will not have free movement on the grommets.

It is essential that the vibrator transformer windings are correctly phased, and the polarity should be checked with a voltmeter to ensure the high tension output is positive with respect to the chassis. If this is not the case, reverse the connections to the secondary contacts of the vibrator. This point must be watched when the receiver is connected to the home lighting mains, and precautions taken to make sure the positive connection from the receiver is connected to the positive side of the mains. This can be overcome by using a 3-pin plug and socket of the regular 240-volt AC mains type—first checking polarities with a voltmeter.

PARTS LIST

- 1 Chassis.
- 1 3-Gang Tuning Condenser (MSP)
- 1 Tuning Dial to suit
- 1 Dual-wave Coil Unit (with RF stage)
- 2 455 kc I.F.T.'s
- 1 60 ma 15H Filter Choke (L4)
- 1 Vibrator Transformer, 32, 24 or 12-volt primary, 200 v. per side secondary, 50 ma.
- 1 Synchronous 6-pin Vibrator Cartridge to suit transformer
- 2 RF Chokes (Filament type), (L2, L3)
- 1 Iron Core Filter Choke (L1)
- 1 Metal Base Plate, 5½" x 4"
- 1 Metal Box, 6" x 4½" x 6" H.

CONDENSERS

- 2 25 mfd Electrolytic 40V.
- 2 8 mfd Electrolytic 525V.
- 4 .5 mfd Tubular 200V.
- 1 .25 mfd Tubular 400V.
- 5 .1 mfd Tubular 400V.
- 3 .05 mfd Tubular 200V.
- 2 .01 mfd Tubular 600V.
- 4 .001 mfd Tubular 600V.
- 4 .0001 mfd Mica

RESISTORS

- 2 2 meg 1 watt.
- 1 1 meg 1 watt.
- 2 .5 meg 1 watt.
- 1 .25 meg 1 watt.
- 2 .1 meg 1 watt.
- 1 .05 meg 1 watt.
- 1 .015 meg 1 watt.
- 1 .01 meg 1 watt.
- 1 5000 ohm 1 watt.
- 1 250 ohm 3w wire wound
- 1 200 ohm 3w wire wound
- 1 40 ohm 3w wire wound (12v operation)
- 1 160 ohm 5w wire wound (32v operation)
- 1 60 ohm 10w wire wound (32v operation)
- 1 16 ohm 5w wire wound (if 24-volt vibrator used)
- 1 1 meg potentiometer with switch
- 1 .05 meg potentiometer

VALVES—2 6U7G, 1 6A8G, 1 6B8G, 1 6V6G.

SPEAKER—Permag. type, with 5000 ohm transformer.

SUNDRIES—5 octal sockets, 1 6-pin socket and 2 grommets, 1 4-pin socket and plug, 3 red terminals, 2 black terminals, 4 valve shields, 4 bolts, 3 ¼", 6 3/8" grommets, 1 ½" grommet, 4 grid clips, 18' resistor mounting strip, hookup wire, shielded wire, solder lugs, power flex, etc.

When purchasing the vibrator transformer see that thé correct value transformer buffer condensers—shown as .01 mfd 600 volt across the secondary of the transformer in the schematic diagram—are supplied. These values are correct for the transformer used in the original receiver, but will be found to vary with different makes. They are necessary to preserve a good output wave form, and consequently it is essential that the correct values be used.

Points to Watch

The construction of the receiver is not difficult, although admittedly a little more tricky than an ordinary battery receiver. However, providing the points mentioned in connection with the vibrator unit are followed, and that reasonable care is taken with the remainder of the wiring, then the would-be constructor should have no trouble in obtaining satisfactory results.

Attention must be paid to the heater wiring, connecting the valves in series exactly as marked on the schematic diagram. It is a good plan to run an earth bus-bar such as two pieces of 18-gauge tinned copper wire, twisted together, down the centre of the chassic. Make all earth connections to this wire, including the negative return from the 6A8G heater marked A in the diagram, as well as the gang rotor plates and all by-pass condensers. The idea is not to have long earth leads running from point to point around the chassis, as these will only lead to incurable hash problems.

The 100 ohm 3-watt resistor shown in the main high tension lead has proved more effective in filtering than an ordinary r-f choke. This should be mounted inside the metal vibrator box, as should all the other components shown within the dotted lines on the schematic diagram, otherwise interference will result.

To prevent any interference from the lighting plant affecting the receiver, it is necessary to fit a metal clad 0.5 mfd 200-volt condenser, as used on car radio installations from the positive output of the generator to frame. If any ignition trouble is experienced from the engine driving the generator, a spark plug suppressor fitted in the lead to the spark plug should overcome it.

Provision has been made for pickup use by fitting three terminals at the rear of the chassis. One connects to the .1 meg resistor

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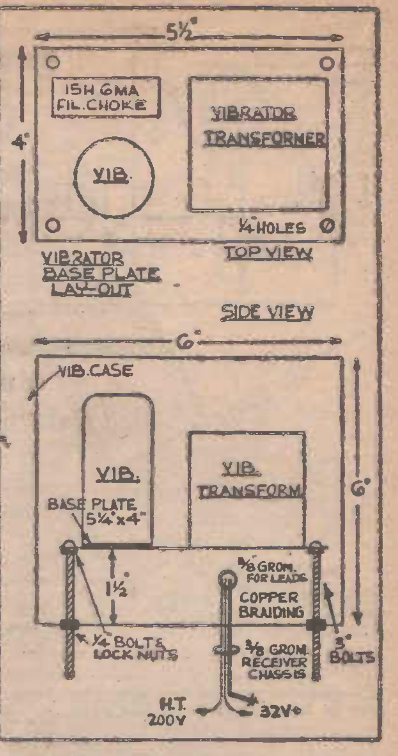

The general layout and dimensions of the vibrator unit are given in these drawings. The complete unit should be mounted in a metal box conveniently earthed at one point on the main chassis.

Servicing With a Vacuum Tube Voltmeter

One of the most versatile instruments a serviceman can possess is the Vacuum Tube Voltmeter. This article details some of the many applications of this instrument in general servicing procedure.

The vacuum tube voltmeter, usually abbreviated VTVM and often referred to as an electronic voltohmeter, is a voltmeter with a very high impedance or resistance represented across its input terminals so that it will not disturb the operation of the radio circuits to which it is connected. It is capable of enabling almost all measurements needed in routine radio servicing to be made quickly and efficiently, and is generally fitted with a probe type of rectifier so that r-f voltages may be measured without appreciably loading the circuit under test.

VTVM Superior

The superiority of the VTVM over low resistance instruments when making d-c voltage measurements across high resistance networks can be more easily appreciated by reference to the example shown in Figure 1. Here a potential of 10 volts is evenly divided across the two 1.0 megohm resistances—that is, 5 volts across each resistor.

Now if a 1000 ohms per volt meter on the 10 volt scale is connected across one of the resistors, it will be seen that its own resistance is effectively placed in parallel with the resistor itself. Since the resistance of the meter on this scale is approximately 10,000 ohms, the combined resistance of the resistor and meter will be slightly less than this amount, and consequently the meter reading will indicate less than one volt, which is, of course, meaningless.

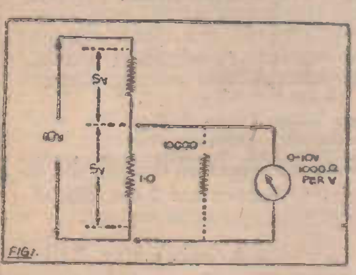

Fig. 1. This drawing indicates how a low resistance voltmeter places its own resistance in parallel with the resistor in the circuit giving rise to an erroneous reading.

On the other hand, if a modern VTVM having an input resistance in the order of 10 megohms is applied to this same resistor, the reading will be over 4 volts. This is an error of less than 10 per cent. and is a considerable improvement over the previous error of 90 per cent. As a result this type of instrument is admirably suited for circuits where no current drain by the meter is a necessity.

Typical Use

A typical example of its use is measuring the voltage at the plate of a resistance coupled amplifier valve as shown in Figure 2. In this circuit the plate current of the 6SQ7GT is about 0.9 ma under conditions of no signal input, and the actual voltage at the plate (assuming a 250 volt source) is about 160 volts.

Now if an ordinary voltmeter, which may require one milliampere of current for its operation, is connected between the plate of the valve and ground, the additional meter current flowing through the 0.1 megohm plate load resistance is sufficient to cause an added voltage drop to take place. Under these conditions the actual reading shown by the meter may be only 60 volts. An ordinary voltmeter therefore will not truly indicate the plate voltage in this circuit, whilst a vacuum tube voltmeter, which requires no current for its operation, will indicate the actual DC voltage.

Checking I.F. Filter

Another use for the VTVM is to check the effectiveness of filter condensers in the receiver without the necessity of disconnecting them from the circuit. Referring to Fig. 2 again, it will be seen that the 50,000 ohm resistor and the two .0001 mfd condensers form a simple filter to prevent any i-f signals from reaching the grid of the first audio valve, where they could possibly cause overloading and distortion.

To ascertain the effectiveness of this filter circuit, simply connect an "unmodulated" signal generator to the input of the receiver and connect VTVM first between the signal diode plate and the chassis.

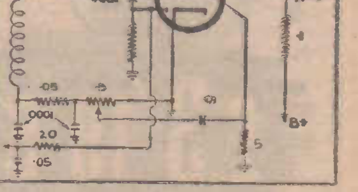

Fig. 2. A typical second detector and first AF stage which serves to illustrate many VTVM measuring applications.

The signal should be present at this point, but on changing the VTVM connections between the audio grid and chassis there should be no measurable i-f voltage.

• One point to watch when making this test is to ensure that no large amount of hiss or other noise is present which could give rise to a reading on the audio grid. One method of overcoming this trouble is to turn up the output of the signal generator to a rather high value. This causes the AVC to become operative with a consequent reduction in sensitivity of the receiver to extraneous noises.

A.V.C. Voltage Check

Another test that can be made in the circuit of Figure 2 is to check the AVC voltage. The filter in the AVC circuit consists of the 2.0 meg resistor and a .05 mfd condenser, and this prevents any audio or i-f voltages from feeding back to the earlier stages through the AVC line. For correct operation only DC should be present on this line, but in view of the high resistance in the circuit, the ordinary low resistance voltmeter will not

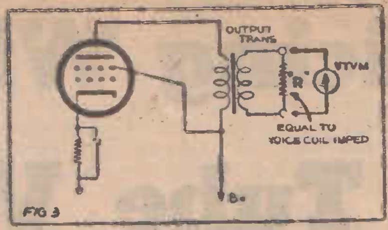

Fig. 3. To determine the voice coil impedance of a speaker, the VTVM should be connected as indicated in this diagram.

indicate any voltage at all. On the other hand, a VTVM will permit voltage measurements to be made at all points in this network without disturbing the operation of the circuit.

The following test can be used to check for the presence of DC on this line. Using a modulated signal input to the receiver connect the VTVM through a .05 mfd or larger condenser to the AVC line at the junction of the 2.0 meg resistor and the .05 mfd condenser. With the VTVM set to read AC volts no voltage should be measurable, but when set for DC measurement with the .05 mfd blocking condenser removed, the DC voltage at this point should increase as the signal input increases.

Coupling Condenser Leakage

A frequent source of trouble is the audio coupling condenser from the volume control to the 6SQ7GT grid. The .01 mfd coupling condenser in Fig. 2 may be checked for leakage in the following manner. With a strong modulated signal applied to the receiver, no DC voltage reading should be measurable at the 6SQ7 grid. Any reading obtained under these conditions would be due to a high resistance leakage in the coupling condenser and consequently should be replaced.

The coupling condenser between the plate of the 6SQ7 and the following valve can also give rise to trouble if its insulation is not the best. By connecting the VTVM between the grid of the following valve and ground, an accurate voltage measurement can be made. The value of the grid resistance of this stage is usually about 0.5 megohm, and a leakage of only two microamperes through the condenser will cause a voltage drop of one volt to be shown on the VTVM. Grid emission, or presence of gas in the valve will give rise to a positive voltage at this point, a condition which can be readily checked with the VTVM.

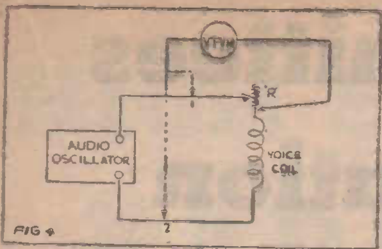

Fig. 4. The method of measuring audio output in watts using a vacuum tube voltmeter.

Determining Power Output

Reverting to the power output stage, the VTVM can be used to determine the power output in watts of the radio receiver or audio amplifier. To make this measurement, it is first necessary to replace the speaker with a fixed resistor of a value equal to the voice coil impedance, and then connect the VTVM across the resistor as indicated in Figure 3. A constant input signal is used—in the case of the receiver this can be a signal generator, whilst for an audio amplifier a test record can be used.

The voltage reading obtained on the VTVM under these conditions may be converted to "watts output" by using the formula:

$$\text{Watts} = \frac{E^2}{R}$$

in which E is the voltage in volts, and R is the resistance in ohms.

Thus if the meter reads, say, 5 volts, and the resistor load is 10 ohms, then the power output is equal to $\frac{5 \times 5}{10}$ and this gives 2.5 watts.

Voice Coil Impedance

Often the occasion arises when it is necessary to replace a speaker in a radio receiver or PA equipment, and it is necessary to know the voice coil impedance so that correct connections can be made. Although this information is rarely marked on the speaker, it is possible to determine the impedance quite readily. An audio oscillator is connected across the voice coil as shown in Figure 4. The variable resistance "R" is a 20 ohm high wattage resistor of the wire wound type. The VTVM should be set to AC volts, and since most speaker impedances are specified at 400 cycles, this frequency should be used in the test.

The variable resistor should then be adjusted, whilst alternately connecting the VTVM to points 1 and 2 until the meter reads the same value at both points. This indicates that the resistor is now exactly the value of the voice coil impedance, and so the final step is simply to measure the value to which the resistor has been adjusted.

When dealing with tuned circuits it is often an advantage to be able to determine the approximate "Q." This can be done by using the circuit shown in Figure 5. The signal generator is considered to have a small internal impedance, and under these conditions the "Q" of the tuned circuit will be equal to the ratio of the voltage measured across the tuning condenser at resonance and at some point removed from the resonance point, that is:

$$Q = E_1/E_2$$

where E_1 is the voltage obtained at resonance, and E_2 is the voltage removed from resonance.

The actual use of this formula may be explained by the following example. Suppose under resonant conditions the voltage read on the VTVM is 7 volts and the voltage at a point other than resonance is 0.2 volts, then the "Q" of the circuit is equal to 7 divided by 0.2, or 35.

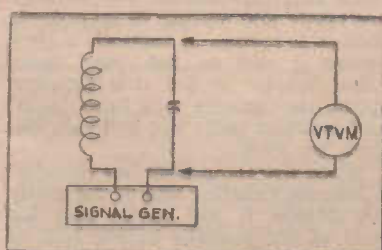

Fig. 5. The "Q" of a coil can be measured by reading the voltage across the resonant circuit. The requisite RF energy is supplied by a signal generator.

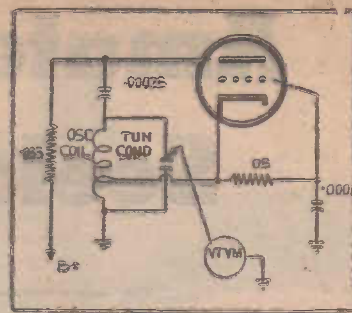

Fig. 6. Measuring the RF output of a typical oscillator circuit.

A commonly used method of checking the oscillator circuit for correct functioning is to insert a meter in series with the oscillator grid resistor and measure the grid current. This involves the necessity of unsoldering leads, and to obviate this trouble a VTVM connected as shown in Figure 6 will enable a ready check to be made the stator of the oscillator gang on the oscillator circuit.

The meter is simply connected to section of the tuning condenser, through a mica condenser value of .006 mfd or larger. Then as the set is tuned across the entire frequency range, the r-f output of the oscillator will vary. If the oscillator fails to function at all or "cuts out" at any time it will be immediately apparent on the VTVM.

INDIVIDUAL RADIO

A person apparently talking to himself while walking down a city street or along a row of corn in a field soon may become a familiar sight in the United States. Actually, he will not be talking to himself but to another person, perhaps an associate at the office or his wife at home.

He will be using the facilities of the Citizens' Radio Service, authorised to begin operations on June 1 by the Federal Communications Commission, a U.S. Government agency. The service will make it possible for one person to talk with another by means of their own miniature radio receiving and sending sets. The set may be carried like a camera under the arm, in a coat pocket, or by means of a strap over the shoulder.

Any citizen of the United States 18 years of age or older will be eligible to receive a "broadcasting" licence from the F.C.C. to use the new service. The authorised range of the sets will depend upon local conditions—from a few blocks in cities where many sets are used, to up to 10 miles in rural areas. All sets will operate in the 460-to-470 megacycle band allocated for the service by the F.C.C.

The F.C.C. has issued special regulations covering the use of the new sets to protect the public interest. For example, a user may not talk too long because other persons in the area may want to use the channel. He cannot charge for sending a message. Although a licence-holder may permit anyone he wishes to use the set, he cannot sell his set to an unlicensed person. A licence, which may be obtained from the F.C.C. merely by sending a postcard, is valid for five years.

A set manufactured by a Cleveland, Ohio, concern has been approved for public use on the Citizens' Radio Service, and other manufacturers are expected to produce sets soon. The approved sets are inexpensive, and weigh only about 2½ pounds, including batteries.

An F.C.C. spokesman says the possible uses for the new service will be "as broad as the imagination of the public and the ingenuity of equipment manufacturers can devise."

Amateur Committees Seek Co-operation

The recently formed Amateur Radio Advisory Committees will endeavor to improve the standard of radio operation in this country. To be successful they must have the full support and co-operation of every amateur.

Amateur radio advisory committees set up in each state to maintain a high standard of amateur radio operating in Australia deserve the full support and co-operation of the whole amateur radio fraternity. Similar to the pre-war "vigilance" committees, the new bodies will "police" the bands in a more tolerant manner than in pre-war years. They will endeavor to help and advise the amateur fraternity more than discipline it.

The committee will comprise members and non-members of the Wireless Institute of Australia headed by a representative of the Postmaster General's Department which is sponsoring the move. All are experienced men. All have spent years of their leisure time with the fascinating hobby and know the regulations fully. They all have a keen technical knowledge and are as eager to help the C.W. man as the 'phone types and will readily offer their assistance to the old timer or the young school boy fresh in the game.

Committee Named

The names of the personnel in the committees are being made public, unlike the pre-war vigilance committees which were disliked by many due to the mystery surrounding their members. This is a sound point and gives one a ready trust and confidence in the committee, its members and its purpose.

The whole scheme is democracy itself—the amateurs governing themselves. As the system develops it is quite likely the election will be made by the rank and file members.

Full credit for the scheme goes to the Federal executive of the W.I.A. Working voluntarily in their own time, these men have planned the advisory committee and the P.M.G's Department has been quite ready to adopt it.

The success, or otherwise, of the venture rests with the Australian radio amateurs themselves. If they are ready and willing to co-operate then it is certain of success; if they ignore it and do not take their "blue tickets" in the true amateur spirit, the scheme will have failed and amateur radio will go to an all-time low level.

When the committee has detected a licensee violating one of the many regulations, it will advise him (or her) of the mistake urging him to take remedial measures immediately. Should the warning be ignored, there will be trouble ahead for this "Mr. Smart Guy" whose case will be referred to the department for appropriate disciplinary action — he might even lose his ticket.

By
ROTH JONES
VK3BG

No doubt many of us will get some of these warnings, but it must always be remembered they are for our good and not meant to be personal in any manner. The present state of the amateur bands leaves much to be desired. The P.M.G. department has a full-time job with its commercial commitments and unfortunately has not been able to devote too much time to checking up on amateur operation.

Common Breaches

The following common breaches of regulations are those most likely to be committed and reported to the committee:

Off-frequency i.e. out of the band operation.

Accepted third party messages.

Over-modulation and splatter—a common occurrence on the 10 and 20 metre DX bands.

Key clicks, easily remedied.

Spurious and harmonic emissions.

Unnecessary and intentional jamming.

High power.

Behind the committee will be the genuine desire to foster the true and now historic amateur experimental spirit. There is far too much needless operating on the bands these days when some of the Q.S.O's sound like a pair of circus clowns rehearsing.

For years the W.I.A. has done its utmost to foster radio experimenting. Its technical committees, functioning in most of its state divisions, have helped many a young licensee to the road of success. The research programmes are based on the amateur's genuine desire to experiment in search of knowledge.

For close on four decades, we have had amateur radio in Australia. It has been a success and has progressed because those within its ranks have helped each other. I often wonder as I reflect back over the years whether this same spirit of co-operation, so evident in the past, has disappeared and selfishness taken its place. At times I think it has, but a later check and ready co-operation from others reveals I am wrong and this same spirit, fostered in the days of the spark, is still with us. Let it always remain!

These advisory committees will foster this spirit of co-operation for co-operation is the success of the venture. Let us help them. They will encourage the genuine amateur spirit and campaign for keenness, experimenting and above all sponsoring good, clean signals, good operating and a fair go to all. They only ask for CO-OPERATION.

Good luck to the Amateur Advisory Committees.

HIGH SPEED RADAR SWITCH

The TR switch mounted in waveguide with standard couplings. Loss of received signals in the transmitter can be prevented either by transmitter mismatch or by use of a second gas -discharge switch. The combination of switches and lines is called a duplex.

An electronic switch, prosaically known as a TR switch, can operate in a few millionths of a second, and repeat that operation a thousand times each second. Called into being by radar it stands beside the magnetron, klystron synthetic crystal and waveguide as a new electronic component, and like them is simple to comprehend.

The need in radar for an ultra-high-speed switch arises largely from the fact that the transmitter and receiver use the same antenna. In a microwave-radar system the transmitter emits a pulse of energy at high frequency for a period, perhaps as brief as one millionth of a second. ,This is followed by a period of silence a thousand times longer than the pulse period during which the receiver *"listens"* for any echo that would indicate some reflective target.

Joint use by transmitter and receiver of the same antenna represents an economy in size, weight, mechanical complexity, and cost but necessitates a means of isolating the receiver during the pulse period. Were the receiver to remain connected to the antenna during operation of the transmitter it would absorb an important portion of the pulse energy, which loss would be serious enough, but more important the receiver being sensitive to the small amount of energy in an echo, might be seriously damaged by the transmitted power.

TR Switch

The means of doing this is the TR (transmit-receive) switch. Although it is a precision device the TR switch is essentially a needle gap in a gas closely controlled as to molecular density and ionisation.

The TR switch protects the receiver from damage with an extremely small loss in both transmitted and received power. The receiver is protected automatically with an overall power loss of only one or two decibels.

The input element of a microwave radar receiver is generally a sensitive silicon-tungsten contact rectifier (crystal) which acts as the frequency converter of the superheterodyne receiver. Under steady-state conditions this element can be permanently damaged by power levels ranging from a tenth of a watt to a few watts depending on the crystal type.

The transmitted power in a radar pulse ranges from some tens of kilowatts to as much as a megawatt. The TR switch must limit the steady-state power level at the receiver to roughly one one-millionth of the transmitted power.

Transient Conditions

Under transient conditions—periods less than 10^{-8} seconds—crystal damage is determined by integrated energy. Typical limits for crystals range from a fraction of an erg to a few ergs, one erg equalling one ten-millionth of a watt second. This together with the rate of rise of the transmitted power determines the speed with which the TR switch must operate. The transmitted power rises to its full level in about 0.1 micro-second. Calculations based on various assumptions concerning the manner in which the transmitted pulse rises, indicates that the TR switch must operate within one thousandth and one hundredth of a microsecond after the onset of the transmitted pulse.

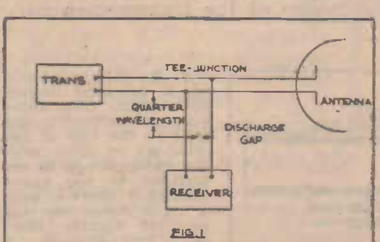

Fig. 1. Schematic circuit of an elementary form of spark gap TR switch. The quarter wavelength spacing of the TR switch from the tee-junction ensures delivery of practically all of the radar transmitter power to the antenna.

At the close of the transmitting period the time in which the TR switch must reconnect the receiver to the antenna is determined by the shortest range targets to be detected. For a minimum range of 500 yards, the necessary recovery time is approximately three microseconds. However, recovery specifications are related to the strength of the received echo because recovery of dielectric strength within the switch (i.e., switch opening) is gradual.

The Gas-Discharge Gap

The simplest TR switch is a discharge gap similar to a lightning arrester, bridge across the line leading to the receiver. As the transmitter power rises, the voltage on the receiver line goes up until the gap discharges. Further increase in transmitted power does not appreciably increase the voltage applied to the receiver because of the gas-discharge characteristic. The TR switch thus short circuits the receiver during pulsing.

When transmission cases, the discharge is extinguished and the system is prepared to receive echoes.

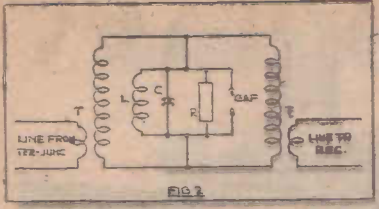

Fig. 2. Idealised lumped circuits for a resonant-cavity TR switch. Transformer T gives an impedance step up from line to gap. R, L and C are equivalent lumped constants.

A basic circuit arrangement employing such a simple point gap is shown in Fig. 1.

High-frequency gas discharges have certain features similar to the more common d-c discharges. To discharge voltage remains constant over a wide range of discharge current. Thus the gap voltage remains practically constant over the entire transmitted pulse. That the discharge voltage is not quite zero means the receiver is subject to certain leakage power during the transmitting period.

Leakage Power

For the simple gap this power is the square of the rms gap voltage divided by the receiver line surge impedance (the receiver is assumed matched to the line). One method of reducing the leakage power is to reduce the discharge voltage.

However, such a simple discharge gap is inadequate for protecting the receiver. Effectively connecting the gap to the lines through transformers gives a large reduction in leakage power, although the relatively large-lumped capacity of the gap requires that the circuit be tuned to resonance. An idealised lump-constant circuit incorporating this idea is shown in Fig. 2. Losses in the resonant circuit result in a loss in received power, depending on the coupling between lines and resonant circuit.

Effect of Gas Pressure

As with d-c discharge, the discharge voltage is dependent on the gas pressure in the gap and is a minimum for a pressure considerably less than atmospheric. The pressure for minimum voltage depends on the gas used but, in general, is about 10 mm of mercury or 1/76 that of atmospheric pressure. Unlike d-c discharges, however, the discharge voltage decreases with gap spacing, because, over a large range of gap spacings, it is the electric field in the gap rather than the voltage that characterises the discharge. At microwave frequencies this is true for any practical gap dimension. Thus for the lowest discharge voltage it is desirable to have a very closely spaced gap—of a few thousandths of an inch—in a sealed enclosure at low pressure.

An actual design of a basic resonant-cavity TR switch must incorporate many features. For example, the resonant cavity must be tunable over a wide-band accomplished by making one cylinder face in the form of a flexible diaphragm to permit one gap nose to be moved relative to the other. The resulting capacity change gives the desired tuning. Tube life is determined by the rate of disappearance of the gas; to extend it a fairly large reservoir is attached to the cavity in the form of a glass cylinder. To ensure rapid striking of the high-frequency discharge an auxiliary d-c glow discharge is operated by means of an ignitor electrode.

Sources of Leakage

There are two other sources of leakage power from the TR switch: (1) *direct coupling*, and (2) *the leakage power* associated with the initial formation of the discharge. Direct coupling is associated with the higher modes of oscillation of the electromagnetic field in the cavity, and is not concerned with the gas discharge; it exists even with the gap short-circuited. Direct coupling leakage is of importance primarily with high-power transmitters. The leakage power associated with formation of the discharge is commonly referred to as the "*spike*" because it is a high level pulse occurring at the very beginning of the transmission period; it is by far the most difficult leakage component to handle.

A TR switch for use at about 10,000 Mc. The adjustable gap is visible within the coupling windows.

In high-frequency discharges free electrons provide the discharge with its conducting properties. The effect of positive gas ions, because of their large mass compared to that of the electron, is practically negligible; however, they do neutralise the electron space charge. In a given discharge the voltage is largely governed by gas type, pressure, and geometrical factors, while current and electron density are governed by circuit considerations.

The electron density adjusts itself automatically to meet the current requirements imposed by the circuit and generator, with the particular discharge voltage. The discharge voltage is not zero because energy must be supplied to the electrons to make up that lost in collisions with gas molecules and to permit them to make up, by further ionisation, the continual loss of electrons from the discharge.

At the beginning of the transmitted pulse the electron density is relatively low. To form the discharge the electron density must be increased by many orders of magnitude. Even if this process of multiplication occurred slowly, the gap voltage would have to be appreciably greater than the steady-state discharge voltage. To provide additional ionisation in a short time interval requires an even higher gap voltage, thus it is reasonable to expect that the initial formation of the discharge is accompanied by relatively high gap voltage for a short period; this is the reason for the existence of the spike. The duration of the spike and its magnitude are strongly in-

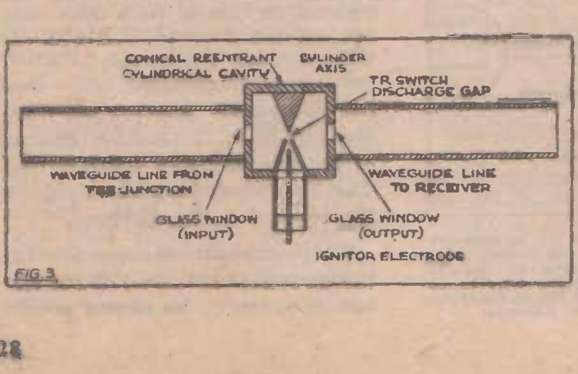

Fig. 3. The elements of a resonant cavity TR switch. The coupling is adjusted by varying the size of the windows so that, with the cavity tuned to resonance at the radar frequency there is only a small power loss for received signals. During transmissions a gas discharge forms across the re-entrant conical gap, limiting the power to the receiver.

(Continued on page 38.)

Amateur NEWS *and* VIEWS

CONDUCTED BY KEN FINNEY

W.A.P. CERTIFICATE

All stations who have worked post war zones 27 to 32 inclusive and have abided by the rules detailed hereunder:

1. The W.A.P. Award for confirmed contacts with thirty (30) or more countries in the Pacific area is available to Amateurs everywhere in the world.

2. Confirmations must be forwarded direct to N.Z.A.R.T., HQ. P.O. Box 489, Wellington, New Zealand.

3. Confirmations must be accompanied by a list of claimed countries to aid in checking.

4. All contacts must be made with Amateur Stations working in the authorised Amateur bands or with other stations licenced to work Amateurs.

5. All stations contacted must be "land stations." Contacts with ships, anchored or otherwise, and aircraft, cannot be allowed.

6. All stations must be contacted from the same call area, where such areas exist, or from the same country in cases where there are no call areas. One exception is allowed to this rule: where a station is moved from one call area to another or from one country to another, all contacts must be made within a radius of 150 miles from the original location.

7. Contacts may be made over any period of years dating post war (i.e., since November, 1945), provided only that all contacts be made under the provisions of Rule 6, and by the same station licencee; contacts may have been made under different call letters in the same area or country if the licencee for all was the same.

8. All confirmations must be submitted exactly as received from the station worked. Any altered or forged confirmations submitted for W.A.P. will result in the disqualification of the applicant.

9. Operating Ethics.—Fair play and good sportsmanship in operating are required of all Amateurs working for the W.A.P. award. In the event of any specific objections relative to continued poor operating ethics, an individual may be disqualified from the W.A.P. by action of the N.Z.A.R.T. Awards Committee.

10. A minimum readability report of three shall be recorded on each confirmation submitted.

11. A minimum signal tone report of T8 is required for all c.w. confirmations.

12. Decisions of the N.Z.A.R.T. Awards committee regarding the interpretation of the rules as here printed, or later amended, shall be final.

13. All applications must be forwarded to the N.Z.A.R.T. by registered mail. Sufficient postage for the return of the confirmations must be forwarded with the application.

14. All certificates will be consecutively numbered and an Honour Roll showing all those issued will be kept by the Secretary of the N.Z.A.R.T.

The call areas of the stations included in W.A.P. are:

The Pacific Area, known also as the "Continent" of Oceania, includes countries with the following prefixes according to Zones:

Zone 27—DU. KG6. WG6.

Zone 28—CR10. PK1. to 7, VK9, VR4, VS1, VS2, VS4. VS5.

Zone 29—VK6, VK8, ZC2, ZC3.

Zone 30—VK1, VK2, VK3, VK4, VK5, VK7.

Zone 31—KB6, KH6, KJ6, KM6, KP6, KW6, KX6, VR1, VR3.

Zone 32—FK8, FO8, FU8, KS6, VR2, VR5, VR6, YJ, ZK1, ZK2, ZL, ZM, VK9.

WAVERLEY RADIO CLUB
13 Macpherson Street, Waverley

Meetings of this club are held at the above address every Tuesday night at 8 p.m.

The half-yearly meeting of the club was held on the 17th May, and resulted in election of office-bearers as follows:

President, H. Banks (VK2MB); vice-president, W. Johnston; secretary, J. Harrington; treasurer, E. Johnson (VK2AFZ).

The club decided at the meeting to proceed with the erection of a W8JK beam, and a short lecture and description of the beam were given by 2MB.

The transmitter has now been overhauled and members are awaiting completion of the beam to commence DX work.

Visitors and intending members are always welcome at club meetings, or further information can be obtained from the Secretary, Mr. J. Harrington, 92 Macpherson Street, Waverley.

• SPOT NEWS

- VK3RW in Gardiner, Melbourne, is using series cathode modulation and has preamplifier on the end of 50 feet telephone line. 2 element Beam and a good signal.
- VK2YK at Kogarah Bay, Sydney, now has a preamplifier in his modulator. His receiver is AR8 and antenna is fullwave zepp. Will have super receiver operating shortly.
- VK2ADC Gordon Mcleod still fairly quiet, though occasionally heard putting 9+ signal into States.
- VK2BN Blakehurst, Sydney, has been heard with a very nice NBFM signal. Reg has just the 100 countries worked post war on an open wire antenna.
- ZL1UZ Auckland, N.Z. Reg is using 100 watts to 813, and tells of big activities in N.Z. of the VHF Boys.
- W8WWI West Virginia Burk runs a kilowatt into 3 element beam and listens on SX28 receiver heard almost nightly on about 14223K/C.

This month should see German Amateurs again active, the call signs are issued in sequence from DL1AA to DL1ZZ, then DL3, 6, 7, 8, 9,. Allied and British stations still holding DL 2, 4, 5.

Antarctica Calling:

The following stations are operating from Antarctica:

VK1ADS—R. Sterrett, Macquarie Island.

VK1FE—A. Burton, Heard Island.
VK1VU—R. Gatt, Heard Island.

News of Amateurs, and Amateur clubs are required for publication each month. Any reader who feels he could supply news of the amateurs operating in his area is invited to forward same for general publication. How about some of you Country and Interstate readers?

Also required is VHF NEWS. It is intended that a VHF CORNER should be commenced and all you interstate readers who know of, or are VHF enthusiasts please forward your information to VK2AIL C/o Box 5047 G.P.O. Sydney.

"WORKED ALL VE AWARD"

To claim this award The Canadian Amateur Radio Operators' Association, points out that one must work two stations in each of the provinces. The following are the provinces:

Prince Edward Island, New Brunswick, Ontario, Quebec, Nova Scotia, Alberta, Manitoba, Saskatchewan, and British Columbia. Refer to QST January for the rules.

Modern Amateur Transmission Techniques

The most important component of a radio transmitter is the system of frequency control. In this, the first of a new series of articles specially written for the radio amateur, the basic design of suitable oscillator circuit to ensure a high degree of frequency control is discussed in some detail.

Under modern conditions, where the portion of the spectrum allotted to the amateur service is rapidly becoming almost insufficient to accommodate the vast numbers of enthusiasts clamouring to indulge in their hobby, it becomes of vital importance that every station on the air should adopt every possible precaution and device to ensure that the radiated signal is stable in frequency. In addition the radiated signal should also be free from such objectional phenomena as parasitic oscillations, modulation splatter, key clicks, or any other of the numerous forms of undesired effects which may quite easily, and often do, take place.

Moreover, it behoves that every operator, having ensured that his equipment is radiating a "clean" signal, should direct his attentions to the attainment of a maximum degree of flexibility and convenience of operation, as for instance, by the use of a properly constructed and operated VFO, and by the provision of facilities for rapid changeover from the receiving to the transmitting condition, even if actual break-in is not employed.

Apart from the obvious advantages to the hobby as a whole of the adoption of this guiding principle, it will be realised that it is the advantage of each individual operator to increase his comfort and convenience, as well as his ability to work more dx, and conduct many more "good" QSO's, by ensuring that his equipment is used to its utmost.

It will be the purpose of this series of articles to outline the modern trend in design principles, and since the successful construction of any form of transmitter involves an understanding of the design principles involved, to emphasise the particular aspects which are of importance with regard to present-day radio communication, from the amateur's viewpoint. It must be stressed at the outset that operating convenience and a large bank account are not synonymous; it will be shown how the simplest of designs may be used to perform a function almost as complete as the largest ham transmitter which could be envisaged.

by

ALAN WALLACE

Basic Considerations

When designing any amateur transmitter, several important points must be considered, and these are as follows:—

(A) What power input to the final is proposed;

(b) What frequency bands are to be covered;

(c) Is it to be crystal or VFO controlled;

(d) Is operation required on 'phone, CW or both.

Obviously, the answer to these questions will be governed by each individual's particular requirements, but a word of advice could perhaps be given—namely, that an efficient, flexible transmitter with relatively low power output will invariably give better, consistent results than a high power cumbersome type, of doubtful efficiency and flexibility. The reason for this is apparent. Here in Australia we are limited to 100 watts, and when up against power of the order of 1 Kw, communication may at times be impossible, whereas if it is possible to shift to a clear spot, even 20 watts will still get through satisfactorily.

Therefore, the aim of this first article will be to discuss the various methods of utilising the piezo-electric effects of a quartz crystal as a means of frequency control, mainly from the point of view of actual stability, in order to maintain an orderly condition on the bands. In the following article we shall then deal with the various types of variable frequency oscillators which provide a flexible means of variation of frequency, and at the same time maintain a stability comparable with that of the crystal oscillator.

Frequency Controls Important

The most important component of a modern transmitter is, without doubt, its system of frequency control. In the early days of radio it was quite sufficient to be able to radiate a signal, the frequency of which was known to be somewhere around a certain figure. Now it is vitally necessary that frequency of radiation should not only be known to within an accuracy of at least

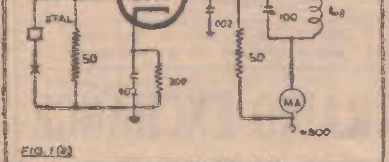

Fig. 1 (a). A simple form of crystal oscillator circuit.

Fig. 1 (b). This diagram shows the relationship between crystal current, plate current and output.

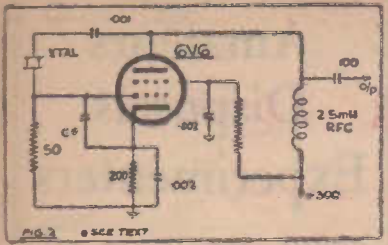

Fig. 2. Another form of crystal oscillator is the "Pearce" circuit.

30 cycles per Megacycle, but should have a stability of the same order.

To this end, in the years immediately preceding the war, the ultimate achievement was to own a crystal controlled transmitter, and much the same situation exists today with regard to the VHF bands, although now, even on 50 Mcs. Crystal control is rapidly becoming a "must." The reason for this is that, due to the very high equivalent Q of a quartz crystal, the frequency of oscillation is very stable, and under normal conditions is not greatly affected by variations in plate supply voltage, or load.

This means then, that no elaborate precautions need be taken to prevent drift, or frequency shift due to variations in the tuning of any amplifier stages following the oscillator, and furthermore, by employing a cut of crystal which exhibits only a small change in resonant frequency with changes in temperature and loading capacity, the drift encountered during the warming up period of the equipment may be made negligible.

Crystal Operation

The principle of operation of the crystal oscillator is based upon the property of the quartz crystal, when excited at its "resonant" frequency, to vibrate at that frequency. Since the resonant frequency determined largely by the crystal thickness, in standard AT and BT cuts, is very critical, oscillation can only take place at this frequency, although very small changes can be effected by variation of the holder capacity. This is the case with various "*Variable frequency*" crystals which have been available from time to time, where arrangements are made to vary the space or "air gap" between the upper plate of the crystal holder and the face of the crystal.

Although not particularly necessary with modern cuts of crystal, it was fairly general practice in prewar transmitters, to incorporate some form of crystal oven, so as to maintain the temperature of the crystal and its surroundings at a constant level. This practice is still employed in broadcast and commercial equipment, but it is no longer necessary for amateur work, as by selection of the appropriate cut of crystal and discreet placing of components, undesired thermal effects can be greatly minimised.

However, should it be desired to instal some form of crystal oven, in a particularly elaborate transmitter, it may be quite easily accomplished using a suitable lamp or resistor as the heating element. Thermostatic control can be obtained by the use of a simple fluid thermostat as is readily available from any supplier of material for hatching incubators.

The crystal oscillator, however, has two disadvantages. Firstly, that it is difficult to alter the frequency of the crystal electrically by more than a very small amount, resulting in the requirement of a separate crystal for each frequency of operation. Secondly, with certain oscillator circuits, there is always a possibility of either puncturing or fracturing the crystal. In this case it becomes quite useless, and entails some cost in replacement, apart from the inconvenience of being off the air, if another crystal should not be on hand.

Typical Circuit

Nevertheless, for many applications, particularly where it is not convenient to maintain precision frequency measuring equipment, the crystal oscillator is most suitable, and in its simplest form consists of the well-known arrangement of a tuned grid-tuned plate oscillator, with the crystal acting as the grid circuit. This circuit, shown in figure 1a, is commonly used, providing as it does, a reasonable power output at the fundamental frequency with negligible risk of crystal fracture, provided the supply voltage and operating conditions are not such as to cause excessive crystal current.

Excessive crystal current is undesirable for two main reasons, firstly, as mentioned above, because of the risk of crystal fracture, and secondly because the heating produced will cause an uncontrollable drift in frequency. This effect may be limited, firstly by limitation of the plate supply voltage to the stage,

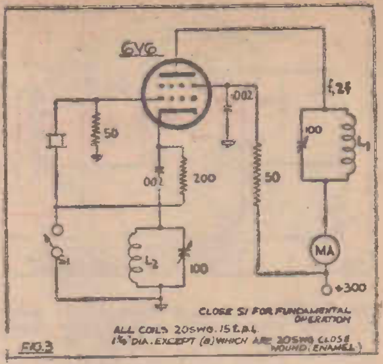

Fig. 3. The Tri-tet oscillator as shown in this circuit provides reliable operation and is often found in low power equipment.

and secondly by correct tuning of the anode circuit. This latter point may perhaps be seen more clearly in the graph of Figure 1b, where it will be seen that the maximum output and minimum plate current conditions coincide, whilst at minimum plate current, crystal current will be high.

For this reason, it is always preferable to tune a crystal oscillator with a slightly higher plate current than the minimum, of course, on the "sloping" side of the curve, not the "steep" side. Little difficulty will be encountered in determining the correct side of the curve for operation since, as one passes through resonance, the plate current rises sharply on the "steep" side, as the crystal drops out of oscillation. Crystal current is best estimated by the insertion of a 60m/a pea lamp (bicycle tail-lamp) at the point X in Figure 1a, and it will normally be found that a moderate glow will be produced when the crystal in use is a standard AT or BT cut.

Effect of Load

It will also be noticed in practice, that as the load coupled to the oscillator is increased, so the crystal current decreases. This is due to the fact that as the load is increased the effective impedance in the plate circuit is reduced, thus reducing RF feedback to the grid circuit, reducing in turn the crystal current. Therefore it follows that if the oscillator is too heavily load-

		OUTPUT FREQUENCY (Mc)				
CRYSTAL		3.5	7.0	14	21	28
3.5 Mc	L1	24t (a)	12t	8t	12t*	8t*
	L2	—	21t (a)	21t (a)	21t (a)*	21t (a)*
7 Mc	L1	—	12t	8t	4t	3t
	L2	—	—	10.5t	10.5t	10.5t
14 Mc	L1	—	—	8t	4t	3t
	L2	—	—	—	7t	7t

*See text.

Fig. 4. Coil details for use in circuit of Fig. 3.

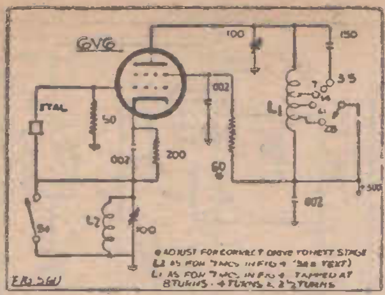

Fig. 5. This switching arrangement using a single tapped coil will provide band coverage from 3.5 to 28 Mc.

ed, there may be insufficient feedback to start, and maintain, oscillation. On the other hand, if the circuit is operated in the unloaded condition, crystal current may be high enough to cause its fracture or puncture.

Occasionally, using modern pentode or tetrode tubes, it may be found that there is insufficient capacity between the elements of the tube to provide the necessary feedback to promote oscillation. In such a case as this, it will be necessary to add a small amount of additional capacity (of the order of 2-10uufd.) between the grid and plate connections to the tube, although care must be always taken that too much is not added, as this will cause excessive feedback, and again, damage to the crystal.

Harmonic Crysals

There are about at present a certain number of crystals of the harmonic type. These are usually "V" cut, and possess the property of being capable of oscillation, i.e., actual mechanicial vibration, at a frequency 3 times that of their fundamental. For example, a 5 Mcs. crystal will oscillate quite readily at 15 Mcs. This is a very convenient phenomenon, and must not be confused with any system such as the Tri-tet oscillator, to be described later, which actually generates the harmonics within the tube. The use of a harmonic crystal is most useful on the higher frequency bands, allowing as it does the use of a relatively thick, stable crystal to accurately control the stability of a high frequency transmitter.

"Pearce" Circuit

Another simple form of crystal oscillator is that known as the "Pearce" oscillator. This circuit has the advantage of requiring no tuning arrangements whatsoever, and provided care is taken with the selection of the grid by-pass condenser ("C" in Fig. 2) no trouble should be encountered with crystal defects.

Although the output of this oscillator is relatively low, its simplicity permits the use of an additional buffer/multiplier stage with little added complication. One of the main points to watch is that since, in order to promote oscillation, the nett reactance of the plate circuit must be capacitive, the value of the RFC in the anode lead should be selected so that it will, in conjunction with stray circuit capacities, resonate at a frequency below that of the crystal. A further detail is that, in order to obtain maximum output, with minimum crystal current, "C" should be selected experimentally, to fulfil this requirement, and will normally have a value in the region of 100 uufd.

Of course, it may not always be convenient, particularly where economy of components and power supply consumption is necessary, to use only the fundamental frequency of the crystal at hand, and it may be desirable to use some form of harmonic generating oscillator, such as the Tri-tet, shown in Figure 3. In this oscillator, which will produce appreciable output up to the fourth harmonic, use is made of a tuned cathode circuit presenting an inductive reactance at the crystal frequency, whilst the output is taken from the anode circuit which is tuned to the desired harmonic frequency.

In this circuit, as with most tetrode oscillators, the screen grid of the tube becomes the virtual oscillator anode. Power is transferred to the plate circuit through the electron stream of the tube, thus resulting in quite good isolation of the actual output load from the frequency determining portion of the oscillator. Although the screen should normally be by-passed effectively for RF, it may be found desirable, when fourth harmonic

CRYSTAL	OUTPUT					
	3.5		7.0	14	21	28
3.5	S1	C	0	0	0	0
	S2	5	44	3	4*	3*
7.0	S1	—	C	0	0	0
	S2	—	4	3	2	1
14	S1	—	—	C	—	0
	S2	—	—	3	—	1

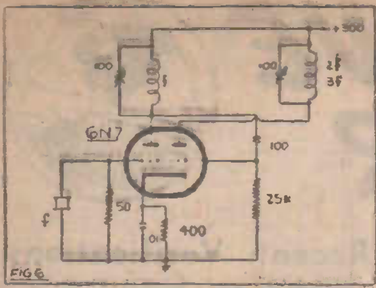

Fig. 6. A twin triode can be used as a combined oscillator and doubler or tripler as required. Coil details can be obtained from table in Fig. 4.

output is desired, to insert a pre-set tuned circuit in the screen lead of the tube, tuned to the second harmonic of the crystal frequency.

It is particularly important with this form of oscillator that the cathode circuit should present the correct reactance, especially when harmonic output is desired. To this end, a small trimmer is normally connected across the cathode inductance, and this should be peaked for maximum output, on the highest harmonic which it is desired to employ. It will then be found that operation and output will be satisfactory on the lower frequency bands also.

Check Operating Conditions

Particular care must be taken with this circuit to ensure correct operating conditions, as it is very easy to encounter large crystal currents, hence the name given this oscillator in some quarters—*"rock crusher."* The main point to be watched is that, in connection with the trimmer connected across the cathode coil. This should always be tuned from the low capacity end, as it is possible, should the oscillator be tuned on with the condenser in the maximum capacity position, to develop excessive crystal current and fracture the crystal. A further "must" with this circuit is that the anode circuit should never be tuned to the crystal fundamental frequency with the cathode coil in circuit, as the resultant feedback very often is the cause of crystal failure.

However, if these considerations are noted, it will normally be found that the Tri-tet is a very reliable form of oscillator which will often afford worthwhile economies in the use of tubes and power, particularly in the smaller variety of low-power transmitters.

Again, where radiation on some frequency other than the crystal fundamental is desired, another form of circuit, well known to old-timers, is shown in Figure 6. This circuit employs a dual triode tube (such as 6NF, 6SN7, 6A6 or 53) as a combined oscillator and doubler or tripler as the case may be, and can normally be relied upon to produce consistent results. The coil constants in this case can be quite easily deducted from the table in Figure 4, bearing in mind the frequencies involved.

Coil Details

For the convenience of prospective constructors we have included a table (Figure 4) indicating typical dimensions of suitable coils for the oscillators in Figures 1, 3 and 6. When used with the circuit constants shown, these coils will resonate with the tuning condenser about 2/3 in mesh, with the exception of the 28 Mcs. coils which will require somewhat less capacity.

It will be noticed that the coil constants are duplicated when 21 or 28 Mcs. output is desired from a 3.5 Mcs. crystal. This is because, since the output of the oscillator is too low at the 6th or 8th harmonics respectively, its output must be taken at either 7 or 14 Mcs. and trebled or doubled in a further stage to produce the desired output frequency.

A useful expedient, when band-switching is contemplated, is to use the coil for the lowest frequency band, progressively reducing its inductance by means of taps. Although this entails a certain loss of efficiency, it can be tolerated in the oscillator stage. It has been found in practice that ample output can still be obtained up to 30 Mcs. from a single 6V6 with 300 volts on its anode to fully drive a 807 running at maximum ICAS ratings (75 watts).

A suitable switching system is shown in Figure 5, and this provides for complete coverage of all bands from 3.5 to 28 Mcs. in five steps, using one coil. However, it will be appreciated, that in order to cover these bands, it will be necessary to use both an 80 mt and 40 mt crystal, as insufficient output would be obtained on 21 and 28 Mcs. from a 3.5 Mcs. fundamental.

For many applications it is very desirable to key the oscillator circuit, thus allowing "break-in" or "listening through," each of which is a facility worthy of incorporation in any modern transmitter, particularly if rapid change-over arrangements can easily be provided on the receiver input. Normally, keying of a crystal oscillator will present little difficulty, although care must be taken that the particular crystal employed will start oscillating quite readily, thus avoiding those clicks and chirps which can quite easily result from the use of a crystal which is somewhat sluggish in operation. Also,

(Continued on page 35)

SHORTWAVE LISTENER

CHINESE STATIONS LIST

The Director of International Broadcasting Station, Director Chung, has furnished the following list of new callsigns for Chinese medium wave and short wave outlets.

CENTRAL BROADCASTING STATION, NANKING: 660 kcs, BEA2; 15105 kcs, BEA 3; 15250 kcs, BEA4; 11880 kcs, BEA 5; 17765 kcs BEA6; 11830 kcs, BEA7; 9730 kcs, BEA8; 5985 kcs, BEA9.

SHANGHAI BROADCASTING STATION, SHANGHAI: 900 kcs, BEB2; 800 kcs, BEB-3; 1390 kcs, BEB4; 11780 kcs, BEB5.

CHEKIANG BROADASTING STATION, HANGHOW, CHEKIANG: 1280 kcs, BEC-3; 1440 kcs, BEC5.

TAIWAN BROADCASTING STATION, TAIWAN: 750 kcs, BED2; 1020 kcs, BED3; 7215 kcs BED9; 1190 kcs, BED22; 1340 kcs, BED29; 960 kcs, BED23; 1040 kcs, BED24; 840 kcs, BED25; 1070 kcs, BED-26; 1060 kcs, BED27; 890 kcs, BED28.

FUKIEN BROADCASTING STATION, FOOCHOW, FUKIEN: 1140 kcs, BED4; 720 kcs, BED7.

KIANGSI BROADCASTING STATION, NANKING, KANGSI: 1080 kcs, BED5.

AMOY BROADCASTING STATION, AMOY, FUKIEN: 1310 kcs, BED6; 9552 kcs, BED8.

CANTON BROADCASTING STATION, KWANGTUNG: 1160 kcs, BEE2; 800 kcs, BEE3; 9700 kcs, BEE4.

KUNMING BROADCASTING STATION, KUNMING, YUNNAN: 700 kcs, BEF2.

CHUNGKING BROADCASTING STATION, CHUNGKING: 1200 kcs, BEF3.

KWEICHOW BROADCASTING STATION, KEWIYANG, KWEICHOW: 1000 kcs, BEF-4; 6065 kcs, BEF9.

CHINESE INTERNATIONAL BROADCASTING STATION, CHUNGKING: 7153 kcs, BEF6; 11913 kcs, BEF7; 1517 kcs, BEF8; 6140 kcs, no callsign listed. (7153 kcs has actually been heard on 7100 lately.—K.R.B.)

PEIPING BROADASTING STATION, PEIPING: 1350 kcs, BEK8; 770 kcs, BEK-25; 1170 kcs, BEK9; 850 kcs, BEK2.

TIENTSIN BROADCASTING STATION, TIENTSIN: 620 kcs, BEK3; 810 kcs, BEK-22; 1110 kcs, BEK25; 1290 kcs, BEK27.

TSINGTAU BROADCASTING STATION, TSINGTAU: 1150 kcs, BEK4; 710 kcs, BEK23.

HANKOW BROADCASTING STATION, HANKOW, HUPEH: 600 kcs, BEL2; 830 kcs, BEL5; 7245 kcs, BEL7.

HUNAN BROADCASTING STATION, CHANGSHA HUNAN: 950 kcs, BEL4.

LANCHOW BROADCASTING STATION, LANCHOW, KANSU: 820 kcs, BEM2; 1400 kcs, BEM4; 9750 kcs, BEM6.

SHANSI BROADCASTING STATION, SIAN, SHANSI: 1300 kcs. BEM3.

KWEISUI BROADCASTING STATION, KWEISUI, SUIYUAN: 970 kcs, BEN2.

SHANSI BROADCASTING STATION, TAIYUAN, SHANSI: 790 kcs, BEN3; 1220 kcs BEN5; 9520 kcs, BEN6.

Siam New Frequency

Some time ago the Overseas Service from Bangkok was heard in the 25-metre band, and then a change was made with quite good results from the listener's point of view to a frequency in the 30-metre band. However, now the station has returned to the 25-metre band, and is using a new channel.

The new frequency is 11.650 megacycles, on the low frequency end of the band, and the programme is from 8 till 9.30 p.m. Australian Eastern Standard Time. It is heard at fair strength in English news and music at 8.30 p.m., and then in the Siamese language. Unfortunately this channel suffers some interference at times from Morse.

Readers' Reports

Readers desirous of submitting Short Wave reports for inclusion in these notes should ensure they reach our Short Wave Correspondent not later than the first of each month. Address all letters to: Miss D. Sanderson, 23 Elizabeth St., Malvern, SE4, Victoria.

Recent Verifications

One never needs to despair at not receiving a prompt reply to any reception reports sent to South American countries. After almost 10 months a letter came to hand this month from Chile, and your Short Wave Editor reports the contents of this verification for help to any readers that may have sent a report on.

Transmissions were being heard with a fair signal when the station opened at 9.30 p.m., and the station announced both in English and Spanish, and requested reports on the strength and clarity of the transmission of CE622 on 48.23 metres. The text of the letter received is as follows:—

"We are indebted to you for your interesting report on reception of our Short Wave Station, and in accordance with your request it gives us much pleasure in sending this acknowledgment letter.

"With good wishes, we are
"Radio Sociedad Nacional de Mineria,
"(National Mining Society)."

The card was signed by the Director, and the address given as Radio Sociedad Nacional de Mineria, P.O. Box 2626, Santiago, CHILI, South America.

Card From Brazil

Another interesting verification from Brazil arrived per air mail this week. The card is quite attractive with a picture of the station building in silver print, with the callsign letters PRL6, and set out hereunder is the text of the card, with some interesting particulars:—

"Confirming your report of our Stations ZYK2-3 on the 28th January last, on 9565 and 15145 kcs.

"Transmitter—Marconi SWB 10, input 15-20 KW high level plate modulation.
"Antennas—258 degrees Beverage arrays for the 19-25-31 and 49 metre bands.

"Schedule—ZYK2, 15145 kcs, 9 p.m. till 5 a.m.; ZYK2, 6085 kcs, 7 a.m. till 12 p.m.; ZYK3, 9565 kcs, 9 p.m. till 3 a.m., 5 a.m. till 12 p.m."

The card was signed by the Engineer, Harry W. W. Walden, and address as follows: Radio Journal De Commercio, S.A. Recife, Pernambuco, Brazil, South America.

Israel

The Forces Broadcasting Service in Tel Aviv has been testing transmitters on medium and short waves. The medium wave transmitter 4X4VA has been heard on 1336 kilocycles, whilst the short wave outlet 4X4EA has been operating on 6.725 megacycles. The callsign is TAHANAH ARBA EX ARBA VAV ALEF.

Reports will be verified and should be sent to Station 4X4EA, Army Post Office, Tel Aviv, Israel. (R.A.)

NEW STATION LOGGINGS

Callsign	Kcs	Metres	Location	Time heard
CBNX	5,970	50.26	Newfoundland	7.30 a.m.
Monte Carlo	7,350	40.82	Monaco	4.00 p.m.
Radio HUE	7,205	41.61	French I. China	9.30 p.m.
KZPA	9,535	31.37	Austria	4.00 p.m.
HED7	15,120	19.84	Switzerland	7.15 a.m.
SIAM	11,650	25.75	Siam	8.30 p.m.
HJCT	1,168	25.68	Colombia	5.15 p.m.

LISTEN FOR THESE

BRAZIL

Mention of this country was made in our verification corner and we have news by way of Radio and Television News, U.S.A., of ZYK3 operating on a frequency of 9565 kcs. At the completion of the English session at 6.45 a.m., the woman announcer stated: "Tune to this station at the same time tomorrow," and said that other English programmes are transmitted on Monday at 4 a.m. (Sugar Plantation Programme) and on Sundays at 3 a.m. in the programme Brazil Calling, the announcer then added: "We will be very pleased to hear your impressions of these programmes, and all letters will be gratefully received."

English announcement at the close of broadcast was: "This programme came to you from Radio Journal de Commercio, Recife, Pernambuco, Brazil."

SWITZERLAND

Another transmitter from Berne has been heard by an English correspondent operating on an announced frequency of 9665 kcs, at 12.15 a.m. till 1.15 a.m Signal strength was at a good level, and recently was heard to close at 1.30 a.m. (Pearce).

Russell Henderson, Swiss Short Wave Service, Berne, informs Ken Boord that Berne's two new 100 KW transmitters now make it possible to broadcast around 170 hours per week instead of the former 135 hours. Schedules will be changed this month so watch for announcements.

SOUTH AFRICA

An air mail letter received recently from M. P. Laubscher, of Transvaal, South Africa, gives details of a station that has been heard testing at 5 a.m. till 5.30 a.m. on a frequency of 17.748 kcs with the callsign of ZUD, and located just outside Pretoria. This is a post office transmitter, and has been loaned to the South African Broadcasting Company for relays of commentaries on the All Blacks (New Zealand Rugby team) matches. (ED.)

PORTUGUESE CHINA

British Short Wave League reports that CR8AA Macau Radio Club will reopen soon with a new transmitter; frequencies most likely to be used are listed by B.S.W.L. as 7530 and 9230 kcs.

BRAZIL

In our last issue we made mention of PRL8 on 11720 kcs and located in Rio de Janeiro. This station is heard at very good strength at 7 p.m. daily in Portuguese language broadcasts.

We now have news that a series of English language programmes for United States has been inaugurated, and is heard Tuesdays through to Saturdays at 12.30 p.m. till 12.45 p.m. Reports are wanted, and they state that the continuance of programmes depends upon the response from listeners (Boord.)

HUNGARY

Magyar Radio, that is the Hungarian Broadcasting Company, have told Swedish DX'ers calling per mail that the transmissions on short wave commenced on April 1, over two stations each with 400 watts power and operating over 6247 and 9820 kcs, relaying the home programme from 11 p.m. until 8.45 a.m. next day These transmissions are of an experimental character. and reports are very much appreciated.

As from July 15 there will be a special short wave service established and the strength of the station will be increased up to 2 KW. The construction of a new 100 KW station has been under way for some time, and will be on the air round about April 15 1950.

Address for reports: Radio Budapest, Budapest, Hungary.

TURKEY

Due to a change to a summer time schedule the Sunday Mailbag, Monday and Thursday talks will be heard from outlets on 9.465, 15.105 kcs at 7.15 a.m., that is one hour earlier.

MOZAMBIQUE

Cushen of New Zealand reports CR7BI on a frequency of 17.915 kcs from Lourenco Marques testing on week days from 10 a.m. to 12 p.m. and 8 p.m. till 9 p.m

The station is asking for reports, and the address is given as Box 594, Lourenco Marques, Mozambique. An air mail letter may be used for reporting. The station is officially listed on this frequency and uses a power of 10 KW.

NORTH RHODESIA

We are indebted to URDXC in California for the items of news from this station, ZQP; details of schedules were received by air mail, when the station forwarded its verification card. Operating times are 8 p.m. to 10 p.m. daily to Africans, 8.30 p.m. to 9.30 p.m. Sundays, and in broadcasts to Europeans on Sundays from 2.30 p.m. till 3.30 p.m. over frequencies of 9.71.7.22 and 3914 mcs.

SWEDEN

From a recent copy of the DX Bulletin of the Swedish Broadcasting Corporation we learn that as from the 1st of May the "Sweden Calling DX'ers" session will be heard at 5.15 p.m. on frequencies of 6065 and 15.155 kcs and rebroadcast at 1.15 a.m over 10.780 and 15.155 kcs respectively on Saturdays.

The schedule for the programme "In Sweden Today" will be heard one hour earlier—that is, at 10.15 p.m. over frequencies of 11.705 and 15.155 kcs, and rebroadcast at 1 a.m. on 10.780 and 15.155 kcs. These are the times for the summer time period.

GREECE

Another station from this country has been testing on 7.040 megacycles with the callsign of Radio Peloponnesos, from 4 a.m. till 5 a.m., A.E.T. Programmes have consisted of Greek recordings and their announcement identifying the station is Ethaw Radiofonicas Peloponnesu.

An unidentified Greek station has been heard on 6.350 megacycles at 7.45 a.m., closing down after playing the Greek National Anthem. The Communist Radio transmits on 9.665 megacycles, from 10 to 10.30 p.m., A.E.T. (R.A.)

ROUMANIA

From a recent issue of Sweden Calling DX'ers we have interesting news of several transmitters operating from Bukarest, and they are to be heard on the following wavelengths, 5990, 6205, 11900 and 9250 kcs and on medium wave of 1051, 823, and 160 kcs. News is given in German at 6 a.m., French at 6.30 a.m., and English at 7 a.m. The callsign is Radio Roumania Libera.

RECENT LOGGINGS

From Mr. E. Williams, Sydney, comes this impressive list of recent station loggings, together with details of reception and listening times.

PLP2, BATAVIA, 19,345 kc. Open at 2 a.m. in Dutch with a good signal.
YDE, BATAVIA, 11,770 kc. Heard at 9 p.m. in Indonesian. Poor signal with bad QRM.
YDQ, MACASSAR, 11,084 kc. Opens at 8 p.m. in Dutch. Good signal at 10 p.m., slight QRM and Morse.
BUKITTINGGI, SUMATRA, 10,570 kc. Heard at 8.45 p.m. in Indonesian. Poor signal most times.
YDQ2, MACASSAR, 9550 kc. Fair signal at 9.30 p.m. in relay with YDQ.
YDQ, MACASSAR, 5030 kc. Poor signal, bad QRM.
YD13, SOURABAYA, 7295 kc. Poor signal at 9.30 p.m.
CR7AB, MOZAMBIQUE, 3490 kc. Fair signal at 6.0 a.m. in relay with CR7BU.
CR7BU, MOZAMBIQUE, 4290 kc. Good signal at 6 a.m. with music and advertisements.
JOHANNESBURG, 9523 kc. Fair signal at 1 a.m., closes at 1.40 a.m.
JOHANNESBURG, 4895 kc. Fair signal at 6 a.m. Classical music and news.
CAPETOWN, 5883 kc. Heard at 5.45 a.m., with popular recordings.
DAKAR, 11,897 kc. Fair to good signal at 6 a.m. News and music in French.
VQ7LO, NAIROBI 4885 kc. Good signal at 5 a.m. Classical music.
CKLO, MONTREAL, 9630 k.c. Good signal at 6.45 p.m. Sundays, beamed to Australia.
CKLX, MONTREAL, 15,090 kc. Fair signal at 1.20 p.m. United Nations beam to Australia.
CBRX, VANCOUVER, 6160 kc. Heard from 5.30 p.m., closes at 6 p.m. Fair to poor signal.
VE9AI, EDMONTON, 9540 kc. Heard after VLR closes. Birthday calls and music. Signal strength weak.
COCQ, HAVANA, 8827 kc. Opens in English at 9.58 p.m. Poor signal, bad QRM from Moscow.
COHI, SANTA CLARA, 6465 kc. Opens in English at 9.24 p.m.
HCJB, QUITO, 5995 kc. Opens in Spanish at 9 p.m., with good signal.
WARSAW, 6215 kc. Fair signal at 5.30 a.m. in English transmission.
BUCHAREST, 9250 kc. Good signal at 7 a.m. in English transmission.
HP5A, PANAMA, 11,700 kc. Heard at 9.15 p.m., with a fair signal at times.
OZF, DENMARK, 9520 kc. Heard at 3 p.m. on Sundays with English programme. Fair to poor signal.
OZH, DENMARK, 15165 kc. From 8 to 9 p.m., Tuesdays, Thursdays, and Saturdays, English at 8.50 p.m. Fair to poor signal.
MONTE CARLO, 7350 kc. Fair signal at 4 p.m. News and music in French.
MONTE CARLO, 9790 kc. Good signal from 4 p.m. in relay with 7350 kc.
TIPG, COSTA RICA, 9615 kc. Poor signal at 3 p.m. Bad QRM from XERQ.
XERQ, MEXICO, 9625 kc. Heard at 3 p.m. QRM from TIPG.
XEBT, MEXICO, 9625 kc. Good signal from 2 p.m., to close at 4.5 p.m.
HVJ, VATICAN CITY, 17,445 kc. Good signal at 1.30 a.m. every Wednesday, in English.
HVJ, VATICAN CITY, 15,095 kc. Fair signal in English at 1 a.m.
HVJ, VATICAN CITY, 9660 kc. Poor signal at 1 a.m. in relay with 15,095 kc.

Modern Amateur Transmission Techniques

(Continued from page 33)

before it is arranged to key the oscillator, it must be ensured that all succeeding stages are provided with some form of protective bias so as to avoid any damage which could occur owing to the removal of excitation.

In conclusion, it may be mentioned that, although practised to a certain extent overseas, it is not normally desirable to use a crystal oscillator to directly excite the aerial circuit, as resultant variations in loading, etc., can cause large variations in the radiated frequency. Similarly, modulation should not be applied directly to a crystal oscillator stage, unless aimed at producing some form of Frequency Modulation, as a certain amount of FM will normally take place under these conditions.

As the subject of crystal stabilised FM oscillators, and phase modulated exciters is rather a large one, no effort can be made to deal with it in this article, but it is hoped to incorporate some material on it at a later date in this series. Next month we shall deal with the various forms of variable frequency oscillators and their characteristics, together with a treatment on the isolator stage which, whilst desirable with a crystal oscillator of the triode type, is very necessary with the normal VFO arrangement.

ON THE BROADCAST BAND

MALAYAN STATIONS

Changes introduced by several broadcasting organisations in Asia should provide additional interest when listening for these stations which are usually received at good signal strength during the winter months.

From Singapore, "Radio Malaya" is operating an additional transmitter on 740 kc, and this carries the Red network programmes with broadcasts in Malay, Indian and Chinese dialects. The presence of 2BL, our main National station here in Sydney on this same frequency will possibly make the reception of this one difficult in many locations before 11 p.m. (when 2BL closes down).

However this station is on the air daily until 1.30 a.m., concluding a two-hour period in Chinese, which follows a two hour feature in Malay. Our thanks to Jan Johnson who drew our attention to the appearance of this new station.

"Radio Malaya's" transmitter on 620 kc is generally one of the strongest signals from Asia at our listening post. Carrying the alternative programme provided by this service—the Blue network—broadcasts are presented in Malay, Chinese and English. This one leaves the air at 1.30 a.m. nightly except Sunday mornings (Saturday night, of course in Singapore) when it signs off half an hour later. English is used during the last several hours of transmissions. News Bulletin goes on the air at Midnight.

Kuala Lumpur appears to be widely heard at present, operating on 1203 kc, and is another unit of the "Radio Malay" service.

All India Radio has added an alternative programme from Delhi for listeners in and around that city. Broadcasting on 720 kc., this new station provides a separate programme from that radiated from Delhi on 886 kc. Art Cushen was first to point this one out to us, it being yet another logging to his credit, and should be added to the list given in the May issue.

This reader has also reported Karachi, Pakistan on 825 kc. This station has been heard carrying the news bulletin in English at 1.30 a.m.

by
ROY HALLETT

American Stations

Our Trans-Tasman friends undoubtedly have the "edge" on us in Australia as far as logging American broadcast stations is concerned due to their geographical set up and smaller number of local stations. However, we have our "Midnight Americans" during summer around the band, in addition to being able at frequent intervals throughout the year to log signals from America on frequencies between 1500 and 1600 kc.

Around 9 p.m. appears a good time to listen just now, although it is a good idea to listen on this band from sunset, or in some locations from as early as 4.45 p.m onwards.

The U.S.A. and possibly other countries on the American continent claim several "24 hour stations," some of which operate in the frequency band mentioned. These may be picked at favorable locations during the suggested listening period WCKY, Cincinatti, Ohio, 1530 kc. WKBW, Buffalo, N.Y., 1520 kc are examples, whilst American West Coast stations may be heard bringing their night programmes to a close around 6 p.m., but one's chances of hearing these is generally greater when opening morning sessions around 8.30 p.m

In reporting these stations, care must be taken to quote correct operating times, and it is well to note that most Eastern States are on Summer Time—one hour ahead of Standard time. KOMA, Oklahama City Oklahama, 1520 kc (try 9 p.m.), KFBK Sacramento, California, 1530 kc and KXEL, Waterloo, Iowa, 1540 kc, are frequently good ones on this band.

ZJV, Suva

As a result of 3YZ's increased power on 920 kc., the Suva Fiji Islands station, ZJV, has, according to Art Cushen, moved from their old 920 kc channel to 930 kc. As 3UZ, Melbourne is also on this frequency, reception of ZJV on this continent may not be so easily accomplished, particularly in the Southern area.

Perhaps the best time to try for this one, would be around Sunset as was the case when on its former channel. As previously mentioned in these columns, one should not be surprised to hear features in Hindustani from ZJV since a considerable number of Indians is employed in these islands. In the past, this station verified correct reports with a most attractive verification card.

N.Z. News

Throughout New Zealand work is proceeding rapidly on the construction and renovation of buildings for housing the new equipment to be brought into service by the National Broadcasting Service in an attempt to improve reception of their programmes in the districts the particular stations are designed to cover. A new station to take the air is 1YZ, operating from Rotorua, on 800 kc. This is being heard fairly well at our listening post from around 5 p.m. till sign off at 8.30 p.m.

An NZDXC report states that 3YZ at Greymouth has just brought its 10 kw transmitter into service on 920 kc, thus an improved signal should be noticed from this one. It is being heard well from opening at 5 a.m. for an hour or so.

It should not be long before the new 2YA transmitter is ready for installation, thus enabling 2YC, 650 kc to take over the present 2YA equipment. This should result in a marked increase in signal strength of 2YC's transmission over here. It is difficult to imagine anything better than 2YA's present transmission and consequently we will be eagerly looking forward to hearing it with the new equipment.

LISTEN FOR THESE

Perhaps the best time to listen for overseas stations on the broadcast band during the coming weeks should be around Midnight or 1 a.m. when signals from Asia should be quite fair at most locations, particularly from such stations as "Voice of America;" Manilla, Philippines, 920 kc relaying programmes, including news at Midnight, by short wave from New York, U.S.A.

WVTR, the Armed Forces Radio Station in Tokyo, is good towards midnight, with, DZRH, Manila, 630 kc, running American type programmes around 1 a.m.

Hawaiians, KULA, 690 kc, KPOA, 630 kc, KMVI, 550 kc, etc., are good signals round 2 a.m., with New Zealand coming in well from 4 a.m. for an hour or so. Listen for 4ZB, Dunedin, 1040 kc, 1ZB Auckland, 1070 kc, and others running commercial type programme, as well as the national stations, operating in this country.

Japanese Station Changes

To the list of stations operating from the islands of Japan, detailed in the last month's issue, must be added several frequency alterations. Although we are not listening here several new stations in the 500 watt group just brought into service, we would point out that should any reader log a station believed to be in Japan and not shown on our list, we will be pleased to check the supplied information against the complete list we have here. We extend our thanks to Ian Johnson and Ray Rooke, for the information forwarded concerning these Japanese stations.

The main programme, according to our correspondent is broadcast over stations on the first network — running, school, farm, religious and children's features, whilst sport, special events, etc., are carried by the alternative or second network. Stations in both networks are scheduled to leave the air daily at midnight (11 p.m. in Japan), the main programme beginning a transmission daily at 6.30 a.m., the second network, one hour later. JOAK, however, has on occasions been heard on the air before this time.

The following are the alterations that should be made to our recent summary of Japanese stations:

570 kc **JOIK, Sapporo (810 kc).**
650 kc **JOHK, Sendai (770 kc).**
670 kc **JOBK, Osaka (690 kc).**
750 kc **JOIB, Sapporo (1200 kc).**
910 kc **JOHB, Sendai (1140 kc).**
930 kc **JOBB, Osaka (940 kc).**
1030 kc **JOGB, Kuomamoto (1170 kc).**
1050 kc **JCFB, Hiroshima (1100 kc).**

All stations in this group employ a power of 10 kw. Frequencies shown in brackets indicate stations' former frequencies.

Are you interested in Broadcast DXing? If so, you are invited to send in reports of your latest logging; equipment being used, as well as any suggestions regarding the information you would like included in this page. All letters should be posted direct to Mr. Roy Hallett, 36 Baker Street, Enfield, N.S.W.

RECENT VERIFICATIONS

Ian Johnston, Manly, has received several interesting verifications in recent weeks. A letter from Tokyo verifies his reception of JOAK, whilst an additional slip containing details of verification also came from this centre. A card has arrived from 2BH, Broken Hill, now 650 kc, and another from KPOA in Honolulu, Hawaii. We received an airmail letter from this one some time ago, but, apparently, they are now sending a card. This is a stencilled job, and carries quite an attractive design.

Art Cushen, Invercargill, N.Z., was pleased with our Indian notes, having been wondering about the identification of a signal he was hearing on 1195 kc, which he now believes to be Baroda. Gauhati, 780 kc is another new logging at his listening post.

QSL's to hand from interesting recent loggings are: KSTB, KANS, KTRN (scored a two column newspaper write up after reporting this one), WHBQ, KCHE, WTSP, KMLB, KRUZ, 1YZ etc., bringing his total of broadcast band QSL's to 814; whilst many others are awaited.

Mr. A. Tonkin, VK5MZ, Salisbury, S.A., has been wondering whether or not it was possible for DXers in this country to receive signals from the European continent on the Broadcast Band as far back as 1932, having discussed the matter with a friend who believed it was out of the question at that time.

We had no experience of DX around that time, so referred the matter to Graham Hutchins, and he says he well remembers hearing Europeans then with signals coming through as early as 2 a.m., building up to quite fair level in some cases by sunrise. Graham is quite proud of the verifications he has in his collection as the result of European DX of that period.

TRANS-TASMAN DIARY

By J. F. FOX
(Special N.Z. Correspondent)

RADIO STATION ZMKQ—PAMIR

Details of the radio equipment carried on the world famous barque—Pamir.

In the early part of this year New Zealanders said farewell to a ship that in the last eight years had become a familiar vessel and of particular interest to people in this part of the world. The story of the barque Pamir, as far as New Zealand is concerned dates back to August 3, 1941, when she sailed from Wellington shortly before her country entered the war. The Pamir was not far out in the Pacific when New Zealand's proud warship, H.M.N.Z.S. Achilles (of the Graf Spee fame) made a hurried exit from Wellington Harbor, to return a few hours later with the sailing barque as a prize of war.

For the remainder of the war years, Pamir was used by the Government for conveying important cargoes to and from the West Coast ports of North America. With only the wind to drive her, and no guns aboard, Pamir was a sitting target for any enemy craft that may have been lurking her way. However, fortune smiled on this magnificent ship, and after the war she made a voyage to Sydney to become a sight remembered by many Australians.

Around The Horn

Following this trip, the Pamir went on a 15.000 mile voyage around the famous Cape Horn to England. Pamir covered the journey in 81 days at an average of 200 miles a day. On this trip went Mr Albert Stanton, a New Zealand wireless officer who in an interview for "*Radio Science*" told us how the "Pamir" kept in touch with the rest of the world.

The 43-year-old sailing vessel was equipped with two transmitters, one being for high frequency operating. This transmitter was a Bendix 100 watt output and covered two to 18 megacycles. The tubes consisted of a 837 electron coupled oscillator, two 1625 multipliers and a 813 output. Phone could be used and the audio line up was 12SJ7 and 6V6 pre-amps. driving two 811 push pull modulators plate modulating the final. This transmitter had auto-tune mechanism with 10 pre-selected frequencies; however, it was no great trouble to tune to some frequency not already set.

The medium frequency transmitter was a 250 watt A.W.A. set which used a 800 oscillator with a 203A power amplifier. Power supply for the transmitters was obtained from a 120 volt, 150 amp-hour accumulator which was charged by a diesel driven generator.

> **CHANGE OF ADDRESS**
>
> **Our New Zealand Correspondent, Mr. Jack Fox, has advised us of a change in his address. In future, he requests all letters should be sent to: Mr. J. F. Fox, 9 Glen Street, Concord, Dunedin, SW2, New Zealand.**

Two receivers were installed on board, one being a six tube medium frequency covering from 100 to 3000 kilocycles, while a nine tube all wave set covered from 15 kilocycles to 25 megacycles.

The antenna, a Marconi "L" went from a stand off insulator on the mizzen mast through another insulator on the mainmast, 180 feet above the deck, thence to the jigger mast at the rear. ZMKQ as the Pamir was known to shore and ship stations throughout the world transmitted in the marine bands on frequencies of 6210, 8280, 12,420 and 16,560 kilocycles. Daily contact with New Zealand was maintained, except for some brief periods when the ship was near the equator, on both the outward and homeward journeys. ZLW (Wellington Radio) received ZMKQ at strength four while they were in the English Channel.

Many Stations Worked

Although it was not usual to call a station unless there was traffic for that particular station some of the stations worked by Mr. Stanton were: Auckland Radio, Wellington Radio, Awarua, Falkland Islands, Capetown, Lisbon, Vancouver, Halifax, San Francisco, Horta (Azores), Mindelo (Cape Verde Islands), Dakar, Sierra Leone, Tristan da Cunha, Perth, Esperance, Adelaide, Melbourne, Sydney, Portishead, Niton, Northforeland, Lands End and Valentia. Ostend and Antwerp were worked on the trip to Belgium. Numerous other ship stations were worked on both the outward and homeward voyages.

Great interest was caused on this voyage and each week the N.Z.B.S. broadcast a weekly report from the Pamir. So interested were the operators of ZLW that they plotted the Pamir's position on a large map which now hangs on the wall of the station.

As ZMKQ was nearing the end of the outward passage the British broadcast a warning to all those on light house keeping and those on watch on the modern steam ships to keep an alert watch for her.

After a lot of debating as to whether the ship should be retained as a training ship or be handed back to her rightful owners, the New Zealand Government decided on the latter. On February 1, of this year, the stately Pamir sailed from New Zealand on what may be her last voyage, for windjammers like the Pamir are all but a memory.

NEW OVERSEAS RADIO STATION PLANNED

Overseas communication services will be greatly improved when a new radio station is erected for the Post and Telegraph Department to provide a Dominion terminal for radio telephone communication with the United Kingdom and with other countries, and at the same time to provide additional overseas high-speed telegraph services. The new station will be built at Himatangi, 14 miles south west of Palmerston North.

The proposed scheme allows for a 50 kilowatt radio telegraph transmitter, while the radio telephone section will have a new 40 kilowatt dual channel single side band radio telephone transmitter, and a 5 kilowatt six channel radio telephone transmitter. Besides the above mentioned transmitters there will be numerous low powered transmitters.

At present, overseas radio telegraph and radio telephone services are operated from Wellington Radio on Tinakori Hills, overlooking the capital. This station which has been in operation for many years is now considerably taxed for building space. Nearly 40 transmitters are crowded in the small transmitter building at ZLW. A 5 kilowatt and 1 kilowatt transmitter carry the radio telephone service from New Zealand at the present time.

Owing to the difficulties of the building situation, it is likely that some time will elapse before a start is made on the erection of the station.

AMATEURS GRANTED TV FREQUENCIES

Radio amateurs have now been allocated frequencies for experimental television in New Zealand.

The frequencies which are regarded as the most suitable for TV work are from 430 to 442 megacycles and 1250 to 1280 megacycles.

It is likely to be some time before any TV experiments are conducted in this country. The high expense involved for the equipment will be the biggest difficulty which faces the amateur operators.

Amateurs were recently granted permission to experiment in the frequency bands of 52.5 to 54 megacycles, 440 to 400 megacycles in the remote control of model aircraft and model seacraft by radio.

IMPROVEMENTS AT RAROTONGA

The Radio station at Rarotonga in the Cook Islands is at present under reconstruction, and when completed will be a major Pacific Island radio station. At the cost of approximately £50,000 the station will provide more efficient navigational facilities for shipping and aircraft.

In March last, a party of 14 Post Office men under the leadership of Mr. J. H. Heyhoe of the Chief Engineer's Office, flew to Rarotonga. The party are at present engaged with the installation of the new station. In accordance with the present day practice the receiving and transmitting sites will be situated at different locations and connected by underground cable.

Although most of the radio equipment was assembled in New Zealand before being shipped to Rarotonga, some material including hardwood poles for the antennas was sent from Australia. The actual construction of the buildings to house the installations was started in July, 1948, by the Ministry of Works Department and was almost completed when the Post Office party arrived.

Since World War I, the Rarotonga Radio station has given excellent service in providing communication with New Zealand, her satellite stations on the various islands in the Cook Group, as well as maintaining contact with the outside world and ships. Those are still of course, important functions, but the demands of aviation have now to be met.

HIGH SPEED RADAR SWITCH

(Continued from page 28.)

fluenced by the rate of build-up of transmitter power. It has been estimated that the discharge forms in about 0.005 microsecond.

At the conclusion of the transmitted pulse the electron density in the gap must drop to a sufficiently small value so that transmission of received signals through the resonant cavity is unaffected by the electrons. The processes of diffusion of electrons to the walls of the cavity and their recombination with positive ions are much too slow to be satisfactory. Water vapor in the gas used allows the electrons to attach themselves to it to form negative ions, which because of their large mass are as ineffective as the positive ions in the high-frequency field.

Data Courtesy "Westinghouse Engineer"

TO ALL READERS

We regret the late arrival of this issue of RADIO SCIENCE, which has been brought about by the current industrial crisis and consequent power restrictions. The normal publishing date for future issues will be reverted to as soon as possible.

BASIC ELECTRICITY AND MAGNETISM

(Continued from page 19.)

available from two tanks when inter-connected is less than when the head of water in one tank is used alone. Again, if two springs of opposing torques are arranged to act so as to transfer energy from one to the other, there is always an *unaccounted* loss of energy.

But another fundamental law of nature states that energy can never be created nor destroyed but only changed in form. How can we explain away an apparent loss of it, which mathematically we can prove, and experimentally we know, does occur?

This is a typical case of the problem which we saw in Part VII of this series, has baffled the physicist for decades. It is still baffling him. It will continue to baffle him and us until we know the mechanism which holds the several parts of the atom together. This is also a typical case wherein the electron cannot be thought of as a particle; we can trace the missing energy mathematically but only when we treat the electron as a wave, which, of course, instantly takes us from the realm of reality, because a theoretical wave is not a physical one.

When we endow the electron with wave like properties, we can conceive of the lost energy being *radiated* into space, not as heat energy, nor as electrical energy, but energy of an indescribable form capable of being supported by space. This concept is confirmed experimentally every time a radio station broadcasts. Energy is radiated. We can predict it mathematically, we can confirm it experimentally, but we cannot explain why.

There are a number of theories which attempt to explain the underlying mechanism of radiation but it is beyond the scope of this particular article to discuss them. We have attempted here to examine a particular case in which the value of mathematics as a means of predicting certain results under prescribed conditions is demonstrated; we have also seen that experiments verify these mathematical predictions despite the fact that we cannot account for them physically. Later, it should be possible to analyse the theories of radiation thoroughly. When we do we will find that Bohr's and Einstein's theories are very important indeed.

The next article will deal with the mechanical forces involved in charged capacitors; the essential difference between conductors and non-conductors, and practical types of capacitors.

32 VOLT FARM RADIO

(Continued from page 22.)

and .0001 mfd condenser which forms the i-f filter, and connects to the 0.5 meg diode load resistor, whilst the other connects to a 0.01 mfd coupling condenser on the volume control. The third terminal is earthed.

A "jumper" wire connects across the first two terminals for radio reception, and then when the pickup is required the "jumper" wire is removed. The pickup leads are then connected across the second and third terminals.

The remainder of the circuit is quite standard, and requires little comment. The only point to mention is that the components marked with an asterisk on the schematic diagram may be included in some of the dual wave units. This point should be checked, and if they are not already fitted, then they will have to be purchased separately.

Receiver Alignment

The alignment of the receiver should be done with a modulated oscillator to gain maximum results, but the following procedure will suffice in most cases. The trimmers on the coils are used to adjust the high frequency end of the band, the oscillator trimmer to bring the high frequency setting and station markings to their correct position on the dial and the aerial and r-f trimmers to give maximum output.

The adjustable iron slugs in the coils are used to adjust the low frequency end of each band. Repeat adjustments at each ends until both are correct, always starting with the iron slugs and making the final adjustments with the trimmers.

After these adjustments have been completed, the i-f transformers can be given a slight adjustment by the iron slugs at top and bottom. Starting from the secondary of the last i-f transformer and working backwards, move them slightly one way or the other for maximum output. However, care should be taken with this adjustment so as not to get the i-f transformers out of alignment, otherwise recourse will have to be had to a modulated oscillator to reset them.

Printed Circuit Techniques

(Continued from page 7)

(c) Solvent.

The solvent is used to dissolve the binder if it is in solid form and to adjust the viscosity of the pigment-binder mixture. Most of the common aromatic and aliphatic solvents may be used in paints for printed circuits. Typical examples are alcohol, acetone, ethyl acetate, butyl acetate, cellosolve acetate, carbitol acetate, amyl acetate, turpentine and butyl cellosolve. Lacquer thinners such as butyl acetate as well as blycol-ether solvents such as methyl cellosolve are also recommended. Solvents that mildly attack the surface of the base plate, such as toluene on a polystyrene base, usually improve the adhesion.

(d) Reducing Agent.

A reducing agent is used to reduce the metallic compound to metal when the base material will not stand high firing temperatures, for example, a plastic. Formaldehyde and hydrazine sulphate are used to convert silver oxide to pure silver. They are driven off at the relatively low temperature 70 deg. C., considerably less than the temperature required to reduce silver oxide by the firing process.

(e) Filler.

The filler is the material used to spread or separate the particles of pigment to increase the electrical resistance. Powdered mica, mineralite, diphenyl, and powdered chlorinated diphenyls are typical types of fillers employed.

B.—Conductor Paints

Although paints for the conductors [5] may be made up in the laboratory, there are commercially available excellent products that have been developed as the result of careful research.

Not only are there a variety of preparations for special purposes, but the manufacturers have demonstrated unusual ability and cooperation in making up special paints for specific applications. The commercial paints require no additional attention prior to application. [6].

There are paints suited for polystyrene or for Lucite and Plexiglas; others are especially prepared for the prime base materials such as glass and steatite. One can go so far as to specify the degree of scratch or abrasion resistance desired

The silver content is usually adjusted according to the manner in which the paint is to be applied. If it is to be brushed on, a paint of at least 50 per cent. of silver by weight is recommended. For spraying a silver content of 35 per cent. by weight is suitable, while for application by use of a stencil screen the silver content should be as much as 60 per cent. by weight. (2)

(5. Conductor paints are used not only for conductors but for inductors, capacitor electrodes, shields and other low resistance elements).

There are several ways of preparing conducting paints in the laboratory. In one the pigment is dispersed in the binder and applied to the surface. The unit is then elevated to the proper temperature required to drive out the solvent and to adhere the metal to the plate. To improve the bond, a flux may be added and a similar procedure followed. The units must now be raised to a temperature above that at which the flux melts and below the melting point of the metal. Although silver oxide may be reduced at approximately 400 deg. C. on steatite, a temperature of 700 deg. to 800 deg. C. is usually employed.

As the temperature is raised, in a typical example of paint, the solvent evaporates at 150 deg. C., followed by the binder at 200 deg. C. At 400 deg. C. the flux melts, and at 800 deg. C. the silver forms into a smooth conducting film. The particles of silver are spread evenly over the surface and held tightly to the base plate by the flux.

The firing temperature depends on both the flux used and the material of which the base plate is made. A minimum amount of flux should be used, just enough to bond the silver tightly to the plate. Excess flux reduces the conductance of the silver film. Care must be exercised in preventing the temperature from rising high enough to produce tiny metal globules that weaken the bond to the plate and interfere seriously with the conductance.

A satisfactory formula for a flux type paint is five parts of metallic silver or silver oxide and one part of binder such as lead borate, bound together in a pint mill with enough vegetable oil to give the paint the proper consistency. The viscosity may be adjusted further if desired by adding a small amount of acetone.

Silver oxide paints using laboratory prepared lacquers as binders and containing vitreous materials such as lead silicate glass (softening point about 550 deg C.) or lead borate (softening point about 500 deg. C.) in several percentages have been successfully prepared in the laboratory. The paints were applied to steatite plates and dried under infrared lamps for several minutes, then fired in a muffle furnace of 800 deg. C. to 850 deg. C. for 1 to 1½ hours. Metallic silver of low resistance was deposited attached firmly to the plate. Other sample formulas used in the laboratory are shown in table 2.

(To be continued.)

The Mail Bag

J.B. (Brisbane, Qld.): Read with interest the recent article "Dielectric Heat—Wood Fabrication Tool," and asks whether the glues mentioned as being suitable for setting at room temperature are available in this country.

A.: Thanks for the letter and remarks, J.B. We have made enquiries at some of the large hardware stores, and to the best of our knowledge, these particular glues are not available in Australia. No indication was given as to whether they would be marketed commercially, since their importation is bound up with the questions of dollars, etc.

A.W.C. (Annerley, Brisbane): Forwards a change of address.

A.: Your letter has been passed on to our Subscription Department, and the change of address noted. This will take effect from the current issue.

J.W. (Glen Iris, Vict.) writes in for a back issue to complete his file of RADIO SCIENCE, and says: "... I am about to build the Miniminor Portable described in your first issue and am quite confident of success. Also I have built the Dual Wave receiver of September, 1948, and had considerable success, although I departed from the valve types, using a 6J8 and 6G8 because I already had them in my set . . ."

A.: Many thanks for the interesting letter, J.W., and the issue you require has been sent off to you. We are pleased to hear of your success with the D/W receiver, and have no doubt that you will be favorably impressed with the personal portable. Let us know of your results with this receiver when you write in again. Your good wishes are reciprocated.

W.K. (Parkdale, Vict.) writes to tell us that he thinks RADIO SCIENCE is "tops," and would like to see some articles dealing with home studio and recording equipment.

A.: Your suggestion has been noted, W.K., and we may be able to do something along the lines you suggest in a future issue. No doubt such a series would be popular with the many home recording enthusiasts. We have not published a circuit using 6A3's, although the amplifier circuit in the June, 1949, issue was designed to allow the interchange of 6L6G and the 6B4, an octal based triode with equivalent characteristics to the 6A3. No doubt this circuit could be readily adapted for your purpose. If you build up this circuit we would be pleased to hear of your results with it.

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 endeavor 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."

R.E.B. (Allenby Gardens, S.A.) renews his subscription to RADIO SCIENCE, and includes several suggestions for future articles. Although mainly a SWL, is particularly interested in UHF experimenting and would like to see the continuance of this type of technical article.

A.: Your subscription has been attended to by the Subscription Department, and the issues you missed have been forwarded, and no doubt in your hands by now. Your radio interests certainly cover a wide field, and no doubt you will be pleased with the new series dealing with modern amateur transmitting techniques. We hope to include further articles on VHF equipment, as well as some practical designs in a future issue. At the moment it is just a matter of using the available space to the best advantage, and providing the reader with a good coverage of widely-diversified topics. Thanks for the interesting letter and appreciative remarks concerning the magazine.

K.A.L. (RNZAF, Christchurch, N.Z.) is interested in the Noise Neutralising Detector article published in the January, 1949, issue of RADIO SCIENCE, and asks for further details of the circuit used.

A.: This particular article was reprinted from an American publication—Tele-Tech—and consequently we have no other information on the subject other than that published. From memory, we think it was a Hazeltine Corporation development and consequently would be covered by patients. However, you might be able to obtain further information by writing direct to the magazine concerned: Tele-Tech, 480 Lexington Avenue, New York 17, U.S.A.

W.J. (East Malvern, Vict.) asks some questions about the World Wide Six, which he is building up, and says: ". . . May I take this opportunity of congratulating you upon the quality of your magazine, and note that in your description of the Radiogram Five in the April issue you set out clearly the wattage values of the various resistors. This is a great help to the mere plodders like myself and one wonders why the "voltage" values of the various condensers could not be shown also, thereby relieving the home constructor of the necessity of seeking this information from the local experts whose information is quite frequently pretty wide of the mark. I hope you will regard the foregoing as "constructive" criticism and look forward to seeing the future circuits incorporating this information . . ."

A.: Your letter was read with interest, W.J., and we agree with your suggestion that the inclusion of the various wattage and voltage ratings be shown in the parts lists. Small points like this are often taken for granted, and it is only when brought to our notice that we see the value of such information. No doubt many other readers will find this information of particular assistance to them also, and we will endeavor to make sure that this information is included. The Red Line components you mention will be satisfactory to use in this circuit, without the necessity for any circuit changes. The slightly higher voltage will be of no consequence in this case. The various ratings for the condensers and resistors in this set have been posted off to you as there would not be sufficient space in these columns to list each item. We trust this information will clear up matters for you, and would be pleased to hear your opinion of this receiver when it is completed.