RADIO SCIENCE

Vol. 2—No. 6 Registered at the G.P.O., Sydney, for transmission by post as a periodical JUNE, 1949

"SUPER - PORTABLE" BATTERY RECEIVER

Atomic Clock — New Frequency Standard

DESIGN FOR AN ELECTRONIC BRAIN

Complete Broadcast & Short Wave Notes

GEIGER — MUELLER COUNTER OPERATION

PRICE 1/-

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.

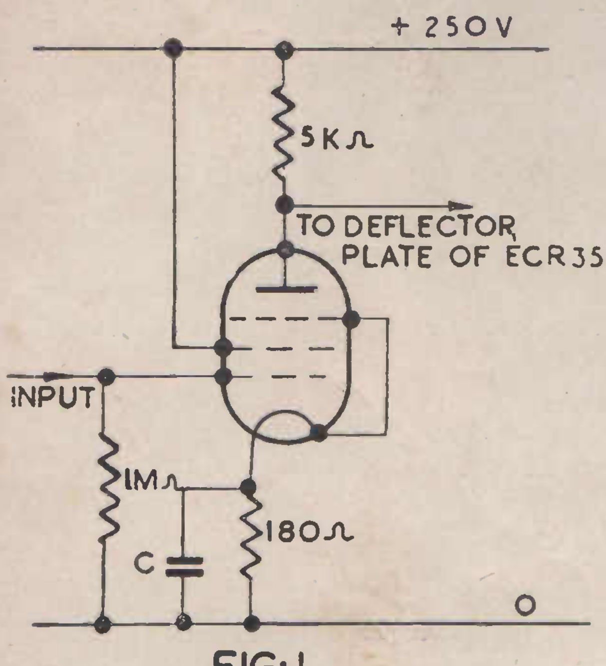
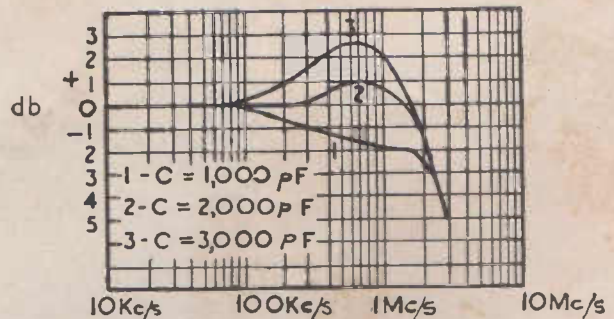


FIG:1

FIG:2



FREQUENCY

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 frequency 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.*

Mullard Australia Pty. Ltd.

35-43 CLARENCE STREET, SYDNEY

592 BOURKE STREET, MELBOURNE

M8-49

editorial.

Communications Problems

For some time past one of the major problems facing the radio engineer has been the definite shortage of sufficient communication channels for the conveyance of intelligence from point to point. The various communications systems have become so extensive and complex that the available high-frequency channels have now become totally inadequate to cope with the tremendous increase in transmitted signals for conversation, relaying and supervision.

Realising the seriousness of the problem, radio engineers have co-opted in an endeavor to overcome this situation and provide improved traffic facilities. One recent method of relieving this communications congestion has been the introduction of single side-band carriers which, in effect, approximately double the number of channels available. In contrast to the more usual amplitude modulation and frequency modulation system, the carrier frequency is suppressed and only one of the two side-band frequencies is transmitted when signals are being conveyed.

A further advantage with this type of circuit is that, being less cluttered with extraneous noise because the narrower channels have proportionately less interference, it will provide an improvement of some 9 db in the signal-to-noise ratio. It is interesting to note that recently amateur operators have resorted to this same single side-band principle for identical reasons—that is, to reduce channel congestion on the various amateur bands.

Another quite different system which is expected to be of assistance in the growing telecommunications load, and especially over short distances, is the microwave space radar, an outgrowth of the war-time radar systems. Although this is not quite so far developed as the single side-band system, many tests are being carried out and a promising future is predicted with its use. This system utilises the highly directional properties of beamed ultra-high frequencies to transmit signals through the air using only very small energies. For example, a few watts are ample for microwave transmission of several channels in the 950 mc. region over a distance of 20 to 40 miles.

Microwave radio, which is still in its earliest development stages for use in general communication, is expected to be of great value in supplementing present-day wire-borne carriers. In this country, plans are already well in hand to augment existing trunk-line transmissions with such a system, and thus provide the much needed additional channels.

The straight line directional property of microwave radio is both its strength and its weakness. It reduces the power required to send a signal to a few watts, but limits the range to approximately line of sight distance, *i.e.*, some 20 to 40 miles. Consequently transmissions over hundreds of miles would entail frequent repeater stations, which are costly in money and signal quality. For this reason microwave radio is more likely to be used to cover short jumps or even close gaps in existing systems.

With the radio engineer's ceaseless search for a new and better means of intelligence transmission, it seems most likely that in the near future we will see more efficient methods of achieving results, which far transcending man' present knowledge, will provide for the ever expanding communication requirements throughout the world.

FIRST AGAIN!

SLADE'S RADIO PTY. LTD.

Proudly Presents

Australia's First F.M. A.M. Radiogram

☆

A powerful 9-valve F.M., A.M. & D.W. Receiver gets world's shortwave stations as easily as locals. Daily demonstrations of F.M. at our Factory and all Registered Dealers of Slade's Radio.

☆

Contains every modern Feature for utmost enjoyment of frequency modulation reception, D.W. A.M. reception and recorded music. with high - grade Record Changer.

F.M. A.M. Combination Model 106

Price Including Special Dipole Aerial £125.

Easy Terms Arranged.

☆ ☆

All the advantages of F.M. Reception are yours with this Six-Valve F.M. Tuner. Housed in an attractive Bakelite Cabinet.

☆ ☆

The ideal instrument for those who already own a good radio, but wish to listen in to F.M. Broadcasting

F.M. Tuner Model 105. **Price Complete £25/-/-**

CONSOLE AND RADIOGRAM CABINETS—FINEST SELECTION IN SYDNEY

SLADE'S RADIO PTY. LTD.

LANG ST., CROYDON, N.S.W. **TEL. UJ5381—UJ5382**

ESTABLISHED 30 YEARS

RADIO SCIENCE

For the Advancement of Radio and Electronic Knowledge

Vol. 2, No. 6 JUNE, 1949

EDITORIAL CONTENTS

OUR COVER: A view of the transmitting unit of the radio-telephone system operated by the New Zealand Post and Telegraph Department. The engineer, Mr C. N. Hair is phasing the equipment prior to commencing the actual transmission, of the photograph mounted on the rotating drum. The operation of this system is detailed in Trans Tasman Diary on page 43.
—(Photograph courtesy Prime Minister's Department).

Published Monthly by RADIO AND SCIENCE PUBLICATIONS, and printed by "Truth" and "Sportsman" Ltd., Kippax and Holt Streets, Sydney.

Address all Correspondence to Box 5047, G.P.O., SYDNEY.

EDITOR and PUBLISHER: C. E. Birchmeier (A.M.I.R.E., U.S.A.)

SUBSCRIPTION RATES:—Single Copy 1/-, Australia, British Empire (except Canada) 12/- per year. 21/- for two years; Canada and U.S.A., 2.50 dollars for 1 year, 4.00 dollars for two years. All other countries 15/- (Aust.) per year. Post free to any address. Foreign remittances should be made by International Money Order or Bank Draft negotiable in Australia.

CONTRIBUTIONS: Articles of a suitable technical nature will be considered by the Editor, and if accepted paid for at current rates. Accepted material is subject to any revision or changes deemed necessary. Contributions will be handled with reasonable care, but this magazine cannot be held responsible for any loss or damage. A stamped addressed envelope should be included for the return of manuscript if unsuitable for publication.

WHOLESALE DISTRIBUTORS: "TRUTH" and "SPORTSMAN" LTD.

THE ATOMIC CLOCK

An atomic clock based on a constant natural frequency associated with the vibration of the atoms of the ammonia molecule will provide a basically new primary standard of frequency and time invariant with age.

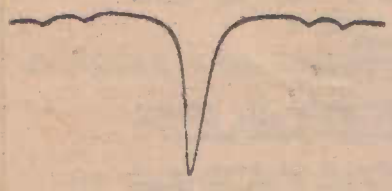
This is the first atomic clock ever built and is controlled by a constant frequency derived from a microwave absorption line of ammonia gas, providing a time constancy of one part in ten million. Based on a principle developed by Dr. Harold Lyons, of the National Bureau of Standards microwave research laboratory, this new clock promises to surpass by one or two orders of magnitude accuracy of the present primary standard—the rotating earth.

High Degree of Accuracy

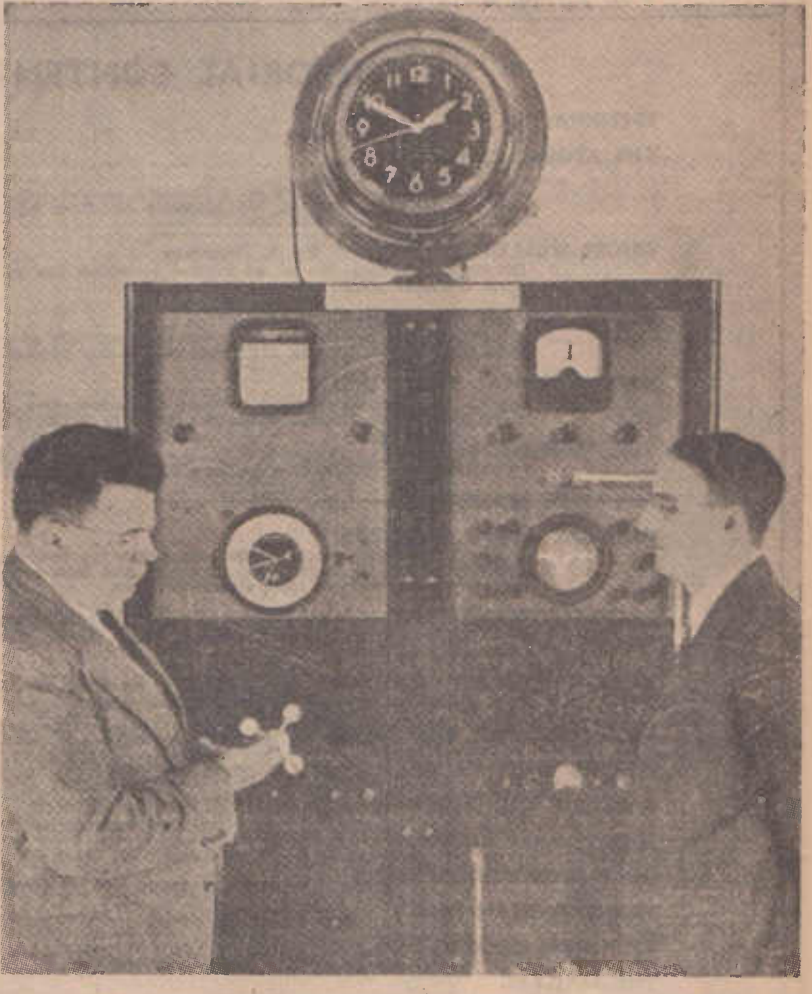
Theoretical considerations indicate a potential accuracy of one part in a billion or even ten billion, depending on the type of atomic system and spectrum line used. The improvements in frequency and time measurement offered by the atomic clock are of fundamental importance in many fields of science.

An absolute time standard will be of special importance in astronomy, where present time standards leave much to be desired. The atomic clock and the method represent important tools of research and development in every technical field where precise measurements of time and frequency are crucial—for example in long range radio navigation systems, in the upper range of the microwave region where atomic systems can serve as electronic components, and in basic research in microwave spectroscopy and molecular structure.

The present time and frequency standards are based on astronomical determinations of the period of the rotation of the earth. However, the earth is very gradually slowing in response to the forces of tidal friction in shallow seas. In addition,



The ammonia gas absorbs only one frequency.



The complete atomic clock. The inventor, Dr. Harold Lyons, is on the right. Note the waveguide coiled around the clock dial.

there are irregular variations—some of them rather sudden—in the period of rotation, the reasons for which are unknown. These two causes are responsible for the changes in mean solar time, and therefore in the frequency of any periodic or vibrating systems measured in terms of such time standards.

Spectrum Lines

In recent years, vibrations of atoms in molecules—or what are more specifically termed spectrum lines originating in transitions between energy levels of these atomic systems—have been found in the microwave region of the radio spectrum. It has been possible to make very precise measurements of these lines by radio methods, using all electronic equipment of unprecedented sensitivity and resolution. When it became evident that such spectrum lines might eventually provide new primary frequency standards, efforts were made to utilise one of these lines to control an oscillator which in turn could be used to drive a clock. The atomic clock was the result of these investigations, and controlled by the invariable molecular system of Ammonia gas, it is independent of astronomical determinations of time.

Basic Clock Units

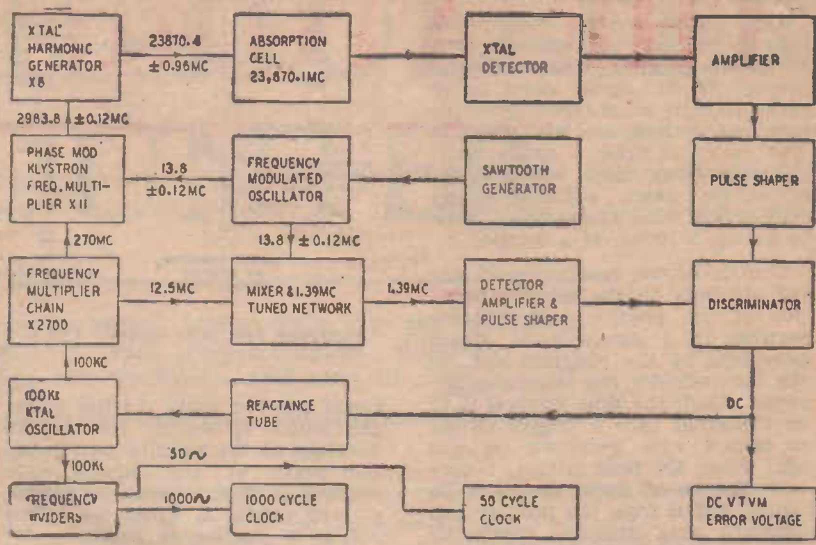
The atomic clock consists essentially of a crystal oscillator, a frequency multiplier, a frequency discriminator, and a frequency divider, all housed in two vertical-type cabinet racks, on the top of which are mounted a special 50-cycle clock and waveguide absorption cell. Ammonia gas under a pressure of 10 or 15 microns is maintained in this cell, a rectangular ½ x ¼ inch copper tube wound in a compact 30-foot spiral about the clock.

The new development uses an absorption frequency of ammonia to hold a microwave signal fixed. The ammonia molecule consists of three atoms of hydrogen and one of nitrogen, with the nitrogen atom slightly above the plane of the hydrogen atoms. Outside forces can make the nitrogen atom change its position, and consequently a radio wave at the natural oscillating frequency of the nitrogen atom can cause large numbers of these atoms to change their positions or oscillate back and forth, drawing power from the wave as they do. Thus ammonia gas absorbs power from a radio wave at its own frequency, and does not absorb power from nearby frequencies. (Fig. 1). The gas molecule thus gives an exact frequency indication.

"Error Signal" Generated

If the microwave output of a generator differs in frequency from the ammonia absorption line, then the control circuits generate an "error signal" which brings the microwave signal back to the frequency of the spectrum line. The oscillator generating the microwave signal is thus controlled, and the setting of the clock which it drives can be compared with a conventional astronomical clock.

The microwave signal is initiated by a 100-kilocycle quartz-crystal oscillator or any other oscillator which, for purposes of convenience and accuracy, is designed for a high degree of stability. By means of vacuum-tube circuits and silicon-crystal diodes, this frequency is multiplied to provide output signals throughout the microwave range. These signals are compared with the frequency of a microwave spectrum line, in this case of ammonia gas, by suitable control circuits, often called frequency discriminator or "servo" circuits.



Complete block diagram of the atomic clock.

If the quartz-crystal oscillator drifts after the microwave signal at the upper end of the multiplier chain has been exactly tuned to the frequency of the spectrum line, the discriminator circuit generates an output signal which, through the proper control circuits, can be applied to the oscillator at the bottom of the multiplier chain to bring it back to the proper frequency. By means of a frequency divider the 100 kilocycles may be reduced to any desired frequency for driving a clock; e.g. one thousand cycles or 50 cycles.

Frequency-discriminator or servo-mechanism control circuits for atomic clocks might be developed in many different forms. The electronic control circuit in the present atomic clock is one successful form of several being developed. It is now being refined to give even greater time-keeping accuracy.

Frequency Multiplying Chain

The fundamental frequency signal generated by the 100-kilocycle oscillator is first multiplied up to 270 mc. by a frequency-multiplying chain using standard low-frequency tubes. In the next step, the multiplying chain is continued up to 2970 mc. by means of a frequency-multiplying klystron, which is also modulated by an FM oscillator generating a signal at 13.8 $\pm$ 0.12 mc. This makes the frequency-modulated output of the klystron 2983.8 $\pm$ 0.12 mc.

After further amplification, the frequency-modulated signal is multiplied in a silicon crystal rectifier to 23,870.4 $\pm$ 0.96 mc., and fed to the ammonia absorption cell. As the frequency of this modulated control signal sweeps across the absorption line frequency of the ammonia vapor, the signal reaching the silicon crystal detector at the end of the absorption cell dips because of the absorption, thus giving a negative output pulse.

A second pulse is generated when the output of the frequency modulated oscillator at 13.8 $\pm$ 0.12 mc. is fed to a mixer (or radio receiver) into which is also fed a 12.5 mc. signal from the quartz crystal multiplying chain. When the signal sweeps across the proper frequency to be tuned in (12.5 mc. plus the 1.39 mc. intermediate frequency of the receiver, or 13.89 mc.), an output pulse is generated. The time interval between the two pulses—that from the absorption cell, caused by the absorption line, and that from the receiver or mixer—is a measure of the degree to which the frequency multiplying chain is tuned to the absorption line.

The two pulses can therefore be made to control a discriminator circuit which will give zero output when the time interval is right (that is when the circuit is tuned to the absorption line) and will generate a control signal when the time interval is wrong. If the quartz crystal oscillator drifts in frequency to higher values, the time interval between the two pulses increases; for frequencies which are too low, the interval decreases. The control signals thus generated are fed to a reactance tube which then forces the quartz crystal circuit to oscillate at the correct frequency to tune to the absorption line.

Frequency Dividers

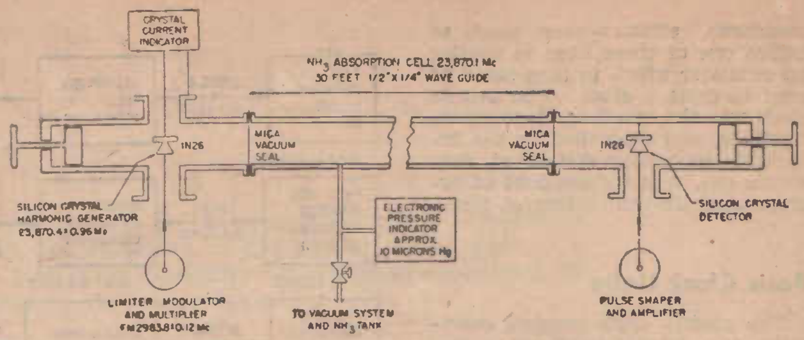
The quartz crystal oscillator is thus locked to the ammonia line. Frequency dividers then divide the precise 100 kc. signal down to 50 cycles to drive an ordinary synchronous-motor clock, and also down to 1000 cycles to drive a special synchronous-motor clock, which is designed for exact adjustment and comparison with astronomical time to within 5/1000th of a second.

Control of the quartz crystal circuit depends on the relative duration of the positive and negative portions of a square-wave signal generated by the discriminator. In the discriminator, the two pulses between which the time interval is to be measured turn a trigger circuit or square wave generator on and off. When the time interval is correct, the on-off cycle generates no output signal from the positive and negative peak detectors driven by the square wave signal. The detectors or rectifiers draw current on the positive and negative peaks of the square wave, but when the positive and negative portions of the square wave are of equal duration, they balance and give no direct current output.

Control Voltages

However, if the time interval between the two input driving pulses gets longer or shorter, the relative duration of the positive and negative parts of the square wave changes so that a resultant direct-current output is generated. This output is positive or negative, depending on the change in the time interval. Thus no control voltage is generated when the quartz-crystal oscillator is on the proper frequency to agree, through the frequency multiplying chain, with the ammonia line; but a positive or negative control voltage is produced for correcting the oscillator circuit when it drifts one way or the other from its proper value.

The atomic clock programme is being carried on at the National Bureau of Standards along several different lines. Among these is a project being developed with the co-operation of the atomic beam laboratory of Columbia University which may result in greatly improved accuracy. In this method, quantum transitions in beams of atoms such as cesium will be used to establish frequency and time standards, and calculations show that an ultimate accuracy of one part in ten billion may be reached. The atomic beam is again used in conjunction with a quartz oscillator and frequency multiplier system, just as in the present method using an absorption cell.



Absorption cell, cross section. Cell is a piece of waveguide coiled around the dial of the clock.

GEIGER-MUELLER COUNTER

One of the most useful instruments for the detection of radioactivity is the Geiger-Mueller counter This article describes the operation and uses of such a unit.

The atomic bomb brought into prominence not only nuclear activities, but also a little instrument that has played a stellar role in its development and use. Reference is here made to the Geiger-Mueller counter. It is used to detect single *alpha* (positively charged helium) particles, *beta rays* (electrons), *positively charged protons, neutrons, gamma (X) rays, and cosmic rays.*

In its most fundamental form, it is deceptively simple in appearance. It consists essentially of two electrodes—one a wire and the other a cylinder coaxial with it, which is filled with a suitable gas. A high voltage is impressed between the two electrodes, and when the gas is ionized by any of the above-mentioned particles, a pulse discharge takes place, which can be observed on an oscilloscope or recorded through suitable electronic means on a tape, film, or even a mechanical counter.

General Arrangement

The arrangement in its general form is shown in Fig. 1. A metallic cylinder A, usually of brass or copper, has a wire B passing along its axis, and suitably insulated from it. The interior of A is filled with a gas, such as argon plus a certain percentage of alcohol vapor. If necessary, a thin window permeable to the particle can be placed in the counter if the cylinder itself is not sufficiently transparent to the particles.

When a particle passes through the cylinder into the gas and ionizes the latter, a discharge occurs in the gas, causing a sudden current to flow through R, and thereby producing a pulse of voltage in it. This can be amplified, or often used directly to actuate an electronic scaling (counting) circuit which adds up a certain number of such pulses, giving in its output one pulse for every, say, 256 pulses of the counter. In this way the strength of the primary ionizing agent can be measured by the number of pulses per minute.

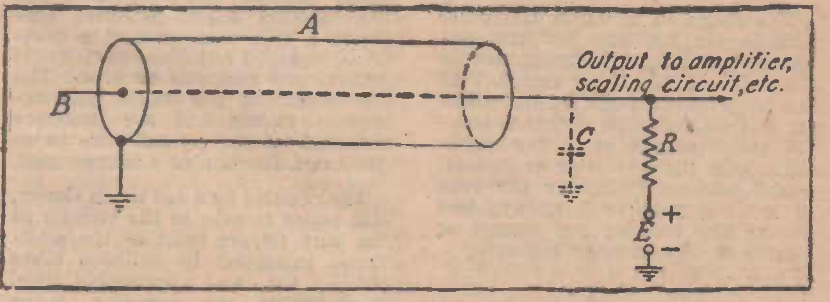


Fig. 1. Fundamental form of a Geiger-Mueller counter.

Three Uses

Actually this device can be used in three different ways. If the impressed voltage E is below the ionizing voltage of the gas, then the voltage merely acts to sweep out the free electrons produced by the ionization of the gas by the primary particles; the central wire collects these electrons and produces a weak pulse across R. Such a device is known as an *ionizing chamber.*

If the potential E is raised to a sufficient degree, then the initial free electrons produced are accelerated sufficiently, particularly in the neighborhood of the central wire where the electric field is inherently high, to produce additional electrons by collision with the neutral gas atoms. This increase in free electrons acts to amplify the pulse, and so-called "gas" amplifications of 10,000 or more are possible. The discharge is non-self-sustaining, i.e., the discharge stops or quenches itself when the primary ionizing agent ceases its action, even if momentarily.

by
A. PREISMAN

At the same time the pulse size in the output is proportional to the number of ions initially produced by the ionizing agent. Thus, a fast alpha particle, such as is emitted by a radio-active substance, may produce as many as 10,000 ion-pairs (positively charged atoms and free electrons) from the neutral gas molecule it encounters. This will result in a large pulse output from the counter.

On the other hand, a cosmic ray may produce only 30 ion-pairs. The pulse output in this case will be smaller in the ratio of 30 to 10,000, or 1/333 as large. For this reason such a counter is called a *"proportional counter."* It has its sphere of use; for example, it can distinguish between a fast alpha particle and a cosmic ray.

Increasing Voltage

If the voltage E is further raised, the difference between the pulse sizes for say, alpha particles and cosmic rays becomes less and less; the pulse amplitude increases in either case, but more so for the weaker ionizing agent. Different ionizing agents can still be distinguished, but the difference is less even though the pulse size and sensitivity are both increased. The counter is now said to be operating in the region of *"limited proportionality."*

Finally, as E is increased, the pulses become in all cases of a large and uniform height, and the counter is now said to operate in the *"Geiger region."* This uniformity of pulse height extends for a certain range of E (depending to some extent upon the gas employed), and beyond this value of E the counter goes into a continuous discharge; i.e., the discharge is self-sustaining and continues after the primary agent ceases to ionize the gas. The discharge is not necessarily self-sustaining, however, in that it requires the primary agent to start or initiate the discharge.

The range of E where the pulse heights are uniform, but the discharge is not self-sustaining, defines the limits of the Geiger region. This is a very useful range for the counter in that the pulse output is several volts instead of a few millivolts, and the device is in general useful because ordinarily the type of ionizing particle is known, and merely the number per second or minute is desired to be measured.

Counter Efficiency

The efficiency of a counter is measured by the number of particles it registers. The efficiency may be less than 100 per cent. in that the counter fails to trigger occasionally for particles, particularly if these occur at too rapid a rate, or else the counter may produce more than one pulse for a particle, in which case false counts are registered.

To gain an insight into this phenomenon, consider once more the circuit of Fig. 1. There is a certain amount of inherent and stray capacity C associated with the output resistor R. When the counter triggers, a group of electrons momentarily charges up C so that the central wire is driven negative. This charge must leak off through R, and the time required for a certain percentage to drain off is given by the RC product. If this is large, such as when R is made very large, then the counter is inoperative for an appreciable period of time, say 10^{-2} second or more. During this time the ionizing agent will fail to register.

One way out is to employ an electronic tube to act as a quick and momentary short-circuit of C, and then to recover and become a high resistance once again. In this way a fast counter can be obtained. Whether R or an electronic tube is employed, the discharge is said to be externally quenched.

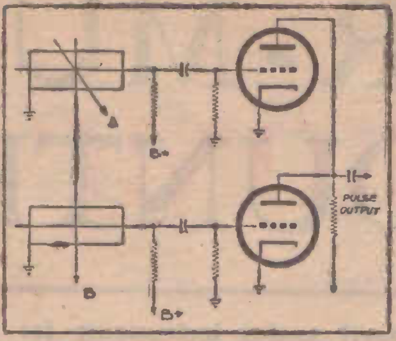


Fig. 2. Arrangement for coincidence counting.

Quenching

Quenching can also occur internally. Mention has been made that the ionizing agent produces ion-pairs; a free electron and a positively charged ion from an initially neutral gas molecule or atom. The free electrons are small and extremely mobile and are therefore collected by the central wire in as little as a fraction of a microsecond.

The positive ions are much slower, and hence remain in the vicinity of the wire (where most of the additional ionization by collision takes place) for an appreciable time. They reduce the negative space charge in the vicinity of the wire and stop further ionization by collision, thus quenching the discharge.

They can do this before reaching the cylinder wall, which discharges them in as little as 10.4 secs., thus permitting a fast counter that is internally quenched.

However, upon reaching the cylinder walls they may cause emission of electrons from the metal by literally pulling them out, or they may produce photoemission owing to the radiation they emit upon being neutralised by electrons from the cylinder. Such electron emission may thereupon start new "avalanches" of electrons and additional pulses. It is to prevent these that a high quenching external resistance is required to depress the potential of the centre wire until this action is over.

Polyatomic Vapor

However, if a polyatomic vapor, such as that of alcohol, is introduced, then this vapor absorbs the radiation from the single-atom gas, such as argon, when the latter's ions are neutralised and no photoemission of additional electrons occurs. Instead, the polyatomic gas breaks down into simpler molecules, and when all the vapor is used up, the counter becomes useless (usually in about 10^{10} counts).

During the life of the counter, however, the device is self-quenching, even if a relatively low external resistance is employed and a fast counter results. The output is, of course, reduced, so that an amplifier may be required, and the introduction of the polyatomic vapor raises the operating voltage somewhat as well as reduces the life of the counter, but the ability of the latter to register rapid counts often overweighs the above disadvantages. One thing that will be noted from the foregoing discussion is that the phenomena in a counter are quite complex in spite of the simplicity of the arrangement.

Uses

There are innumerable uses for the counter. It has been empoyed in the atomic bomb tests to indicate whether a battleship is *"hot"* with radiation or not. In medical experiments it is used to detect where a radioactive chemical goes in a body. Thus, iodine made artificially radioactive in a cyclotron can be fed to a patient and ultimately detected by a counter in the region of the neck where the thyroid gland is located. Other *"tracer"* chemicals can be similarly tracked, not only in the human body, but in metallurgical processes, etc.

Neutrons, as their name suggests, are in themselves inert. But if borium fluoride gas is employed in the counter, then the neutrons react with the borium nucleus to produce unstable nuclei which, then break up and liberate ionising particles which can actuate the counter. Also X-rays, by virtue of their ionising effect, both in the gas and on the inner cylinder wall, will register on the counter.

A rather simple yet ingenious arrangement of counters enables the direction of travel of an ionising particle to be detected. The arrangement is called a *"coincidence counter"*, and is illustrated in Fig. 2. It will be noted that two (or more) counters are arranged to intercept the ionising particles or rays. The counters are connected to the grids of individual vacuum tubes whose plates are connected to a common load resistor RL.

Method of Operating

Normally both tubes are drawing maximum current and the voltage drop in RL is a maximum. If a negative pulse is produced by one counter, but not by the other, then the tube connected to the first is biassed to cut off, but not the other. Thus only the first tube has no plate current flowing through RL; current from the other tube continues to flow through RL, so that the voltage pulse produced across RL is only half the maximum size.

(Continued on Page 47)

Design for an— ELECTRONIC BRAIN

By W. R. ASHBY, M.A., M.D.

A highly controversial article which discusses the possibilities of an electronic brain. As stated by the author—" . . such a machine if perfect could eventually play with a subtlety and depth of strategy beyond that of its master".

Twenty years ago the idea of building a brain would have been considered fantastic. Mind and matter had been carefully separated by the philosophers who were mostly convinced that any non-living connection was impossible. No mere machine, they said, could produce the remarkable features of the brain. In a sense, of course, they were right. When they thought of a machine they imagined objects like a wheelbarrow, a typewriter, or a steam-engine. They had observed that such machines if controlled, like a typewriter being tapped, were inflexible in action, and if uncontrolled, like a motor car without a driver, were apt to destroy themselves.

But nowadays the word "machine" has a much richer meaning, the position having been transformed by the invention of the electron tube. This device has two main properties; it allows power to be injected freely into a machine, causing high activity, and it provides a means by which one part of a machine can affect the behavior of another part with little back-action. At last those who would build a brain have something comparable in functioning powers with the nerve cell.

The Nature of a Brain

But even if we are given an abundance of highly active and sensitive devices like nerve cells or tubes we have yet to assemble them into something that makes sense. And what does "make sense" mean in the brain or in a machine? Here wide differences of opinion occur. To some, the critical test of whether a machine is or is not a "brain" would be whether it can or cannot "think." But to the biologist, the brain is not a thinking machine, it is an *acting* machine; it gets information and then it does something about it.

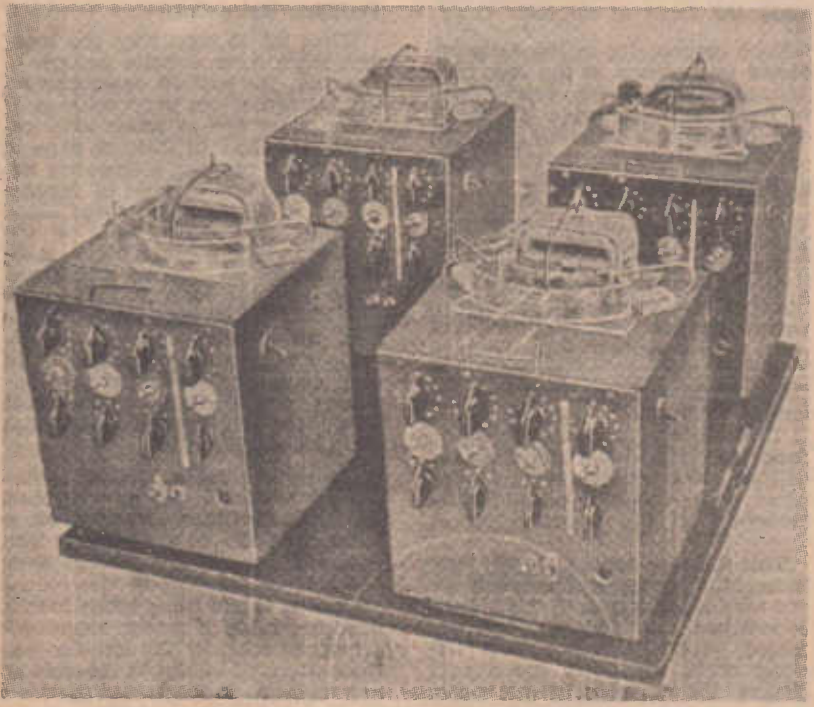


Fig. 1. The Homeostat, with its four units, each one of which reacts on all the others.

Like every other organ in the animal body, it is a means to survival.

This last property decides its fundamental mode of construction; it must have certain permanent goals —the essential conditions for its existence—and it must be able to attain them in a variety of circumstances. If one path to the goals is blocked it must find another. If the circumstances change, it must readjust its methods. The brain of an insect has available a few perfected inborn patterns of behavior. It will try them in turn, succeeding if the circumstances are of a standard type.

The brain of a mammal is of more interest to us, for it has a diffuse ability to puzzle out some sort of adaptation to an indefinitely large variety of circumstances. Man is himself the outstanding example of the potentialities inherent in this subtle mechanism.

Negative Feed Back Required

The ability of the brain to look after itself by correcting all deviations from a central, optimal state, and particularly its ability to do so by a variety of methods, being flexible about the route but unchanging in its aim, was usually regarded as quite beyond the powers of any machine, but it has been known since 1940 (1-2) that machines of the more dynamic type can do this quite easily. All that is needed for this goal-seeking flexibility is that the system should have negative feed-back.

When there is no feedback, as when a door-bell button is pressed and the bell rings, there is neither sense nor nonsense — it does just what its present state of repair or disrepair enforces. But when a radar-controlled anti-aircraft gun receives impulses both from the target plane and from its own shells, and is affected by the distance between the two so that it tends to make the distance between the two zero, then such a system has negative feed-back and is "goal-seeking." The important point here is that *the property of being "goal-seeking" is not that of life or mind but of negative feedback,* and any machine, however, inanimate, which has negative feedback will show this feature.

Self-organising Machines

But this does not complete the requirements. Thus, if the gun-radar - plane system had *positive* feedback it would tend to make the distance between shell and plane a maximum and would therefore seem to be trying to get its shells as far away from the plane as possible. Clearly, the introduction into a system of feedback in general does not solve the problem; for if without feedback the gun will aim anywhere, yet even with the feedback it may either seek the target or it may positively avoid it. What is to ensure that the feedback has the correct sign?

In the gun radar-plane system the problem is easily settled; the designer carefully arranged the construction so that the feedback was negative. In the brain of an insect, all variations born with wrong feedbacks were eliminated by natural selection ages ago. But in the higher animals the position is different. Large numbers of the feedbacks are left at first undecided, since it is experience and not the inborn (genetic) characters which are to determine the feedbacks. Thus, a cat may have to learn to go towards red meat (negative feedback), but to go away from red embers (positive feedback).

That a kitten's initial feedbacks are rather chaotic is shown by the way in which it may shrink away from a saucer of milk and then run towards a red-hot fire. Yet we know from experience that day by day the kitten's feedbacks change, always improving, and tending to those values, positive and negative, which ensure the animal's survival. The problem of the mammalian brain, then, is that as a machine *it has to work out an essential part of its own wiring.*

The Homeostat

Such ability to learn and to adapt by internal re-organisation was regarded as a great mystery, but the principles are now better understood.[3] To demonstrate them and to show that these principles do, in fact, produce such behavior, a machine has been constructed and has recently been demonstrated.[4]

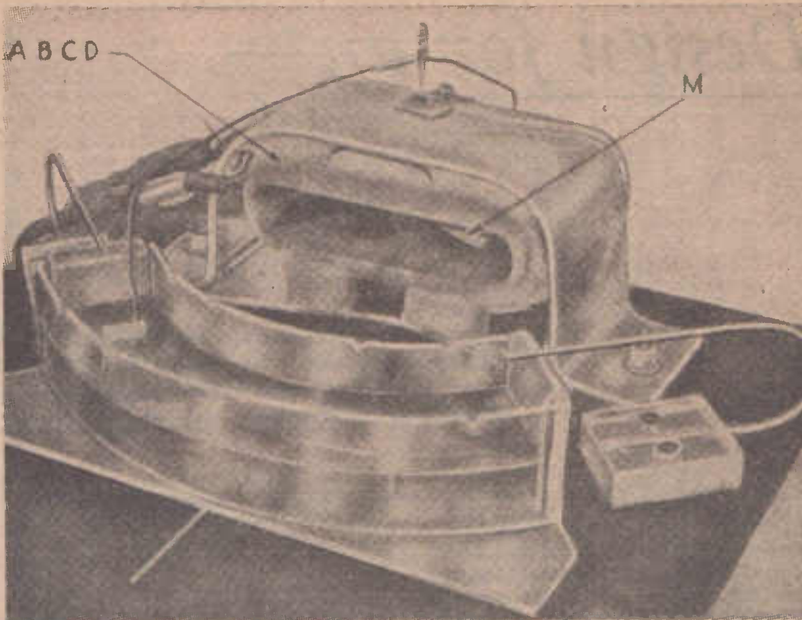


Fig. 2. Quadruple coil ABCD encircles magnet M which is suspended by the needle pivot. The suspending wire extends forward on its end into the water in the semi-circular plastic trough which has electrodes at each end. Potential for grid is taken from the pivot socket.

The homeostat consists of units, four of which are shown in Fig. 1. Each carries on top a suspended magnet, shown in Fig. 2 and the behavior of these four magnets provides the focus of interest.

Each magnet (M in Fig. 3) is affected by currents in the four coils around it, the currents coming partly from the other units (A, B, C) and partly as a self-feedback (D). (The apparently single coil of Fig. 2 is composed of the four coils of Fig. 3). In front of each magnet is a trough of water with electrodes at each end at—2v and—15v respectively. The magnet is suspended on a needle pivot by a wire sling which dips into the water and picks up a potential which depends at each moment on the position of the magnet. The potential goes to the grid of a triode and thus controls the d.c. output of the unit. (The resistor E is first adjusted so that when the magnet is central the unit has zero output). This output goes to the other units in series where it becomes one of their inputs.

This arrangement sets all four units into action and reaction on one another. As soon as the system is switched on the magnets are moved by the currents from the other units, but these movements change the currents, which cause fresh movements, and so on.

These actions and reactions can be modified by various constant settings. Thus, the current form, say, unit 4 to unit 2, can be controlled as to its polarity of entry into the coil by X (Fig. 3). In addition, the potentiometer P decides what fraction of the input current actually goes through the coil. These controls can be hand set by the upper two rows on the front panels.

Pattern Behaviour

When set in some way, the magnets show some definite pattern of behavior, the pattern depending on the pattern of the hand settings. If these latter give a stable arrangement then the four magnets move to the central position where they actively resist any attempt to displace them. If displaced, a co-ordinated activity brings them back to the centre, rather as an animal positively seeks its optimal conditions. Other seetings may, however, give instability in which case a "runaway" occurs and the magnets diverge away from the centres. In such cases the feedbacks are producing "vicious circles" which would be driving the animal away from its optimal conditions.

But the feedbacks, instead of being set by hand, can be controlled by similar wirings arranged on a uniselector (V) in each unit. The values chosen for the wirings were deliberately randomised the actual numerical values being taken from a published table of randon numbers.[5] When controlled by the uniselectors, the pattern of feedbacks depends at any moment on the values provided by the uniselectors at that time.

Twenty-five positions on each of four uniselectors means that 390,625 combinations of feedback patterns are available.

Finally, in each unit the uniselector moves to a new position when and only when the output current of that unit exceeds the value sufficient to close the relay (F), the latter energising the coils (G) of the uniselector.

When the control is diverted by the switches S-S so that not the hand controls but the uniselectors determine the settings, then a new feature emerges in the behavior of the system. As before, the units start acting on one another, but the uniselector settings change whenever the system is unstable, i.e., whenever the magnets diverge far from the central position. In other words the machine starts to hunt for a combination of uniselector settings giving a stable system, i.e., giving the proper internal feedbacks. When it finds a combination with the right feedbacks it holds that combination and will then demonstrate that it has assembled that feedback system which results in a co-ordinated maintenance of its variables at optimal values, like a living thing. The important point is that it finds its own arrangement of feedbacks, the designer having merely provided it with plenty of variety.

"Environment" Control

Not only will it find the appropriate feedback initially but if we alter the basic conditions in any way it will proceed to re-adapt itself to the new conditions. Thus, we may use hand controls on the two of the units, setting them at arbitrary values to represent some "environment" to which the other two units, representing "nervous system," must adapt, i.e., find combinations of their two uniselectors settings which, in relation to that particular "environment" forms a stable system. When the machine is switched on, it proceeds, as described above, to find such an adaptation. But if now we alter the hand settings, i.e., change the "environment" to which the other two units are adapted, then the machine promptly abandons those unselector combinations and hunts for new ones which will restore adaptation to the new environment. If now we change the hand-setting again, a new appropriate combination will again be found. And this process can be repeated as often as we please.

But the homeostat will adapt not only to random changes in hand settings but to *any* change in the dynamic nature of the machine, whether of a type originally intended or not. Here, for instance, are some alterations suggested by my colleagues who have tried to confuse it. After it had found a stable combination we reversed the polarity of the connection of an output to an input; it promptly changed its uniselector settings till it found a new combination of settings which was stable in conjunction with the new conditions. We reversed the polarity of a trough, thereby changing some of its feedbacks; it changed its uniselector settings till it found a new combination of settings stable *in conjunction with the new conditions.* A magnet was reversed; it readapted to the new condition. Bars were placed across the troughs so that the magnets could swing only to one side: it readapted. We joined two of the magnets together with a light glass fibre so that they had to move together; it readapted.

In all cases, whatever conditions were imposed, it rearranged its own wiring through the uniselectors until it developed the proper feedbacks in relation to the new conditions.

Is the homeostat a brain then? Hardly, for it is as yet too larval. But it uses a new principle and can easily be extended to give much more powerful developments. Its chief fault in its present form, with only four units, is that it has little room to accumulate new adaptations, but, if it has to adapt to a new environment, must obliterate its established adaptations to make room for the new. This, of course, is a serious handicap, just as a child would be handicapped at school if it could learn what was two times three only by losing its memory of what was two times two. The difficulty, however, is a minor one and could be overcome by a mere increase in the number of units together with some minor alterations.

The making of a synthetic brain requires now little more than time and labor. But there is one point on which we must be quite clear: a proper synthetic brain must develop *its own* cleverness—it must not be a mere parrot. No matter how dazzling the performance, we must always ask how much of the performance has been enforced in detail by the designer and how much is contributed by the machine itself.

Typical Example

Let us suppose that two machines have been developed to the point where they can actually play chess. First we consider an electronic computer of the ACE or ENIAC type.[6,7] Instructions may be fed into it so that it will make only legal moves, but this is insufficient—a random series of legal moves will not win games. The machine may have great powers of analysis, but unless this ends in a demonstrated mate, the analysis must stop at a judgment. (I assume that chess, like living, cannot always be analysed out completely).

If the designer supplies it with criteria for judging whether positions are to be aimed at or avoided, then the criteria must be decided by the designer. This being so, such a machine *if perfect*, will produce chess based on a strategy as good as its designer's but *no better*.

The second feature of such a system is that its thousandth game will be no better than its first.

The third feature is that every part has an exact duty set by the designer, who can say at any moment whether it is or is not working in accordance with his design and instructions. In short, it is a slave-brain.

The other type of machine, the homeostat, is based on quite a different principle. It needs no detailed instructions, only some method by which it is informed of the occurrence of illegal moves and mates. How the machine is to avoid these undesirable informations (feedbacks) is left entirely to the machine to puzzle out for itself. (The adaptations already shown by the homeostat encourage the confidence that with only minor developments the machine will succeed).

Let us suppose the homeostat perfected and contrast its behavior with that of the first machine. The homeostat would start off like any other player — simply by making more or less random movements.

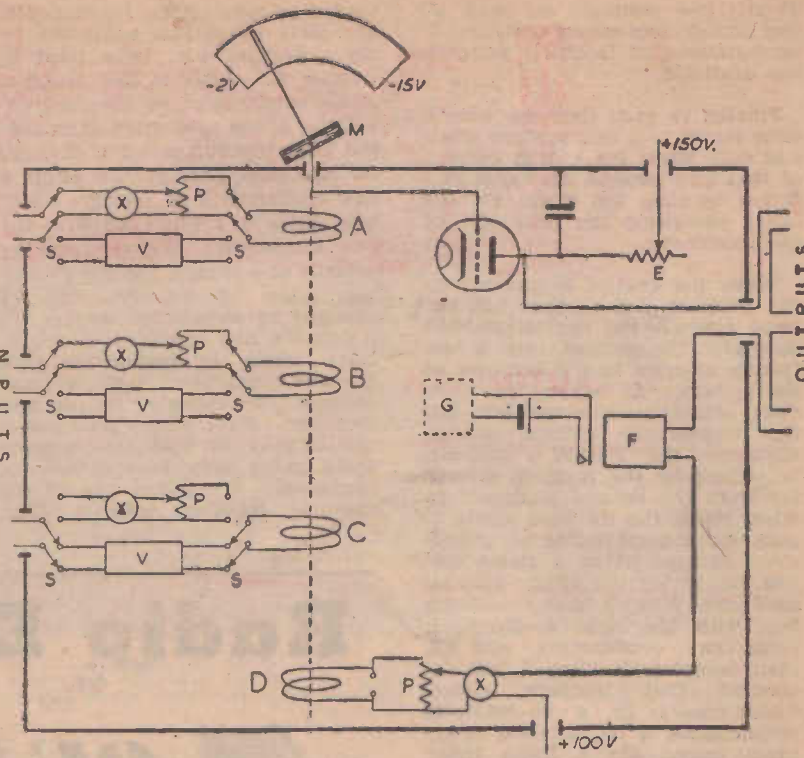


Fig. 3. Diagram of one unit, the others being replicas. The inputs come from and the outputs go to the other three units.

But the feedback would soon stop it making illegal movements, and it would tend steadily to avoid the moves that lead to a rapid loss of the game. But it must be admitted that its first games would be very bad—as bad, in fact, as the first games of any future world champion. But the homeostat would tend steadily to shed bad moves. Lines of play would be developed or dropped simply according to whether they did or did not lead to a win.

These improvements would be in no way dependent upon the particular details provided by the designer: they would be developed by the machine out of the indiscriminate variety provided, the feedback being the dominating and controlling factor. Consequently, such a machine, *if perfect,* could eventually play with a subtlety and depth of strategy *beyond that of the man who designed it.*

The aim of some has been to produce the perfect slave-brain. Though undoubtedly useful for some purposes, yet we must not lose sight of our objective: a synthetic brain should not only play chess, but should eventually beat its own designer.

This prospect is now in view.

And the Future?

And what after that? Some facts seem clear even at this distance.

The construction of a machine which would react successfully to situations more complex than can be handled at present by the human brain would transform many of our present difficulties and perplexities. Such a machine might be used, in the distant future, not merely to get a quick answer to a difficult question but to explore regions of intellectual subtlety and complexity at present beyond the human powers.

The world's political and economic problems, for instance, seem sometimes to involve complexities beyond even the experts. Such a machine might perhaps be fed with vast tables of statistics, with volumes of scientific facts and other data, so that after a time it might emit as output a vast and intricate set of instructions, rather meaningless to those who had to obey them, yet leading, in fact, to a gradual resolving of the political and economical difficulties by its understanding and use of principles and natural laws which are to us yet obscure.

The advantages of such a machine are obvious. But what of its disadvantages? There are at least two.

(Continued on page 46.)

INTERNATIONAL RADIO DIGEST

A TECHNICAL SURVEY OF LATEST OVERSEAS DEVELOPMENTS

INTELEX—AUTOMATIC RESERVATION SYSTEM

Recently a public demonstration was given of Intelex—an automatic reservations system specially designed for handling seat reservations, etc., for railways, airlines, bus companies and steamship lines.

Basically the system may be compared with the modern dial telephone switching system. It is designed to permit direct interrogation of the reservation mechanism by standard teleprinter from any ticket office, local or distant, and will report within a matter of seconds whether the reservation has been made, or if unavailable, what the best substitute may be. No human intervention occurs between the time the order is typed on the teleprinter keyboard in the ticket office and the reply is received on the same machine.

The system consists of a central machine, and a number of subsidiary offices which feed information and inquiries by teleprinter into the computing mechanism or "mechanical brain." When a teleprinter operator types out the reservation request, a series of electrical impulses are transmitted over the wires to the Intelex unit, which with lightning speed sorts through the available space. If the space requested is available, the brain automatically confirms the fact and relays the information by teleprinter to the originating office.

Speedy Action

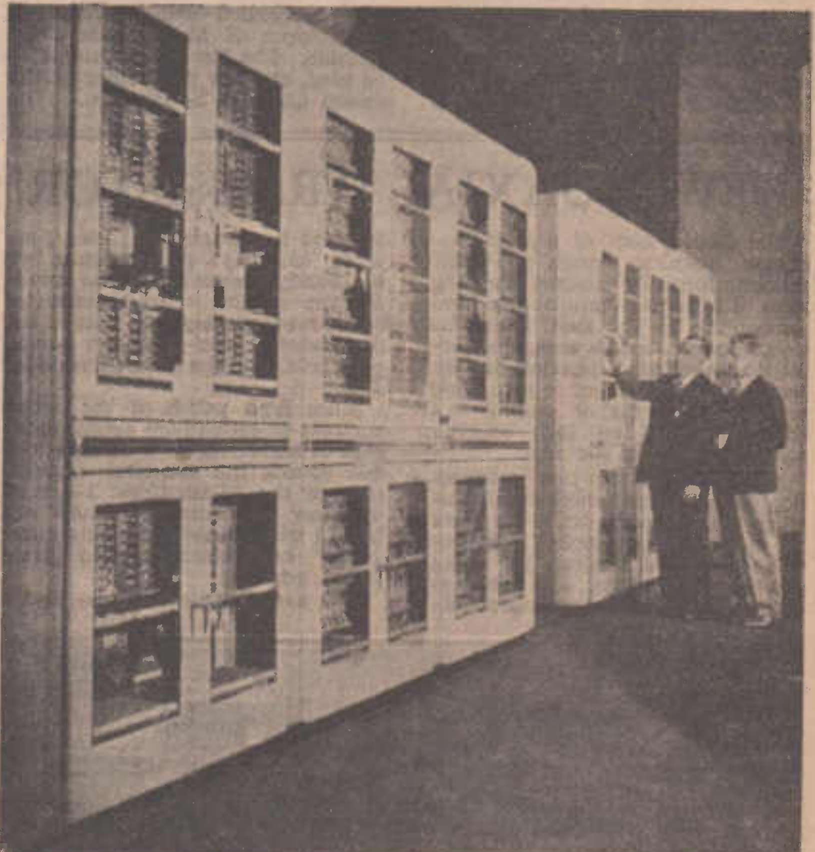
The ability of Intelex to translate a request for a reservation into a definite answer is uncanny. If the space asked for is available, the machine advances its storage record for the number of seats requested and answers by repeating the message and adding a serial number. This serial number indicates that the space requested has been confirmed; it also provides a means of reference should the need for future inquiry arise. In a request of this type, confirmation can be obtained in less than 20 seconds.

Absolute Reliability

To ensure accuracy and reliability of operation, the designers of the new system have employed only standard components which have been thoroughly tested by many years of use in other applications. Relays have double contacts so that failure in any one contact will not disrupt the operation of the machine. Power supplies also have been doubled.

Inspection is regular, and faulty components can be replaced as easily as an electric light bulb. If, in spite of all these precautions, power failure should halt operations, the machine is so constructed that all markers will remain in the last position and the stored information is kept intact. Further, monitor printers record all transactions of Intelex, thereby providing a printed record which may be examined manually, if necessary.

—Courtesy International Review



The "mechanical brain" of the Intelex system, which sorts the available space with lightning speed. If the space is available the "brain" automatically confirms the fact and relays the information by teleprinter to the originating office.

"Electrontype" Speeds Messages

"Charactron"—new type cathode ray tube, can reproduce printed messages at a million words per minute rate.

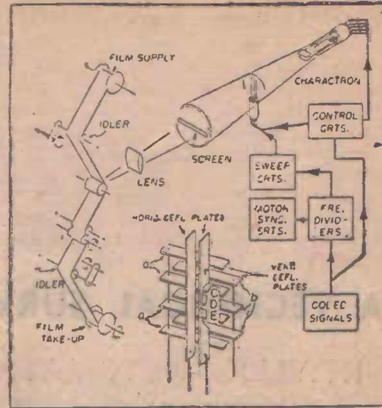
An ultra-high-speed electronic unit for use in the transfer of messages and data has reached the development stage and is expected to replace many current methods of sending and recording printed material. Equipment can be designed to produce messages in printed form at the rate of one million words per minute, according to its designer.

Operating Principles

The operating principles of one type of Charactron can be represented as a type of cathode ray tube equipped with means by which the ray is converted into shapes of predetermined characters, by a character-shadowing disc in the path of the beam. The cross section of the electron beam conforms to shapes of aperture configurations in this disc when directed through the individual openings. Electron shadows of these characters can then be selectively focused on fluorescent viewing screens.

The individual character openings in the disc, arranged vertically in a line, each have respective shapes and quantity depending on the intended application. Any character is selected for presentation by means of a voltage applied to a pair of selector plates. After the beam is directed through an opening in the disc, its cross section will be representative of a message character, which by the H. and V. deflection plates can be directed to any part of the screen.

In the enlarged portion of the deflector assembly shown, characters "C, D and E" represent typical openings in the shadow disc. Each vertical plate is common to two individual characters, while the horizontal plates are common to all characters. Thus a series of input signal potentials will produce lines of information on the viewing screen. Such a screen, 8-in. in diameter, could accommodate 60 or more lines, or approximately 150 words. Presentations of this type are intended for either projection on larger screens or for recording purposes but increasing the size of characters (and reducing the lines) permits messages to be read directly from the fluorescent screen. The application will determine if other types of displays are more suitable. The size of characters to be used, and the persistence of the screen can also be modified.



One version of a complete electrontype recorded which displays single line of symbols with space provisions for 70 symbols per line.

70 Symbols per Line

One version of a complete Electrontype recorder is shown which displays a single line of symbols, with space provisions for 70 per line. A short persistence fluorescent screen is provided 7½-in. in length and 3/16-in. in height.

Provisions within the tube allow for a selection from 40 different characters the letters of the alphabet, digits 1 to 9, and various punctuation marks. Introducing other characters does not necessarily present a problem. Several hundred may be incorporated in a tube, and it is not necessary that they be arranged in a single straight line as indicated. Viewing the apertures in the shadowing disc from the face of the present tube, they are lined up at right angles to the rectangular-shaped screen.

Other major units of the complete recorder include: servo-controlled film supply and film take-up mechanisms, film synchronising circuits and control mechanisms, lens system, input selector and sweep control circuits and the usual power supplies.

Information is taken from the coded signals unit and coupled to control circuits and frequency divider units. The coded signals unit can represent a data memory device, or a radio receiver of coded intelligence. Output from control circuits is coupled to selector plates and vertical deflection plates. Signals from frequency dividers are coupled to sweep circuits and motor synchronising circuits. Potentials from the sweep circuits control the start and completion of each line in accordance with the rate of received characters.

With 70 exposures per line, when using 35-mm film, it is possible to expose 10,000 characters on 150 mm of film. At input signal speeds of 20,000 characters per second, for instance, the film will only be travelling through the printer at approximately 300 mm per second.

—Courtesy Tele-Tech.

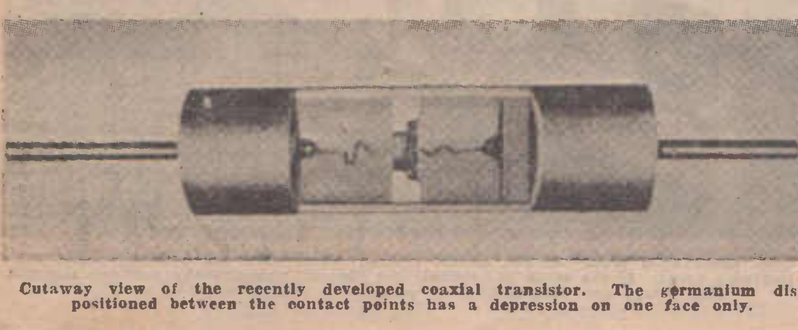
NEW COAXIAL TRANSISTOR

The development of a semi-conductor amplifier using two point contacts pressing against opposite sides of a germanium disc has been announced by the Bell Telephone Laboratories. In this case, the germanium disc has a spherical depression ground into either or both faces to give a spacing of only a few thousandths of an inch between coaxially mounted contacts.

Advantages of this new construction are improved mechanical stability of the points since they rest in depressions, complete electrostatic shielding between the input and output circuits, and elimination of the constructional problems involved in placing two spring contacts side by side within a few thousandths of an inch. The amplification of this coaxial transistor compares favorably with that of the conventional semi-conductor having both points on the same germanium face.*

Since high polish of the active surfaces of germanium permits passage of higher currents before burnout occurs, the spherical depressions in the 20-mil-thick, 1-8 inch diameter germanium blanks are lapped with diamond lapping compound and electropolished after initial grinding.

* See RADIO SCIENCE, October, 1948.



Cutaway view of the recently developed coaxial transistor. The germanium disc positioned between the contact points has a depression on one face only.

Surgical Operation Televised In Europe

For the first time in Europe a surgical operation has been televised. At the hospital at Leiden, Holland, recently, a television camera in the operating theatre followed a complete surgical operation which was viewed by an audience of 200 medical practitioners and students in the lecture hall in another wing of the hospital.

Philips, Holland, who supplied the equipment and undertook the technical arrangements for this demonstration, used two viewing screens 4ft. 10in. x 3ft. 3in. Newspaper and university representatives who witnessed the screening acclaim the quality and value of this television demonstration which made European history and which showed beyond all doubt the enormous possibilities of television as an aid to medical training.

A general view of the operating theatre. The operation was televised to an audience of 200 medical practitioners and students who were able to closely follow every detail of the operation.
—Photograph courtesy Philips Industries

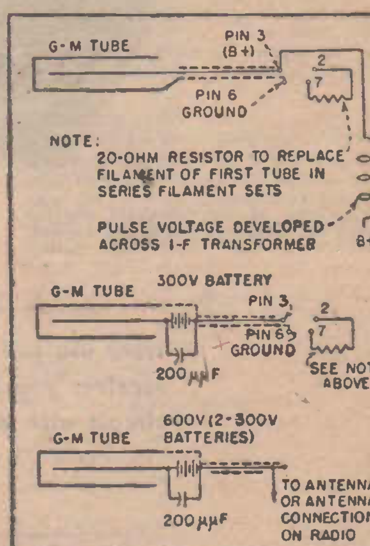
NUCLEAR INDICATOR

In a recent issue of Electronics details are given of a method of connecting a self-quenching Geiger-Mueller tube to a standard broadcast receiver to form an indicator of nuclear radiation. The practical value of this scheme is that in the event of a national emergency it provides a readily procurable detector of radioactivity. As most homes have at least one receiver all they would need would be the G-M tube and possibly the battery.

The diagram shows the method of connecting the tube into a typical receiver. This G-M tube responds to beta or gamma rays of radioactive elements or fission products, producing clicks or thumps in the loud speaker in proportion to the density of the radioactivity.

The impulse delivered to the r-f section of the radio by the self-quenching G-M tube shock excites the resonant circuits in the front end, producing a damped wave that makes a click in the loud speaker. The rapidity of clicks increases as one approaches a radio-active area. Of the connections shown, the third would probably be the easiest to make to the receiver, since it would not require an adapter on the tube socket.

To determine whether the equipment is operating or not, simply hold a radium treated watch dial near the G-M tube, as this will emit sufficient radiation to operate the tube.



These three circuits indicate how the Geiger-Mueller tube can be connected to any existing radio receiver to provide a convenient means of checking on radio-active areas.

Ultrasonic "Stethoscope"

An ultrasonic *"stethoscope"* which will enable engineers to examine solid pieces of steel by means of sound waves and thus assure flawless quality has been devised by the Westinghouse Electric Corporation.

By means of this new technique, ultra-high frequency sound waves are transmitted through massive steel parts. Electrical impulses are changed into sound waves and when projected through the metal reveal tiny cracks, cavities or foreign particles. They reflect sound back to the crystal and on being converted into electrical impulses, these reflections appear as bright vertical lines on the viewing screen of an electronic receiver.

This new testing process is called *"ultrasonic"* instead of *"supersonic"* because the word *"supersonic"* refers to speed faster than sound, whereas *"ultrasonic"* refers to sound waves beyond the range of hearing.

Color-Blind Camera-Tubes

It still seems impossible to determine the color-sensitivity of camera tubes in advance of manufacture, and so scarce and precious are these tubes that every one made must be put to and kept in use. One television studio had a camera sensitive to blue, another sensitive to red. When a basketball game was being screened in which one side wore blue pants, the other red, the teams suddenly seemed to switch sides every time a camera cut-over was made!

"Bifocal Radar"

A commercial radar set with two viewing screens, which give the ability to see near and distant objects at the same time, has been developed in U.S.A. Designed for the narrow channels and harbors of the Great Lakes as well as the open ocean, the new set has seven-inch and twelve-inch scopes.

The former gives a radar picture with a two-mile radius at all times and is called a *"safety"* scope. The larger screen, known as the *"working"* scope, is adjustable to one-half, one, three, eight 20, or 40 miles.

BUILD IT YOURSELF ! ! —

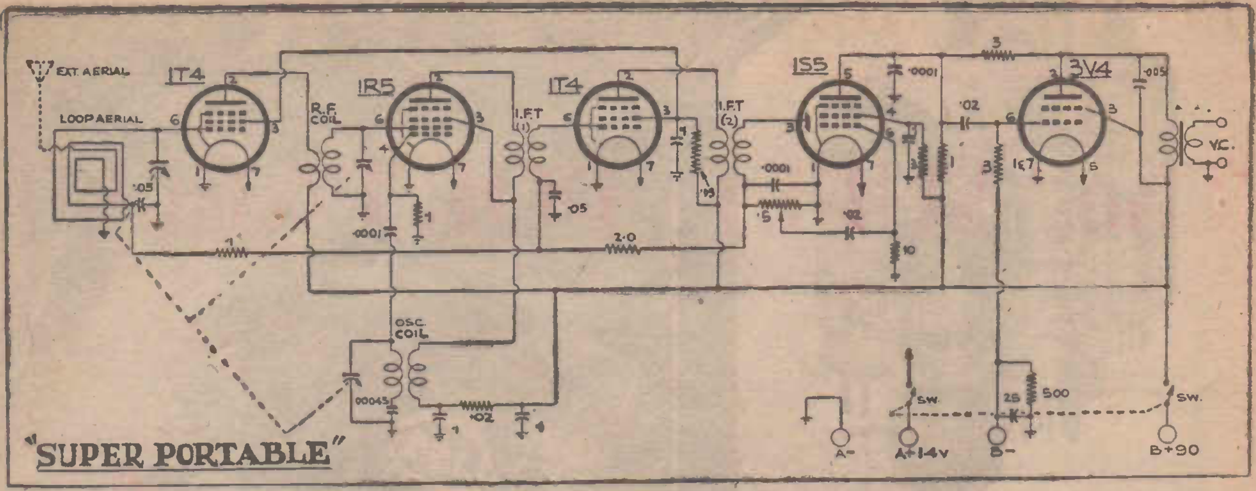
The "SUPER PORTABLE"

A front view of the completed receiver showing the attractive leatherette cabinet.

Here are full constructional details of the type of portable receiver you have been waiting for. Featuring a superhet. circuit with an RF stage, this five valve receiver is capable of a really excellent performance.

Although portable receivers are usually associated with the advent of the spring and summer months, we think this description of a high performance portable receiver will be of great interest to many readers. Since the description of our "Countryman's Five" battery receiver, there has been a demand for a portable set based on the lines of this circuit. In view of this, it had been intended to present such a receiver in the January issue, but at that time it was finally shelved in favor of the "Porta-Gram"—the battery-operated radio-gramophone combination. However, as readers have still been asking for the portable design, here is our idea of a first-class battery portable, which we think you will find is more than comparable to the average receiver, both in appearance and design.

This compact five valve receiver is housed in an attractive leatherette cabinet, having a separate compartment for the batteries immediately below the chassis shelf. To enable the home constructor to readily duplicate this model, a standard type of cabinet, now available from some of the radio stores, has been used. This measures 13 x 11



The circuit follows standard practice and should present little difficulty to the average constructor. A small amount of negative feedback is provided by means of the 3 meg resistor from the 3V4 plate to the 1S5 plate, and this reduces the harmonic distortion without greatly affecting the overall gain. The numerals around each valve diagram indicate the appropriate socket connections.

x 6½ overall, which will be found is a convenient carrying size.

The overall performance of the receiver is quite high, and in one of the suburban areas there was no difficulty in receiving all local as well as stations such as 2WL, Wollongong, and 2KA, Katoomba, at excellent volume during daylight hours. During the evening it is possible to tune in most country stations as well as many of the interstate stations using the loop aerial only. The addition of a short length of wire to the external aerial terminal will enable the weak or borderline stations to be received at good volume. This performance is in no small measure due to the addition of the r-f stage, as this ensures high sensitivity as well as providing an improved signal to noise ratio.

So much then for the general consideration of the design.

Circuit Details

Reference to the schematic diagram will show that for all practicable purposes, the circuit used is identical with that of the "Porta-Gram" described in the January, 1949, issue. The r-f and i-f valves are 1T4's, the converter a 1R5, combined detector AVC, and audio amplifier a 1S5, and a 3V4 for the power output valve. This arrangement follows standard practice and provides the constructor with a simple but reliable circuit. In the interests of simplicity, the pickup terminals and associate switching to cut out the r-f section and which were a feature of the earlier receiver, have now been omitted.

Although the operation of this circuit was detailed in the January issue, some of the main considerations will be briefly mentioned for the benefit of those who may not be able to refer to the issue in question.

As pointed out previously, one of the major considerations with battery-operated equipment is to keep the total current drain to some economical operating value. For instance, if the valves used in this receiver were operated under the ratings listed in the valve data handbooks, it would be found that the total receiver current would work out well in excess of 20 ma—a figure which would quickly ruin the portable type of battery. As a result it is necessary in practice to arrange a compromise on the current drain in such a manner that the overall performance of the receiver is not unduly affected.

Reduced Current Drain

This can be brought about in any of several ways, and in this receiver it will be seen that the two 1T4 screens and the 1R5 plate and screen voltages are lower than usual, whilst the output valve has been slightly overbiassed. This arrangement gives a maximum current drain of slightly under the 12 ma—a reasonable figure for this type of receiver, and yet providing ample sensitivity and power output for most needs. However, in cases where more output is required the bias voltage on the output stage can be reduced, at the same time decreasing the r-f section voltages, whilst if maximum range (sensitivity) is desired, then the output stage can be overbiassed, with the r-f section operating under maximum conditions. This is a point for the individual constructor to decide, depending on the use of the receiver.

The two 1T4 screens are connected together, with the necessary voltage being obtained by the use of the .03 meg dropping resistor. The screen of the 1R5 is connected to the B plus lead of the first i-f-t,

PARTS LIST

1 Chassis 12 x 5 x 1¾
1 Cabinet
1 3 gang tuning condenser (midget)
1 Tuning dial SLV21
1 Loop aerial
1 R-F, 1-Osc. Coil
2 I.F.T.'s 455 kc

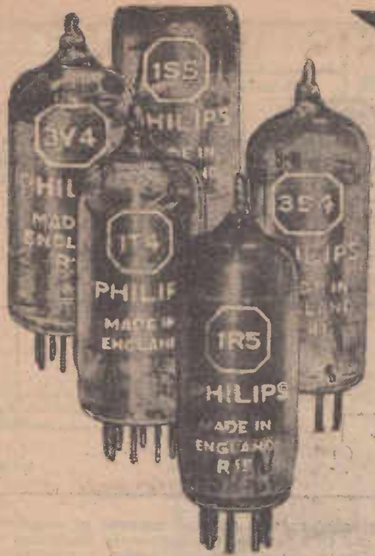
CONDENSERS

1 25 mfd Electrolytic
4 .1 mfd tubular
3 .05 mfd tubular
1 .02 mfd tubular
1 .005 mfd mica
3 .0001 mfd mica
1 .00045 mfd mica

RESISTORS

1 10 meg ½ watt
3 3 meg ½ watt
1 2 meg ½ watt
1 1 meg ½ watt
2 .1 meg ½ watt
1 .03 meg ½ watt
1 .02 meg ½ watt
1 500 ohm ½ watt
1 .5 meg potentiometer with DPDT switch

VALVES: 2-1T4; 1-1R5; 1-1S5; 1-3V4.
BATTERIES: 1-1.4 volt "A"; 2-45 volt "B."
SPEAKER: 7-inch Amplion permag. matched to output valve.
SUNDRIES: 5 valve shields, complete with sockets, 2 knobs 3 air trimmers, hookup wire, braided wire, nuts and bolts, etc.



little fellows with a BIG FUTURE

These Philips miniatures are small in size but really **big** in performance. Miniaturisation is the modern trend in valve technique. It's the answer to compact design, circuit flexibility and generally streamlined amateur gear.

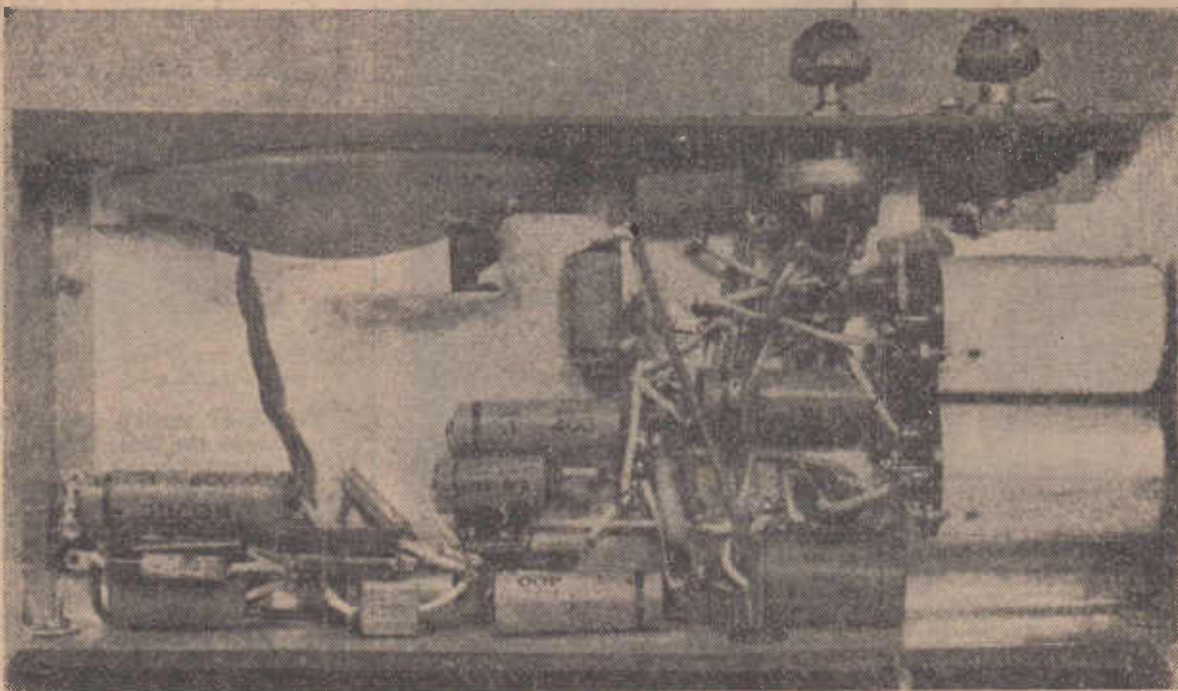
The range of Philips miniature 1.4 volt battery valves includes the 1R5 Pentagrid Converter, the 1T4 Radio Frequency Amplifier Pentode, the 1S5 Diode Audio Frequency Amplifier Pentode and a choice of two Output Pentodes, types 3S4 and 3V4; the 3S4 for either 67.5 or 90 volt operation and the 3V4 for 90 volt operation.

PHILIPS ELECTRICAL INDUSTRIES OF AUSTRALIA PTY. LTD.

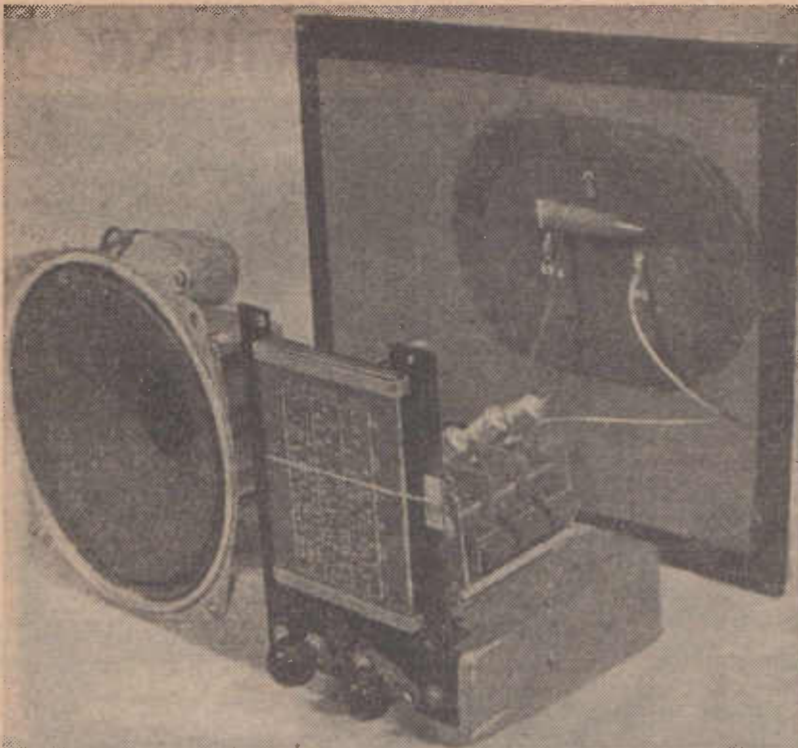
Sydney • Melbourne • Brisbane • Adelaide • Perth

V16B-48.

VIEW OF UNDER CHASSIS WIRING



By grouping the various components around the respective valve socket an efficient layout will result as shown in this underneath chassis view.



Another view of the receiver showing the loop aerial installation. The leads from the loop should be left sufficiently long to enable the back cover to be removed without difficulty. The use of the seven-inch permagnetic speaker ensures better than average tonal reproduction.

which is in turn connected to the H.T. line through the oscillator coil and the .02 meg resistor. These connections are quite standard, although the resistor valves specified are slightly higher than normal, so as to provide more economical operation.

Second Detector

The 1S5 is used as a combination diode detector and first audio amplifier, and the connections here call for a little comment. It should be noted that this valve contains a single diode, and consequently only a simple series AVC arrangement is possible. The control voltage is obtained from the DC voltage drop across the diode load resistor, and this is applied to the i-f and r-f stages only. This leaves the converter stage uncontrolled, thus permitting it to operate at maximum sensitivity at all times.

The diode load consists of a .5 meg potentiometer, which is used as the audio volume control. The output is taken via the centre moving arm through the .02 mfd condenser to the grid of the 1S5. The values chosen for the pentode audio amplifier section are those recommended by the valve manufacturers and will provide maximum gain from the circuit. The bias for this valve is obtained from the 10 meg resistor connected from the grid to earth.

The output stage is a 3V4, and this is operated under slightly overbiassed conditions. A back bias system is provided by means of the 500 ohm resistor connected from the B minus lead to earth. The grid of the 3V4 is connected to the B minus lead through a 3 meg resistor.

As a tone control has not been provided in this circuit, it will be seen that a small amount of negative feedback is obtained by connecting a 3 meg resistor from the plate of the 3V4 to the 1S5 plate. This will be found quite effective in reducing the harmonic distortion, especially noticeable with this valve, to a low figure, and yet the gain is not unduly reduced.

Constructional Details

The receiver has been built up on a chassis measuring 12 x 5 x 1¾ inches, and the location of most components can be seen by referring to the various photographs and chassis layout drawing. The vertical dial—an SLV 21—is mounted on the extreme right-hand side of the chassis with the miniature three-gang Roblan condenser immediately behind. It will be necessary to fit two small aluminium brackets on this condenser so that it can be bolted direct to the chassis.

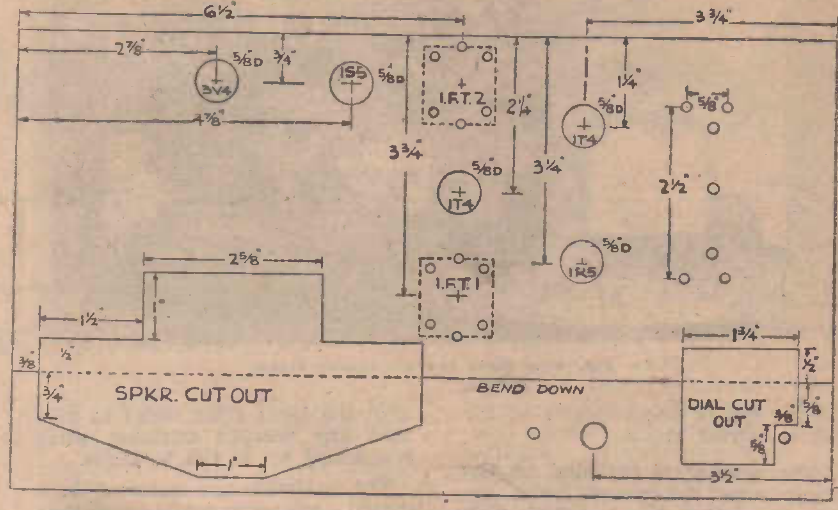
When the dial is fitted, the screw holding the dial drum in position should be removed so that this drum can be slipped down on to the condenser spindle. A small bushing should be fitted on the condenser shaft to ensure a tight fit, otherwise the drum will tend to twist as the set screw is tightened up, and make the dial difficult to operate.

Mounting Coils

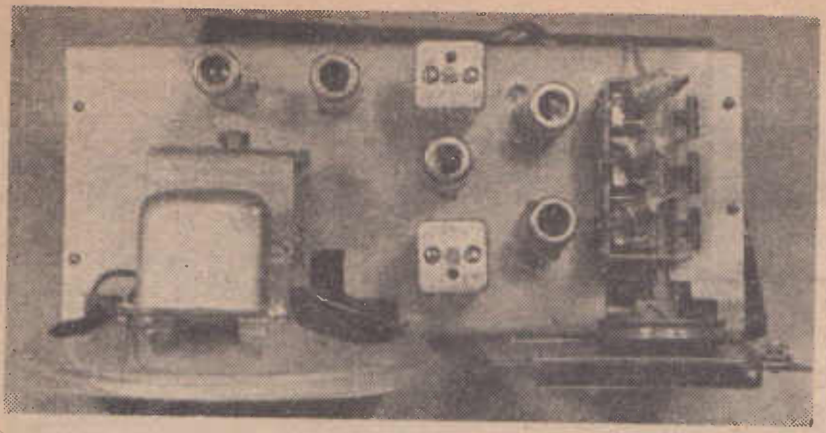
The r-f and oscillator coils are mounted under the chassis, immediately below the gang condenser, and these are bolted to the side of the chassis. In cases where coils are used not having a mounting bolt on the top of the can, it will be necessary to drill a hole and fit an ordinary 3/8-inch brass bolt for this purpose. The 1T4 r-f amplifier and 1R5 converter are mounted alongside the tuning condenser, an arrangement which permits short direct connections to the respective coils below the chassis.

Immediately alongside the 1R5 at the front of the chassis is the first i-f-t, followed by the 1T4 i-f amplifier. Then along the back of the chassis are mounted the second i-f-t, 1S5 and 3V4 output valve. This logical arrangement permits all components to be grouped around the respective valve sockets, thus permitting short leads. It will be noted that all valves are fitted with special shield cans, designed for the miniature type valves. Whilst these are not essential from the stability point of view, they are particularly useful in holding the valves securely in position, and prevent any likelihood of them becoming loose and

Chassis Layout Details



This chassis diagram will be of assistance to those who prefer to make their own chassis. The layout shown will enable short direct connections to be made to all components.



This view shows the top chassis layout.

falling out of their sockets as the set is carried around.

The speaker is mounted on the front edge, the cutout being arranged so that this fits flush with the edge of the chassis. As the vertical type dial used decided the height of the cabinet, it was found that a larger than usual speaker could be used.

7" Speaker Used

The speaker fitted on this receiver is the new Amplion 7-inch permagnetic speaker and the use of this larger speaker will provide increased sensitivity and tonal qualities better than that usually found in the average portable. When the chassis is fitted in place, it will be seen that the speaker fits flush against the front cabinet, thus obviating the necessity for any additional baffling around it. A screw through the top mounting holes will hold the speaker and chassis firmly in place.

The volume control is fitted through the end blank dial spindle hole, being held in position with the usual nut and lock washer. The control is one of the new miniature types having a double switch fitted. This enables the "A" and "B" battery leads to be broken when the set is switched off, obviating any possible "B" current leakage as could occur when only the "A" lead is broken. The leads from the batteries are brought in through the back of the chassis, with the leads color coded to prevent any possible mistakes when connecting up to the batteries.

The batteries are mounted in a special compartment immediately below the chassis shelf. Two 45 volt Minimax "B" batteries and a 1.4 volt "A" battery are required. The 45 volt batteries are connected in series—that is the minus lead from one, connecting to the positive terminal of the second battery—to provide the necessary 90 volts high tension.

Fitting Loop Aerial

The loop aerial is screwed on the back lid of the cabinet, being placed near the top, so as to minimise interaction with the metal chassis. This will be found suitable for all normal listening, but in the case of weaker stations it may be advantageous to open the back, swinging the lid clear of the chassis. For this reason the back should be fitted with hinges, leaving the leads to the set sufficiently long to enable this to be opened as desired.

An external aerial connection is provided, and this terminal should be fitted on the cabinet back with the necessary lead soldered before screwing the loop in place. Connections from the loop to the receiver are: one lead to the aerial gang section (rear one), and a lead to the AVC line. Make sure trimmers are fitted across each gang section, to enable the circuits to be aligned. In our case we used the air trimmer variety, mainly in the interest of efficiency, but the ordinary compression type will also be satisfactory.

The remainder of the details can be seen in the photographs and the actual construction should cause little difficulty. The main points to watch are that all leads are kept short, particularly to grid and plate, and mount the components as close as possible to the respective section of the circuit. The leads to the volume control, other than the battery leads, should be made with shielded wire, with the outer braid earthed.

Once the wiring is completed the final step is to align the receiver, and this should be done in accordance with the instructions given in previous issues. Particular care should be taken with this, as the ultimate performance rests largely on the accuracy of these adjustments. For this reason, the align-

(Continued on Page 48)

CIRCUIT CHANGE

In the Direct Coupled Five circuit (May, 1949 issue), the following alteration should be made. The two resistors connected to the 6B8G A.V.C. Diode are incorrect values and these should be 1.0 meg. and NOT .1 meg as shown.

For your note book

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

SOME RESISTOR TROUBLES

In an earlier issue some of the common faults usually found with the carbon type of volume control were detailed. Although at the time special emphasis was placed on the carbon type control, it should not be inferred that the wire wound control, used in circuits where relatively low resistance is sufficient, never gives offence.

Scratchy Controls

These controls become scratchy and jumpy after a period of use, because the movement of the slider finally wears out some part of the wire winding ahead of the other parts. This scratch can be reduced or eliminated in some cases by lubricating the winding with a mineral type oil, but it will be found that freedom from trouble remains only so long as the coil covers the offending parts of the control.

However, it will be found that after a period of time the same old trouble will recur, and for this reason all repairs to such controls should only be classed as of a temporary nature. The real solution to the problem is, of course, a replacement with a new control having the same resistance characteristics.

Fixed Resistors Offend

While on the subject of variable resistors, a few words concerning fixed resistors will not be out of place. These units have a tendency for changing their resistance values, and what once may have been a 50,000 ohm is perhaps only 15,000 ohms, with the result that a voltage somewhere in the set, frequently on the screens, may be far different from that originally intended.

If a fixed resistor differs from the required value by more than 10 per cent., then it should be replaced, and under no circumstances should a resistor be permitted to remain in a set that differs from the intended value by more than 20 per cent. However, in the case of many commercial receivers, the appropriate service manual should be used as a check in this respect, as manufacturers have been known to vary considerably the values of some resistors as the production run has progressed.

Frequently resistors may be the cause of fading, which may be defined for service purposes as "any intermittent stoppage or reduction of intensity of reception" in the receiver. In this regard a difficulty always exists in the fact that resistors causing the trouble do not necessarily show up as defective on any "cold" test, e.g., by direct resistance measurement, or even measurement of voltage drop across the resistor made immediately the set is started operating. The resistor may yield only when the resistor and the air about it get hot enough, or when the signal amplitudes reach certain heights. Thus the cause of fading, even when due to a defective resistance unit, may be difficult to find.

Check End Connections

The connections made to fixed resistors are often a source of trouble, as these may become loose after a time. Some types that are made with soft metal ends may cause trouble, or other types with hard metal ends may do likewise, although less frequently. Where metal is mixed with the carbon and the soldered connection is made to this almost fused mass, the contact may be expected to be good, but should not be trusted too much. Sudden tension alone is sometimes a good aid to ascertaining the seat of trouble, but in general the integrity of the contact cannot be checked sufficiently while the resistor is "cold."

Curing Oscillation

Whistles and oscillations in a receiver can often be traced to the filter condensers, even though these may measure up to their rated capacities. These condensers frequently develop a high r-f resistance which can only be cured by fitting a new unit of the correct capacity. In some cases it will be found that connecting a .1 to .25 mfd tubular condenser across the filter condensers when new will eliminate this form of trouble.

Locating Ignition Noises

By connecting an r-f coil across a pair of headphones and using the same as an exploring coil, it is a simple matter to locate ignition noises, etc., in a car installation. By holding the coil close to the various wires under the dash, the one causing the trouble can be readily located and the noise eliminated by the use of a corrective filter.

Soldering Litz Wire

One of the problems of using Litz wire is the means of removing the enamel covering from the many fine wires. One method of doing this is to dip the wire into liquid cement solvent, and as the enamel coating softens scrape it off with the fingernail. It will be found that this method is both simple and effective.

UNUSUAL HIGH-FIDELITY AMPLIFIER

By J. D. GOODELL and C. W. FRITZE

An interesting amplifier circuit which allows a direct listening test to be made between triode and tetrode output valves. The main features of this unit are exceptionally low harmonic and intermodulation distortion as well as a wide frequency response.

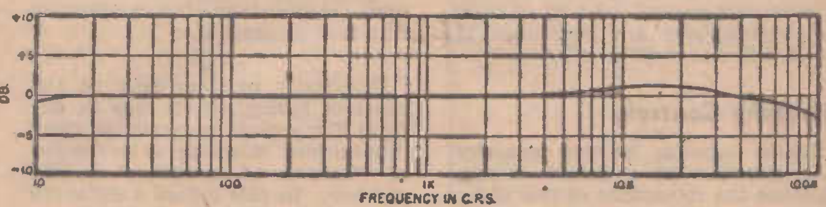
The controversy concerning triode versus beam power tetrode output tubes has probably been the subject of more discussion than any other single topic in the audio industry.

Since most people do not have the facilities for making their own choice, they are forced to depend on the recommendations of others who presumably have made controlled comparison tests. Whether an individual is purchasing an amplifier or building one, the investment is sufficiently large in time and/or money so that he would like to know in advance that his choice of output tubes is as close to ideal as possible.

The amplifier design to be described was developed to eliminate this problem. This amplifier, as nearly as it has been possible to determine by laboratory measurements and listening tests, literally doesn't care whether triodes or beam-power tetrodes are inserted in the output sockets. Its characteristics, within the maximum output power set by the inherent design of the tube type used, are very much the same. The few instances in which this is not strictly true are indicated in later paragraphs. The owner of the amplifier may decide experimentally whether he prefers one tube type over the other and leave in the tubes he finds most satisfactory in the amplifier.

Freq.	Response	Frequency	Response
18	0	10,000	+.8
30	0	12,000	+1.0
40	0	14,000	+1.0
60	0	16,000	+1.0
100	0	20,000	+1.2
200	0	25,000	+.75
400	0	30,000	+.5
600	0	50,000	0
1000	0	60,000	0
1500	0	70,000	—.8
2000	0	80,000	—1.0
3000	0	90,000	—2.0
4000	+.25 db.	100,000	—3.0
5000	+.4	200,000	—3.8
7000	+.6		

Actual check points used in preparing the overall response curve.



Overall response of the amplifier. Note that the response is down only 3db at 100,000 cycles.

General Considerations

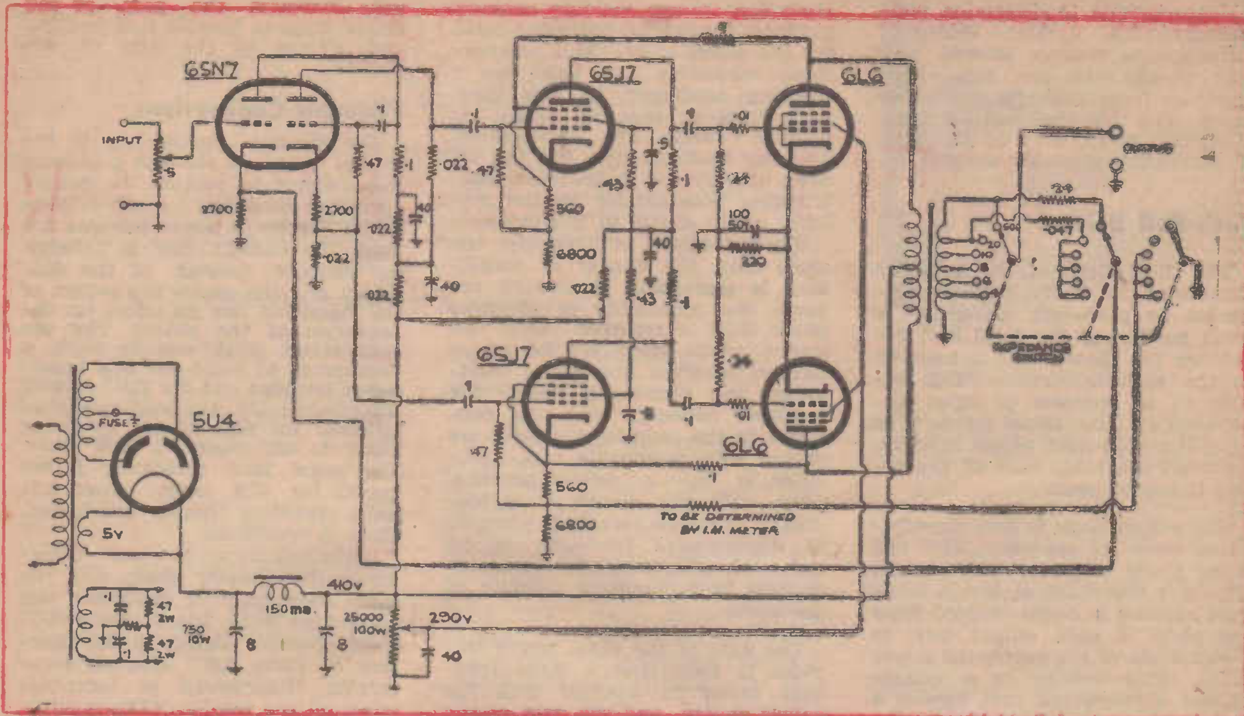
The first stage of this amplifier is a conventional triode voltage amplifier stage with the cathode bias resistor left unbypassed in order to obtain a convenient return point for the feedback voltage taken from the secondary of the output transformer. This feedback loop, which includes the entire amplifier from input to output, is intended principally to correct nonlinearity in the output transformer and generally to compensate for phase shifts and attenuations in the input circuits. Note that the impedance-changing switch in the output circuit automatically adjusts the feedback resistor for optimum results at varying output impedances.

Obviously, if only the 500 ohm line is tapped to obtain feedback voltage, the amount of feedback obtained will depend on whether this impedance tap is loaded or not. In most instances, it is adequate to select a different resistor for feedback from the line impedances and the voice coil taps. However, with some output transformers, and in any design where the feedback quantity is critical, it is necessary to change the feedback resistor for each output impedance used. The point, of course, is that if the maximum feedback without instability is desired, and if it is connected to the 20 ohm tap and adjusted with this tap loaded, when the 10 ohm tap is used the amount of feedback will increase and instability may result.

The maximum amount of feedback that can be applied to any amplifier is a function not only of the frequency response range but of the shape of the attenuation curve at both ends of the spectrum. The criterion is that the phase shift shall be less than 180 degrees in the feedback loop with respect to the input signal at any frequency where the amplitude of the feedback component is unity or greater.

Phase Shift vs. Attenuation

Phase shift is related to attenuation. If the tail of the attenuation curve is too abrupt, causing an excessively rapid phase shift in the region just ahead of the frequency at which the amplitude falls below unity in the feedback circuit, the



The complete schematic diagram with necessary component values. The resistor to be determined by the I.M. meter is discussed in the text. The 6B4 triodes referred to are the octal based equivalent of the well-known 6A3, and this latter valve can be used to make comparative listening tests by fitting a suitable adapter base.

design will be unstable. Thus the amount of feedback it is possible to apply without instability and tendencies toward oscillation is related to the total pass band of the amplifier and the rate of attenuation at both ends of the pass band.

In general, this means that for every 8-10 db. of feedback it is necessary to add a minimum of one to one and one-half octaves to the pass band. It becomes obvious that large amounts of feedback require control over a very wide response range. Three octaves above 250 cycles per second is only 2000 cycles per second, but three octaves above 20,000 cycles per second is 160,000 cycles per second—a radio frequency. Few designers realise the necessity of observing the characteristics of an audio amplifier in this region.

On the other end of the spectrum the same comparison may be made. Three octaves below 250 cycles per second is only about 30 cycles per second, while adding three octaves to a pass band that normally includes 50 cycles per second at the low end, without attenuation, means controlling the response down to 6 cycles per second —a low brain wave frequency.

Phase Inverter

The second stage of the amplifier is a split-load type of phase inverter with the load impedance in the cathode circuit and half in the plate circuit. The only disadvantages in this design are: (a) that the maximum gain from the stage is always less than 2.0; (b) that raising the cathode so far above the ground may introduce hum from the heaters (so that this phase inverter cannot normally be used satisfactorily in low level stages); and (c) that there is a difference between the shunting capacitance across the plate load and across the cathode load.

Theoretically this difference in shunt capacitance may introduce a certain amount of unbalance between the two halves of the circuit at frequencies above approximately 6000 cp.s. This, obviously, is particularly true if the value used for the load resistors is high. With low values of load resistors the effect is not sufficiently observable to warrant consideration, although it could be balanced out without great difficulty if required.

The intermodulation distortion in the cathode load is too low to measure accurately with available equipment, and at low levels of output signal requirements from this stage intermodulation in the plate circuit is equally negligible. Where this type of phase inverter is required to furnish a very large signal it is necessary to increase the plate voltage to the limits that the tube will stand if absolute minimum values of non-linear distortion are to be obtained in the plate circuit. In this amplifier, the signal required is relatively low under all conditions of operation and this consideration is not important.

One advantage of this type of phase inverter, in addition to its stability and freedom from distortion of all kinds, is the very high effective input impedance obtained. This may approach ten megohms with a one megohm grid resistor and conditions where the gain is 1.8.

Fundamental	25	100	200	400	1000	2500	5000
2nd Harmonic	2.0	0.4	0.43	0.15	0.36	0.6	0.75
3rd Harmonic	1.3	0.23	0.2	0.18	0.16	0.15	0.14
4th Harmonic	0.4	0.06	0.05	0.06	0.08	0.08	*
5th Harmonic	0.2	0.05	0.02	0.02	0.02	0.01	*
Total	3.9	0.74	0.7	0.41	0.62	0.84	0.89+

Actual measured harmonic content of amplifier at 5 watts output with either 6B4's or 6L6's. Asterisk indicates values not readable on equipment. Measurements were made at 12 watts with 6L6's were identical or only slightly higher, never exceeding 1.5 per cent. except at 25 cycles where readings were masked because of broad handwith of wave analyser.

Measurements to determine non-linearity with various values of cathode bias resistor showed very little change over the wide range of values from 1500 ohms to 10,000 ohms. The 2700 ohm resistor finally selected was chosen on the basis of maximum available output.

Push-Pull Drivers

The third stage of the amplifier consists of two 6SJ7's, pentode connected as push-pull drivers. A small portion of the total load resistance for these tubes is inserted in the cathode circuit. This results in an increase of input impedance in the same manner as with the split-load phase inverter, although the magnitude of the effect is not so great.

The output stage is first considered in terms of operation with 6L6 beam power tetrodes. The general circuit is conventional, but a feedback resistor is direct-coupled from the plate of each output tube to the cathode of the associated driver tube. This results in a voltage divider arrangement that applies a certain amount of fixed bias to the cathode circuit of the driver.

The value of the cathode bias resistor is chosen so that the combination of self bias and fixed bias from the voltage dividing network produces the correct operating point for the driver stage. This arrangement eliminates the need for a blocking condenser in this feedback loop so that no series reactance effects are encountered, and the feedback does not fall off even at very low frequencies, contributing considerably to the stability of the circuit in this region.

Where feedback is taken over one stage only, the danger of oscillation is essentially eliminated because the probability of excessive phase shift is removed. Over two stages, where there are no transformers involved and series reactances are eliminated from the feedback network, and the constants in the coupling networks are chosen with reasonable care, oscillation is not a serious problem. Thus, with this circuit, it is possible to introduce very large amounts of degenerative feedback, in an order of magnitude exceeding 30 decibels, with complete stability of operation.

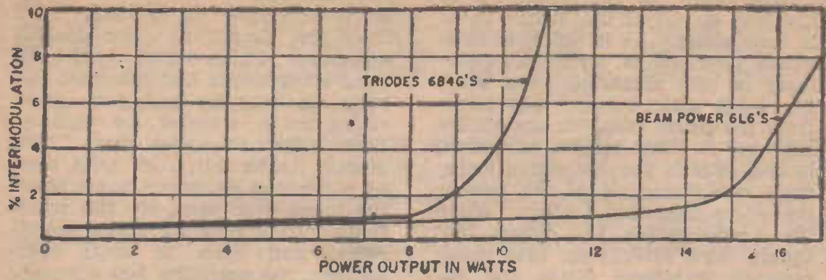
The gain of the beam power tetrodes is such that a large feedback factor is obtained with the values chosen, and the gain of the driver stage is greatly reduced thereby. When triodes are used in the output sockets, the much lower gain of the triodes greatly reduces the feedback factor and automatically increases the gain of the driver stage to provide sufficient input voltage to the grid of the triodes.

Filament Connections

The filament centre tap is returned to ground through a suitable bias resistor to provide the proper operating condition for the triodes. When the beam power tetrodes are used, the current flow is through the cathode instead of the filaments and the centre tap return of the filaments has no effect on the operation of the circuit. The pin connections work out in such a manner as to make the 6L6 beam-power tetrodes and the 6B4* triodes interchangeable. The load resistance required for 6B4 triodes operating Class A, self biased is 5000 ohms. The same load resistance is required for 6L6 beam power tetrodes operating under self-biased, Class A conditions.

Experimentally, it was determined that greater power with the same percentage of distortion was obtainable with beam power tetrodes operated slightly in the direction of Class AB1, with no measurable (instrument of listening) effect on the results. Consequently, although the normal requirements for optimum operation of 6L6's

*Except for bare connections the 6A3 triode has the same characteristics as a 6B4.



Intermodulation distortion at various power levels

operated Class AB1 is somewhat higher with regard to the load impedance, the cathode bias resistor was increased beyond the value determined theoretically as being ideal.

In operation with either tube type, the intermodulation distortion at five watts measures less than 1 per cent. using 100 and 7000 cycles per second mixed 4:1. At ten watts for the triodes and 16 watts for the beam power tetrodes, this increases to 5 per cent.

Determining Resistor Value

In the diagram shown in fig. 4, it will be noted that one resistor—connected from the junction of the cathode bias and cathode load resistors in one of the 6SJ7's to one section of the output impedance switch is marked *"To be determined by I.M. meter."* It is very difficult to obtain output transformers with absolutely perfect balance, particularly where multiple secondary taps are required. This resistor is inserted to compensate for whatever unbalance exists on various impedance taps. With the output transformer used in the circuit shown, it was found that balance was obtained with this resistor connected in the circuit when the 4, 6, 8, and 10 ohm taps were used, and with the resistor out of the circuit on the 20 and 500 ohm taps. With other output transformers, it may be necessary to change the value of the resistor and connect it in or out of the circuit in various combinations for each impedance tap.

Any unbalance in the output circuits is strongly indicated by an increase in the intermodulation distortion. This being the most sensitive measurement of non-linearity it is the easiest and most accurate method of determining the correct value for this resistor on each of the impedance taps. Experimental construction with a variety of output transformers indicates that even in very high-quality and high-priced output transformers appreciable unbalance and consequent non-linearity will often be observed.

Output Transformer Important

In some instances, the more elaborate transformer designs of very high cost have been found less satisfactory in measurements of intermodulation distortion than less complicated and less expensive designs. As almost all investigators of power amplifiers eventually conclude, the output transformer is probably the most important individual factor in obtaining the best possible results. Obviously, the side of the driving stage that requires compensation by using this resistor to obtain satisfactory balance will vary with the characteristics of the output transformer.

This resistor, when connected in the circuit to ground, shunts the cathode load resistor on one of the push-pull driver tubes. This reduces the cathode load across which the feedback voltage is developed and lowers the percentage of feedback applied to this side of the push-pull circuits. Effectively, this increases the gain of the associated circuit and, with proper adjustment, can be made to compensate almost perfectly for unbalance in the operation of the output transformer. Once adjusted, it does not need further attention.

Obviously in making this adjustment the output tubes and the push-pull driver tubes should be carefully selected for inherent balance in these stages so that the measurement will not be confused by unbalance in the tubes. All resistors in the push-pull stages, as well as the cathode and plate load resistors for the phase inverter, must be balanced with as much accuracy as possible. Any unbalance in these components will tend to increase the non-linear distortion appearing in the output.

Checking Voltages

After construction of the amplifier is complete, it is essential to check all of the voltage measurements in the balanced circuits to make certain that the components have not changed in value through excessive heat in soldering connections. In the effort to make short connections, which is indeed desirable, it is not uncommon to apply sufficient heat to change the value of a resistor appreciably and permanently. If the voltage measurements indicate such a change, the component must be replaced.

However, once the stages are properly balanced, there appears to be relatively little danger of a change in values that will cause unbalance, except, of course, with components that are inherently defective in a way that shows up only under continuous operation. Otherwise, since all of the balanced components are operating under identical conditions, any change caused in them by heat or other factors will tend to be in the same direction and in the same order of magnitude.

Waveform Checks

After the circuits are properly balanced with regard to the output transformer and "mirrored" push-pull components, small changes, with age, in the characteristics of the tubes do not appear to make any appreciable difference in the results obtained.

Observation of the waveform in the grid circuit of the output tubes is interesting. As in all amplifiers where feedback is used, this waveform is very distorted even when the input and output waveforms from the entire amplifier are perfect sine waves. The reason, of course, is that this is the corrective waveform containing all of the inverse corrective distortion factors. When the output tubes are driven into square wave distortion, this intermediate waveform shows the extremely high peak in the centre of the wave developed by the feedback voltage as the circuits "try" to correct the square wave and bring it back into sine waveform.

Frequency Response

Fig. 3 shows the frequency response of the amplifier over the audio range. It is flat within a fraction of one decibel over a range that extends appreciably above and below the spectrum of normal hearing. In fact, it is down only one decibel at 10 c.p.s. and down 4 decibels at 200,000 c.p.s.!

Neither the content of this article nor the design of this amplifier pretends to resolve the triode/beam power tetrode controversy. It does offer a means for the average person to conduct his own listening tests and reach his own conclusions without buying or building more than one amplifier. One distinct advantage in this regard is that the same components and the same circuits are used for both tube types, ruling out a number of variables that would otherwise exist. Obviously, to be fair, such tests must be conducted at power levels below the break-over point for the triode tubes. In almost all home installations and even in small auditoriums, the amplifier has adequate reserve power with either tube type provided that reasonably efficient loud-speaker systems are used.

ARE YOU A REGULAR READER?

Make sure you receive every copy of "RADIO SCIENCE" by placing a definite order with your newsagents TO-DAY.

If your newsagent is unable to supply your copy each month, subscriptions may be forwarded direct to Box 5047, G.P.O., Sydney.

Subscription rates are 12/- per year, or 21/- for two years, post free, to any address in the Commonwealth.

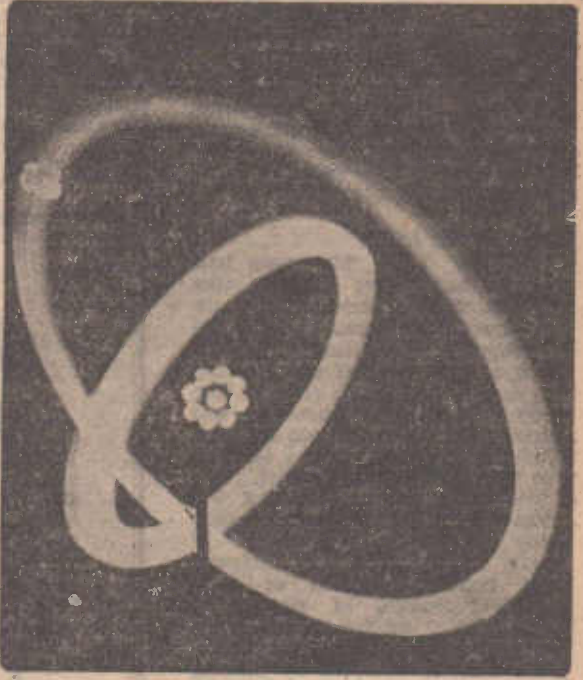
Basic Electricity and Magnetism

After detailing the evolution of the electron theory, the author discusses such topics as the "Quantum Theory," "Bohr's Atom" and the "Theory of Relativity."

It has been continually stressed throughout this series that basic electrical concepts are mathematical in character. These basic ideas are valuable because they enable us to predict the electrical behaviour of various substances under prescribed conditions. Obviously, however, mathematics cannot supplant reality; mathematical and physical entities must in some way be combined, and we have reached a stage whereat we must consider means whereby mathematical deductions can be applied in real life.

The *link* between mathematical and physical entities is a *theory.* Anyone who postulates a theory is simply trying to explain phenomena of which we are physically aware in terms of results deriving from logical deduction.

In this article we consider the *electron theory* because the electron theory is the basic link between fundamental notions about electricity and every day electrical effects. The apparent change in subject is not as illogical as may first appear.



This working model shows an atom magnified 10 million times. The central cluster represents a nucleus of protons and neutrons, whilst the white orbits incate the movement of electrons.

The Evolution of the Electron Theory

The *electron theory* evolved from the *molecular theory.* The molecular theory attempted to explain away the nature of matter by assuming that all substances were composed of infinitesimal, but indestructible particles of the substance. It was found, however, that chemical analysis, broke the molecule into simpler substances, and these simpler substances were called chemical elements.

Centuries before chemistry reduced the molecule to the simpler particles, Galileo suggested the existence of atoms, but Galileo's atoms were more philosophical than practical; they were not the atoms that we think of; the name we have given the ultimate particles of a chemical element.

Elements were defined as substances which could undergo *any known* chemical treatment and still retain all their original characteristics; it was found that there were only 90 or so such substances, so that all matter throughout the cosmos consisted of 90 odd elements or combinations of them. This was a simple and very satisfactory notion because it plausibly explained a host of physical phenomena.

But chemical analysis indicated that the elements were in some way related to each other, and this could only be explained by assuming that the elements were not the indestructible particles they were supposed to be but were, themselves, composed of still simpler substances. But, since the elements defied all chemical efforts to reduce them it was clear that some other method of breaking them down had to be found.

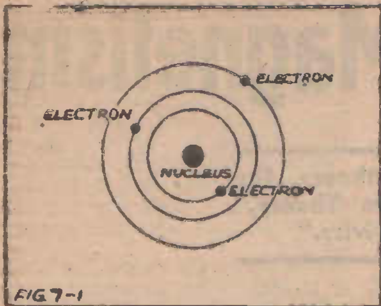
By
A. L. THORRINGTON, A.S.T.C.

Discovery of "Cathode Rays"

Between the years 1895 and 1900 a series of extraordinary experiments showed definitely that the atom was not a simple entity. These were experiments dealing with electrical discharges. It was found that the *negative electrode* in a primitive form of the modern X-ray tube, hurled a stream of "something" from it with terrific force, and this stream was capable of exerting a mechanical force. The "something" was called *cathode rays,* because the stream emanated from the negative electrode.

Cathode rays could be deflected by magnetic and electric fields; if they were allowed to play on a tiny vessel, this became electrically charged. The rays carried negative electricity; further they posessed the extraordinary property of penetrating thin sheets of metal. In 1897, Sir J. J. Thompson advanced the theory that these cathode rays consisted of negative particles which were, because of their penetrative power, much smaller than the atom.

It was found possible to determine the precise size of these particles, and it was discovered that they were all identical and nearly



The Rutherford theory considers the electrons to revolve around the nucleus similar to a miniature solar system.

2000 times lighter than the lightest atom—viz., hydrogen. With this evidence it was easy to conjecture that these tiny particles—*electrons* as they were called—were the foundation stones of the universe.

Increase In Mass

Now, Sir J. J. Thompson had noticed that when a body was charged with electricity its mass was apparently increased, and the interesting question arose as to how much of the mass of the electron was due to its electric charge. The query, when finally answered, was bewildering. It turned out that the *whole* of the mass of the electron was due to its electric charge.

The electron was nothing but electricity. There was no such thing as "ordinary" matter. If matter was built up with electrons, then matter consisted of "disembodied charges of electricity." The world of matter became completely unsubstantial. The theory could only be accepted by making our notion of matter more abstract. We would have to discard the notion of "substance" and substitute the notion of "behaviour." Anything which had the cardinal property of matter, or inertia, consisted of electricity.

But since electrons were in some way connected with atoms, and atoms—which built up the elements—were electrically neutral it was evident that there was something else besides electrons in matter. Since atoms are stable particles, and a mere assemblage of electrons would be unstable, it was obvious that somewhere and somehow positive charges of electricity existed and brought about neutrality and stability.

Solar System Analogy

If these positive charges existed, how were they situated in space relative to the electrons which they neutralised? Sir Ernest Rutherford suggested an arrangement which has met with considerable success. This was the famous theory of the atom resembling a "miniature solar system."

According to this idea, which is graphically represented in Figure 7-1, the positive charge was located at the centre of the system, while the electrons, like so many planets, circulated around it. In every case the central positive charge was just enough to balance electrically, the sum of the electrons circling it. The difference in elements was explained by assuming different atomic "solar" systems.

When Rutherford's theory was applied to the actual atoms, complications arose in that the nucleus of most atoms was found to be complex containing both electrons and positive charges; further it was found that the electrons pursued orbits of an extremely complicated pattern, and did not confine their movements to simple circular paths. Further, the orbits of the electrons did not lie in the same plane.

This model of the atom, though satisfactory to the physicist, did not satisfy mathematicians. Mathematicians pointed out that this atomic model defied the accepted laws of thermo-dynamics because electrons circulating in the way that the physicist wanted them to circulate must, in accordance with thermo-dynamic laws, radiate energy *continuously*, and approach ever closer to the nucleus into which they must finally fall. The whole atom would vanish in a flash of radiation, and, doubtless, the world would vanish with it.

Quantum Theory

Such an atom was impossible, but it so happened that a new theory of radiation had been suggested by Max Planck several years before.

Planck had come to the conclusion that when heat was radiated by a hot body, it was not radiated in a continuous manner, but in little jerks, or *quanta;* neither was heat absorbed continuously. According to the old theory of radiant energy, radiant energy spread from its source in the form of waves; according to the new theory, the *Quantum Theory,* it spread like a flight of bullets.

Max Planck postulated that the amount of energy, e, in an elementary quantum was given by,

$$e = hv, \quad \ldots\ldots 7.1$$

where h is Planck's Constant, usually known as the quantum of action, and which, according to latest available figures, has a numerical value $6.622 \pm 0.007 \times 10^{-27}$ erg. sec., and v is the frequency of the radiation.

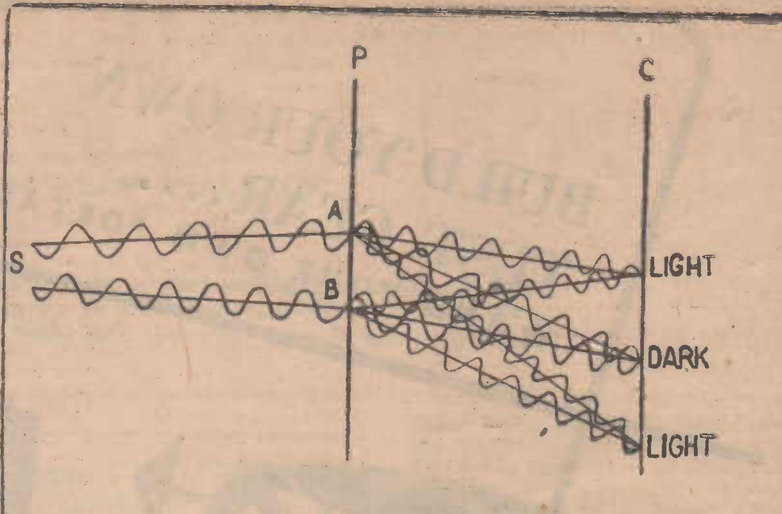


FIG. 7-2

This diagram illustrates how waves of different phases interfere and produce the phenomenon called "diffraction."

Bohr's Atom

It occured to a brilliant young Danish physicist, Niels Bohr, that Planck's Quantum Theory, could, with modifications, be applied to the atom. Bohr assumed that the energy of motion of an electron revolving in any given orbit was a multiple of the quantum corresponding to the frequency of the electron in that orbit. He then assumed, as was of course necessary, that this electron, so long as it moved steadily in its orbit, did not radiate any energy.

When it radiated, it lost a whole quantum of energy, and therefore moved to another orbit appropriate to its lesser energy. When absorbing energy it did so again in quanta and moved to a correspondingly higher orbit. This picture of electronic behaviour could only be dealt with mathematically, but it was possible to explain not only the stability of the atom, but also to predict new properties.

While Bohr's theory explained why the atom was stable and satisfied mathematicians, it did not explain from whence electrons obtained their energy of motion; neither did it account for electrons producing *interference* patterns, a phase of electronic behaviour we will shortly consider.

Einstein's Theory of Relativity

In 1905, five years after Planck's discovery, Einstein suggested that light cannot be regarded as spreading out from its source in the form of continuous waves, but its energy was concentrated at points along its wave front. Light was not a wave, or if it was a wave, it had particle like properties as well. The interchange of energy between light and atoms took place in quanta.

Einstein expressed the idea mathematically and his basic equation,

$$E = \tfrac{1}{2}mv^2 = hf-p \quad \ldots.7.2$$

won for him the Nobel prize. In Einstein's fundamental expression, E is the energy of the electron, m is its mass, v is its velocity, h is Planck's constant, f is the frequency of its wavelength, and p is the work done in displacing the electron from its orbit.

It is beyond the scope of this discussion to consider Einstein's Theory of Relativity beyond considering one of its more important aspects, and that is the phase which considers our notion of straight lines. According to the Relativity Theory, a line which appears perfectly straight to us, could, to another observer, appear curved, while a line which appears curved to us, would become straight if we could see it from some other space-time continuum. While it is impossible to get any mental picture of this, the idea is readily expressed mathematically.

General Significance

So far as we are concerned the significance of the idea lies in the fact that while we mentally picture the electrons of an atom pursuing complicated but *curved* paths around the nucleus, the electrons are in fact not moving in a curved path at all, but, relative to the space-time system wherein they exist, follow what we regard as a *straight line.* If this is true—and mathematics can prove it is true — then Newton's laws of motion are valid, for the electron can move along a straight path forever iwthout gaining or losing any energy. The query as to where the electron gets its energy of motion does not arise because the electron simply doesn't need any.

If we find the notion hard to accept it is because it is not picturable. In terms of these assumptions the atom is no longer picturable at all. Each electron, for instance, requires a three dimensional space-time configuration of its own, two electrons need a six dimensional space-time configuration and so on, so that the idea is a mathematical device and not a description of physical reality. It is justified because it predicts results which are confirmed by experiment.

These ideas, revolutionary as they were, would have been accepted merely as an instance of the ordinary process of scientific advancement. But a curious and disconcerting fact is that the old theory of radiation cannot be completely abandoned. In some cases, the propagation of light can only be explained by regarding light as a wave; in other cases its behaviour must be accounted for by thinking of it as a shower of particles. More important, in so far as we are concerned, is the fact that some kinds of electrical phenomena can only be explained by treating electrons as if they were *waves.*

Although the resolution of electrons into waves could be accepted as a mathematical device, it is distinctly baffling to find there is experimental evidence of it. Probably the most staggering proof of all is the discovery that electrons can produce interference patterns similar to those of light.

(Continued on Page 47)

RADIO FREQUENCY MEASURING EQUIPMENT

By ALAN WALLACE

In the concluding article of this series, the applications of measuring equipment in the VHF and UHF regions—that is from 30 to 3000 Mc. are discussed in some detail.

It must be realised that as the frequency under consideration is raised, several problems immediately arise which are not of importance at the lower frequencies. The first and foremost of these problems is that of power loss in various forms, due to such phenomena as skin effect and dielectric heating. The prime consideration of the designer of any instrument to operate above 30 Mcs. must be the minimisation of these effects, if anything like reasonable efficiency and sensitivity is to be realised. Notwithstanding any improvements which may be obtained, however, the efficiency of normal units at these frequencies is low, and this necessitates the use of more accurate indicating devices, irrespective of whether the equipment in question be a simple wavemeter, a field strength meter, or perhaps a modulation indicator.

A further problem which arises, whenever the problem of frequency measurement is encountered, is that it is not possible to construct an efficient fundamental oscillator in this range which has a stability even approaching sub-standard requirements, and hence use must be made of high order harmonics of a suitable low frequency oscillator. However, since these harmonics are relatively low in amplitude, any heterodyne equipment of the type featured in Part 3* of this series is out of the question.

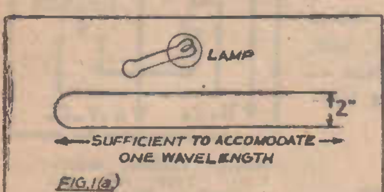


Fig. 1 (a): Simple form of a Lecher system.

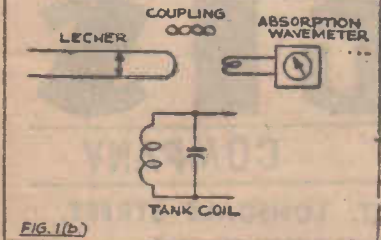


Fig. 1 (b): This arrangement gives greater accuracy, and is more frequently used.

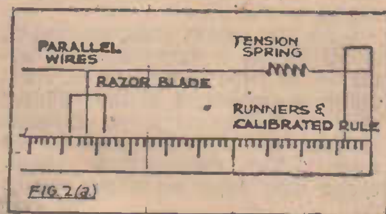


Fig. 2 (a): An easily constructed unit which enables standing waves to be readily determined.

PART 7
SPECIAL MEASURING EQUIPMENT

As the degree of accuracy usually required at these frequencies is not of such a high order, the use of a stable low frequency oscillator (for instance in the 7 Mcs. region) followed by a harmonic amplifier will give very satisfactory results. This should be used as a heterodyne frequency meter in conjunction with some suitable device to allow of discrimination between the various harmonics produced, as for example, an absorption type wavemeter, or Lecher wire system.

Lecher Bar

In the initial measurement of the frequency of any radiation in this range, a most useful device is the well-known Lécher Bar, in which direct measurement is made of the distance between nodes of the induced standing waves. Whilst lacking somewhat in sensitivity, this device has the unique advantage of requiring no calibration, as the frequency may be calculated quite simply when the distance between standing waves has been measured.

In its simplest form the Lecher system is shown in Figure 1a where two parallel lines terminated by a loop are excited by the desired radiation. Standing waves will be formed on these lines, and the distance between the nodes may then be determined by moving a lamp attached to a pick-up coil up and down the lines, noting the distance between points of maximum or minimum brilliance. Incidentally, it might be as well to point out at this juncture that the distance between standing waves on the tuning lines of a tuned line oscillator bears no direct relationship to the frequency of oscillation, as their properties are modified considerably by the presence of circuit capacitances.

However, to return again to the Lecher system, although this system may be used well up into the VHF and UHF regions, it is obviously incapable of precision measurement, and the arrangement shown in Figure 1b is more commonly used where any degree of accuracy is required. By ensuring that the short circuit point is known with a high degree of accuracy, and employing a meter with good sensitivity as the indicating device, this system is capable of quite good results if carefully used.

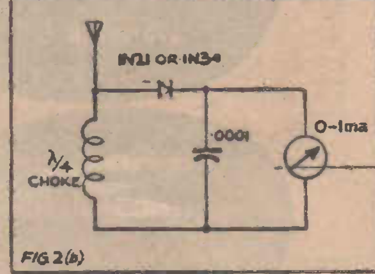


Fig. 2 (b): An untuned field strength meter.

* Radio Science, February, 1949.

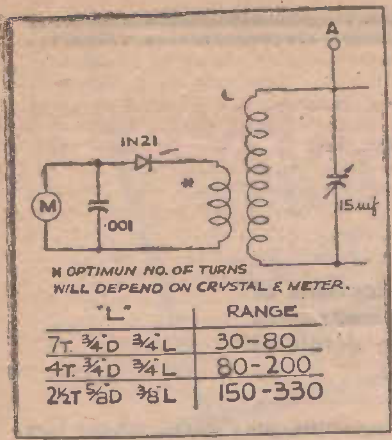


Fig. 3: A portable type of field strength meter. Coil details are included for those intending to build up this unit.

Principle of Operation

The principle of operation is that normally, with the Lecher System not at resonance, energy from the tank coil will produce a reading on the field strength meter, which may be a simple untuned device, as at Figure 2b. However, when the line is tuned to resonance, that is, when the shorting point is such that its distance from the closed end is some multiple of one-half wave-length, the system will absorb an appreciable amount of energy. Since the close spacing of the wires prevents re-radiation, the reading on the field strength meter will fall sharply, thus giving an accurate indication of the precise position of the standing waves.

A convenient form of construction for this type of unit is shown in Figure 2a. It will be seen that the shorting bar takes the form of a knife-edged piece of metal (as for example, a razor blade), firmly clamped between blocks, and mounted so as to be capable of movement along the lines, but at the same time rigidly held at right angles to the wire.

Some convenient scale, marked in either inches or centimetres, is attached in such a way as to allow ready measurement of the "Slider" position to ascertain the distance between minimum positions on the meter. The frequency in Megacycles may then be readily calculated using the expression $f = \frac{1.5 \times 10^5}{l}$ where l is the distance in centimetres between nodes.

As has been pointed out before, it is essential with an instrument of this type, which relies for its operation upon the extraction of power from the circuit under test, that the mutual coupling must be kept to the minimum possible value consistent with a satisfactory reading. Unless this is done the accuracy will suffer, owing to the tendency of the Lecher system to shift the oscillator frequency if it be of the self-excited type.

Portable Unit

If a more portable form of instrument be required, a field strength meter of the type shown in Figure 3 will give quite accurate

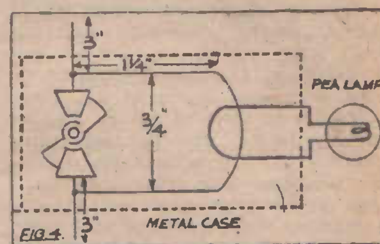
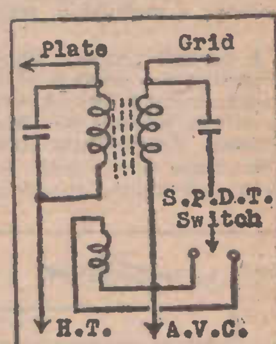


Fig. 4: An improved version which employs a Lecher system.



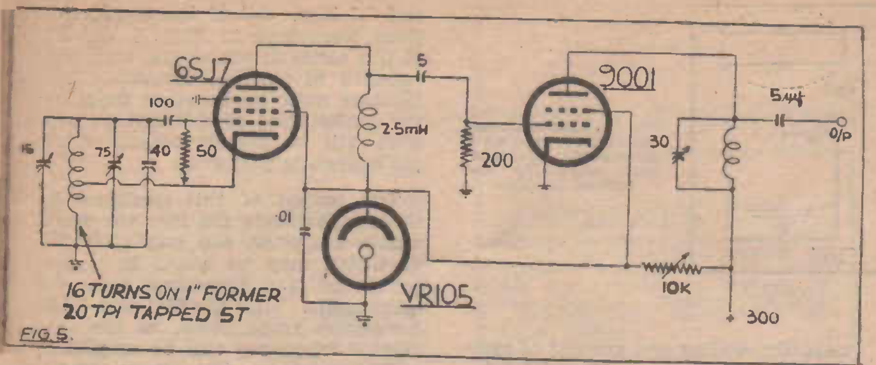


Fig. 5: A simple electron coupled oscillator which will provide an accurate harmonic output suitable for frequency checks.

results. However, this suffers from the disadvantage of requiring an initial calibration against some known frequency source, such as a VHF signal generator, although if this should not be available it may be calibrated using a simple oscillator of the tuned line variety in conjunction with a Lecher wire system as outlined above.

In this arrangement we have a simple resonant circuit, the voltage developed across which is applied through a crystal rectifier (a VHF diode, such as an EA50, could be used with an in-built battery for the heater supply) to the indicating meter which should have a full scale deflection sensitivity of 1 m/a, and preferably, if available, 100uA.

If desired, pick-up could be provided by means of a loop, feeding through a co-axial cable to the unit. As this would only be necessary in special cases as for instance where it is desired to use the instrument in determining the frequency of particular circuits in a multi-stage transmitter, the system shown, using a wire rod or aerial will be more convenient for general use, allowing as it does the instrument to be taken into the field and used for such purposes as checking the radiation pattern of an antenna.

Avoiding "Hand Capacity"

In order to avoid undesirable hand capacity effects, it is advised that the unit should be constructed in a metal case, with only the pick-up rod protruding. For highest accuracy it is preferable to use separate coils for each range, rather than any switching arrangement, although quite good results can be obtained using a high-grade ceramic switch. The sensitivity, of course, can be varied by alteration of the length of the pick-up rod, and again best results will be obtained if a minimum of coupling is used when the instrument is being employed in the vicinity of any self-excited circuit.

It is very desirable, but by no means essential, at these frequencies to use silver-plated wire of large diameter, and silver-plated variable condensers. Both of these measures tend to reduce the losses in the circuit, thus raising its Q and ensuring good sensitivity and accuracy.

It becomes increasingly difficult, at frequencies above 300 Mcs, owing to the increased effect of stray circuit capacities, to obtain satisfactory results with this type of instrument, although it is possible to obtain a fair degree of flexibility and accuracy using the construction shown in Figure 4, up to frequencies of the order of 500-600 Mcs. In this construction, notwithstanding the fact that the circuit capacitance is kept to a minimum, there is sufficient inductance in a single closed loop of wire to allow resonance to be achieved at these frequencies, and tuning is accomplished by variation of the capacity of the small butterfly condenser shown.

Actually, this system could be considered to be a Lecher system where the lines are shortened capacitively by the addition of shunt capacitance. The procurement of this condenser should present no difficulty, as there are many suitable components available through disposals channels. However, care must be taken that the condenser employed is of the very low capacity type, with a maximum capacity of the order of 4-7uufd.

It is desirable, if the unit is to cover its full range with uniform sensitivity, for the pickup dipole to be capable of easy adjustment, and also that it should have a relatively low Q. This latter aim is best accomplished by making these rods of rather large diameter.

Superior Instrument

A much more sensitive and accurate form of instrument, if carefully constructed, is shown in Figure 6, and it takes the form of a resonant cavity, the frequency of which may be adjusted by means of a calibrated plunger. This type of construction is suitable for use on all frequencies in the range between 500 and 3000 Mcs, and thus will be most useful to those enthusiasts who are engaged in work in the 570, 1350 and 2300 Mcs bands, although, of course, separate cavities of the appropriate size will be required for each band. As the principles of operation of the resonant cavity may not be familiar to all readers, a brief description of the considerations involved would be in order.

Resonant Cavities

As is well known, the voltage distribution on a quarter wave line, shorted at one end, is as shown in Figure 7a. This line may be considered to possess all the properties of a parallel connected inductance and capacitance, the inductance being represented by the lines themselves, whilst the capacitive component may be considered to be the capacity between the lines.

Owing to the large surface area of the conductors, with the resultant low RF resistance, and the very low distributed capacity, the Q of a resonant line of this type may be quite high, and is likely to be many times that which could be achieved using conventional circuits at a comparable frequency. This equivalent arrangement is shown in Figure 7b.

Now consider two such quarter wave lines to be connected end to end, as in Figure 7c, and the result will be that although the resonant frequency of the arrangement will be as before, the Q will be raised, as the RF resistance of the system

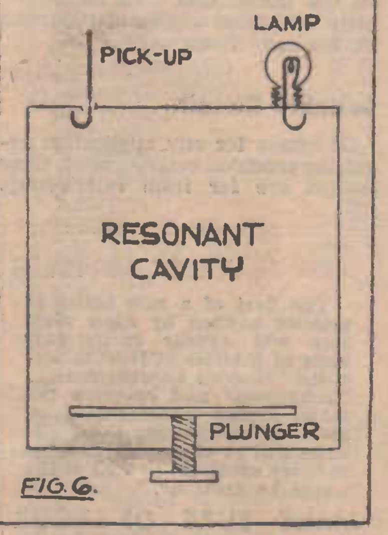


Fig. 6: The frequency of this resonant cavity can be adjusted by means of the adjustable plunger.

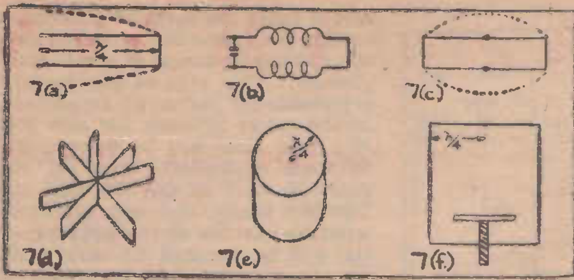


Fig. 7: This diagram illustrates points mentioned in the text concerning resonant cavities.

has been reduced. The same effect will be seen with a system as in Figure 7d, where many quarter wave sections have been joined at the centre to form a cage, the resonant frequency is the same as before. However, the Q is now rapidly increasing, with the result that if one can imagine an infinite number of quarter wave lengths to be joined together, a box or cavity will be formed, as in Figure 7e. Since it has a very low RF resistance, and no radiation loss, a very high Q will be realised.

This cavity may be considered to possess inductance and capacitance in the same way as a resonant line, and its resonant frequency may be adjusted by the insertion of an adjustable plunger which serves the function of varying the capacitive component. This may be seen in Figure 7f. It is a simple matter to induce energy into this cavity, or extract energy from it, in each case by means of a probe or loop connected to the external circuit, as for example the probe and indicating lamp in Figure 6.

Whilst it is quite possible to use any available can of the required dimensions as the resonant cavity, the results obtained will justify the time spent in constructing a well finished job, preferably silver-plated on the inside, and with an accurately calibrated means of adjusting its resonant frequency.

Suitable Circuit

Of course for any application requiring precision measurement, these devices are far from satisfactory, notwithstanding any amount of care which may be taken with their construction, and it becomes necessary again to use some form of heterodyne frequency meter. As was mentioned earlier, at the frequencies under consideration, a fundamental sub-standard is out of the question, and reliance must be placed upon some form of harmonic generating equipment, a suitable circuit being shown in Figure 5.

In this circuit, the type 6SJ7 is used as a simple electron coupled oscillator, on a fundamental frequency of 7Mcs, with its frequency variable between the limits of 6.85 and 7.1 Mcs. All of the considerations mentioned in Parts 1 and 2* of this series in connection with the stability of variable frequency oscillators must be borne in mind in the construction of this unit, as any drift will be greatly magnified at the operating frequency.

The output of this oscillator is then capacitively fed into the harmonic amplifier, the anode circuit of which may be tuned to either 144 or 288 Mcs. depending upon requirements. Thus the 21st and 42nd harmonics respectively, of the oscillator frequency will be amplified and passed to the output circuit from whence the signal may be fed to a receiver so as to produce the desired beat note. Whilst it may be realised that the accuracy obtainable with this instrument will not approach the accuracy obtainable at lower frequencies, it will certainly give a greater degree of precision than the simpler devices mentioned earlier in the article, and the errors encountered will be of smaller magnitude than in any purely resonant equipment.

* Radio Science, Nov.-Dec. 1948, January, 1949.

R.C.A. REPORT ON 45 R.P.M. RECORDINGS

The major objectives in the development of this new system were the elimination of distortion and surface noise for the first time in a popularly-priced system. In addition it enabled the elimination of mechanical difficulties, noise, slow action and record damage presented by earlier types of changers.

The actual development of this system was started more than 10 years ago, and the first objective was the design of a record-changing mechanism that would overcome all the difficulties encountered in conventional system. This was ultimately achieved by perfecting a changer with a simple drop mechanism which could be housed inside a spindle slightly less than 1½ inches in diameter at the centre of the turntable.

This change necessitated the designing of a record with a 1½in. centre hole, and with surface contours suited to the new changer mechanism. To provide a small air space between the edges of the centre holes, allowing for insertion of the record-changer blades without touching the edges, a raised shoulder in the label area was incorporated in the design.

Since an entirely new type of record was needed, it was decided to design the best record that technical skill could create, entirely free of discernible distortion, with an absolute minimum of surface noise, in a size and form offering maximum convenience.

One factor which was predetermined was the playing time of slightly more than five minutes, which commercial research has shown to be the maximum compatible with public demand.

The slower the revolving speed, the more compressed the modulation must be at the start, with progressively increasing compression in succeeding turns of the groove . . . The larger the reproducing stylus, the greater difficulty of tracking compressed modulation.

Consequently, the smallest practicable stylus, with a .001 inch tip radius was selected. To permit use of the optimum recording level and allow an ample safety factor for groove walls, the maximum groove spacing was fixed at 274 inches to the inch.

When all of these factors had been determined—the size of the centre hole and the surface contours required by the new trouble-free record changer, the playing time, the quality level and volume level, the size of the stylus and the spacing of the grooves—it became apparent that the desired objective could best be met with a 6 7-8in. record with an operating speed of 45 r.p.m.

With these factors duly considered it was found that the size, design, and operating speed now incorporated in its new record would offer to the record-playing public the optimum in reproduction quality, convenience and economy.

Amateur NEWS and VIEWS

CONDUCTED BY KEN FINNEY

SPOT NEWS

● VK5LN is at present inactive, but is rebuilding an AT13 transmitter. Also building a double conversion receiver and hopes to be on the air again shortly.

● VK2AWW; Now at Woomera Rocket Range. Will shortly be operating with the prefix VK5.

● 5CB, 5AF, 5RG quite active on the amateur bands, and 5AF sends the information that two metres at present is not very active in South Australia. Quite a lot of activity on 144 m/c beams, with VK5AG building a 24 element beam. 5AF runs 40 watts to 815 3 element beam and dipole on 144 m/s, and is at present building a tower.

● VK5RG quite active on 20 metres looking for rare DX stations.

● VK2UK, Wollongong, is up to his ears in work, but still finds time to dabble in home recordings. It is noticed he is gradually losing his hair (by the handful).

● VK2PI rebuilding his station and anticipates being on 50 m/cs in the near future.

● VK2TV running push-pull 807's with 75 watts input. Listen on 50 m/c for these boys from Canberra.

● VK2ALJ: Norm Beard runs 65 watts input to a 828 receiver in an 8 tube home-built superhet with a preselector. Receiving aerial is a 6 element sterba curtain and transmitting aerial is a 3 element beam. Located at Toongabbie, he has so far worked 5000 stations on 1½ metres with 18 months of operation.

● W2GX: Russ Balantyne sends the following information that he has "worked all continents" in 50 minutes of operation with 150 watts input!

● VE7ADK: Tel Pattison, 1820 7th Avenue, Vancouver, operating on 28592 k/cs on phone wants Australian contacts on the air or by mail. How about it some of you fellows!

● VK2ZQ: Fred Philips runs 50 watts input to a 813 with a command transmitter as a VFO. His aerial is a full wave zepp, receivers are A.M.R. 101 (Australian HRO) and BC 453.

● VK2NT is active on 10 metres working some DX running 50 watts input to 830 B modulated by a pair of 830 B's in class B. Rebuilding a new final with a pair of 834's to 100 watts. Aerial is at present a 3 element beam.

● VK2DK sends the following information from Narrabri. He has a new transmitter on the aerial running 12 watts to a pair of 807's push-pull, designed so that when A.C. comes through the town he will have 100 watts. This is cathode modulated by a pair of 6V6's A.B. His receiver at present is an FS6, but in the near future he will be using an Eddystone 640. His aerial is a half wave fed with 75 ohm Telcon Cable operating on 7 m/cs; he has pirate trouble!

● VK2JC: Hart Wall, also of Narrabri, runs 813 to 100 watts on 80, 40, 20 metres crystal controlled antenna half wave coax fed.

● VK2NN: Don McLaren also operates from Narrabri.

● VK2ATS: Reg Stockman, of Inverell, has an 809 in the final and listens to the stations on a home-built receiver.

● VK3BE and VK2GR, of Ballarat, Victoria, heard consistently on 40 metres and 20 metres, and VK2GR is very active hitting tennis balls around Ballarat Lawn Tennis Association's courts.

● VK3UT, "Uncle Tom" to the boys of Ballangeich, Victoria, is a W.I.A. correspondent for the northern district of Victoria.

● VK7CA: Max Chaplin, of Hobart, Tasmania, who puts a strength 9+ signal into Sydney on 20 metres, will be shortly visiting Sydney.

NEWS ITEMS WANTED

Amateurs are invited to forward any news concerning club or other amateur activity for inclusion in these notes. Photographs of stations, together with equipment details, etc., are welcomed and will be published as space becomes available. Address your letters to VK2AIL, Ken Finney, Box 5047, G.P.O., Sydney.

WWV Transmissions

Standard-frequency transmissions are made continuously day and night, as a public service by the National Bureau of Standards over its standard-frequency station WWV on the following frequencies:—

Frequency mc	Power (kw)	Audio Freq. (cycles)
2.5	0.7	1 and 440
5.0	8.0	1 and 400
10.0	9.0	1 440 and 4000
15.0	9.0	1 440 and 4000
20.0	8.5	1 440 and 4000
25.0	0.1	1 440 and 4000
30.0	0.1	1 and 440
35.0	0.1	1

A 0.005-second pulse may be heard as a faint tick every second, except the 50th second of each minute. These pulses may be used for accurate time signals, and their one-second spacing provides an accurate time interval for physical measurements.

RARE AMATEUR AWARDS

It is our intention from time to time to give you information on interesting and rare amateur awards. The following is to be taken as the first of a series. The **"Decagon Certificate"** of achievement is offered by a Corpus Christi Radio Club to any amateur who can prove contacts with 10 stations in Corpus Christi, Texas. The reward is a handsome job and has a centrepiece the decagon, whose 10 sides are lettered the calls of stations worked. Applications are to be addressed to:

The Secretary,
Hewitt H. Penton,
1656 Armada Park,
CORPUS CHRISTI, TEXAS.

The Nashville amateur radio club issues an attractive certificate for working "10 Nashville Tennessee Stations." Applications for this award are to be addressed to:

W. J. Johnson,
W4HOJ,
Secretary, N.A.R.C.,
2701 Belcourt,
NASHVILLE, 5 TENNESSEE.

Another classy certificate for working "10 Greater Orlando," Florida, stations, issued in conjunction with the Chamber of Commerce, Orange County, has a background which pictures one of their prettiest bathing beauties! W4CMI Club Secretary says it is possible to work 10 Orlando stations in one sitting. However, stations worked on 29120 k/c on the 2nd and 4th Monday of each month will not count on the award. Applications should be addressed to:

Orlando Amateur Radio Club,
Box 2067,
ORLANDO, F.L.A.

* * *

HURSTVILLE AMATEUR CLUB

Forest Road, Hurstville

As from this month, the Hurstville Amateur Radio Club will go into recess for the winter months. Activity will recommence next Spring, when notice will be given to present potential members of the meeting dates, etc.

GEELONG AMATEUR RADIO CLUB

Malop Street, Geelong

At a recent meeting two more members joined this club. At this meeting one of the members, Mr. Brian Lloyd, gave a talk on the "Advantages and Disadvantages of the straight super and double conversion receivers." At the following meeting Mr. Peter Perkins was the lecturer and he spoke on "Distortion."

On May 1st, members went off on a Field Day with DF loops, the object being to find a hidden transmitter operated under the Club's call-sign VK3ATL by VK's 3AJF and 3IC. The first to reach it was 3AKC and company, closely followed by 3BU. A picnic was then held at Torquay and later the transmitter was hidden again. This time it was located first by 3ALG, 3SY and 3APL, who were operating together.

New members are always welcome and can obtain particulars of membership by writing to the Secretary, Bob Wookey, VK3IC, 158 Kilgour Street, South Geelong.

IS THIS YOUR CLUB?

Reprinted from a recent issue of Q.S.T., here is how one member views his club's activities. Read this article carefully and see how your own club compares with it.

Our club meeting starts at 8 p.m. (it says in the rules), but it's usually 8.15 p.m. or 8.25 p.m., before a quorum straggles in. Some of the members are on hand at 6.45 p.m., however, sitting around in an informal bull session.

To start with, we have an ideal set-up for a meeting place, good offices, and there isn't any reason why we shouldn't have good meetings, but we don't.

Our club roster shows 36 members, but we frequently fail to get a quorum, or 12 members. Our meetings are held at regular intervals, and all members are aware of this. When asked why they don't attend, it's usually, "You don't do anything but sit around and chew the rag." Of course, the logical answer to this is, "What would you like to see in our meetings?" The reply is always, "Well-ll—," and that ends the subject. They always squawk, but never turn a hand to help.

The president, shortly after election, instituted code and theory classes, both of which petered out in short order because of lack of interest, although some members had howled for the classes. Also along an educational line, we attempted having a technical talk every other meeting, but some of the big-mouths in the club finally overruled those as "uninteresting (to them, anyway) and too frequent."

Mindful of this, the president asked the programme committee to arrange such talks on a monthly basis, with movies in between. That plan soon fizzled out, too, because no member was willing to lead discussions on various technical subjects after the first three or four.

The club attempted having a weekly door-prize drawing through donations from members, but it got to the point where certain members were donating all the prizes, while the others sat back and tried to win, without ever donating a thing.

Our club dues have been paid with the same spirit. Most of the members paid in full, but there are a number who paid only part of their dues and, despite any number of suggestions and hints from the treasurer, still attend regularly, expecting full membership. Under the club rules they can be refused a vote on any subject, but until now, the president has not invoked the rule.

Generally speaking, a majority of our members are doing just that—generally speaking. Regardless of who is recognised by the president, and has the floor, a half dozen members are chewing the fat among themselves around the room, paying no attention to the subject at hand. Good manners? They never heard of them!

In short, our club has deteriorated to about this: Approximately seven members take care of all activities, with a dozen or more barnacles hanging around the edges. Our meetings are called to order, occasionally some old business is discussed, possibly an item or two of new business, a motion is made for adjournment, and carried, and

(Continued on page 44.)

AMATEUR RADIO EXHIBITIONS

By ROTH JONES, VK3BG

Plans are being prepared to hold Amateur Radio exhibitions shortly in the larger capital cities of Australia. This type of exhibition, revived after six years of war, has proved very popular in both Great Britain and America.

Veteran members of the Wireless Institute of Australia recall with pleasure and pride the pre-war Australian amateur radio exhibitions. They, with the thousands of recently-licenced young Australian radio amateurs, keenly look forward to the proposed exhibitions, the first of which is expected in Melbourne early next year.

Tentative plans for the Melbourne exhibition have already been submitted to the Victorian division of the W.I.A. Much careful planning and administrative work will be necessary before the exhibition becomes a reality.

Trade Co-operation

With the co-operation of the radio trade, the exhibition should be an outstanding success; so successful that members will make it an annual function. The trade, too, will benefit from the exhibition, but more of that later.

There's something about amateur radio exhibitions that gets any interested radio experimenter "in." These exhibitions have a far more important role than the display of sundry pieces of radio equipment. They allow the radio amateur to discuss his problems with the trade which frequently sends some of its best technicians to the show. Reports from England recently showed that special pieces of equipment had been built following suggestions received by the trade at the Radio Society of Great Britain's 1948 show.

Current paper restrictions frequently make it difficult for manufacturers to give full publicity to their products through the medium of advertising in the Australian radio publications. The same restrictions also prevent the publication and distribution of comprehensive catalogues and technical data.

The Australian exhibitions will provide visitors with an opportunity to examine critically the wide range of components, valves and equipment displayed and to discuss with the manufactureres their own particular design problems. Manufacturers, too, should benefit from these exchanges of viewpoint, for only in this way can they be assured of keeping abreast with current requirements.

A view of an Amateur Radio Exhibition held recently in England.

Australian radio trade representatives interviewed recently have stated there is no justification now for the once-heard cry that "the amateur market is too insignificant to warrant the production of specialised equipment, valves and components." Since 1939 the membership of the W.I.A. has increased considerably, which means that the demands for transmitting, receiving and measuring equipment have also increased.

Imports Restricted

The restrictions and high tax imposed upon the import of foreign-made short-wave radio equipment is providing Australian manufacturers with a unique opportunity of capturing the amateur radio market. That market is worthy of the fullest support and encouragement. By their presence at the exhibition, an important section of the industry will recognise its value and demonstrate in a practical manner that it will make every effort to hold the market against the fiercest outside competition.

The exhibition will also allow the W.I.A. to "boost its own stocks" by providing a technical information service from its technical advisory committee. Hundreds of country radio amateurs will be making their way to the city for the show. These lads have a hard battle working their own problems as best they can. An information service will settle their problems in a short time.

The Postmaster-General's Department can also be relied on to provide a first-class stand and possibly a technical information service. In London the R.S.G.B. has had the willing co-operation of the Post Office officials, while the Federal Communications Commission has been a staunch supporter of the exhibitions organised by the American Radio Relay League or its affiliated clubs.

The Australian exhibitions will also provide a social atmosphere allowing W.I.A. members to meet each other personally, after perhaps several years of "invisible" acquaintance over the air. To some this may sound trivial and unimportant, but to the experienced radio amateur it is a top priority in any radio society. Country members will rush to any metropolitan show sponsored by the W.I.A. They will be there in all force when the first post-war Australian exhibition is held.

See you at next year's amateur radio exhibition!

SHORT WAVE LISTENER

Argentine Station Changes

Listeners will be interested in the recent changes made by Latin American stations to include English programmes in their various transmissions.

An added interest to listeners in Latin American Short Wave stations is the use of English in their programmes, and the Government of Argentina has recently inaugurated a new International Service of daily broadcasts in French, Spanish, Portuguese and English. Transmitters in the 19, 25, and 31 metre bands carry English news items of South American interest, and these can be heard at good strength during the afternoons here in Australia.

LRS 2 Radio Splendid in Buenos Aires, formerly heard on 11.840 kcs., has moved up to 11.880 kcs. approx., where it is heard with very good signals. Especially round 2200 GMT or 8 AM (Bampton).

Very good signals are being heard from this country by way of LRS on 11.88 Mcs Radio Splendid, and LRY on 9.45 Mcs and announcing as Radio Belgrano, the station broadcasts daily, English, French, Spanish, Portuguese, and gives callsigns on hour and half-hour, with a chime of four notes on gong.

English news is heard at 9.15 a.m., and 10.30 a.m., again at 11 a.m., over Radio Splendid on 11.88 Mcs and at 2.30 p.m. Radio Belgrano gives English news on a frequency of 9.45 Mcs.

The address for reports is given by the station announcer as follows:—International Division of the Argentine Broadcasting Service, 1841, Buenos Aires, Argentine. (Ed.).

Radio Israel Schedules

Kol-Yisrael (the voice of Israel), operating from Tel-Aviv, on 6515, and 6820, kcs., from Haifa, on 8170 kcs. Monday to Friday inclusive, 0445-0600 GMT or 2.45 p.m. to 4 p.m.; Saturday, 0530-0630 GMT or 3.30 p.m. to 4.30 p.m.; Sunday, 0445-0630 GMT or 2.45 p.m. to 4.30 p.m.; Daily, 0930-1215 GMT or 7.30 p.m. to 10.15 p.m.; Sunday to Friday, 1500-2030 GMT or 1 a.m. to 6.30 a.m.; Saturday, 1500-2100 GMT or 1 a.m. to 7 a.m.; English at 1200 and 1500 daily or 10 p.m. and 1 a.m. ([illegible]), (R.A.).

"Happy Station" Schedules

Schedule for Happy Station Programmes: Sundays and Wednesdays, 1530-1700 GMT or 1.30 a.m.-3.0 a.m. over 6025.15220 17775, and 21480 kcs. Rebroadcast same days at 2100 GMT or 7 a.m., and the following night at 3.0 a.m. over 6025, 9590 and 11730 kcs.

The Programme for Indonesia, Far-East and Pacific Areas each Tuesday at 8.30 p.m.-9.30 p.m. over 6025, 15220 and 21480 kcs.

All comments are welcome, address your letters to the Happy Station, Radio Nederland, Box 137, Hilversum, Netherlands.

STATION ADDRESSES

ZOY, Accra: Broadcasting Department, P.O. Box 250, Accra, Gold Coast, Africa. **Radio Andorra:** Roc de los Anellettes, Andorra la Vieja, Principality of Andorra, Europe.

PCJ, Holland: Post Office Box 137, Hilversum, Holland.

JJOY, Greece: District Engineer, Grecian District, Corps of Engineers, Athens, Greece.

KZOP-KZPI, Manila: Philippines Broadcast Station, 4th Floor, Ramon Foces Buildings, Soler and Calero Streets, Manila, P.I.

Leipzig: Mitteldeutcher-Rundfunk, Sender-Leipzig, Springerstrasse, 20/24, Leipzig N22, Germany.

Newfoundland Station Changes

A Canadian correspondent states that on March 31st he tuned to St. John's Station on 5970 kcs., and the announcement was "this is the Broadcasting Corporation of Newfoundland, stations VONF and VONH in St. Johns." On the following evening, however, the station announced: "This is the Trans-Canada Network of the Canadian Broadcasting Corporation, stations CBN and CBNX at St. Johns."

The address is now the Canadian Broadcasting Corporation, Newfoundland Division, Post Office Box E5372, St. Johns, Newfoundland, Canada. (R.A.).

Readers' Reports

Until further notice would all S.W. listeners forward their list of station loggings direct to the Short Wave Editor, Box 5047, G.P.O., Sydney. Copy for inclusion in July notes should reach us not later than the 1st June, 1949.

Verifications From Philippines

Of interest to readers will be the extract taken from the New Zealand DX Radio Association's Journal "Tune In," relating to verifications from the Philippines stations DZRH and DZMB.

Mr. W. H. Wallace of DZRH says that both DZMB and DZRH do send out QSL cards, and in the past few months have had a number of DX reports both from New Zealand and Australia. As far as had been checked these have been verified, but the mail between the Philippines and Australia and New Zealand is frequently slow, and sometimes non-existent, but please assure fellow DX-ers that we will be glad to verify any reception reports received by us."—(N.Z. DX. Radio Assn.).

Greek Station News

RADIO ATHENS—The Voice of Greece—Schedule: 9607 kcs.—0530-0735 GMT—3.30 p.m.-5.30 p.m., E.A.S.T.; 15345 kcs.—1500-2135 GMT—1.0 a.m.-7.35 a.m., EA.S.T.; 7300 kcs.—at same times. News in Greek at dictation speed at 1500 GMT or 1 a.m., in English at 1540 GMT or 1.40 a.m., Turkish at 1600 GMT or 2 a.m. Followed by Russian, Rumanian, Serbian, Bulgarian and Albanian, in Greek again at 2115 GMT or 7.15 a.m.; at 2130 GMT or 7.30 a.m., details of the following day's programme are given, and stations close at 2135 GMT or 7.35 a.m., with Greek National Anthem.

Frequencies of 15345 and 7300 kcs. are heard at good strength in Perth, Western Australia (Mitchell), 15345 kcs. carried special programme for U.S.A. from 2230 GMT or 8.30 a.m. News in English at 2230 GMT or 8.30 a.m. (W.R.H.).

A Swedish correspondent, Borje Johnson gives some details of the National Greek Army Transmitter in Larissa, on 6745 kcs. This station gives English Bulletins, after 1930 GMT or 5.30 a.m., transmissions are on Sundays, Mondays, Tuesdays and Fridays, being on the air at that time from 05.15-0700 and 1630-1930 GMT or 3.15-5 p.m.

They ask for reception reports, criticism, and advice and the address is as follows—Radio Broadcasting Station of the Army Corps, Larissa, Greece.

NEW STATION LOGGINGS

Callsign	KC.	Metres	Location	Time Heard
SIAM	9.798	30.62	SIAM	8.00 p.m.
OZF	9.520	31.51	DENMARK	3.00 p.m.
LRY (Radio Belgrano)	9.450	31.73	ARGENTINE	3.30 p.m.
VLX	9.610	31.22	PERTH, W.A.	6.00 p.m.
MONTE CARLO	9.790	30.67	MONACO	4.15 p.m.
LRU (Radio El Mundo)	15.290	19.62	ARGENTINE	1.00 p.m.
XERQ	9.430	31.81	MEXICO	8.30 p.m.
LLP	21.670	13.83	NORWAY	7.45 p.m.
RADIO SRINAGAR	4.856	61.79	KASHMIR, India	10.0 p.m.
LRS (Radiosplendid)	11.880	25.23	ARGENTINE	9.15 a.m.
VLX2	6.130	48.94	PERTH, W.A.	8.30 p.m.

Listen For These Stations

ALGIERS: A correspondent from Sweden writes to tell of Radio Algier, carrying out experimental transmissions over 11836 kcs. from 1645-1730 GMT or 2.45 a.m.-3.30 a.m.

SUDAN: The same correspondent tells us that Radio Omdurman is audible at 1630-1800 GMT or 2.30 a.m.-4 a.m. They operate on a frequency of 9746 kcs., and are heard in an English programme each Friday at 1730-1800 GMT or 3.30 a.m. till 4 a.m.

SWITZERLAND: This country has added another short wave transmitter to its already interesting service and it operates in the 13 metre band on a frequency of 21.520 kcs. The programme consists of French and German news, and musical items or orchestral and yodelling.

Time of transmission is 1000 GMT or 8 p.m., 1230-1245-1430 GMT or 10.30 p.m.-10-45 p.m. and 12.30 a.m.—(Ed.).

PORTUGUESE-INDIA: Station Goa operates on 7230 kcs. from 1400-1530 daily or 12 a.m.-1.30 a.m. Sundays, in Portuguese, and week-days in India. Languages: Concannin, Urdu, Marathi, and Gujarati. (Sampat).

BULGARIA: An air mail letter received from Radio Sofia, Bulgaria, recently gives the English XMNS as follows:
2030 GMT or 6.30 a.m. on 39.11 MCS on short wave band. 2150 GMT or 7.50 a.m. on 352.9 metres medium wave band.

INDIA: Radio Srinagar or Kashmir Broadcasts three daily programmes in the 61 metre band from 12.30 to 2 p.m., 4 to 5.30 p.m. and 9.30 to 2.30 a.m. Eastern Australian time. This station relays English News Bulletins from all India Radio—12.30 p.m., 10.30 p.m. and 1.30 a.m. (R.A.). Radio Jodhpur in Rajputana operates on 3775 mc/s in the 80 metre band, from 11 p.m. to 12.30 a.m., Mondays to Saturdays, and from 11 p.m. to 1 a.m. Sundays. News in English is broadcast daily at 11.40 p.m.

Our correspondent in India who reports these two stations, also advises that Radio Jodhpur will shortly change frequency for its summer — our winter—months. The frequency to which the station will move is 8550 mcs in the 35 metre band.

MEXICO: XEQQ on 9.68 mcs now has English programme "South of the Border" Sundays around 0345 GMT-0415 GMT or 5.45 p.m. to 6.15 p.m., and is asking for reports to be sent to the following address—Post Office Box 940, Mexico City, Mexico. (KRB/Radio and Television, U.S.A.).

SOUTH AFRICA: Mervyn Laubcher of South Africa reports that ZRB South African Air Force Station at Pretoria, is at last using 6210 in dual with 9110 kcs. Boice of Conn., U.S.A., reports ZUD, Victoria, on 17.749 kcs., testing daily except Sundays, from 1900-1930 GMT or 5 a.m. to 5.30 a.m. (KRB).

MOZAMBIQUE: Lourenco Marques seems settled on about 9.76 mcs at 0500-0600 GMT or 3 p.m. till 4 p.m. and 1330 GMT or 11.30 p.m. or earlier to sign off at 1600 GMT or 2 a.m.

PORTUGAL: Emissora Nacional· Lisbon, heard at various times now on 15 160 kcs. to sign off at 2300 GMT or 9 a.m.

BRAZIL: PRL8-11720 kcs., heard with an excellent signal from 0900 GMT, or 7 p.m. daily. According to the World Radio Handbook this station does not verify (R.A.).

URUGUAY: CXA 19, Montevideo, on 11835 kcs., gives a special news bulletin in Spanish for overseas listeners at 2200-2230 GMT or from 8 a.m. till 8.30 a.m. Announcements are made in French, English and Spanish. (Bampton).

ANGOLA: Reg. H. Greenland, of Yorkshire, England, says that station CR6RH Hilla, Angola, on 8232 kcs., have extended their schedule with a half hour programme at 2000 GMT or 6 a.m.

CZECHO-SLOVAKIA: English programmes from Prague as from 10th April, can be heard over 9550 kcs. from 1945-2000 and 2145-2300 GMT or 5-45-6.0 a.m. and 7.45-9 a.m. and on 11840 kcs. from 1745-1800 GMT or 3.45 a.m.-4 a.m. (Warren). The 11840 freq. has been heard recently in the afternoon with a quarter hour broadcast in the Czech language.—(Ed.).

MANCHURIA: Radio and Television, U.S.A., report a message saying that Station Harbin, Manchuria, is operating on 7.099 kcs., having an English news session at 13.40 daily (this may be the station with a callsign XNNR which was heard at quite good strength on approx. 7097 kcs., in Sept. of 1948, at 11 p.m.), (R.A.).

BELGIUM: Brussels—21450 kcs., heard testing around 0900 GMT or 7 p.m., with announcements in English and French (R.A.), (Bluman).

GERMANY: Summer time in Germany beoame effective on April 10th.

MONACO: Radio Monte Carlo says in a press message that the outlet over medium wave has been changed to 959 kcs. It was also stated that the short wave transmitters operate on 6035 and 9494 kcs. with 25 kilowatt power each. Now heard on 9.790 kcs. at 4 p.m.—(Ed.).

IRAN: Regional broadcasting station for for the Province of Fars, Iran, at a place called Shiras, is transmitting on 7960 kcs on Mondays and Thursdays at 1630-1700 GMT or 2.30 a.m. till 3 a.m.

SYRIA: Damascus, on 12000, 7275, 6000. 592 and 752 kcs. heard in an English period daily from 1230-1300 GMT or 10.30 p.m.-11 p.m. French at 1300—GMT or 11 p.m.—1330 GMT or 11.30 p.m. (Bluman).

MALTA: Forces Broadcasting Service MELF should be operating from Malta by now or very soon. Watch for this one (KRB. Radio and Television, U.S.A.).

CHINA: There has been considerable difficulty in identifying the Chinese transmitter on 11.683 mcs., heard at fair strength during our evenings. It has been reported as PCAF, BCAF, BEAF, and is now suggested by Rex. Gillett of Adelaide, that it is BEA7.

Checking over the past week it was not possible to get positive identification, it could be PCAF or BCAF. However, as most Chinese calls now appear to use "BEA" it is assumed to be BEAF.

The station is no doubt that of XGAF, which was previously in Nanking, but now appears to be on Taiwan Island (R.A.).

ADDRESSES OF S.W. STATIONS IN AFRICA

ALGERIA: Radio-Algerie, 10 Rue Hoche, Algiers.

AZORES: Emissor Regional Dos Azores, Ponta Delgada, San Miguel, Azores.

BELGIAN CONGO: Radiodiffusion Nationale Belge a Leopoldville, Congo Belge.

CANARY ISLANDS: Radio Club Tenerife, P.O. Box 225, Santa Cruz de Tenerife, Canary Islands.

EGYPT: Egyptian State Broadcasting, Broadcasting House, Cairo.

ETHIOPIA: Radio Addis Ababa Press and Propaganda Dept., Ministry of Pen Addis Ababa, 83 Patriots Road, Addis Ababa, Ethiopia.

FRENCH CAMEROONS: Radio Doula, Service Radio Electrique Doula, French Cameroons.

FRENCH EQUATORIAL AFRICA: Radio Brazzaville, Poste National Francois, Brazzaville.

GAMBIA: Electrical Branch Pud. Bathurst, Gambia.

GOLD COAST: Broadcasting Department, Accra, Gold Coast Colony.

PORT-GUINEA; Radio Bissau, Portuguese Guinea.

KENYA: Cable & Wireless Ltd., Electra House, Kabete, P.O. Box 777, Nairobi.

MADAGASCAR: Radio Tananarive, Office of the French High Commissioner, Tananarive, Madagascar.

FRENCH MOROCCO: Radio Maroc, Immeuble Des. P.T.T., Rabat, French Morocco.

SPANISH MOROCCO: Radio Tetuan, Calle O'Donell 11, Tetuan, Spanish Morocco.

MOZAMBIQUE: Radio Clube de Mozambique, P.O. Box 594, Lourenco Marques, Colonia de Mozambique.

REUNION: Radio Denis, Radio Diffusion Francaise, St. Denis, Reunion.

NTH. RHODESIA: Information Officer P.O.B 209, Nth. Rhodesia Broadcasting Station, Broadcasting House, Lusaka, Nth. Rhodesia.

STH. RHODESIA: Broadcasting House, Manica House, Salisbury, Sth. Rhodesia.

FRENCH OCC. AFRICA SENEGAL: Poste Federal de Radio Dakar, Dakar, Senegal.

SOMALILAND (BRITISH): Information & Broadcasting Department, Government Headquarters, Hargeisa, British Somaliland.

TANGIER: Radio International Sociedad Africana de Radiodiffusion, S.A., 54 Goya Street, Tangier.

UNION OF STH. AFRICA: South African Broadcasting Corporation, P.O. Box 8606, Johannesburg, Sth. Africa.

ON THE BROADCAST BAND

JAPANESE BROADCASTING STATIONS

As signals from the islands of Japan should be heard at most locations in this country during our winter months, we present a summary of the higher powered stations operating from this area. This should prove an invaluable guide to many an additional logging during the coming weeks.

Operated by the Broadcasting Corporation of Japan, stations carrying the Japanese home service number some 62. However, as many of these only run to approx. 500 watts, we list here only those of higher power, and which are most likely to be tuned in from this country.

Two Programmes

Two programmes are provided by this service—and stations in the first network, which carry the main programme are indicated in the list by the letter M appearing after the station details. Those taking the alternative programme are designated by the letter A. At present the best time to listen for these stations is late at night, when our local stations sign off leaving clear channels.

Reports to stations in this group should be addressed: C/o The Broadcasting Corporation of Japan, in the respective cities. The words "Nippon Hoso Kyokai" (Japanese for BC of J) may sometimes be heard spoken by announcers, but as Japanese characters or letters are quite different in appearance to those we use, it is perhaps as well to address the envelope in English.

590kc. **JOAK Tokyo, 50kw. M.**
690kc. **JOBK Osaka, 10kw. M.**
730kc. **JOCK Nagoya, 10kw. M.**
770kc. **JOHK Sendai, 10kw. M.**
790kc. **JOGK Kumamoto, 10kw. M.**
810kc. **JOIK Sapporo, 10kw. M.**
830kc. **JOFK Hiroshima, 10kw. M.**
850kc. **WLKH Saga, 10kw, AFRS.**
870kc. **WVTR Tokyo, 50kw. AFRS.**
940kc. **JOBB Osaka, 10kw. A.**
990kc. **JOCD Nagoya, 10kw. A.**
1080kc. **JOAB Tokyo, 10kw. A.**
1100kc. **JOFB Hiroshima, 10kw. A.**
1140kc. **JOHB Sendai, 10kw. A.**
1170kc. **JOGB Kumamoto, 10kw. A.**
1200kc. **JOIB Sapporo, 10kw. A.**
1230kc. **WVTC Nagoya, 10kw. AFRS.**
1310kc. **WVTQ Osaka, 10kw. AFRS.**
1360kc. **WLKI Fukuoka, 400 watts. AFRS.**
1370kc. **WLKE Sendai, 5kw. AFRS.**
1420 kc. **WLKD Sapporo, 7kw. AFRS.**
1440 kc. **AKAA, Yamaguchi, 500 watts BCOF.**
1440 kc. **— Iwakuni, ? W, RAAF.**
1470 kc. **WLKS, Kure, 200 w AFRS.**
1520 kc. **AKAB, Kokura, 250 watts, BCOF.**
AFRS indicates "Armed Forces Radio Service."

We extend our many thanks to Ian Johnston, Manly, for passing on the information he received from Tokyo, and upon which this list is based. We also thank Art. Cushen, N.Z., for his offer of a similar list, and Graham Hutchens, Radio Australia DX compere, for additional information, concerning stations in the Forces entertainment group.

According to Graham, a friend working at WLKS advises that all reports on reception of the station at Iwakuni should be addressed — Block 4, RAAF Station, Iwakuni, Japan. The officer in charge is Flight-Lieut. Laurie, while studio manager is Sgt. R. Brennan.

by
ROY HALLET

With the Listeners

Stuart Kerr, has written from Maryborough, Victoria, reporting receipt of some interesting verifications plus some of his latest loggings. Recent QSL's are from such stations as: KMJ, Fresno, California, U.S.A., 580 kc., which usually sends a pictorial card depicting life in the U.S.A., KNBC (formerly KPO) 680 kc., an NBC station, and KFRC, 610 kc. a Don Lee Mutual Network unit, both in San Francisco, KSJB, Jamestown, N.D. 600 kc. and WKZO, Kalamazoo, Mich., 590 kc. 5kw in the "Midnight American" Group, most of which may not be audible again until around October.

From Asia: Saigon, 1050 kc., Kuala Lumpur, 1203 kc., and BEB5, 900 kc., which we understand is the new call sign for XORA, Shanghai, have all verified. Additional loggings include: KLX, Oakland, California, 910 kc. KCRA Sacramento Calif. 1320 kc. only 1kw., KFWB, Los Angeles, Calif. 980 kc., KYA, San Francisco, Calif. 1260 kc. **From Europe,** Frankfurt, Germany, 1165 kc., Hilversum, Holland, 722 k.c., and Nice, France, 1186 kc. have been heard, plus 1XN, 970 kc. Whangarai, N.Z. and others from New Zealand, making quite an imposing list.

* * *

Ray Rooke, Manly, is another reader to have added some interesting QSL's to his collection recently, mainly from Australian stations. Among these are ones from: 5DN, Adelaide, S.A., 970 k.c., a new blue and white card somewhat similar in appearance to the card formerly issued, 2RG, Griffiths, N.S.W., 1070 kc, 200w. a white card with blue printing, a somewhat plain white card from 3DB's relay station, 3LK, Lubeck Vict., 1090 kc., 2kw., while 3UZ Melbourne, 930 kc. 600w., appears also to have replaced their card showing one of their studios with a white one with call letters superimposed on it in red.

2GZ, Orange, 990 kc., sent their usual card, showing an outline map of N.S.W. with 2GZ's location indicated on it, whilst letters were received from 3SR, Shepparton, 2kw 1260 k.c., 2AD, Armidale, N.S.W., 1130 kc. 200w, and 2NU, Manilla, N.S.W., 660kc., 10 kw., the latter coming from the ABC in Sydney. This procedure is not so unusual, as often reports sent to ABC regionals in country areas have to be sent to the state capital for checking.

Are you interested in Broadcast DXING? If so, you are invited to send in reports of your latest loggings, 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..

NORTH AMERICAN STATIONS

As reception of signals from North American stations operating on frequencies from 1500 to 1600 kc. should prove interesting during the next few weeks—there is usually something available on this band the year round—the following additional details of stations operating on these channels should be of assistance to many readers.

Best time for listening is from sunset until about 9 p.m. to Midnight, EST. 9 p.m. EST corresponds to 3 a.m. Pacific time (California), 4 a.m. Mountain Time, 5 a.m. Central (Minnesota, Iowa, Ohio, etc.), 6 a.m. Eastern Standard Time, U.S.A. (New York, District of Columbia).

1500 kc. **KSTP,** with studios in St. Paul and Minneapolis, is a good one to listen for. This channel is clear from when 2BS leaves the air around 10.15 most nights, till 3AK, Melbourne opens at 11.30 although it closes the break by opening at 10 a.m. on Sundays. In some areas 5DR, Darwin may trouble some listeners when tuning in KSTP, as it is on later than 2BS.

Operating on the same frequency **WTOP** in Washington, DC, would be more likely to be heard around sunset. We have not heard this one at our listening post, but others in Australia and several readers in New Zealand have.

1510 kc. **WLAC,** Nashville, Tenn., and KGA, Spokane, Wash., are possibles on this channel. Try around 9 o'clock.

1520 kc, **KOMA,** Oklahoma City, Oklahoma, is a good one around 9 p.m.

WKBW, Buffalo, across the country in N.Y. State, has been heard in this country, particularly on the Queensland coast.

1530 kc. **KFBK,** Sacramento, Calif. ("Your Sacramento 'Bee' Station") the "Bee" being the name of the newspaper operating on KFBK, is sometimes a good one, while others have heard **WCKY** in Cincinnati. Try for this one around 7 p.m. However, don't forget that 5AL, Alice Springs is now operating on this frequency, and may possibly spoil overseas DX for many.

1540 kc. **KXEL,** in Waterloo, Iowa, is an old favorite here, and those of you who live on the land, will find much of interest in their agricultural talks. This station, as others in the group are presenting their breakfast session. Listen for this one around 9 p.m. also.

1560 kc. **KPMC,** Bakersfield, California. 10kw. Can be heard on occasions.

1570 kc. The popular **XERF** widely heard here, with studios in Del Rio, Texas, U.S.A., and transmitter at Villa Acunna in Mexico. This location is now believed the correct one, and not as shown in the previous issue.

Philippine Island News

We had been wondering of late the whereabouts of the Manila, Philippine Island station KZOK, 1000 W, and consequently the following information proved very interesting. A member of the Short Wave League of W.A. has been advised in a letter accompanying his verification card from DZBU, Cebu, 1250 kc, that DZAB, the new station reported last month, on 860 kc. has actually replaced the former station on the air.

Art. Cushen advised us earlier this year that KZOK's associate station, now DZPI, 800 kc., had increased power to 10 kw. from Dec. 15 last, remaining on the air until 2.5 a.m., thus this company appears to have been making some sweeping changes in their service to listeners.

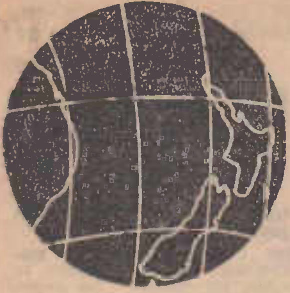
Most readers will have no doubt noticed DZMB, Manila's change from 950 kc. to 760 kc. This one is operated by the Manila Broadcasting Company, as is DZRH, 650 kc.

Listen for These

As a guide to the listeners, we might mention the following stations as being ones likely to be heard in most locations during the coming weeks. **2YA, Wellington,** N.Z., 570 kc. is still coming in at good strength, and can be heard from sunset until closing time about 9.20 p.m., and also again around 5 a.m. Several other New Zealand stations can also be heard at good signal strength at this time.

It will be noticed that many Australian stations begin transmission much earlier than previously. In addition to 2UW, and 3AK (on all night, of course) and 2CK, we hear 2KO, 2GB and 2HD before 6 a.m.

"Radio Malaya," Singapore, 620 kc. is fairly good around 12.10 a.m. with English news, as is Manila, Philippine Island, on 920 kc. relaying news from New York, U.S.A. **KPOA, Honolulu, Hawaii,** is very good from opening at 1 a.m., and at our listening post we also notice fairly good signals just now from China, particularly around 1 a.m.



TRANS-TASMAN DIARY

By J. F. FOX

(Special N.Z. Correspondent)

WORLD'S LONGEST RADIO-PHOTO LINK

Operating between New Zealand and London, the Radio-Photo link installed by the N.Z. Post and Telegraph Department is the longest such system in the world.

The New Zealand Post and Telegraph Department's radio-photo service operates over the longest radio-photo link in the world on its London-New Zealand service. In the early hours of November 20-21, 1947, the Post Office made Press history in New Zealand with the receipt over newly-installed radio-photo equipment of photographs of the Royal wedding ceremony. These photographs were received within 2½ hours after they had been taken by Fleet Street photographers.

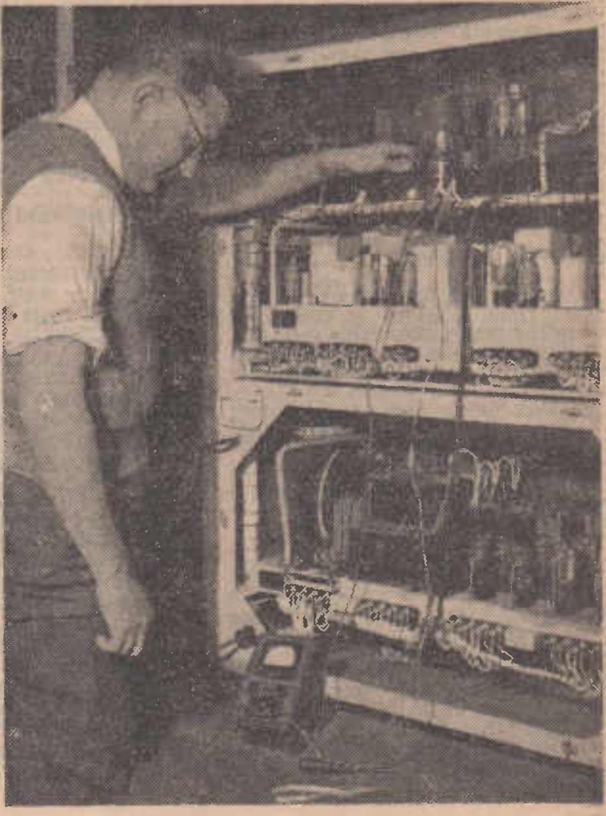
To do this, an elaborate organisation commencing at the London end with special courier services between photographer and the transmitting terminal was operated. Special care was taken with the receiving apparatus at the Makara Post Office radio receiving station, and at the photo terminal in the General Post Office building at Wellington.

Despite reception conditions which were far from good, photo prints of excellent quality were received and published in the morning editions of all Wellington newspapers.

Additional Links

The Post Office radio-photo terminal commenced on link with Melbourne and with the relay station at Colombo at 10 p.m. on the evening of November 20. Prior to the actual ceremony, three negatives were received showing Buckingham Palace and scenes of the London police holding the crowd back. At 1.7 a.m. the following morning the first of the actual wedding photographs was received, it being one of the bridal procession passing up through Whitehall. This photograph was taken about 11.15 p.m. New Zealand time and was ready for delivery to the local newspapers at 1.30 a.m. New Zealand time.

Post Office technicians and engineers, both at the actual receiving station at Makara and at the terminal in the General Post Office (which is connected by landline with Makara), worked long hours to obtain these pictures. Mr. A. F. Smith was the engineer in charge of the Makara receiving station. Mr. S. T. A. Emmett was the engineer in charge of the photo installation at the General Post Office, while Mr. S. Hall was the photographer who carried out the processing and developing of the negatives. Press reaction throughout New Zealand paid tribute to the excellence of the photographs received and the speed with which they were handled.



Radio technician G. Arthur checking the intricate equipment at the actual terminal centre. This equipment is of a design produced by the British Post Office.

—Photo courtesy Prime Minister's Department.

Technical Description

The idea of the electrical transmission of pictures to a distance is not by any means new. As far back as 1842 Alexander Bain, a British physicist, first proposed a device to send pictures from one place to another by line wires. At that time Bain conceived and solved the problem in its broadcast aspects so accurately that practically every system devised since then has employed the principles laid down by him.

Essentially, there is provided in the transmitting point a means to scan, by using the light beam, each tiny area of the picture to be transmitted and to convert the reflected light from each tiny area into an electric current proportional in strength to the reflected light. At the receiving point the received electric current from the transmitting location is converted into light of an intensity directly related to the electric current, the current being conducted by line wires provided between the two places concerned. In other words, the transmitting device produces an electric current whose magnitude varies with the shade of the picture at any given instant, while the receiving device translates this varying current into marks of varying density on a sensitive paper strip.

At the beginning of the century interest in photo transmissions quickened and very many investigators took up the problem. The more difficult problem of transmitting pictures over a radio link instead of line wires was also attacked. In 1926 the Radio Corporation of America inaugurated a public radio-photo service between New York and London. Further commercial services between New York and Berlin, New York and Buenos Aires, and London and Australia followed in the period 1926-1934.

Method of Operation

The present practice is to clamp the picture to be transmitted around a cylindrical rotating drum which is also moved slowly lengthwise. In this way, scanning is effected by an intense spot of light illuminating each small area of the picture. At the receiving location, a similar rotating drum, carrying a photograph film, is illuminated point by point by a corresponding spot of light. Its brilliance is controlled by the amount of light reflected from the picture at the transmitting location.

As the motions of the two drums are synchronised, a reproduction of the transmitted picture is obtained at the receiving location. Processing of the photographic film at the receiving location is arranged in much the same manner as in normal photographic work. Generally, the time taken to receive a picture is approximately 15 minutes, but a further period of one hour for photographic processing is required before the picture is available.

Station at Makara

Reception of the radio transmissions from overseas is conducted from the Post Office radio receiving station at Makara. Transmission of pictures from New Zealand is undertaken from Wellington Radio, the Post Office radio transmitting station situated on Tinakori Hills. Land lines link the two radio stations with the terminal equipment which is installed in the high speed morse room of the General Post Office.

Since its inauguration the service has not dealt with any large bulk of traffic, but many interesting uses of the service have been made. Instances have occurred in which documents and plans have been transmitted. With many major news events, such as the Hamilton tornado, the Ballantyne fire, the Ruapehu eruption, the recent air disasters, numbers of news pictures were forwarded. It is expected that a very great use will be made of this service during the forthcoming New Zealand cricket tour of England.

Today the New Zealand Post Office operates a radio-photo service, or, as it is termed officially, a "photo-telegram service," with England, Australia and the United States of America.

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.

Professor Shelley to Retire

The Minister of Broadcasting, Mr. Jones, has announced that Mr. William Yates will succeed Professor James Shelley as Director of Broadcasting.

Professor Shelley is retiring after 13 years as the head of the New Zealand Broadcasting Service.

Mr. Yates, who has been assistant director since 1944, recently returned from a visit to England, Canada, and the United States of America, where he studied modern methods of broadcasting.

Increase in Licences

An increase in the number of radio receiving licences current in New Zealand at September 30, 1948, was 430,490, compared with 333,366 on September 30, 1939.

IS THIS YOUR CLUB?

(Continued from Page 38.)

that's that. One or two members (who constructed it with parts donated by the half dozen or so good members) drift in to the club's 100-watt transmitter, pound out a couple of QSOs, and we go home.

The solution? Who knows? Our club has been in existence 22 years, with some of the original members still attending. While the field is almost unlimited, very few new members have been added in the past three years, and no member goes out of his way to hunt up a new candidates. There is some talk of the "solid" members withdrawing and forming a new club with strict membership requirements, to weed out the deadwood.

It is hoped this doesn't describe your club, too. Maybe there are other clubs with similar problems who will read this and see the light and correct their situation. If so, this article has served a constructive purpose.

—Courtesy Q.S.T.

Technical BOOK REVIEW

ESSENTIALS OF RADIO by Morris Slurzberg, B.S., M.A., and William Osterheld, B.S., M.A. Published by the McGraw-Hill Book Company, Inc. 806 pages. Stiff cloth cover. Price 42/- plus postage.

This text is the companion volume to the author's earlier work, *"Electrical Essentials of Radio,"* and as the title implies it is a basic text suitable for all students of radio. Its main purpose is to present at an intermediate level, a comprehensive study of the principles of operation of vacuum tubes, their basic circuits, and the application of these circuits to low-frequency radio receiver applications.

Being clearly and simply presented, this book will be of particular value to persons studying radio by self instruction or even those attending regular classes, as it provides the much needed bridge between the elementary texts, and those of the engineering level. A minimum knowledge of mathematics is presupposed on the reader's part, and the use of equations, graphs and vectors, is fully explained as required in the text. Examples of complex as well as simple circuits are given for DC circuits, and AC circuits and vacuum tube circuits.

The text comprises some 15 chapters, and covers such subjects as: Introduction to Radio, Circuit Analysis, Simple Receiving Circuits, Vacuum Tubes, Detector Circuits, Tuning Circuits, R-F Amplifier Circuits, A-F Voltage Amplifier Circuits, Power Amplifier Circuits, Vacuum Tube Oscillator Circuits, Power Supply Circuits, Audio Units, Transmitting Circuits, Receiving Circuits and Test Equipment. Each chapter includes a bibliography of additional reading, and questions and problems covering the subject matter of the chapter. The answers to most problems are also included, thus permitting the home student to check on his own calculations.

A particularly valuable feature of the book is the inclusion of 18 appendices dealing: electronic symbols, conversion factors, radio and electronic formulae, wire tables, standard colour codes, trigonometric tables, common logs, etc. These are comprehensive enough to provide sufficient reference data to solve all of the problems in the book without the need of any additional references.

The many detailed drawings and lavish use of half-tone illustrations makes this an ideal text book for the serious student, and it is specially recommended as a home study text.

FREQUENCY ANALYSIS, MODULATION AND NOISE by Stanford Goldman, Ph.D. Published by the McGraw-Hill Book Company, Inc. 434 pages. Stiff cloth cover. Price 58/6, plus postage.

This is a mathematical text in which three virtually unrelated phases of radio engineering—namely Fourier Integral Analysis Modulation and Random Noise, are discussed in some detail. Much of the material presented is entirely new, never having been previously treated in any other text or periodic literature, and consequently provides the engineer with information that has assumed great importance in the radar and television fields.

The first portion of the book—some 140 pages — is devoted to a thorough treatment of the Fourier integral analysis, detailing both the series and integral basic Fourier transforms. A variety of problems is given to illustrate its applications to radio problems.

The section of Modulation discusses this theory very fully with particular emphasis on the resolving the sideband distribution into symmetrical and antisymmetrical components. Both amplitude and frequency modulation are covered with specific information regarding adjacent channel interference and distortion of both systems being given.

The final section deals with the solution of noise problems, and provides probably the most comprehensive treatise at present available on this important subject. Various types of noise are discussed, together with the appropriate formulae, and examples are given to indicate the method of calculating total noise values, noise figure and sensitivity.

This book will be of particular value to the radio engineer, and the prerequisites for its understanding are a sound knowledge of both the calculus and radio engineering principles.

INDUSTRIAL ELECTRONICS AND CONTROL by Royce G. Kloeffler. Published by John Wiley and Sons, Inc. 478 pages. Stiff cloth cover. Price 42/6, plus postage.

Written not only for the electrical engineer, but for the mechanical and chemical engineer as well, this new text provides a complete survey of the theory and applications of electronics in industry. The first eight chapters are devoted to basic electron tube theory, and cover such topics as: Electron Emission, Vacuum Diodes, Grid Controlled Vacuum Tubes, Gaseous and Vapour Tubes, and Photoelectricity.

The remaining 14 chapters deal with direct electronic circuit applications: Principles of Control, and Servomechanisms, High Frequency Heating, Resistance Welding, Photoelectric Control Devices, X-Ray Applications, being some of the typical chapter headings.

The book is well supplied with additional problems at the end of each chapter, together with further reading references. The subject matter is presented in a lucid, easy to read style, and can provide much valuable information to the reader interested in the field of electronics, and its commercial applications.

Books made available by Angus and Robertson Ltd., 89 Castlereagh Street, Sydney.

TELEVISION BEHIND THE SCENES By John K. Newnham. Published by Convoy Publications Ltd. Stiff cover, 103 pages. Price 8/3. Australasian Distributors: Truth and Sportsman Ltd.

This book deals with the fascinating story of the human side of Television in an entertaining and enlightening manner. It is in effect the story of the B.B.C.'s development of television in England, and gives an interesting insight to the workings of the studios at Alexandra Palace.

Written in a non-technical language, it tells how the announcers work and who they are, reveals the secrets of television shows and the men and women who produce them. Other highlights include details of Outside Broadcasts, how films are televised, and information on many of the regular B.B.C. programmes.

The book is well illustrated with 21 half-tone plates, and although many of the personalities referred to may be comparatively unknown to readers in this country, there is still much information of great interest to all those wishing to gain a knowledge of the working of a modern television station.

Our copy from Invincible Press, Sydney.

DESIGN FOR AN ELECTRONIC BRAIN

(Continued from Page 12)

Firstly, in its construction, many a detail will have to be fixed at some arbitrary value selected witnout full knowledge of what features it may impose ultimately on the type of reactions. Are the tubes, for instance, to have an anode voltage near the maximum or much lower? Once made, such a decision will result in an all-pervading tendency in the machine's behavior. One machine, for instance, might try to solve all problems by exploring the possibilities of immediate violent activity, while another machine might react to all problems by a tendency to go on collecting interminable information, doing nothing as long as there was a shadow of doubt.

"Temperament" in Machine

We are, in short, up against the fact of "temperament." The designer will put in some temperament or other whether he intends it or not: once he builds a machine which works in its own way there is no such thing as "no" temperament. The peculiar difficulty here is that the machine will manifest it in a form too complex and subtle for the designer's understanding.

But perhaps the most serious danger in such a machine will be its selfishness. Whatever the problem, it will judge the appropriateness of an action by how the feedback affects itself: not by the way the action benefits us.

It is easy to deal with this when the machine's behavior is simple enough for us to be able to understand it. The slave-brain will give no trouble. But what of the homeostat-type, which is to develop beyond us? In the early stages of its training we shall doubtless condition it heavily to act so as to benefit ourselves as much as possible. But if the machine really develops its own powers, it is bound eventually to recover from this.

Use in Social Planning

If now such a machine is used for large-scale social planning and coordination, we must not be surprised if we find after a time that the streams of orders, plans and directives issuing from it begin to pay increased attention to securing its own welfare. Matters like the supplies of power and prices of tubes affect it directly and it cannot, if it is a sensible machine, ignore them.

Later, when our world-community is entirely dependent on the machine for advanced social and economic planning, we would accept as only reasonable its suggestion that it should be buried deeply for safety. We would be persuaded of the desirability of locking the switches for its power supplies permanently in the "on" position. We could hardly object if we find that more and more of the national budget (planned by the machine) is being devoted to ever-increasing developments of the planning machine. In the spate of plans and directives issuing from it we might hardly notice that the automatic tube-making factories are to be moved so as to deliver directly into its own automatic tube-replacing gear; we mightly hardly notice that its new power supplies are to come directly from its own atomic piles; we might not realise that it had already decided that its human attendants were no longer necessary.

How will it end? I suggest that the simplest way to find out is to make the thing and see.

References

(1) Ashby, W. R., J. ment. Sci., 86, 478 (1940).

(2) Rosenblueth, A., Wiener, N., and Bigelow, J., Phil. Sci., 10, 18 (1943).

(3) Ashby, W. R., J. gen. Psychol., 32, 13 (1945).

(4) The Electroencephalographic Society at The Burden Neurological Institute, Bristol, on 1st May, 1948.

(5) Fisher, R. A. and Yates, F., Statistical tables. Edinburgh, 1943.

(6) Electronic Engineering, Dec., 1946, p. 372.

(7) Nature, 185, 500 (12th Oct., 1946).

Reprinted with permission from Electronic Engineering, England.

AUDIENCE MEASUREMENT COUNTER

Operation of a newly-developed Instantaneous Audience Measurement system, known as IAMS, was detailed in a recent issue of Electronics, U.S.A. The system involves having 1000 transceivers located in pre-selected homes and actuated by pulses sent out by a master broadcasting station along with its regular programme.

When these units are interrogated, they broadcast uhf pulses, which in turn are picked and collated at the measuring location. The results appear in the form of a graph on paper tape, showing the percentage of sets in use and tuned to a particular station at the time of interrogation.

Each transceiver is about the size merely involves plugging into a wall of a cigar humidor. Installation outlet and connecting to the AM, FM and TV sets in the home. Motor driven clocks in the transceivers are synchronised with a master clock at the transmitter that has its face divided into 60 information segments, 20 each for AM, FM and TV receivers. As the hand of the clock in each transceiver reaches a segment, the transceiver sends out a pulse if the set and station assigned to that segment are on in that home. The clock hand makes one revolution in 2½ minutes, and the 1000 transceivers polled at each of the 60 segments can thus send up to 60,000 separate responses to the system receiving antenna.

Additional features that can be incorporated include a yes-no push button that allows the listener to vote on various questions on asked over the air, and means for identifying in which of three income groups and three geographic groups the responding transceivers are located.

NEW TV DEFINITIONS

New words and new definitions appear in an NBC TV glossary of terms now used in telecasting.

In it are such new words as *womp*, which means a sudden flare-up of brightness in the picture; and *woof*, which is telephone slang used by TV engineers to signify okay and goodbye.

The word *busy* has taken on a new meaning, for now it seems to describe a setting or background that is too elaborate and obscures the movement of actors or detracts from the logical centre of interest on a scene. *Free perspective* has a new definition too, now; the deliberate falsification of normal perspective in a painting or construction of television settings to achieve an apparent greater depth or distance. *Freeze it* is used to indicate that set designs and arrangements or positions of furnishings are approved and should be executed as planned.

Getaway is now an offstage means of descent from a raised flooring area within a set. It's also a passageway behind the settings provided as a means of unobserved access to other settings or locations within the studio.

High hat is not a topper in TV talk, but a camera mount for use on a table top, and *inky* is an incandescent lamp. And *noodle* is not something to eat, but the playing of a few bars of background music, usually in an improvised style behind the titles of scenes. The art is known as noodling. By the way, *stretch* now means a stall for time.

—Courtesy Radio and Television News (U.S.A.).

BASIC ELECTRICITY AND MAGNETISM

(Continued from Page 31)

Diffraction is characteristic of any wave phenomena such as light; it is the result of the interference of light of different phase. Proper treatment of the subject can only be mathematical, but a simple case is shown in Figure 7-2. A source S, produces a parallel beam of light which is sent through two slits, A and B, in a plate P, and is received on a screen, C.

The resultant patterns on the screen are not sharp edged; the light spreads. If the slits are close enough together, the light from one interferes on the screen with the light from the other. At a point equi-distant from the two slits on the screen, the waves arrive in phase and reinforce each other.

Wave Cancellation

At points either side of this, one train of waves passes over a greater distance than the other train and if this distance is greater than half a wave length, the result, when they meet, will be darkness, one wave cancelling the other. At further points where the difference in distance is a whole wavelength, the waves reinforce each other. This interference between the light waves produces diffraction.

If S is made a source of electrons, and a photographic plate is substituted for the screen, the pattern found on the photographic plate will be the same as that obtained with the light rays. On the plate there will be places where no electron strikes, yet if *we block up one slit*, electrons will apparently fall there. The only possible explanation is that each electron goes through both slits at once, or, that it guides its movements when passing through one hole by reference to whether the other one is closed or not. Both notions are nonsensical when we think of the electron as a particle.

The only sensible conclusion is that electrons are waves, but opposing this notion is the evidence of other experiments which prove them to be particles. Their behavior can hardly be taken as confirmation of mathematical theory because this theory is only concerned with theoretical waves and not physical ones at all. Research has brought us to a stage whereat we can conclude that all we know about an electron is its mathematical specification, and we do not know what physical reality obeys that specification.

The Electron Theory Applied to Electrical Phenomena

You will note that this article has considered the evolution of the Electron Theory rather than the Theory itself. We have dealt with the Theory in this way because it gives us a deeper and broader concept of what the Electron Theory is about.

Most electrical phenomena can be explained satisfactorily by thinking about the electron as a particle, and many electrical texts never hint, when dealing with electronic behavior, that the electron is more than a particle. Such books conveniently use illustrations and analogies in which the notion that the electron has wave characteristics, is never necessary.

There are, however, a number of electrical phenomena of even an elementary nature which cannot be satisfactorily explained, when the electron is regarded as a particle. One particular case is that of a capacitor using a vacuum as a dielectric, e.g., the grid and plate of a thermionic valve. The radiation of electrical energy as occurs in the instance of radio transmission is another phase of electronics which cannot be thought of in terms of tiny marbles being hurled into space.

Lack of information regarding the exact nature of the electron compels us to explain some kinds of electronic behavior by regarding the electron as a particle, and explain other kinds by thinking of it as a wave. In general, we will regard the electron as a particle when dealing with tangible substances and treat it as a wave when we are dealing with such intangible entities as space, energy and inertia.

We can hope, meantime, that some genius will suggest something that will solve the problem which has baffled the physicist for centuries. Is light corpuscle or wave? Are electrons particles or only waves of probability undulating into nothingness?

The next article will deal with the energy aspects of capacitance, and the mechanical forces involved with charged capacitors. The electron theory will be used frequently in subsequent articles, and the necessity of regarding the electron as having dual characteristics will then be obvious.

GEIGER-MUELLER COUNTER

(Continued from Page 8)

On the other hand, if both counters operate simultaneously both tubes are cut off, and the maximum pulse voltage is developed across RL. A suitably biassed tube following the ones shown can be made to respond to the maximum pulse and not to the half-maximum pulse. As a result, the arrangement will indicate when an ionising particle or ray traverses both counters (practically simultaneously) or only one.

Thus, ray A will actuate the top counter only, whereas ray B will actuate both, and register in the output of the electronic system. By orienting the counter system with respect to the ray or particle path so that the maximum number of counts per second or minute is obtained, the direction of the ray may be ascertained. For greater resolving power, a stack of as many as ten counters may be employed in a coincidence system.

Other Variations

Many variations are possible. For example, if it is desired to distinguish between single cosmic rays that pass through a sample in a definite direction and cosmic ray bursts that pass through it from all directions, then a coincidence system can be set up on either side of the sample along the single ray path (say, above and below the sample), and additional counters can be placed on all sides of the sample. The latter counters can be connected to furnish a positive pulse by using an additional amplifier stage per counter, and the second tube whose plate is connected to RL can be initially biassed to cut off.

Pulses from the side counters therefore produce increases in the current in RL and accordingly counteract pulses from the counters above and below. Hence cosmic ray bursts, which may produce radiation from all directions, do not produce any appreciable output, whereas single rays, which affect only the top and bottom counters, produce a definite output. In this way one phenomenon can be distinguished from another, and the arrangement is known as an *anti-coincidence circuit*.

The subject of counters is very broad, and the literature has become very extensive. In this article it has been attempted to give a brief exposition of the theory and operation, so that the reader may have some idea of the action of these devices. Further and more detailed material may be found in the many admirable books that have been published, as well as articles in the technical magazines.

The Mail Bag

K.T. (Lidcombe, N.S.W.), forwards a hint on removing radio knobs when the grub screw is sheared off, for inclusion in the "For Your Notebook" columns.

A.: Many thanks for the letter and hint, K.T. This will be suitable for publication and will be used in a future issue. The details given will be elaborated on, and for clarity the drawing will be included. We note your interest in the "Scratch Filter Unit," and would be pleased to hear of your results with it when you build it up.

J.B.W. (Harwood Island), forwards a change of address.

A.: Your new address has been noted and this will take effect from June issue. The May issue was forwarded to your old address, but it is possible you may have received this before your departure. We are pleased to hear you enjoy reading RADIO SCIENCE and thank you for recommending it to your friends. We trust you will have a pleasant journey, and wish you "Bon Voyage."

E.M. (Mt. Lawley, W.A.), intends building up the "Dual Wave Seven" described in the RADIO SCIENCE for May, 1948, and requests a copy of this issue.

A.: The issue requested has been forwarded and no doubt will have been received by now. We would be pleased to hear of your results with this receiver, as many appreciative reports have been received from readers who have built it up.

M.C.H. (Koorda, W.A.), compliments us on the style of RADIO SCIENCE and forwards a subscription for two years.

A.: Thanks for the subscription, M.C.H., and this has been attended to by the Subscription Department. To date we have not had many enquiries for the description of 32 volt equipment, but agree that an article on the lines you suggest would be of interest to many country readers. It may be possible to include some data on these receivers in a future issue, but at the moment it would be impossible to say when this will be. We appreciate your complimentary remarks about RADIO SCIENCE and feel sure you will find all future issues even more interesting than those in the past.

J.C.F. (Kingsford, N.S.W.), is interested in building up the Signal Tracer described in the April, 1948, issue of RADIO SCIENCE, and asks for details of this unit.

A.: The issue containing full details of the Signal Tracer has been forwarded to you. We migh mention that the following changes are necessary with this circuit, if they are not already marked on your copy. Firstly, the .025 meg potentiometer should be replaced with a .025 meg fixed resistor, and one of the 500 ohm resistors should be a 500 ohm potentiometer. The other change is to connect a minus lead to earth and not to the B minus lead as shown. If these changes are made then you should have no trouble in getting the unit to operate correctly.

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.A. (Petersham, N.S.W.), advises us of his change of address.

A.: The new address has been noted by our Subscription Department and this becomes effective with the June issue.

J.E.L. (Millswood Estate, S.A.), forwards a subscription for two years and writes: "I am a regular reader of RADIO SCIENCE and look forward each month to receiving each copy. I have tried out quite a few of the circuits printed with complete satisfaction and would like to see more of the articles on Hints to Servicemen. I have constructed a multimeter, multivibrator, RF oscillator and signal tracer and enjoy getting a faulty receiver into working order again."

A.: Your interesting letter was appreciated, J.E.L., and we are pleased to hear you enjoy reading RADIO SCIENCE. Your subscription has been attended to, and the additional issue requested has been forwarded. We note your interest in servicing articles and might mention that we have some on hand which are due to appear in future issues of RADIO SCIENCE.

CHASSIS AND CABINETS

Although most of the components used in RADIO SCIENCE constructional articles are standard lines available from most radio stores, some readers have difficulty in obtaining the special chassis and cabinets when required.

If you have any trouble in this regard, and cannot obtain any chassis required, through the usual channels, then write in and let us know and we will make arrangements to assist you in this regard.

E.M.T. (Glenthuntly, Vic.), has built up the Signal Tracer described in the April, 1948 issue of RADIO SCIENCE, but is having trouble in getting it to operate correctly.

A.: As there were two errors in the circuit as printed, it is possible you may have missed the corrections mentioned from time to time in these columns. Firstly the .025 meg potentiometer should be a .025 meg fixed resistor, and one of the 500 ohm resistors should be changed to a 500 ohm potentiometer so as to provide the correct balancing circuit. Also the A minus lead shown connected to the B minus line is incorrect; this lead should be earthed. The meter you are using should be satisfactory as it is only a relative strength indication that is being made. The 3S4 connections you indicate are correct, but make sure that pins 2 and 6 are connected to the same section of the circuit. Both these pins connect to the plate. The grid return lead is as you mention. We suggest you make these changes and then if the rest of your wiring is correct, you should have no difficulty in making the unit operate as it would. Let us know how you get on.

M.H.S. (Brisbane, Qld.), requests the name and address of the reader D.K.C. (Seaforth), mentioned in April issue "Mailbag."

A.: The information you require has been sent off by mail to obviate any delay. We trust you will obtain the information required, or if we can be of assistance, then we would be pleased to hear from you again.

THE "SUPER-PORTABLE"

(Continued from Page 22)

ment should be carried out using a signal generator, with the loop mounted close to the receiver, in the position it will occupy when in the cabinet.

We would be pleased to hear from all readers building up this receiver, as we know you will find the performance is excellent and better than the average portable receiver.

RED LINE

TRANSFORMERS OF DISTINCTION

FILAMENT TRANSFORMERS

ITEM 34. **Type No. 7038**
Prim: 230v. .... 50 cps.
Secondary 6.3v-3A
Base: 2½ x 2 x 2⅛" H .... Wgt 1lb. 4ozs.
Mntg: MH1A .... "S" is1"
Insulation .... 500 volts

ITEM 35. **Type No. A246**
Prim: .... Auto Winding
V: Common .... 2.5v .... 4v 6.3v-3A
Base: 2½ x 2 x 2⅛" H .... Wgt 1lb. 4ozs.
Mntg: MH1A .... "S" is 1"

ITEM 36. **Type No. 2500**
Prim: Com-10-210-220-240v .... 50 cps.
Fils: .... 2.5v 10A CT
Base: 4 x 3⅛ x 3¾" H .... Wgt 4lb 8 ozs
Mntz: V10 .... "S" is 1"
Insulation .... 2000 volts

ITEM 37. **Type No. 5526**
Prim: Com-10-210-220-240v .... 50 cps
Fils: 5v-4A .... 2.5v-10A CT
5v-2A .... 6.3v-4A CT
Base: 4 x 4 x 3¾" H .... Wgt. 6lb 12ozs
Mntg: V10 .... "S" is 1¾"
Insulation .... 1000 volts

ITEM 38. **Type No. 5566**
Prim: Com-10-210-220-240v .... 50 cps
Fils: 5v-4A 6.3v-3A
5v-4A 6.3v-3A
Base 4 x 4 x 3¾" H .... Wgt. 6lb 12 ozs
Mntg: V10 .... "S" is 1¾"
Insulation .... 100 volts

ITEM 39. **Type No. 66105**
Prim: Com-10-210-220-240v .... 50 cps
Fils: 5v-4A .... 6.3v-3A CT
10v-8A-CT .... 6.3v-3A CT
Base: 5 x 4¾ x 4⅝" H .... Wgt. 12lb 8 ozs
Mntg: V15 .... "S" is 2"
Insulation .... 1000 volts

VIBRATOR POWER TRANSFORMERS

ITEM 40. **Type No. 60256**
Primary 6v/6v
Secondary .... 250/250v 60 mA
Base: 3 x 2¾ x 2⅛" H .... Wgt. 2lb 8ozs
Mntg: V2 .... "S" is 1¼"

ITEM 41. **Type No. 602512**
Primary 12v/12v
Secondary .... 250/250v 60 mA
Base: 3 x 2¾ x 2⅛" H .... Wgt. 2lb 8ozs
Mntg: V2 .... "S" is 1¼"

ITEM 42. **Type No. 15136**
Primary 6v/6v
Secondary .... 130/13/v 15 mA
Base: 3 x 2½ x 2⅛" H .... Wgt. 2lb
Mntg: V2 .... "S" is 1"

OUTPUT TRANSFORMERS

The units in this section comprise a useful range of output transformers for the sound engineer specialising in amplifiers for public address, "Music-while-you-work," paging systems, etc., where it becomes essential to minimise losses due to the necessary use of multiple speakers at varying distances from the amplifier. They are not "High fidelity" transformers, and are not intended as such.
Their frequency response, in all cases is designed to be plus or minus 2db from 50 cps to 7 Kc/s, and particular care has been taken to reduce power insertion losses, which are of considerable importance in this field
Complementary types to match speaker voice coils to line will be listed in the future.

ITEM 43. **Type No. AP1**
Primary Z. 5000 ohms .... Plus 29db
6V6 Class A1. 4.5 Watts. DC Max. 50 mA
Secondary Z .... 500 ohms
Base: 2½ x 2 x 2⅛" H .... Wgt. 1lb 8ozs
Mntg: MH1B .... "S" is ⅞"

ITEM 44. **Type No. OP1**
Primary Z. 5000 ohms .... Plus 29db
6V6 Class A1. 4.5 Watts. DC Max. 50 mA
Sec. Z: 12 ohms tap at 8.4 and 2 ohms
Base: 2½ x 2 x 2⅛" H .... Wgt. 1lb 8 ozs
Mntg: MH1B .... "S" is ⅞"

ITEM 45. **Type No. AP2**
Primary Z: 9000 ohms .... Plus 34db
6V6's pp Class AB1 .... 15 watts
Sec. Z: 500 ohms tapped 250 ohm.
Base: 3 x 3⅛ x 2½" .... Wgt. 3lb
Mntg: V2 .... "S" is 1½"

ITEM 46. **Type No. OP2**
Primary Z: 9000 ohms .... Plus 34db
6V6 pp Class AB1 .... 15 watts
Sec. Z: 12 ohms tap at 8.4 and 2 ohms.
Base: 3 x 3⅛ x 2½" H .... Wgt. 3lb
Mntg: V2 .... "S" is 1½"

ITEM 47. **Type No. AP3**
Primary Z: 6600 ohms .... Plus 37db
6L6's pp. Class AB1 .... or 807's
Secondary Z: 500 ohm tapped 250 ohm.
Base: 4 x 4¾ x 3¾" H .... Wgt. 6lb
Mntg: V10 .... "S" is 1½"

ITEM 48. **Type No. OP3**
Primary Z: 6600 ohms .... Plus 39db
6L6 pp or 807's Class AB1 .... 30 W
Sec. Z: 12 ohms tap at 8.4 and 2 ohms.
Base: 4 x 4¾ x 3¾" H .... Wgt. 6lb
Mntg: V10 .... "S" is 1½"

ITEM 49. **Type No. AP4**
Primary Z: 2500 ohms .... Plus 30db
6L6 (807) Class A. 6W .... 72 ma DC
Secondary Z: 500 ohm tapped 250 ohm.
Base: 3 x 3⅛ x 2½" H .... Wgt. 3lb
Mntg: V2 .... "S" is 1½"

ITEM 50. **Type No. OP4**
Primary Z: 2500 ohms .... Plus 30db
6L6 (807) Class A. 6W .... 72 ma DC
Sec. Z: 12 ohms tap at 8.4 and 2 ohms.
Base: 3 x 3⅛ x 2½" .... Wgt. 3lb
Mntg: V2 .... "S" is 1½"

ITEM 51. **Type No. AP5**
Primary Z: 5200 ohms .... Plus 40db
809's Class B .... DC Balanced
Sec. Z: 500 ohms tapped 250 ohm.
Base: 4 x 4½ x 4¼" H .... Wgt. 9lb.
Mntg: V11 .... "S" is 2⅛"

RED LINE EQUIPMENT PTY. LTD.

TRANSFORMER ENGINEERS

WORKSHOP: Cent. 4773. 2 Coates Lane, Melbourne. CITY OFFICE: MU 6895 (3 lines), 157 Elizabeth St., Melbourne.

KEEP THIS CATALOGUE
Cut out and file for reference

RED LINE

VICTORIAN DISTRIBUTORS
Homecrafts Pty. Ltd.
Veall's Electrical & Radio Pty. Ltd.
Radio Parts Pty. Ltd.
Howard Radio Ltd.
A. G. Healing Ltd.
Healings Pty. Ltd.
Motor Spares Ltd.
Warburton, Franki Ltd.
Lawrence & Hanson Ltd.

INTERSTATE DISTRIBUTORS
NEW SOUTH WALES
U.R.D Pty. Ltd.
Homecrafts Pty. Ltd.

QUEENSLAND
B. Martin Pty. Ltd.
A. E. Harold.
Denradio Industries (Maryborough).
J. Michaelmore & Co. (Mackay).

SOUTH AUSTRALIA
Gerrard & Goodman Ltd.
Mewton & McLaren Ltd.
Unbehaun & Johnson Ltd.
Radio Wholesaler's.

TASMANIA
Lawrence & Hanson Ltd.
Noyes Brothers (Aust.) Ltd

A GUARANTEE OF DEPENDABILITY