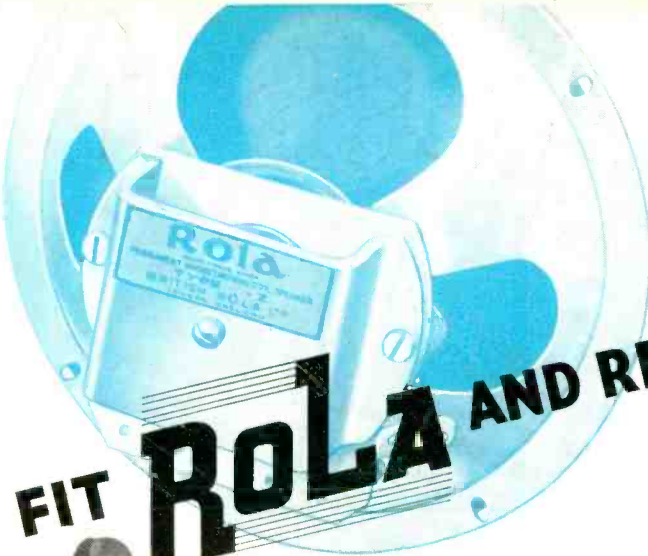
Wireless World

RADIO AND ELECTRONICS

JUNE 1947
1/6
Vol. LIII. No. 6

IN THIS ISSUE: NEW TESTING AND MEASURING EQUIPMENT



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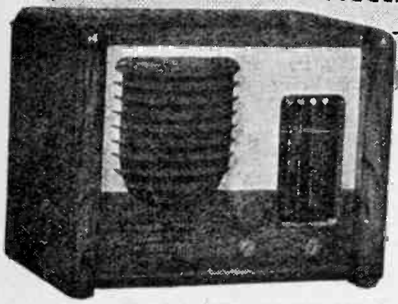
Wireless World *July, 1946*

Test Report

SOBELL Type 615

A.C. Table Model Superhet
(Five Valves + Rectifier)



The following are brief extracts from a report which appeared in the July 1946 issue of "Wireless World" on the Sobell 615 6-valve A.C. Table Model Superhet :—

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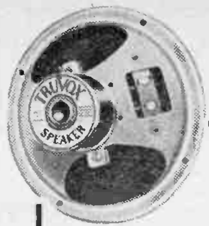

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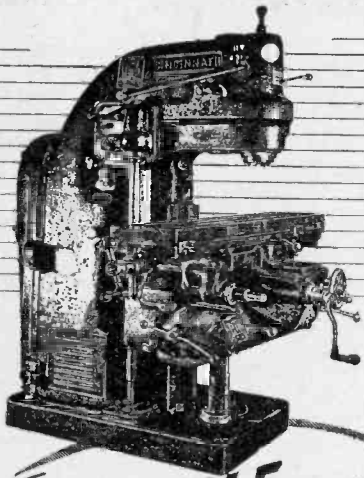

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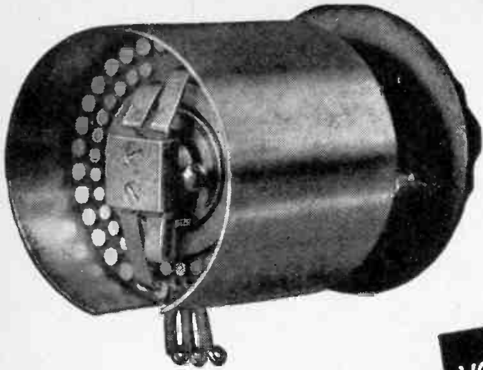

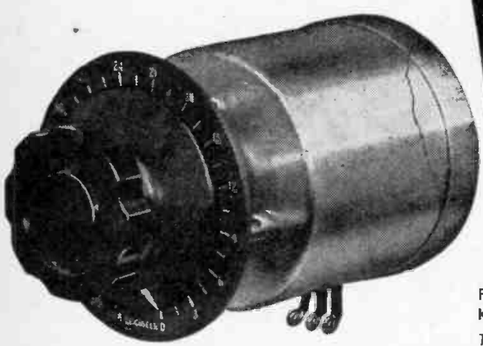

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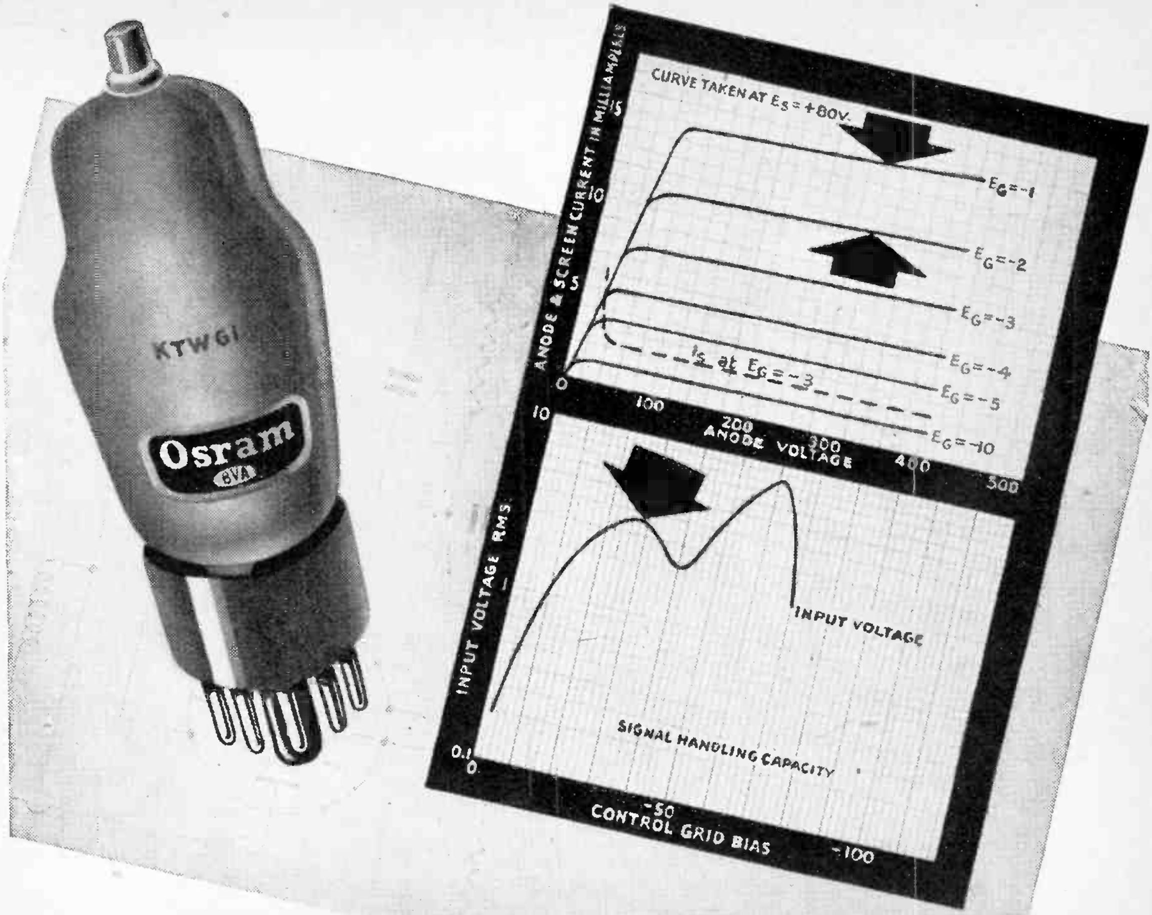

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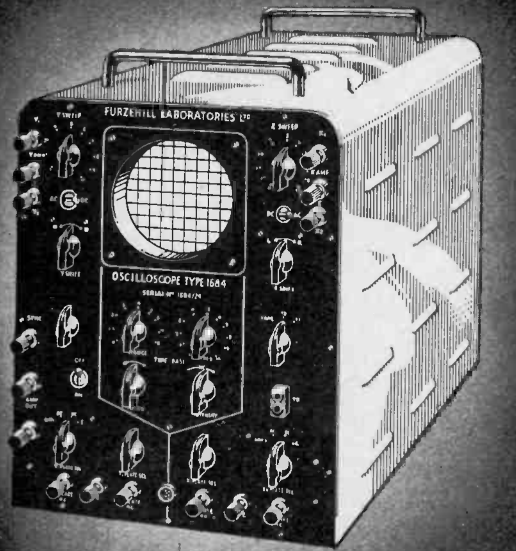

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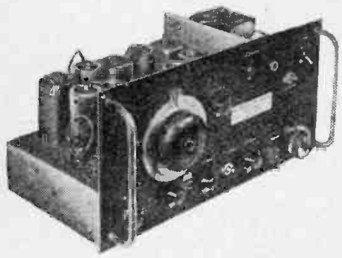

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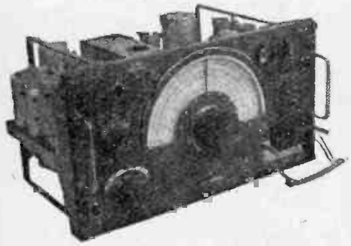

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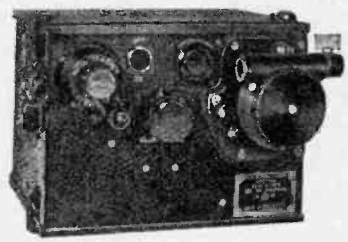

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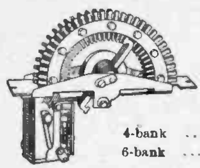

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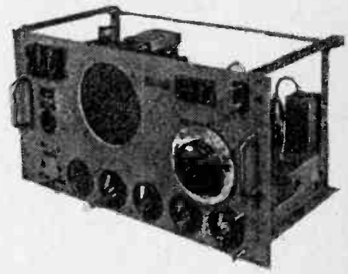

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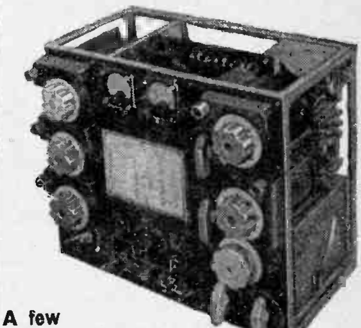

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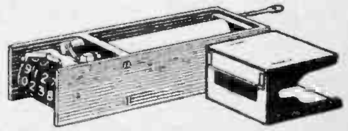

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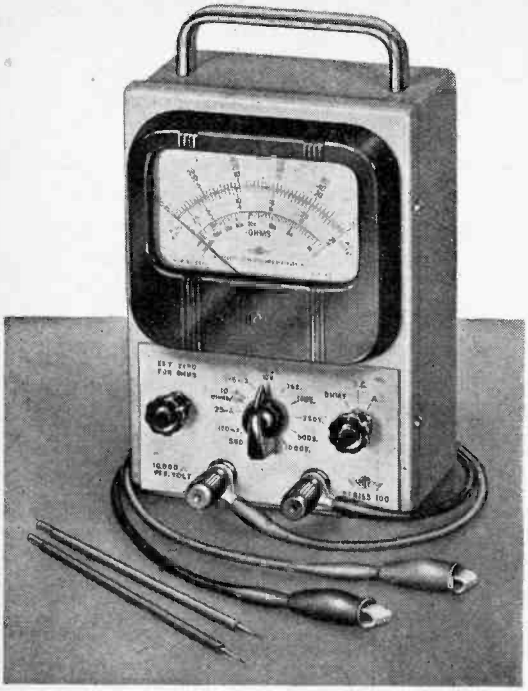

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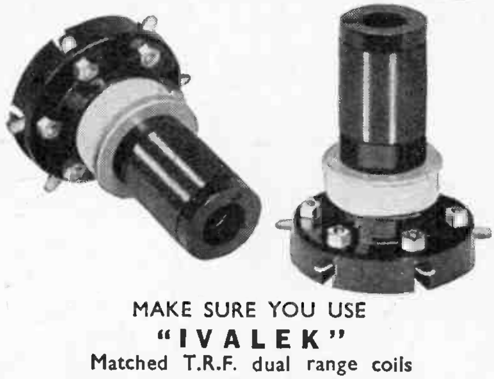

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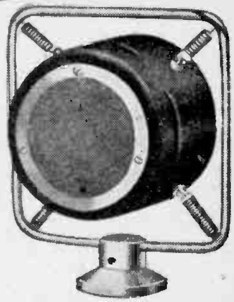

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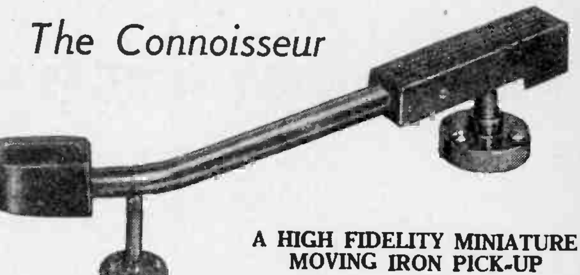

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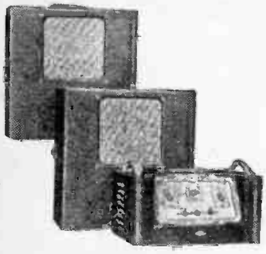

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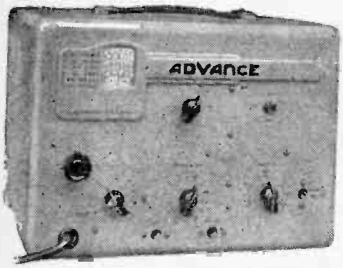

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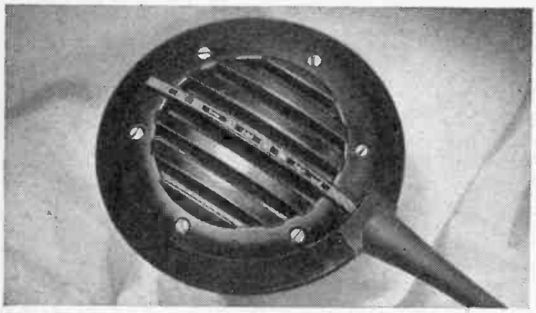

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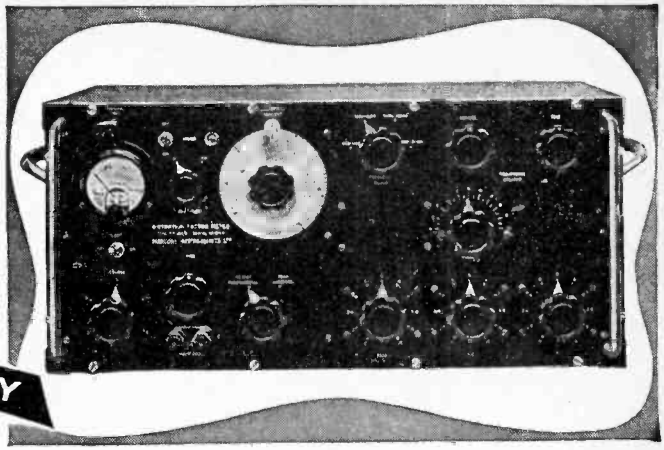

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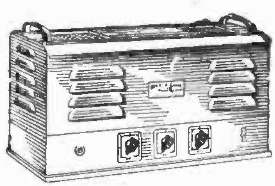

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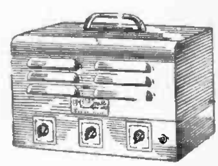

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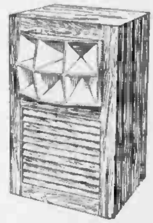

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As many of the circuits and apparatus described in these pages are covered by patents, readers are advised, before making use of them, to satisfy themselves that they would not be infringing patents.

VALVES AND THEIR APPLICATIONS

By M. G. SCROGGIE, B.Sc., M.I.E.E.

No. 6: Mullard MERCURY VAPOUR RECTIFIER RG1-240A

GENERALLY speaking, vacuum rectifiers are suitable for domestic receivers, and mercury-vapour for transmitters and high-power amplifiers. The dividing line is in the region of 100 watts; perhaps higher if the load is constant, or lower if it is variable.

The vacuum rectifier is simple and foolproof. But owing to its high resistance it is unduly large, expensive, and wasteful for high-power units. And output voltage varies considerably with current — i.e., it has bad regulation, as shown at A in Fig. 1.

The drop across the mercury rectifier is steady at about 15 V even when passing heavy current, so anode dissipation is slight and quite a small valve serves for d.c. of the kilowatt order. And, as shown at B, regulation is excellent over a wide range of current.

Although one of the suitable circuits (Fig. 2) is, except for the absence of reservoir condenser, identical with the usual vacuum rectifier arrangement, it works differently and requires quite different components and design. Omitting the reservoir condenser is not optional; in the interests of valve life it must never be used, nor must the first smoothing capacitance exceed the valve-makers' limit. The choke is particularly important, because regulation is good only so long as its reactance is sufficient, relative to load resistance, to maintain current through itself uninterrupted. The critical ratio is about 2 : 3.

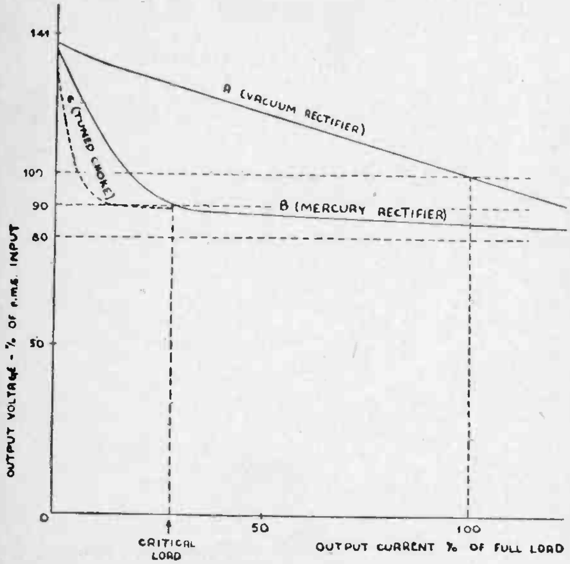

FIG. 1. POWER UNIT REGULATION, USING TYPICAL COMPONENTS.

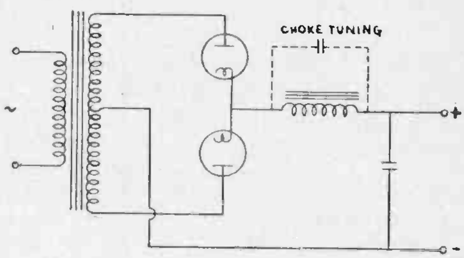

FIG. 2. FULL-WAVE CHOKE INPUT CIRCUIT.

For example, the maximum output rating of two RG1-204A rectifiers in Fig. 2 is 500 mA at 1,500 V — a load resistance of 3,000 ohms. So the choke reactance should be at least 2,000 ohms. With 50 c/s supply, ripple is mainly 100 c/s, and the minimum inductance at full load is $2{,}000/200\pi$, = 3.2H. (To allow a margin, the valve makers advise 4.5H).

If less current is drawn (i.e., load resistance increased), inductance should rise in proportion. Another requirement is low choke resistance. These characteristics are promoted by using no air gap. Ideally, if the undesirable voltage rise shown by curve B is to be avoided, the reactance at zero current should increase to infinity. This being impossible, the load circuit should be arranged to ensure that its resistance never falls below the critical value. One way of extending the permissible load ratio is to tune the choke to the ripple frequency (curve C).

Another thing; the peak voltage across the choke is of the same order as the output, so the winding must be insulated to suit.

If a 3-phase supply is available, six RG1-240A valves can be arranged to give 3.35 kW d.c. at 4,470V, with a r.m.s. input of only 1,920 V per phase and a choke of 1H.

There is no room here for more, but further notes on how to get the best from mercury rectifiers are obtainable from the makers.

This is the sixth of a series written by M. G. Scroggie, B.Sc., M.I.E.E., the well-known Consulting Radio Engineer. Reprints for schools and technical colleges may be obtained free of charge from :

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Wireless World

Radio and Electronics

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Monthly Commentary

Marconi Jubilee

WE are in the midst of celebrating the fiftieth anniversary of the inception of wireless telegraphy as a practical means of communication. On 13th May, 1897, the culmination of a series of successful transmission tests across the Bristol Channel convinced Sir William Preece, Engineer-in-Chief of the Post Office, that official encouragement could be given to the young Marconi and to his "system" of wireless telegraphy. As a result, the Wireless Telegraph and Signal Company was formed on 20th July of the same year; the title was changed three years later to Marconi's Wireless Telegraph Company. To this great company—"the only wireless firm in existence formed in the reign of Queen Victoria"—*Wireless World* offers sincere congratulations and expresses its hopes for success in the task of carrying on the torch that was lighted by its illustrious founder.

Making it Work

Marconi's first great technical contribution to the art was his addition of an elevated aerial and an earth connection to the oscillator evolved by Hertz a few years earlier. But that contribution, fundamental as it was, sinks into insignificance as compared with Marconi's single-purposed devotion to the idea of using Hertzian waves for long-distance communication. That idea, commonplace to us, but a brand-new conception in the years immediately following the publication of Hertz's work in 1888, was not seized upon wholeheartedly by other early workers. Hertz himself belittled the idea when it was propounded to him by the German engineer Huber. Popov and Tesla tended to dissipate their energies by following relatively profitless fields; Popov used his apparatus for the investigation of atmospheric disturbances and Tesla was largely interested in the transmission of power without wires. It is not on record that Marconi demonstrated true wireless telegraphy earlier than Popov, but it now seems certain that to him is the credit for taking it out of the lecture theatre and proving to the world that mankind had at its disposal a new means of exchanging intelligence, unfettered by the need for metallic connections or other tangible links. Marconi was the first to "make it work" on a sufficiently large and impressive scale. In a few short years he convinced all but the most sceptical that the new method of communication had far-reaching potentialities.

World-wide Communication

This principle of "making it work" and keeping the practical end always in sight has remained as the animating force of the Marconi Company. As each successive extension of wireless technology has loomed up, the company's development engineers have worked steadily to translate ideas into practical working methods and apparatus. Of their many achievements perhaps the most outstanding has been the evolution of the short-wave beam system, by which the dreams of the pioneers were turned into reality. But, in recalling this fact, we must not forget the more academic Marconi research work in short-wave propagation that formed part of this development.

This journal takes particular pleasure in recording the Marconi jubilee, and on this special occasion we may be permitted to glance back over our own past. We have an almost filial interest in Marconi progress, as *Wireless World* started life as *The Marconigraph*. Though we began our career as house organ of the company we had from the first a certain limited outside circulation, which rose to quite a considerable figure as interest in wireless increased. Since we discarded our parent's leading strings and ventured out into the world as an independent public journal our progress has been steady, and we have now achieved the largest circulation of any comparable publication. And, even if we are still some 14 years short of our half-century, we can at least claim to be by far the oldest wireless journal of any kind in the world.

PHYSICAL SOCIETY'S EXHIBITION

Testing and Measuring Equipment on Show

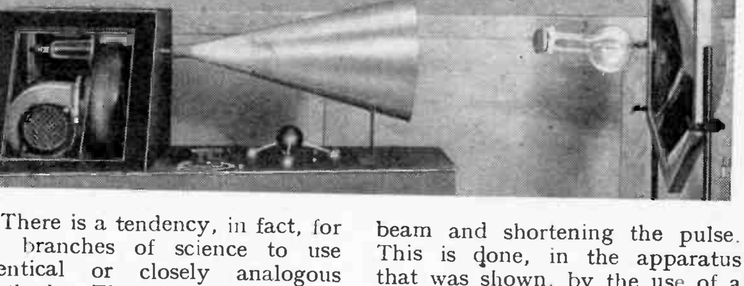
THE second post-war Exhibition of the Physical Society, held from April 9th-12th in London, was on a somewhat larger scale than in 1946. There were 118 trade stands; while the Research Section, which will be dealt with first in this report, had been considerably enlarged.

Research Section

This year's exhibits demonstrated still more strikingly how methods and tools that used to be considered characteristically "wireless" are now common to all branches of scientific research.

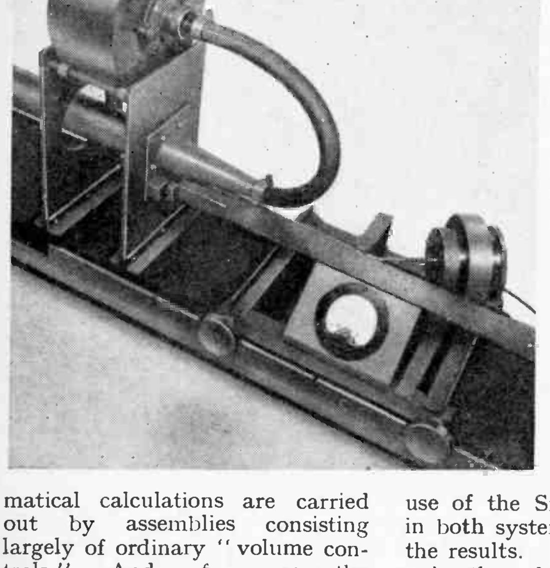
For instance, building research might seem to be a rather remote branch of investigation; yet variations of strain in large structures are observed by the changes in modulation frequency of a radio transmitter placed at the position being studied. Modulation is by a valve-maintained vibrating wire, the tension of which, and hence the frequency of vibration, is controlled by the strain under observation. Weather data in the upper atmosphere are observed in a similar manner, using "radio-sonde" balloons. Abstract mathematical calculations are carried out by assemblies consisting largely of ordinary "volume controls." And, of course, the cathode-ray tube is ubiquitous, as, for example, in measuring camera shutter speeds, in atomic research, and in mathematical investigation.

G.E.C. set-up for detecting mm waves using an ammonia filled flask.



There is a tendency, in fact, for all branches of science to use identical or closely analogous methods. The apparatus that was shown by Metropolitan - Vickers for measuring acoustic impedance was remarkably like that shown by the Admiralty for measuring electro - magnetic impedance. Each consists of a metal pipe, excited by a suitable generator, with means for observing the standing wave ratio when the pipe is terminated by the impedance to be measured. The similarity extends even to the use of the Smith circle diagram in both systems, for working out the results.

Met.-Vick acoustic impedance measuring set.



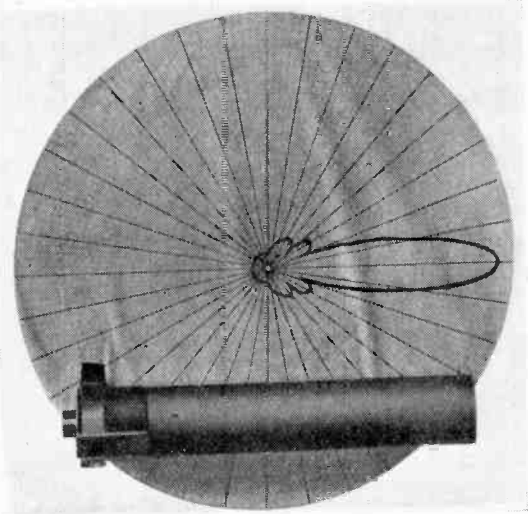
Another close parallel between radio and acoustic devices could be seen on the stand of T.R.E., famous for its developments in radar. It had been found that the thickness of many airfield runways, hurriedly laid during the war, was unknown. To avoid having to hack them up to find out, a system is being developed which is analogous to radar, using supersonic sound waves. As in radar, confusion of echoes is minimized by narrowing the radiated beam and shortening the pulse. This is done, in the apparatus that was shown, by the use of a magnetostriction generator.

The gap between radio and heat waves is continually being reduced. Bolometers, in which the change in resistance of one arm of a bridge is observed when under the influence of the current or radiation to be measured, were shown both for infra-red and for millimetre waves.

One of the factors that limits the frequency which can be usefully employed for radio communication is atmospheric absorption. The N.P.L. exhibited apparatus for measuring the absorption and reflection of 12-mm waves by water, and so arriving at its complex dielectric characteristic. A striking demonstration of absorption of 12-mm waves by an atmosphere of ammonia was staged by the G.E.C. A flask containing ammonia gas was placed at the focus of a mirror receiving a powerful beam of waves, modulated at an audible frequency. The heating and consequent expansion of the contents, due to absorption, therefore also varied at audible frequency, as could be confirmed by placing the ear to the mouth of the flask, which was covered by a rubber diaphragm: wireless reception without a receiver.

An outstanding wartime radio technique was the revival of the obsolete crystal rectifier, in vastly improved form, as the most effective detector of centimetre waves. The crystal, once the apotheosis of unreliability and variable performance, is now reaching the stage of being incorporated in measuring instruments. A.C. meters using metal rectifiers are generally limited to about 10 kc/s; but the B.T.-H. Co. were showing 10,000-ohm-per-volt A.C. voltmeters, using silicon crystal rectifiers, useful up to 1,000 Mc/s. The possibilities of germanium rectifiers were suggested by a G.E.C. display. With a forward resistance of 50 Ω and a backward resistance of 0.2 MΩ, they promise to displace the much less convenient diode valves from all but high-impedance and high-voltage circuits. Their negative resistance properties may also find uses.

The notable development of electrical methods for mathematical computation and research has been mentioned. Some of the techniques employed are: counting, by triggering flip-flop or similar circuits by pulses; measuring time intervals, either by counting cycles of a standard frequency or by condenser discharge (integrating) methods; adding and multiplying by potentiometer networks. R.A.E. showed a time and frequency rack using the counting system, to a scale of 2. The potentiometer technique was exemplified by a simple assembly shown by De Havilland Propellers, capable of solving four simultaneous equations. This company will no doubt receive many enquiries from the upper forms of schools! The calculator shown is a try-out for a 12-order-equation solver, for tackling certain problems in propeller design. An elaborate apparatus was that demonstrated by Dr. Rymer, of Reading University, for harmonic analysis and synthesis. It is based on the method of selected ordinates. Taking ordinates at 10° intervals necessitates a 36-pole 36-way switch. This rather formidable requirement has been neatly met by a compact frame containing 36 pairs of stationary parallel silver-plated brass wires, each pair constituting one of the "poles." At right angles to them are mounted 36 strips of insulation, each controlling 36 silver-plated beryllium copper wire "hairpins," which normally clear the parallel wires. Pulling a strip forward causes one set of these hairpins to be brought into good contact with the parallel wires.



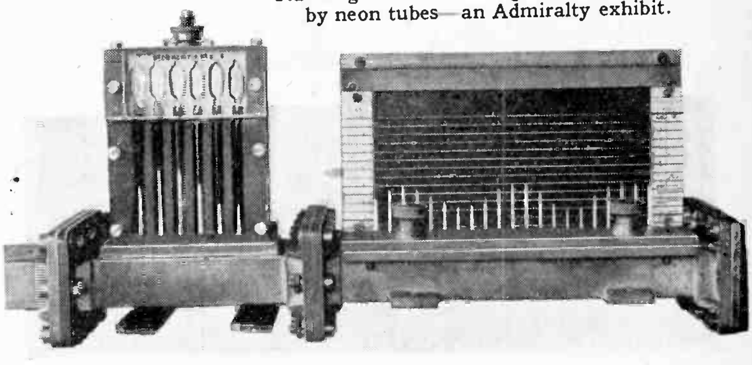
Admiralty experimental cardboard tube radiator with its polar diagram.

An example of another technique was the polar diagram computor shown by Standard Telephones. Partly mechanical and partly electrical, using stationary selsyn motors as transformers, it enables the radiation diagram of an array of up to five unit aerials to be determined, given their spacing and electrical and spatial angular relationships.

A more abstruse type of equipment was the Fourier transformer, by the Ferranti research department in conjunction with Edinburgh University. This is not a transformer in the electrical sense, but a cathode-ray apparatus for performing the class of mathematical operation known as a Fourier transformation. To illustrate by an example in our own field: a pulse—say a television synchronizing signal—can be represented diagrammatically either by its waveform (an amplitude/time graph) or by its frequency spectrum (an amplitude/frequency graph). Time and frequency are, of course, reciprocal; and given the data in either form the other can be derived. To do so by calculation is often tedious; but by placing the waveform in the Ferranti instrument as a transparency, the spectrum instantly appears on the cathode-ray screen. It is also possible to determine the distortion of a signal by a network of known amplitude/frequency characteristic, or conversely.

Outstanding for variety were

Standing waves on waveguide demonstrated by neon tubes—an Admiralty exhibit.



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the exhibits on the Admiralty Experimental Establishment's stand. Only some of them can be mentioned, and that briefly. An awkward problem is the accurate attenuator calibration of standard signal generators, especially at very high frequencies and low microvoltages. A simple solution was demonstrated, in which the generator output was heterodyned, using a diode frequency-changer followed by a cathode follower feeding an attenuator and 200-kc/s I.F. amplifier. By performing all measurements at this comparatively low frequency, the usual difficulties largely disappear.

A demonstration of high-speed facsimile, or "slow television," using the Skiatron dark trace cathode-ray tube, suggested interesting possibilities. The definition was 500-line, and owing to the characteristics of the screen the effective focus was very much finer than the beam focus, and the line structure could only just be seen by very close scrutiny. The frame frequency was 0.1 c/s; in other words, a picture or diagram was completely "painted" on the screen in 10 seconds, after which it would persist in moderate light or be quickly erased by bright light. The use of a trace of aluminium in the screen coating was responsible for improved decay speed.

Not the least interesting and thought-provoking of a number of narrow-beam centimetre-wave aerials was an ordinary cardboard mailing tube excited by a dipole. Notwithstanding the presumably high loss of this material at 10,000 Mc/s, its polar diagram showed a good 25° beam with little side-lobe radiation.

Other centimetre gear included a 1-cm spectrometer, in which a resonant cavity was tuned cyclically over the band to be analyzed by means of a loudspeaker drive.

A naval 10-cm transmitter was used to provide Prof. Randall with radiation for demonstrating reflection, refraction and all the usual optical phenomena. This equipment was interesting for its multiple neon tube monitor. The tubes stood in a row along a section of the wave guide, and by the respective heights of glow indicated the output power and standing wave ratio. Some interesting research has been carried out on the pulse excitation of these tubes.

One of the troubles of modern mariners was displayed. Apparentaly the numerous signalling frequencies used on naval vessels are liable to cross-modulation by rusty bolts in the ship. Not only does this annoy by causing local inteference in the receivers, but the difference frequency produced from, say, 100 Mc/s and 120 Mc/s may actually be detected by an enemy at a greater range than either of the primary frequencies. The need for surveying vessels for rusty bolts, as well as for resonant structures, was illustrated.

Trade Section

Materials.—A ceramic semi-conducting material known as "Varite" has been introduced by Mullard. It has a marked negative temperature coefficient of resistance, and has been used for the series heater resistance in A.C./D.C. receivers where the thermal time delay provides protection for valves and pilot lamps. It differs from silicon carbide in having a negligible voltage coefficient, the resistance depending solely upon physical dimensions and temperature. Ceramic dielectric materials of high permittivity with a wide range of properties including zero and negative temperature coefficients are also being produced by Mullard under the name of "Kaymax."

Muirhead non-reactive wire-wound resistor.

A non-conducting magnetic material known as "Caslox" has been introduced by the Plessey Co. It consists of a mixture of cobalt and iron oxide powder in a plastic matrix and can be conveniently moulded by conventional methods. It has a high coercive force and is very suitable for applications in which an open-circuit magnet of large area and short length is required.

The technique of powder metallurgy in making sintered magnets of awkward shape in hard and brittle alloys was well exemplified by the exhibit of Murex who specialize in this class of work.

Alloys for transformer cores, shown by Transformer Steels, Ltd., included "Crystalloy" in which a fine crystalline structure, oriented in the direction of the magnetic field, is produced by cold rolling. The material is available as continuous strip and can be cut and made up into conventional core shapes with overlapping joints. Alternatively the core may be wound as a continuous spiral and then cut for fitting into pre-formed windings; in this case the flux traverses the length of the strip at all parts of the circuit and losses in turning corners are avoided. The alloy can be worked at a much higher flux density with consequent economy in weight and overall dimensions. An example of a transformer with a wound "Crystalloy" strip core, made by Johnson and Phillips, was shown in which the working flux density was 17,500 lines/cm^2. The loss at $B = 10,000$ at 50 c/s is 0.32 watt per lb.

The joint exhibit of Mond Nickel and Henry Wiggin afforded many examples of the use of nickel in electrical alloys including "Nilo K" for glass-to-metal seals and alloys for magnetostriction. An alloy known as 5,000Z with a practically rectangular hysteresis loop was shown by the Telegraph Construction and Maintenance Co. This has been used for the construction of heavy current rectifiers.

Components.—Most of the recent developments in receiver components has already been covered in the report of the R.C.M.F. Exhibition in our last issue, but one or two new items were noted, primarily of interest to makers of test and measuring instruments.

Muirhead were showing wire-wound non-reactive standard resistances, hermetically sealed in ceramic tubes. Covering a range of 1Ω to $57\,k\Omega$ they are available with a rating of $\frac{1}{2}$ watt with an accuracy of 0.1 per cent or 1 watt at 0.5 per cent. Sullivan were also showing tubular non-reactive resistors with an accuracy of 0.1 per cent and a temperature coefficient of 0.0025 per cent per deg. C. These resistances are also available in decade units.

Salford have produced a new decade switch of substantial construction. It has a laminated phosphor bronze rotor and studs spaced at 30 deg in the moulded body. The same firm were also showing a 44 : 1 ratio slow-motion dial with epicyclic friction drive giving 350 deg. rotation. An alternative version of the Muirhead slow-motion dial is now in production in which the scale is detachable for calibration.

A quartz crystal standard with thermostatically controlled oven is now made by Salford as a compact plug-in unit very little larger than a standard vibrator unit. Muirhead were showing a low temperature coefficient tuning fork of small dimensions with a constancy of two parts per million over a range of temperatures from 14 to 26 deg. C. Temperature compensation for tuned circuits by means of a bi-metal controlled condenser of 2 pF was shown by Sullivan. This unit has been recently redesigned to give improved accuracy under cyclic conditions.

Relays are components of a wide variety of equipments for industrial control and automatic adjustment. The Type T.D.R.O. made by Electro Methods for switching the anode circuits of gas-filled valves incorporated a thermal delay mechanism in conjunction with an electromagnetic relay. The load is carried by both elements and the circuit is not completed until the thermal switch has cooled and reset itself. Faults occurring during the combined delay period cannot cause damage, as they might with the conventional thermal delay switch. A compact polarized relay weighing only $1\frac{1}{2}$oz and measuring $\frac{5}{8}$in × $\frac{3}{4}$in × $\frac{7}{16}$in was also shown by this firm. The operating power is of the order of 10 microwatts and the relay is mechanically balanced to withstand vibration. Shock tests of 500g have been successfully completed.

Electro Methods miniature polarized relay.

A wide range of relay equipment was shown by Londex, including process timers and photoelectric control equipment, and L. A. Steiner were demonstrating the application of electronic relay to a number of industrial control problems.

Industrial Electronics. — The "Radyne" series of R.F. heaters made by Radio Heaters, Wokingham covers a wide range of applications and is notable for the compact design of the heater and H.T. units. Models are available with outputs up to 6.5 kW, and silica envelope valves are used in which a new filament can be fitted and the valve evacuated for half the cost of a new valve. The guaranteed life is 1,500 hours. The models designed for plasticising and moisture evaporation are fitted with ovens on top of the cabinet and may be adapted to work with a conveyor belt.

In addition to a seam welder for thermoplastic sheet Radio Heaters also produce an R. F. moisture tester in which the loss of weight from evaporation in the sample is indicated by a calibrated spring balance.

Moisture meters depending on measurement of change of dielectric properties in the sample were shown by the Baldwin Instrument Co., Mullard, and Marconi Instruments. The Marconi Type TF818 continuous moisture recorder for grain sampling depends on the flow of grain falling between the electrodes of a condenser and works in conjunction with a disc-type pen recorder.

The portable battery-operated strain gauge Type D-423-A, made by Muirhead, employs valve maintained stretched steel wires. The strain to be measured alters the frequency of one of the wires and produces beats with a standard which are indicated either by a rectifier meter or in headphones. Adjustment of the standard by means of a calibrated tension spring to zero beat, gives a measure of the strain. The instrument is capable of indicating strains of the order of one part in a million.

Ultrasonic methods of testing materials, preparing emulsions, etc., seem to be attracting more attention. The crack detector shown last year by Henry Hughes is now available in portable form, and Salford Instruments were showing a recently developed general-purpose ultrasonic generator with a range of 14 to 1,200 kc/s and a power output of 30 watts.

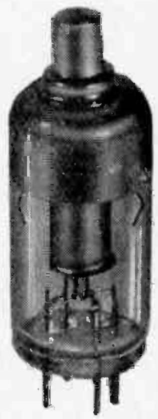
Valves.—The new pressed-glass base type valves were shown in wide ranges by the M-O Valve Co. in both directly and indirectly heated types. The triode-hexodes are claimed to be effective at frequencies as high as 300 Mc/s and the types include variable-mu R.F. pentodes, duo-diode-triodes, output tetrodes and H.T. rectifiers.

Among the miniature glass-base types a television-type RF pentode is of particular interest. It is the Z77 with a mutual conductance of 7.5 mA/V.

M.O. Valve Co. Types KT81 and Z77.

Ferranti have a high-voltage rectifier with this same base but with a top-cap anode connector. The H.R.1 is designed for television E.H.T. supplies derived from the line flyback and the filament takes only 55 mA at 0.65 V. It is rated for a peak inverse of 12.5 kV and a mean output current of 50 μA.

International Television Corporation showed the Nagard F.M.1 frequency multiplier. This is a deflection valve giving a frequency multiplication of 2, 4, 6, 8 or 10 times without tuned circuits. Similar in general form to a C.R. tube, the deflection voltage sweeps an electron beam across a number of spaced bars. Each time the beam crosses a bar a pulse is generated in the output circuit. With a triangular input wave, 10 output pulses are generated for each input cycle. By reducing the input voltage the number of bars swept is reduced and hence the degree of multiplication.



Ferranti HR1 high-voltage rectifier.

Cathode Ray Equipment.—With each succeeding year the C.R. oscilloscope becomes more and more a precision instrument, and the synchronizing is now so improved that perfectly steady pictures are easily obtained.

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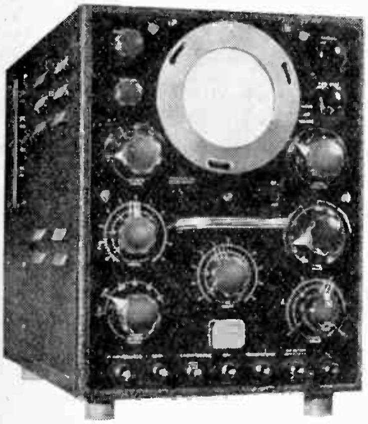
The Cossor model 1035 has a double-beam tube with a two-valve amplifier having a 7-range directly calibrated voltage scale with an accuracy of ± 10 per cent. The frequency response drops by 10 per cent at 7 Mc/s for an amplification of 3 times and at 60 kc/s for an



Cossor 1035 oscillograph.

amplification of 3,000 times. The time base provides sweeps of duration ranging from 15 μsec to 150 msec and can be used repetitive, triggered or single stroke. There is switch selection of synchronizing from either a positive or negative input.

The Furzehill Laboratories Type 1684B oscilloscope, with a 3½-in tube, has a deflection sensitivity of 24 mV R.M.S. per cm with the amplifier adjusted for a response of zero to 3 Mc/s or 8 mV per cm with it adjusted for a response to 1 Mc/s. Direct-coupled amplifiers are used with either balanced or unbalanced inputs. A sweep expansion of 0.2 to 5 screen diameters is provided; since it operates on the X-amplifier it does not affect the synchronizing.

A smaller oscilloscope made by the same firm is the Type 1936 with a 2¾-in tube. This has an amplifier covering 1 c/s to 15 kc/s. There is sweep expansion and the saw-tooth voltage is generated by a thyratron with a linearizing pentode. The sync input is fed through a limiter.

The Nagard Type 1025 oscilloscope, shown by International Television Corp., differs from normal design in that it uses the Nagard SC1 signal converter for generating the saw-tooth voltage. This is a deflection-modulated valve.[1] The tube is of the 5½-in type and reliable synchronization with frequencies up to 1.5 Mc/s is claimed or 6 Mc/s if the input is modulated. The Y-amplifier response is −4 db at 2 c/s and 3 Mc/s with a deflection sensitivity of 0.36 mm/mV. The maximum writing speed is 10 mm/μsec and voltage measurements of 0.01-200 V with an accuracy of 2 per cent are claimed.

Taylor Electrical Instruments have a model using a 3½-in tube with a time-base covering 10-10,000 c/s. A Y-amplifier is included. Mullard have two models—the E800 and the E805—designed respectively for very low and high frequencies. The L.F. model has an amplifier with a response of −2db at 0.1 c/s, whereas the H.F. model amplifier is usable up to 5 Mc/s.

Perhaps the smallest oscilloscope is the G.E.C. Miniscope with a 1½-in tube and measuring 8¼in × 6⅝in × 2¼in overall. A Y-amplifier is included and the time-base covers 30 c/s to 80 kc/s.

Apart from the oscilloscope the C.R. tube is widely used in measuring equipment. For instance, Southern Instruments make an instrument for measuring force, pressure, strains and so on in which the component to be measured is made to frequency-modulate an oscillator covering 0-20 kc/s and the C.R. tube is used to measure the frequency change.

An electronic clock-timer was shown by Furzehill Laboratories. The "tick" is picked up by a microphone and can be listened to via a loudspeaker. It also generates pulses which are compared with the output of a crystal oscillator and are used to brighten the trace of a circular time-base. An incorrect rate for a clock is shown by the movement of the brightened spot around the trace.

Furzehill Laboratories Type 1936 oscilloscope.

The bad effects of a rapid sweep in a "wobbulated" signal generator are well shown by the Plessey I.F. Alignment Oscillator. Basically of conventional type with a frequency-modulated oscillator and cathode-ray presentation of the receiver response curve, it is most unusual in having a tube with a long-persistence screen and an F.M. rate variable from 50 c/s down to zero. It is thus possible to sweep slowly enough to get a true picture of even the sharpest response curve.

Signal Generators. — The wide difference that at one time existed between the so-called serviceman's type of test equipment and other varieties has now largely disappeared and one range of test sets is provided for both purposes. For example, really effective attenuators are fitted in even the relatively inexpensive type of signal generators and this one feature alone has necessitated better screening of the R.F. circuits.

Exemplifying this new trend in design is the Type E signal generator made by Advance Components. With a fundamental frequency coverage of 100 kc/s to 60 Mc/s it caters for radio servicing needs in most fields.

The attenuator gives a signal output of 1 μV to 100 mV with optional internal modulation at 400 c/s. The frequency coverage can be extended to 120 Mc/s by using harmonics of the 30 to 60 Mc/s range.

A comprehensive receiver test set—Type TF888—is one of a new range of equipments developed by Marconi Instruments. It comprises three entirely separate instruments, a signal generator, output meter and a crystal frequency calibrator; thanks to the judicious use of miniature components the whole is contained in a case measuring only 15in × 11in × 6in. The signal generator covers 70 kc/s to 50 Mc/s in eight bands with a scale accuracy of 2 per cent. Since it includes a dual crystal oscillator on either 500 kc/s or 5 Mc/s having an accuracy of two parts in 10^4 the accuracy of the instrument is effectively raised to this order on spot frequencies, and these are available as a separate output in addition to checking the calibration of the variable oscillator. The output meter, which is also used as a monitor for the attenuator input, provides three ranges with full-scale readings of 10 mW, 100 mW and 1 W respectively. Internal modulation is at 1,000 c/s and mains or battery operation is optional.

A new signal generator has also been introduced this year by Avo; while Standard Telephones now have a new V.H.F. model, the Type QD1 covering 90 to 160 Mc/s in one range.

[1] *Wireless Engineer*, June, 1943, Vol. 20, p. 273; September and October, 1945, Vol. 22, p. 29 and p. 489.

Crystal controlled calibrators, generally including two crystals, are obtainable from several makers for use as generators of spot frequencies and for checking the calibration of R.F. oscillators. The calibrator made by Pye has a long-period stability of ± 1 part in 10^6 and is fitted with 100-kc/s and 1-Mc crystals. Other examples are included in the products of Furzehill Laboratories, Standard Telephones and Salford, the last mentioned being a really miniature model.

A frequency standard having a Hartley oscillator as the R.F. signal source has been added to the Sullivan range of laboratory type instruments. It has plug-in coils and a feature of its design is that each coil serves for two ranges, a dual condenser with a switch connecting one or both sections in parallel being fitted. The coverage is 30 kc/s to 24 Mc/s and the calibration accuracy is better than 1 per cent.

Marconi Instruments TF888 receiver test set.

Multi-range Meters.—Many new multi-range test meters have become available this year, the general idea being to make them as versatile as possible, at the same time keeping to a reasonable size. G.E.C. has one known as the Selectest, providing 34 ranges of A.C. and D.C. volts and current; it is also an ohmmeter. Super Ranger is the title of the new 28-range model produced by British Physical Laboratories, which, in addition to the usual A.C., D.C. and ohms ranges, is calibrated for use as a rectifier-type output meter reading 0 to −60 db.

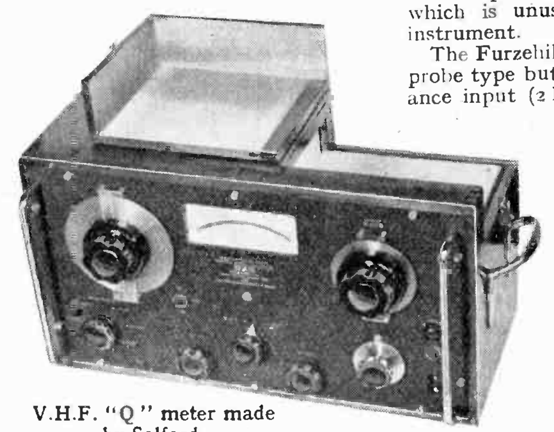
Among the other firms making this class of instrument can be mentioned Avo, Ferranti and Weston (whose Model S75 has 54 ranges) and Taylor.

Panel and bench type pointer instruments were as much in evidence as hitherto and of the new models now available mention should be made of the Turner high-voltage electrostatic models in 3½-in and 6-in sizes for A.C. voltage measurements up to 10 kV and 15 kV respectively. This style takes negligible current and is ideal for the E.H.T. measurements in television sets.

Very low consumption, incidentally, is now a feature of most of the latest multi-range test instruments, sensitive movements taking only 50 μA for full-scale deflection and thereby giving a voltmeter resistance of 20 kΩ/V being commonly used.

The new Ferranti model, Taylor 70A and Weston S75 meters all provide these facilities. But delicate instruments of this kind, and also those of the 1 kΩ/V class, are easily damaged by overload. Thus considerable attention has been given to protecting devices, some taking the form of quick-acting overload cutouts which isolate the meter before the current can attain a damaging magnitude. Avo, G.E.C. and Weston meters all incorporate a device of this kind.

A.F. Oscillators.—For the generation of audio frequencies both the beat-frequency principle and the resistance capacity coupled oscillator are still being used. Marconi Instruments still favour the former type, their TF894 A.F. oscillator having a frequency range of 50 to 12,000 c/s and a maximum output of 300 mW.



V.H.F. "Q" meter made by Salford.

A ladder attenuator with a 600 Ω output is incorporated and the signal is monitored by a bridge-connected rectifier output meter which can be used separately.

British Physical Labs. 28 range test set.

The British Physical Laboratories A.F. generator is an R.C. pattern with a range of 30 to 33,000 c/s. Again the output is at 600 Ω impedance and a calibrated attenuator gives an output range of 4 mV to 40 V.

Valve Voltmeters.—The probe type of valve voltmeter has now become the predominant pattern and the majority have one of the miniature diodes fitted in the exploring head with a D.C. amplifier, or its equivalent, in the main instrument.

Langham Thompson make one of this pattern having a diode head with an input impedance of 7 MΩ and a capacity of 5.5 pF. It is a four-range meter, the lowest being 0-3 V and the highest 0-100 V and it incorporates an overload relay which is unusual in this class of instrument.

The Furzehill Model 378A is not a probe type but it has a high impedance input (2 MΩ) and incorporates a two-stage amplifier feeding a bridge-connected diode rectifier, the indicating meter reading the D.C. output of the rectifier. Its normal working range of frequencies is 50 c/s to 250 kc/s and the lowest voltage range is 0-1 mV while the highest is 0-100 V. This firm also have a probe model for R.F. operation

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which is effective up to 250 Mc/s. Marconi Instruments make a self-contained valve voltmeter capable of operation up to 300 Mc/s and further examples were shown by Dawe.

Bridges.—As usual, measuring bridges took a variety of forms. There were the high-precision instruments shown by Sullivan, Pye and Gambrell and in addition there were a number of production testing equipments. There were two "Q" meters shown by Salford. One, the BW424, covers a frequency range of 25 kc/s to 50 Mc/s; the other, type BW431, is a V.H.F. instrument for frequencies of from 15 Mc/s to 150 Mc/s. Both have the same "Q" ranges, 0-250 and 0-500 respectively.

A comprehensive inductance bridge was included in the exhibit of British Physical Laboratories. Described as an inductance and "K" bridge it gives coil inductance measurements of from 1 μH to 1 H and "K" (coupling coefficients)

Baldwin Logohm resistance bridge.

from 0.001 to 999. A feature of this instrument is that coils can be measured *in situ* even if they are shunted by capacitance, provided the resonant frequency of the circuit under test is not less than eight times the measuring frequency, which for this bridge is 20 kc/s.

A universal-type bridge covering inductance, capacitance, "Q" and resistance is included in the new range of test sets made by Marconi Instruments.

Among the Baldwin Instruments was a new resistance bridge described as Logohm, having a range of 0.05 Ω to 5 MΩ in four bands. It is a wheatstone bridge type and includes a galvanometer in which the pole pieces are shaped to give high sensitivity in the vicinity of the centre zero and low sensitivity at maximum deflection, thus providing a form of meter protection.

Miscellaneous.—A magnetic tape recorder for speech, using oxide coated plastic tape, was shown by Plessey. The instrument is portable and measures 8in × 7in × 6in. A

Plessey magnetic tape recorder.

3-in loudspeaker serves also as the microphone, and the three-stage amplifier is mains operated. The tape spools are 4in in diameter and give a recording time of five minutes.

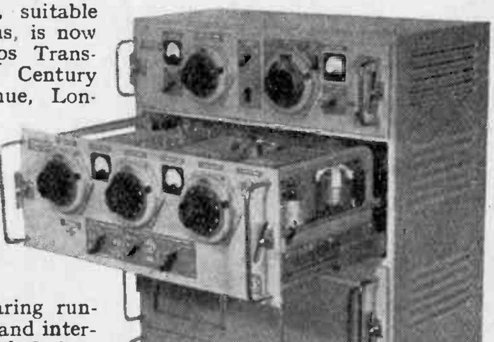
The direct recording electro-encephalograph now produced in commercial form by the Edison Swan Electric Co. is based on the design of the Burden Neurological Institute and is a fine example of the contribution of electronic methods to medical research. Continuous records of the electrical activity of the human brain can be made from six or more pairs of electrodes and a high discrimination is provided against outside electrical interference. Associated with this instrument is a wave analyser with 24 interchangeable plug-in selectors covering 1.5 c/s to 30 c/s and operating on the principle of the feedback R.C. oscillator. The selectors are followed by integrators which alternate over periods of 10 seconds and record the frequency distribution of the energy. A third integrator is available for periods longer than 10 seconds.

Two interesting examples of loudspeaker permanent magnet design were seen. Mullard were showing a "Ticonal" magnet produced for the Lowther Manufacturing Co. having an average flux density of 22,000 lines/cm², and a double loudspeaker unit for cinema use with centre-pole "Alcomax" magnets was among the examples exhibited by the Permanent Magnet Association. This magnet energizes a tweeter, the throat of which is formed in white metal through the centre core of both magnets. The low-frequency cone has a gap 3in in diameter, 0.08in wide and 0.5in deep. Average fluxes are 17,000 lines/cm² in the tweeter and 10,000 lines/cm² in the large-diameter unit.

PHILIPS TRANSMITTERS

A RANGE of transmitters known as the MZ600 series, suitable for fixed or mobile stations, is now being produced by Philips Transmission (Philips Lamps), Century House, Shaftesbury Avenue, London, W.C.2. Unit construction has been adopted and the driving circuits of the high powered transmitters can be used as complete low-powered transmitters. The smaller units are readily accessible on extending ball-bearing runners and may be lifted off and interchanged. Components and fittings are proofed against tropical and arctic conditions.

In all there are five transmitters covering 200-500 kc/s and 1.5-24 Mc/s, suitable for A1, A2 and A3 communication (C.W., I.C.W. or M.C.M. and telephony). Three of the transmitters are in use in H.M.S. *Vanguard*.



Philips MZ601 transmitter.

DESIGNING AN F.M. RECEIVER

2.—*Limiter and Discriminator Circuits*

By THOMAS RODDAM

IN the first part of this article the problems associated with the construction of a receiver for the experimental B.B.C. transmissions of frequency modulation were discussed. Only the "ordinary" part of the receiver was considered, and it was assumed that the reader was not going to embark on the job of building a frequency-modulation receiver unless he was familiar with the difficulties of constructing a receiver for very short waves. It is true that there is nothing to it once you know how, but a little experience is needed before it becomes automatic to remember that an inch of wire is not a direct connection, but a finite impedance. Only an unstable amplifier can teach the constructor which points are really critical and what liberties can safely be taken with decoupling and screening. Fortunately it does not take very long to reconstruct one of these amplifiers. Incidentally, through a draughtsman's error, coupling condensers between anode and grid circuits in Fig. 3, Part 1 were omitted. These should be assigned a value of the order of 0.001μF.

This article is devoted to the heart of an F.M. receiver, the limiter and discriminator. As we saw last month, the limiter has the job of making sure that the input to the discriminator is absolutely constant. It does not matter that in doing so it works in a non-linear fashion which would cause hopeless distortion with an amplitude-modulated signal: indeed the limiter's job is to distort any amplitude modulation out of existence. The discriminator is consequently provided with a pure frequency-modulated signal, and provides at its output the required audio frequencies resulting from F.M. "detection."

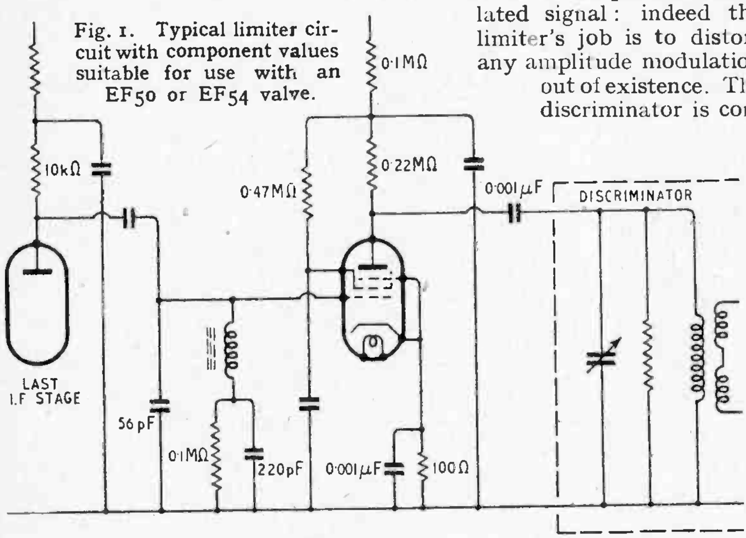


Fig. 1. Typical limiter circuit with component values suitable for use with an EF50 or EF54 valve.

For the ordinary home constructor there is not very much difficulty about limiters. "Hit it hard and stop it dead" is the rule, and so long as plenty of gain is provided to drive the limiter properly, it is quite a straightforward job. If you are trying to save a valve, or to eliminate one resistance costing 1¾d, you can spend a lot of time on limiter design, and the commercial set makers will no doubt produce some very pretty tricks. For my part I prefer to use brute force at this point. With the amplifier described last month it should be possible to get about 10 volts applied to the grid of the limiter, and an EF50 or EF54 valve with low anode and screen volts and a high resistance in the grid will drive from cut-off to grid limiting on a lot less than this. The circuit is shown in Fig. 1 and the values shown should be regarded as indicating the sort of thing needed. If a lower H.T. voltage than 300 is used, rather lower resistances are permissible. With this circuit the grid-stopping effect is not really sufficiently marked, and one of the two circuits shown in Fig. 2 may be tried: Fig. 2(*a*) seems attractive, but I have not yet tried it. Both circuits provide the required 10kΩ damping for the anode coil which tunes with the valve capacitances, at the same time giving a higher resistance for the flow of grid current. The screen of the valve may, if preferred, be fed by a voltage divider circuit: the important thing is that the valve should drive well beyond cut-off, not just

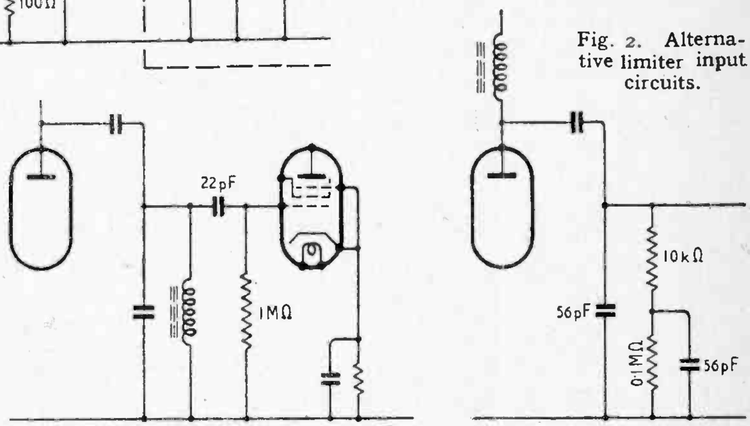


Fig. 2. Alternative limiter input circuits.

Designing an F.M. Receiver—
down the tail of the characteristic. It is surprising what high values of screen resistance can be tolerated in a circuit of this kind.

The discriminator is, of course, the really interesting part of the circuit. Properly speaking the discriminator converts a frequency-modulated R.F. (or I.F.) signal into an amplitude-modulated signal, but it is usual to include the diode detectors which provide the audio output in the design. This we shall do here.

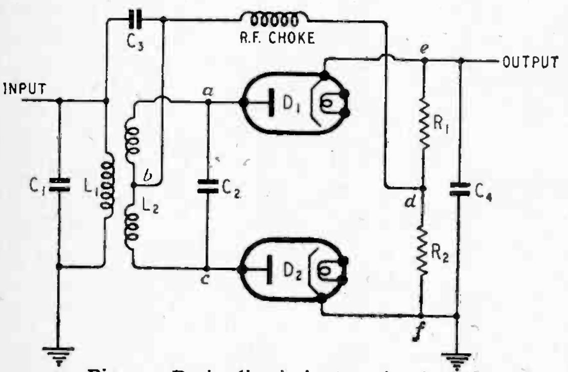


Fig. 3. Basic discriminator circuit.

The "phase discriminator" circuit has been described elsewhere by Sturley and the circuit is shown in Fig. 3. A full mathematical description is available for those who want it in reference (1), but here we shall give only the basic ideas about how the circuit works and how to calculate the circuit values. Fundamentally the circuit is made up of a tuned coupled circuit arrangement like an ordinary I.F. transformer, C_1L_1 and C_2L_2, followed by a pair of diodes. In the actual construction of the circuit two things must be remembered: it is an ordinary coupled circuit in principle, and the secondary is balanced with respect to earth. When C_3 is left out, the voltages appearing across the two halves of L_2 are, as shown in Fig. 4, 180° out of phase with each other, and ± 90° out of phase with the voltage across the primary. This, of course, is at the middle of the pass band of the circuit. As the frequency is increased, the voltages *a-b* and *c-b* remain 180° apart, but are no longer ± 90° out of phase with the primary voltage: the state of affairs is shown in Fig. 5 by the solid line; the dotted line shows the phases for a frequency below the mid-band frequency. When we apply our frequency-modulated signal to the primary circuit, therefore, the *phase* of the voltages across the halves of L_2 varies backwards and forwards, the amplitude remaining constant (C_3 is still disconnected). The diodes shown in Fig. 3 are connected in such a way that under these circumstances there would be no rectified output, for *e* and *f* would each be driven positive by the same amount, so that the resultant voltage *e-f* would be zero.

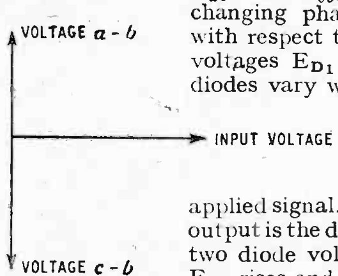


Fig. 4. Phases of voltages in coupled circuits at middle of pass band.

When C_3 is connected to the mid-point *b* of L_2, the voltage vectors become as shown in Fig. 6. E_{bd} is constant, and so are E_{ab} and E_{cb}, but owing to the changing phase of E_{ab} and E_{cb} with respect to E_{bd}, the resultant voltages E_{D1} E_{D2} applied to the diodes vary with the *phase* variations of E_{ab} and E_{cb}, and thus follow the *frequency* variations of the applied signal. As we have seen the output is the difference between the two diode voltages, so that when E_{D1} rises and E_{D2} falls, a positive output appears across R_1 and R_2, and when E_{D1} falls and E_{D2} rises, there is a negative voltage across R_1R_2. This output voltage is dependent on the secondary *phase*, which depends on the primary *frequency*, and the circuit is therefore a detector of frequency modulation. The resulting characteristic is shown in Fig. 7.

It is not easy to get an absolutely linear characteristic of volts against frequency, such as is shown in the region between f_1 and f_2. The curvature of the characteristic is reduced by careful choice of the double-humping

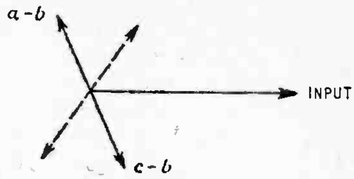


Fig. 5. Phases of voltages at a frequency above mid-band.

of the transformer and the design below makes provision for this. If the primary and secondary circuit Q's are not equal, the response is skewed, as shown in Fig. 8.

In building a discriminator, the design formulae given by Sturley were used. It seems worth-while to use the conditions for maximum linearity, because the loss of gain is only about 4db and this is easily made up in the amplifiers.

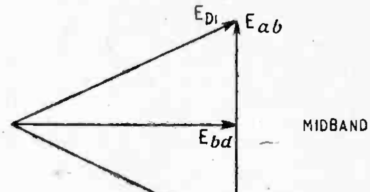


Fig. 6. Voltage vectors in phase discriminator.

The quantities involved are:

f_m, the mid-band frequency
L_1, L_2, the coupled circuit self-inductances
k, the coefficient of coupling
Q, the ratio of shunt resistance to reactance at mid-band frequency
Δf, the frequency off-tune from f_m ($= f - f_m$ at any frequency f)
F, the normalized off-tune frequency (twice the "fractional de-tuning") $= 2\Delta f/f_m$

For maximum linearity, Sturley gives $L_2/L_1 = 1.414$ and $Qk = 2$. Under these conditions the system is linear up to a value of $QF = 0.8$ from $QF = 0$. Applying these

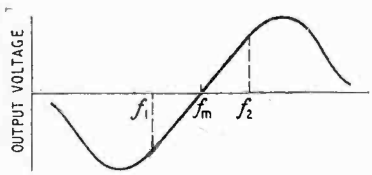


Fig. 7. Ideal discriminator characteristic.

criteria to our problem: we are working at an intermediate frequency of 10Mc/s, $f_m = 10 \times 10^6$, we should make the discriminator linear over a range of about $\pm$100kc/s to allow for tuning drift, and so we shall take $\Delta f = 100 \times 10^3$ when $F = 0.8$. This gives us $Q = 0.8 f_m / 2\Delta f = 40$. As $Qk = 2$, $k = 0.05$.

To determine L_2 we need to choose C_2. Small air condensers of the concentric cylinder type are very suitable and a mid-value of 20pF may be chosen. This gives $L_2 = 1/4\pi^2 f_m^2 C_2 = 12.5\mu H$. As $L_2/L_1 = 1.414$, $L_1 = 8.8\mu H$.

The total primary capacitance is given immediately by the conditions $L_2/L_1 = 1.414$ and $L_1C_1 = L_2C_2$, as $C_1 = 1.414\ C_2 = 28pF$. This includes the limiter output capacitance.

It is now necessary to determine the damping resistance. The actual value of shunt resistance required is given by the formula $R = 2\pi f_m LQ$, and on substitution this becomes $R = 2/10\pi\Delta f \cdot C = 2/\pi \cdot 10^6 C$, when $\Delta f = 100kc/s$. As $C_2 = 20pF$, $R_s = 31{,}000$ ohms, $C_1 = 28pF$, $R_p = 22{,}000$ ohms.

We cannot just connect these resistances in the circuit. Part of the damping is provided by the losses in the coils themselves and part by the resistances R_1 and R_2 which form the diode loads. The anode resistance of the limiter valve will also add to the damping if the discriminator is shunt-fed. Sturley assumes values for R_1 and R_2, but here we shall find what values of R_1 and R_2 may be used if all the primary damping is to be provided by the diode loads. It can be shown that the apparent resistance presented by two equal resistances R forming the loads of D_1 and D_2 is R/6 at the primary. To get the required damping of 22,000 ohms, therefore, we require R to be 132,000 ohms. As we shall need to adjust the damping in lining up the circuit, the value chosen is 220,000 ohms: the coil losses will represent about 50,000 ohms across the primary and an additional resistance of this order should be used for trimming.

On the secondary side, the diode load resistances R_1R_2 contribute their actual value to the damping, so that most of the 31,000 ohms

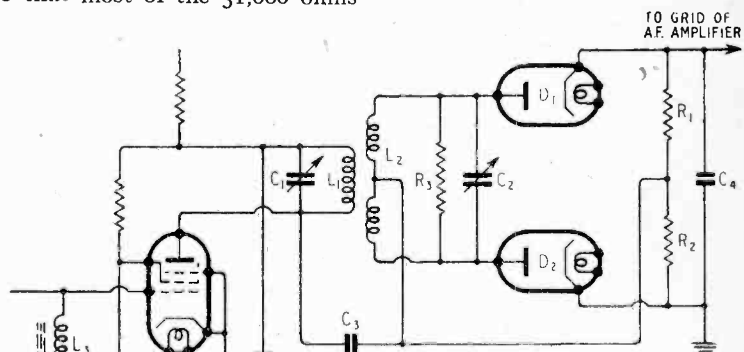


Fig. 9. Discriminator circuit actually used.

required must be provided by a separate resistance. It is fairly safe to start off with 47,000 ohms across L_2.

The coil inductances are $8.8\mu H$. On the formers with dust cores used for the I.F. coils in Part 1 these inductances are best obtained by using small polystyrene bobbins which fit over the formers. About 30 turns of 40 S.W.G. wire will give the $8.8\mu H$, and about 36 turns the $12.5\mu H$. The exact inductance

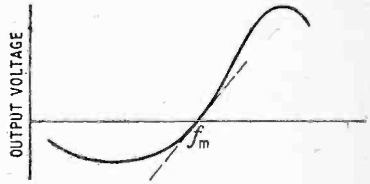


Fig. 8. Discriminator characteristic when primary and secondary Q values are not equal.

obtained depends on the way the winding is put on, but these figures will provide a good first shot. To get the coefficient of coupling required, the two coils should be mounted on separate formers held back-to-back by means of threaded rod: the spacing between coils will be about ½ inch, and if the cores do not pass through the coils, the coupling will not be greatly affected by movement of the cores, so that the inductance can be adjusted by the cores, and the coupling by the spacing, without very much inter-dependence of adjustment.

The circuit as it was actually used is shown in Fig. 9. L_1 has been put in the anode of the limiter valve, although this has the disadvantage that C_1 is connected to the H.T. supply. As R_1R_2 are large, the R.F. choke shown in Fig. 3 has been omitted. Suitable values for C_3 and C_4 are 47pF; both must present low impedance to the signal frequency, but high impedance to the modulation fre-

Designing an F.M. Receiver—

quency. C_4, of course, can be larger, as it can play a part in providing de-emphasis.

Lining up the discriminator is rather tricky. Sturley's method involves reducing the coupling to well below critical, but this was found to be inconvenient, and a rather different technique was

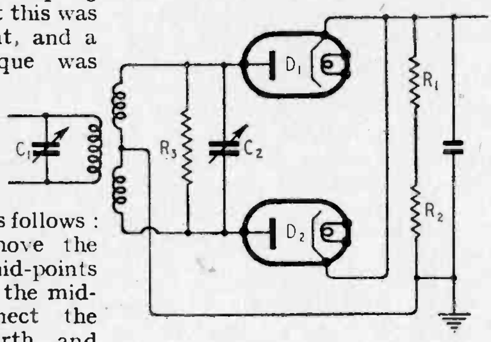


Fig. 10. Rearrangement of circuit for initial alignment.

used. The procedure is as follows: disconnect C_3 and remove the connection between the mid-points of L_2 and R_1R_2. Earth the mid-point of L_2. Disconnect the cathode of D_2 from earth, and connect it to the cathode of D_1. This gives the circuit shown in Fig. 10. The values of C_1, C_2 are then adjusted in the usual way with tuned transformers to give the double-humped characteristic shown in Fig. 11, with humps equally spaced about 240kc/s away from f_m and the voltage across R_1R_2 rising by 9db (×2.8) at the humps compared with mid-band. After adjustment of tuning and coupling, the circuit is restored to its normal form.

Final trimming is now needed. Looking back to Fig. 7, we see that the output for an input of constant frequency f_m should be zero. A carrier of f_m is applied to the input of the receiver, and C_2 adjusted until there is no output

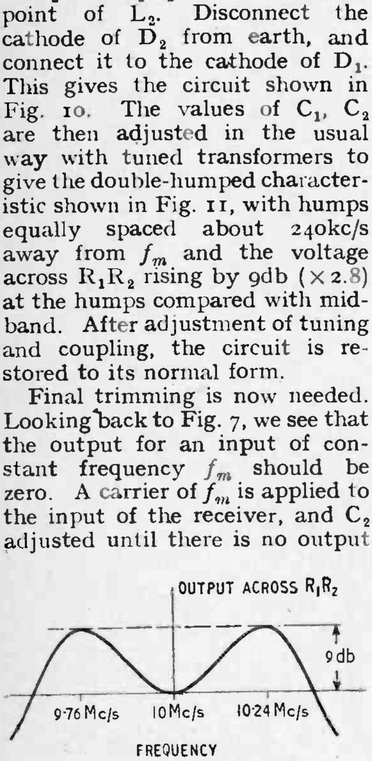


Fig. 11. Response of circuit of Fig. 10.

across R_1R_2. The input frequency should then be changed alternately to f_m + 100kc/s and f_m − 100kc/s, and C_1 adjusted to give equal but opposite voltages across R_1R_2 under these two conditions. A final correction of C_2 may then be needed. The overall response curve should then be plotted in terms of output voltage across R_1R_2 against frequency, making sure that the input level is high enough to keep the limiter in action. If there is any asymmetry, the damping resistance may be altered until a completely symmetrical curve with a linear mid-portion is obtained.

The average D.C. output from the discriminator circuit is a measure of the amount of detuning of the circuit. It can therefore be smoothed and applied to an A.F.C. system in just the same way as the detector output in an amplitude-modulated receiver is applied to the A.V.C. line. Elaborations of this kind are best left until a satisfactory receiver design has been achieved.

These notes on the construction of an F.M. receiver are based upon experience with a rather special receiver which, by reason of its frequency and bandwidth, presented awkward problems not encountered in building a receiver for broadcast transmissions. The chief difficulties were, however, not those caused by the frequency modulation, but the ordinary troubles which are always encountered at the high frequencies involved. I should recommend any reader who wants to start in this field to build himself a receiver for the television sound channel first of all, to get the feel of V.H.F. working. After he has produced a straight R.F. and detector receiver and a superhet for this, he will be quite prepared to break into F.M.

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3. K. R. Sturley, *J.I.E.E.*, Vol. 92, Pt. III No. 19, p. 212 (Sept. 1945), (for list of reference on F.M.).

NEW DOMESTIC RECEIVERS

IN the Murphy Type A104R radio-gramophone an interesting "acoustic tube" is employed to suppress radiation from the back of the loudspeaker diaphragm and thus to eliminate interference effects which curtail bass response. A number of tubes each 1/10th inch in diameter and 20 inches long are formed in parallel by a block of corrugated cardboard sheets, and sound is attenuated in the interstices without reflecting an excessive load on the loudspeaker diaphragm. A 10-inch permanent magnet unit with high-note diffuser provides the drive. The record changer plays up to eight 10in or 12in records and is fitted with a light-weight pick-up using miniature steel needles. On the radio side the specification is similar to the A104 reviewed in our Dec., 1946 issue. The price of the radio-gramophone version is £75 plus £16 13s 4d purchase tax. Makers: Murphy Radio, Welwyn Garden City, Herts.

The G.E.C. "Compact" receiver is a four-valve superhet plus rectifier and barretter for A.C. or D.C. supplies. It is housed in a moulded black and ivory cabinet measuring 12in × 7¾in × 7⅜in and weighs 10½lb. Short, medium and long waves are covered and the price is £14 14s plus £3 3s 3d purchase tax. Makers: The General Electric Co., Magnet House, Kingsway, London, W.C.2.

A table model (M.A.S. 305) for A.C. mains in a moulded cabinet with internal plate aerial is announced by the Mullard Wireless Service Co., Century House, Shaftesbury Avenue, London, W.C.2. It is a superheterodyne (three valves + rectifier) and covers 16.2 to 52 metres, 170-560 metres and 708-2,000 metres. The price is £18 18s plus purchase tax £4 1s 4d.

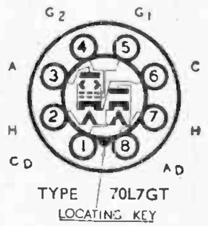
The Model SC70 portable introduced by the Rees Mace Manufacturing Co., 40, Welbeck Street, London, W.1, takes the place of the Model AD70 described in our Feb., 1947, issue. It will make use of 2-volt valves with a Varley dry accumulator and Ever-Ready "Batrymax" H.T. battery.

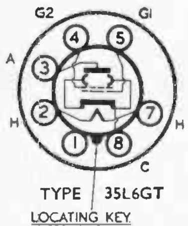
A midget A.C./D.C. superhet (medium and short waves only) is announced by the Dulci Co., Villiers Road, Willesden, London, N.W.2. This is housed in a bakelite cabinet 7¾in × 6in × 5¼in and is available in a variety of colours. The price is £13 13s (purchase tax extra).

Short of a 70L7GT? – then ★BRIMARIZE!

70L7GT

—change to a BRIMAR 35L6GT. This valve is similar in characteristics to the 70L7GT and both are Octal types so that the necessary alterations are straight forward. The principal change is the substitution of a metal rectifier for the rectifier section of the 70L7GT. Wherever possible this rectifier should be mounted horizontally in order to ensure adequate cooling, and it is advisable to check the total *rectified current. If it is above 40 mA a series resistance should be inserted in the smoothing circuit.*





RATED CHARACTERISTICS

	35L6GT	70L7GT
Heater Volts	35V	70V
Heater Current	0.15A	0.15A
Anode Volts	110V	110V
Anode Current	40mA	40mA
Screen Volts	110V	110V
Grid Bias	-7.5V	-7.5V
Output	1.5W	1.7W

TYPE	CHANGE SOCKET FROM	CHANGE SOCKET TO	CHANGE CONNECTIONS FROM OLD SOCKET	CHANGE CONNECTIONS TO NEW SOCKET	OTHER WORK NECESSARY
			PIN 1	+ VE RECT	Increase line cord resistance by 175 ohms. SenTerCel miniature rectifier TYPE SB2 (2½" x 3½" overall) may be fitted to chassis or cabinet. **Please Note—Supplies to be obtained through Wholesalers who should now order from S. T. & C. LTD. Brimar Valve Works, Footscray, Kent.** LIST PRICE 9/- complete with arms and including packing and postage.
			„ 2	PIN 2	
			„ 3	„ 3	
35L6GT	INT/OCTAL NO CHANGE		„ 4	„ 4	
			„ 5	„ 5	
			„ 6	„ 8	
			„ 7	„ 7	
			„ 8	— VE RECT	

NOTE that in the case of the 70L7GT the cathode of the tetrode section is connected to Pin 6 instead of the more usual Pin 8 and that, owing to the lower heater voltage of the 35L6GT an alteration in line cord resistance is essential.

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INSTRUCTIONS: Punch holes where indicated and cut away this portion. Cut out and file them in the order in which they appear. This column will then give you a quick reference index.

3

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SP.250B.	250-0-250 v. 60 m/a. 4 v. 1-2 a., 4 v. 3-5 a.	25/-
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SP.300B.	300-0-300 v. 60 m/a. 4 v. 2-3 a., 4 v. 3-5 a., 4 v. 1-2 a.	25/-
SP.301A.	300-0-300 v. 120 m/a. 5 v. 2-3 a., 6.3 v. 3-4 a.	28/-
SP.301B.	300-0-300 v. 120 m/a. 4 v. 2-3 a., 4 v. 2-3 a., 4 v. 3-5 a.	28/-
SP.350A.	350-0-350 v. 100 m/a. 5 v. 2-3 a., 6.3 v. 2-3 a.	29/-
SP.350B.	350-0-350 v. 100 m/a. 4 v. 2-3 a., 4 v. 2-3 a., 4 v. 3-5 a.	29/-
SP.351.	350-0-350 v. 150 m/a. 4 v. 1-2 a., 4 v. 2-3 a., 4 v. 3-6 a.	36/-
SP.351A.	350-0-350 v. 150 m/a. 4 v. 2-3 a., 4 v. 3-6 a., 4 v. 1-2 a., 4 v. 1-sa.	39/-
SP.352.	350-0-350 v. 150 m/a. 5 v. 2-3 a., 6-3 v. 2-3 a., 6.3 v. 2-3 a.	36/-
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SP.425A.	425-0-425 v. 200 m/a. 6.3 v. 2-3 a., 6.3 v. 3-5 a., 5 v. 2-3 a.	47/-
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,, ,, 12 v. ,, ,, 1 amp.	22/6
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An Extra Coil can be supplied, covering 600-1900 metres at **4/-.**

TELEVISION E.H.T. SUPPLY

Use of Line-Deflection Fly-Back

By
W. T. COCKING, M.I.E.E.

When electromagnetic deflection is used the anode of the valve which feeds the line-deflector coils has a peak potential of several thousand volts developed on it. This is an unavoidable by-product of deflection and the voltage arises because the current must necessarily change rapidly on the fly-back and the circuit is inductive. Normally, this voltage serves no useful purpose but it so happens that the C.R. tube requires a steady voltage of the same order of magnitude for its dnal anode and it is possible to derive this from the fly-back voltage.

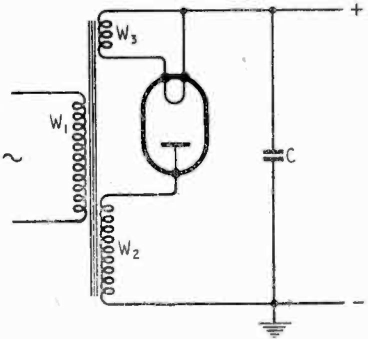


Fig. 1. Conventional half-wave rectifier for E.H.T. supply from a sine-wave input voltage such as the mains.

There are several advantages in so doing. The conventional E.H.T. (extra-high tension) supply has a circuit like that shown in Fig. 1 whereas with a supply from the line fly-back an arrangement such as that of Fig. 2 can be employed. Here only V_2, C and the winding W_3 are additional to the line-scan circuit. The mains transformer of Fig. 1 is saved and on account of the much higher operating frequency the reservoir capacitance C need have only 1/200 of the value required with a mains supply. This not only reduces the cost, but makes for increased safety, because the quantity of electricity stored in C is proportional to its capacitance.

The rectifier in Fig. 2 works with an input of pulse waveform and the peak voltage across it when it is non-conducting is but little greater than the output voltage across C. With a rectifier fed from a sine-wave input as in Fig. 1, however, the peak inverse voltage on the rectifier is about twice the output voltage. Because of this the circuit of Fig. 2 enables a lower-voltage rectifier to be used for a given output and also, in some cases, eases the insulation problem in the transformer.

In these days of shortages, the saving of copper and iron effected by deriving the E.H.T. supply from the line fly-back is of considerable importance. However, simple though the circuit of Fig. 2 may appear, it requires very careful design if satisfactory results are to be obtained, and there is a very definite limit to the maximum voltage economically to be obtained from it.

The difficulties which arise are not in connection with the rectifier circuit but lie in the transformer. They arise because the voltage inevitably occurring on the anode of V_1 is rarely much more than one-half of that needed for E.H.T. Because of this the winding W_3 is added to give a step-up of voltage for the rectifier. The windings W_1 and W_3 act as an auto-transformer of ratio $(W_1 + W_3)/W_1$.

The rectifier circuit, as such, does not appreciably load the scanning circuit because the output power needed by the C.R. tube is exceedingly small. It is an experimental fact that if the scanning waveform is observed on an oscilloscope, the connection and disconnection of the rectifier causes no observable change in the amplitude or waveform of the scan.

The practical difficulties in using the circuit of Fig. 2 all lie in the circuit capacitance of which the transformer self-capacitance is the major item. The importance of this capacitance was stressed in an earlier article[1] dealing with the amplifier but it is much more important here because the transformer ratio between the whole primary $W_1 + W_3$ and the secondary W_2 is greater than in an amplifier. The latter would not have W_3 and the ratio would be W_1 to W_2 only.

The self-capacitance of a transformer winding does not vary very much with the number of turns. If an increase of turns results in an increase in the number of layers or sections, then the capacitance will fall as the turns increase. In general, however, if the form of construction remains the same the self-capacitance falls quite slowly as the turns increase. This is especially so when the primary and secondary windings are interleaved, for then quite a large part of the self-capacitance is interwinding capacitance.

Now if a 2 : 1 step-up is needed for E.H.T. W_1 and W_3 will have equal turns and W_1 and W_2 will be the same as if W_3 were absent. If the total self-capacitance

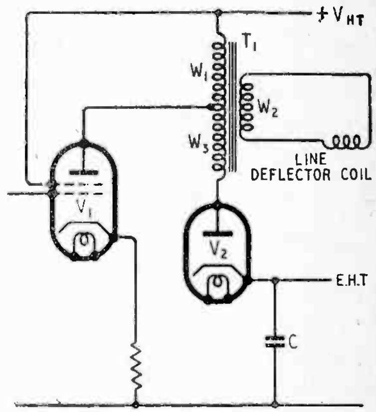


Fig. 2. The basic arrangement for obtaining E.H.T. from the line time base involves the addition of W_3, V_2 and C to the time base.

measured across W_1 and W_3 is the same as that across W_1 alone

[1] "Electromagnetic Deflection," by W. T. Cocking, *Wireless World*, July, 1946, Vol. 52, p. 217.

Television E.H.T. Supply—

when W_3 is absent, then the capacitance effectively across W_1 with W_3 present is four times as great. If we consider an amplifier circuit which produces across W_1 a peak voltage of one-half the required value of E.H.T. and the capacitance has the maximum permissible value for the required fly-back time, then when W_3 is added to produce the required voltage the transformer must be re-designed so that the total capacitance across $W_1 + W_3$ is one-quarter of its previous value.

It is this capacitance which, in practice, proves the only real limitation on taking the E.H.T. supply economically from the line fly-back voltage. Most of the relevant circuit equations were given in an appendix to the article already referred to, but some of them were not in the best form for the present purpose. In particular, it is necessary to take into account the fact that while the E.H.T. voltage is directly proportional to the deflector-coil current, the current required for a given deflection is proportional to the square root of the E.H.T. voltage.

Unless it is properly allowed for, this is liable to cause confusion in design, for while there is little or no tolerance on the deflection there is usually considerable latitude in the E.H.T. voltage. An increase in the latter from 5 kV to 6 kV, for instance, results

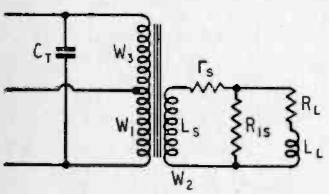


Fig. 3. The equivalent circuit of Fig. 2; R_L and L_L are the constants of the deflector coil.

in quite a small improvement in picture brightness and definition, but reduces the picture width from 7.5 in to 6.8 in which is very noticeable. Picture width must be maintained, but in economical design it is often permissible to adopt a value of E.H.T. rather different from the original target figure.

All the equations necessary for the design of an amplifier providing E.H.T. and scan are given in the appendix and are based on the equivalent circuit of Fig. 3. Equation (1) gives a value for the transformer secondary inductance which will give an adequately linear scan provided that the current supplied to the transformer by the valve is itself linear. In practice, valve and transformer distortion are inverse and a lower value for L_S is then permissible. This is especially the case if negative-current feed-back from the transformer secondary is used; L_S can then be as low as three times the deflector-coil inductance without introducing excessive non-linearity.

TABLE I.

L_L = 8.9 mH	k = 0.98
L_S = 33 mH	k_1 = 1.53
R_L = 15 Ω	k_2 = 1.08
r_S = 8 Ω	a = 1.148
d = 7.5 in	$1/T_L$ = 1.68

As far as E_{HT} is concerned equation (14) clearly shows the fundamental limitations. It is instructive to take an actual case with typical circuit values such as, those listed in Table 1. Taking the rectifier voltage efficiency η as 0.95 for the half-wave rectifier of Fig. 2, and inserting values in equation (14) we get $E_{HT} = 75{,}000/C_T$. A typical value of C_T is 50 pF, for which $V_{HT} = 1{,}500$V.

The values taken are typical of a reasonably good transformer; that is, reasonably good from the scanning point of view. Its efficiency is given by (13) as $\eta_T = 0.65$. This means that the valve must provide $1/0.65 = 1.54$ times more volt-mA than are actually needed in the deflector coil itself.

With a given tube and deflector coil assembly there are three ways only of increasing E_{HT}. The first is to reduce C_T. If E_{HT} is to be 5.5 kV, C_T must be reduced to about 15 pF only; as possibly up to 10 pF of the total is provided by elements outside the transformer this really means reducing the self-capacitance of this component from 40 pF to 5 pF, which is almost impossible.

The second method is to increase the factor a which means increasing the transformer secondary inductance L_S or reducing k or both so that the leakage inductance is increased. To obtain 5.5 kV with C_T = 50 pF, we must increase a to some 3.9 and then η_T drops to 0.13 for the same value of L_S. The provision of E.H.T. has involved an increase in the volt-mA supplied by the valve of $0.63/0.13 = 4.85$ times. As it is usually quite difficult to obtain sufficient output for the scan alone, one cannot view with equanimity the need for providing such an enormous increase.

It is to be noted that the first and second methods would, in practice, be applied simultaneously. The transformer windings would be arranged for the minimum possible self-capacitance and some reduction of the coupling coefficient would be helpful in achieving this. By reducing capacitance and transformer efficiency together a practicable compromise can be reached. Some increase in the secondary inductance L_S will also be helpful, but the transformer efficiency is still below that obtainable when E.H.T. is not taken from the fly-back.

There is a third possibility, however, which has very much to commend it. This is the use of a voltage-multiplying rectifier circuit. With a voltage-doubler, for instance, the voltage efficiency of the rectifier, η becomes 1.8 instead of 0.95 and the immediate result is that the permissible capacitance is increased by $(1.8/0.95)^2 = 3.6$ times. With a capacitance of 50 pF and other values as before the maximum value of E_{HT} becomes 5,400 V.

It is to be noted that this is not an ideal theoretical figure. The values adopted in computing it are typical ones derived from the measurement of actual components and, in practice, the writer has had no difficulty in securing measured outputs up to 8 kV. More could no doubt have been obtained, but as the voltage ratings of some of the components in use were already being exceeded it was considered wiser not to attempt it!

Using the voltage-doubler W_3 in Fig. 2 is usually unnecessary; a 1 : 1 ratio between the valve and the E.H.T. circuit, or even a step-down ratio, is used.

The equations in the appendix contain all the information needed to determine approximate circuit values for both the E.H.T. and deflector parts of the circuit. They are derived on the assumption that the circuit will be damped mainly by a resistance in shunt with the transformer primary or secondary. However, it is found that the scanning efficiency can be increased by something like 20 per cent if a capacitance is inserted in series with the damping resistor. This modifies the shape of the fly-back somewhat and so effects the peak voltage. The value of E.H.T. obtained with this method of damping is of the order of 10 per cent less, so that

TABLE II.

Values of Table I	$E_{HT} = 5.5$ kV.
By equation—	
(2)	$I = 600$ mA
(3a)	$E_L = 68$ V.
(11)	Deflection V-mA = 40,800
(4a)	$E = 80$ V
(5a)	$V = 765$ V
(13)	$\eta_T = 0.65$
(12)	Amplifier Output = 62,600 V-mA.
With $\eta = 0.95$	
By equation—	
(6)	$n_2 = 7.55$
(9a)	$C_T = 14.7$ pF.
(10)	$R_{1S} = 2.71$ kΩ
With $\eta = 1.8$	
By equation—	
(6)	$n_2 = 4$
(9a)	$C_T = 52$ pF.
(10)	$R_{1S} = 2.71$ kΩ

when it is used the transformer ratio n_2 should be about 10 per cent greater than the calculated value. An exact design procedure with this method of damping is quite difficult, for the equations become very involved.

The proper procedure is to regard the design equations as enabling good approximations to the final values to be obtained, but it will usually be necessary to make some experimental adjustment to them.

As an example of their use, suppose that it is desired to operate a 9-in tube at 5.5 kV and to have a deflection of 7.5 in with a deflector coil having $L_L = 8.9$ mH and $R_L = 15\ \Omega$. It is necessary to know the factor k_2 and this can be determined by setting up the tube and deflector coil and measuring the current needed to give a convenient deflection with any convenient tube voltage; k_2 is then determined from equation (2). In the case being considered it has the value 1.08. With the above values $1/T_L = 1.68$ and so from equations (2), (3*a*) and (11) we have $I = 600$ mA p-p, $E_L = 68$ V and deflection V-mA = 40,800.

Before we can proceed further it is necessary to know *a* and to determine this we must know the transformer secondary inductance L_S and the coupling coefficient *k*. It will often be necessary to try a number of different values and afterwards to see whether it is possible to build a transformer which possesses them. It is here that experience of transformer design is most helpful.

For the purpose of this example we shall take $L_S = 33$ mH and $k = 0.98$ with $r_S = 8\Omega$, all as in Table I. The results of working through the equations is shown in Table II for two different values of η, 0.95 and 1.8 corresponding to half-wave and voltage-doubler rectifiers respectively.

With the former C_T comes out at 14.7 pF only and it is almost certainly impracticable to achieve such a low value. With the voltage-doubler, however, C_T is 52 pF and it is by no means difficult to achieve this.

The remaining equations enable the transformer ratio n_1 to be calculated. This depends on the operating conditions of the amplifier valve and will vary according to whether it is more convenient to operate at high current and low voltage or vice versa. It is quite independent of the E.H.T. circuit and is exactly the same if E.H.T. is taken directly from the mains instead of from the fly-back.

Suppose the amplifier H.T. supply is fixed at 350 volts and E_a is 70 V, then $\Delta E_a = 280$ volts and from (7) $n_1 = 3.5$. From (12) Δi_a is 224 mA p-p. It might, however, be more convenient to operate with a lower current—say $\Delta i_a = 150$ mA. In this case we should have from (12) $\Delta E_a = 418$ V and so with $E_a = 70$ V, (15) gives $V_{HT} = 488$ V and (7) gives $n_1 = 5.24$ With this ratio it is necessary to check from (9*a*) that it results in a practicable value of C_T; it works out at $C_T = 30.5$ pF and there will be great difficulty in achieving it.

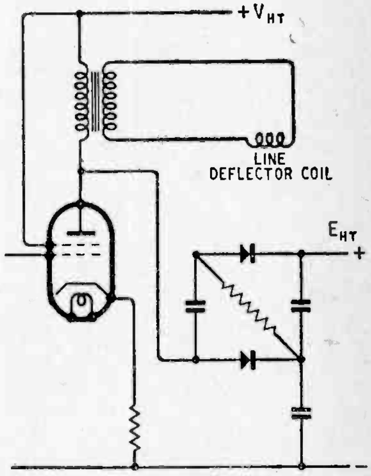


Fig. 4. Voltage-doubler rectifier circuit which greatly eases transformer design.

In most practical cases Δi_a is of the order of 200 mA and V_{HT} is around 400 V. This usually leads to a transformer ratio of the order of 4 for n_1 and rather less for n_2. The circuit takes the form shown in Fig. 4 where metal rectifiers are used in place of valves since no cathode-heating supply is required.

As this voltage-doubler circuit adopted is not well known some explanation of its operation may be advisable, and it is more easily understood from Fig. 5 in which valve rectifiers are shown.

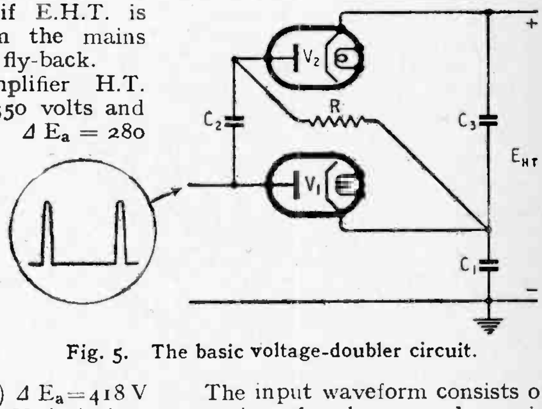


Fig. 5. The basic voltage-doubler circuit.

The input waveform consists of a series of pulses, as shown in

Television E.H.T. Supply—

Fig. 5. First of all, consider V_1 and C_1 alone. In effect, V_1 acts as a switch which closes when its anode becomes more positive than its cathode on a pulse, and opens when it becomes negative. The pulse, therefore, makes V_1 conductive and charges C_1 through it. At the end of a pulse the input terminal returns to a potential close to that of earth and remains there during the scan stroke of the time-base. The cathode of V_1, however, is held positive by the charge accumulated on C_1 so that V_1 is non-conductive.

The load circuit draws current from C_1 and it consequently loses charge; during the scan period, therefore, the voltage across it falls. The amount of the fall of voltage depends on the capacitance, the load current, and the scanning period, and it can be made very small by making the capacitance sufficiently large; 0.001 μF is usually sufficient.

The other components C_2, C_3, R, and V_2 must now be considered. Assume that at the end of the fly-back C_2 and C_3 are charged to equal voltages which are less than the voltage on C_1. Then when V_1 becomes non-conductive V_2 does so also, for since the voltages on C_2 and C_3 are equal and there is no input, its cathode is positive with respect to its anode by the voltage on C_1.

Since the voltage on C_2 is less than that on C_1, during the scanning period C_2 charges from C_1 through R, so that the voltage across C_2 rises during this period. At the same time C_1 and C_3 act in series to supply the load current and the output voltage is the sum of their individual voltages. The voltages across both C_1 and C_3 fall during the scan; that on C_3 falls because it supplies current to the load and that on C_1 because it supplies both load current and the charging current for C_2.

On the fly-back pulse, V_1 becomes conductive, as before, and C_1 is charged by the pulse. Also with V_1 conductive C_2 is virtually joined to the junction of C_1 and C_3. But the voltage on C_2 is now greater than that on C_3, for they were initially equal and the one capacitor has been charging and the other has been discharging. Therefore, V_2 becomes conductive and C_2 and C_3 are virtually in parallel. There is then a redistribution of charge between them and the voltages across them become nearly equal, the voltage across C_2 falling and that across C_3 rising.

Briefly, the action is: C_1 charges from the source during fly-back and C_3 is charged from C_2. During the scan, C_2 charges from C_1, and C_1 and C_3 act in series to supply the load current.

It has been found experimentally that the output voltage is about 1.8 times the peak input voltage with the normal load current of a cathode-ray tube. All capacitors can be of 0.001 μF capacitance with a resistor R of 2 MΩ. No component is subjected to a voltage of much more than one-half the output voltage. The voltage on V_1 and C_1 is actually at 55 per cent of the output.

One practical difficulty which arises with the circuit of Fig. 5 is the need for two well-insulated windings for the heaters of V_1 and V_2. That for V_2 must withstand the full output voltage and that for V_1 about one-half of it. This is very easily overcome, however, by using metal rectifiers. The circuit then has the form shown attached to the scanning circuit in Fig. 4 and the writer has found it to function extremely well.

Before concluding it may be as well to list a number of the more important fundamental facts about the scanning circuits which the writer has found particularly helpful in experimental work.

1. If the transformer ratio between amplifier and E.H.T. circuits is maintained constant and if the current (Δi_a) supplied by the amplifier is also kept constant, then changing the transformer ratio (n_1) between amplifier and deflector coil has no effect on the picture width, but the E.H.T. voltage varies as the square of the transformer ratio and the amplifier H.T. voltage needed varies nearly as the square of the ratio.

Thus, suppose that with $n_1 = 3$, the full scan is obtained with 4 kV for E.H.T., the amplifier H.T. supply is 300 volts, and it is desired to operate at 6 kV. The valve is presumed to be working at its maximum current output. By making $n_1 = 3\sqrt{6/4} = 3.67$ and increasing the H.T. supply to $300 \times 6/4 = 450$ V, about, the required output can be secured.

2. For a constant amplifier H.T. supply and for constant E.H.T. an increase of deflection beyond the maximum obtainable with a given transformer ratio n_1 necessitates a change of transformer ratio inversely proportional to the deflection and an increase of current proportional to the square of the deflection.

Thus, to take a common example, suppose that the scan obtainable is 6 in only and 7½ in is required, the H.T. supply to the amplifier cannot be altered. What is to be done?

Reduce the transformer ratio to $6/7.5 = 0.8$ of its present value and increase the current supplied to it by $(7.5/6)^2 = 1.56$ times.

This applies whether or not E.H.T. is taken from the fly-back. In the former case it is still unchanged if the transformer ratio between the amplifier and the E.H.T. circuit is kept the same.

3. If E.H.T. is taken from the fly-back and all the transformer ratios are kept constant the deflection volt-amps needed are proportional to the fourth power of the deflection.

Thus, if a 7.5 in picture is required and only 7 in is obtained and the transformer ratios cannot be altered it is necessary to increase the output of the valve by $(7.5/7)^4 = 1.32$ times. This will demand an increase of current and H.T. voltage of $(7.5/7)^2 = 1.15$ times each.

4. For a constant scan/fly-back ratio, the deflection volt-amperes needed are proportional to the number of scanning lines per second.

Thus a change in the transmission from 405 lines to 1,000 lines would need an increase in the deflection volt-mA of 1,000/405 = 2.47 times, which is not inconsiderable.

5. When E.H.T. is taken from the fly-back, the voltage obtainable for a given deflection, tube and deflector coil assembly is inversely proportional to the circuit capacitance and directly proportional to the transformer leakage inductance and to the square of the E.H.T. rectifier voltage efficiency.

APPENDIX.

Symbols.

$a = 1 + 2(1 - k) L_S/L_L$

C_T = total effective capacitance in shunt with the whole primary.

d = total deflection on screen of C.R. tube.

E = maximum voltage developed across L_1 on scan.

E_a = minimum permissible anode-cathode voltage of amplifier valve on scan.

$\Delta E_a = n_1 E$ = maximum voltage developed across L_p on scan.

E_{HT} = final anode operating voltage of C.R. tube.

E_L = maximum voltage developed across L_L on scan.

I = current (peak-to-peak) through L_L.

$i = I/n_1$ = current (p-p) in L_p.

i_a = mean anode current of amplifier valve.

Δi_a = saw-tooth current (p-p) supplied by amplifier valve.

k = coupling coefficient of transformer = $M/\sqrt{L_p L_S}$

$k_1 = 1 + r_S/R_L$.

k_2 = deflection efficiency factor (see below).

L_L = deflector-coil inductance.

L_p = transformer primary inductance.

L_S = transformer secondary inductance.

$L_1 = L_L + 2L_S(1 - k)$.

M = mutual inductance between primary and secondary.

n = turns ratio (whole primary)/(whole secondary W_2).

n_1 = turns ratio (amplifier winding) / (whole secondary W_2).

n_2 = turns ratio (E.H.T. primary)/(whole secondary W_2).

R_{1S} = Shunt damping resistance across secondary W_2.

R_L = deflector-coil resistance.

$R_S = R_L + r_S$ total secondary circuit resistance.

r_S = transformer secondary winding resistance (Note: the value to be used is double the measured value to allow approximately for the primary winding resistance which is otherwise neglected).

T_1 = total scan time.

T_2 = total fly-back time.

$T_L = L_L/R_L$ = time constant of deflector coil.

V = maximum peak voltage on fly-back across L_1.

$V_a = n_1 V$ = maximum peak voltage on fly-back on amplifier anode.

V_{HT} = H.T. voltage of amplifier.

η = E.H.T. rectifier voltage efficiency.

η_T = transformer efficiency.

The factor k_2 is determined for a given C.R. tube and deflector-coil assembly by measuring the current I′ needed to produce a deflection d' when operating at a voltage E'_{HT}, then $k_2 = \dfrac{I'}{d'\sqrt{E'_{HT}}}$

It is to be noted that L_L, T_L and k_2 are not independent variables. In general, L_L cannot be changed without affecting the current needed for a given deflection and, so, without affecting the value of k_2. Throughout the following equations L_L, T_L and k_2 are to be treated as constants specifying the characteristics of the tube and deflector coil in combination. The units are: volts, mA, Ω, mH, μsec, pF, in.

$$L_S = 4.2\,R_S \quad (1)$$

$$I = dk_2\sqrt{E_{HT}} \quad (2)$$

$$E_L = \frac{IL_L}{T_1}\left[1 + 0.001\frac{T_1}{2T_L}\right] \quad (3)$$

$$= 0.0119\,IL_L\,[1 + 0.042/T_L] \quad (3a)$$

when $T_1 = 84.5\mu$sec.

$$E = \frac{IL_L}{T_1}\left[a + 0.001\,k_1\frac{T_1}{2T_L}\right] \quad (4)$$

$$= 0.0119\,IL_L\,[a + 0.042\,k_1/T_L] \quad (4a)$$

when $T_1 = 84.5\ \mu$sec.

$$V = 1.8\,a\,IL_L/T_2 \quad (5)$$

$$= 0.122\,a\,IL_L \quad (5a)$$

when $T_2 = 14.8\ \mu$sec.

$$E_{HT} = n_2\eta V \quad (6)$$

$$\Delta E_a = n_1 E \quad (7)$$

$$\Delta i_a = \frac{I}{n_1}\left[1 + a\frac{L_L}{L_S} + \frac{R_S}{R_{1S}}\right] \quad (8)$$

$$\approx \frac{I}{n_1}\left[1 + a\frac{L_L}{L_S}\right] \quad (8a)$$

$$n = 6.2\,T_2/\sqrt{aL_LC_T} \quad (9)$$

$$= 92.4/\sqrt{aL_LC_T} \quad (9a)$$

when $T_2 = 14.8\ \mu$sec.

$$R_{1S} \approx 2.25 \times 10^6/(n^2C_T) \quad (10)$$

$$\text{Deflection Volt-mA} = E_L I = I^2\frac{L_L}{T_1}\left[1 + 0.0005\frac{T_1}{T_L}\right] \quad (11)$$

Volt-mA supplied by valve

$$= \Delta E_a \Delta i_a = I^2\frac{L_L}{T_1}\left[a + 0.0005k_1\frac{T_1}{T_L}\right]\left[1 + a\frac{L_L}{L_S}\right] = E_L I/\eta_T \quad (12)$$

$$\eta_T = \frac{1 + 0.0005T_1/T_L}{(a + 0.0005k_1T_1/T_L)(1 + aL_L/L_S)} \quad (13)$$

Combining (2), (5), (6) and (9),

$$E_{HT} = 125\,(\eta d k_2)^2\,aL_L/C_T \quad (14)$$

$$V_{HT} = E_a + \Delta E_a \quad (15)$$

By expanding (13) in terms of L_L/L_S and k, differentiating and equating to zero a relation between L_L/L_S and k which makes η_T a maximum can be found. It is:—

$$\frac{L_L}{L_S} = \sqrt{\frac{2(1-k)[1 + 2(1-k)]}{1 + 0.0005k_1T_1/T_L}} \quad (16)$$

and with this value

$$a = 1 + \sqrt{\frac{2(1-k)(1 + 0.0005k_1T_1/T_L)}{1 + 2(1-k)}} \quad (17)$$

and then the optimum efficiency is

$$\eta_T = \frac{1 + 0.0005\,T_1/T_L}{\left[\sqrt{2(1-k)} + \sqrt{(1 + 0.0005k_1T_1/T_L)\{1 + 2(1-k)\}}\right]^2} \quad (18)$$

RECEIVER REMOTE CONTROL

Use of the Extension Loudspeaker Leads

By J. F. O. VAUGHAN,
Grad.I.E.E.

THE extension loudspeaker is a familiar sight in homes today, and in many instances it offers a cheap and satisfactory alternative to a second receiver. Some kind of volume control is often fitted to it, but it is very rare indeed to find that any provision is made for switching the set on or off from the remote point. This is a serious disadvantage but one which is not difficult to overcome. The facility is provided by the remote control system described in this article, and it does it without requiring any additional wires between the receiver and the extension loudspeaker. The writer has had the system in use since 1942, and it has needed negligible maintenance.

The basic circuit is shown in Fig. 1, and it will be seen that blocking capacitors are inserted in one extension loudspeaker lead; one at the receiver end and the other at the loudspeaker. The extension leads can then be used to carry a unidirectional control current as well as the speech currents. The insertion of the capacitors theoretically introduces some loss of bass which depends on their capacitance and on the output impedance of the receiver. In the writer's case, the set had a pentode output valve without negative feedback. The impedance in this case being high, two capacitors of 100 μF each were found to be adequate, the loss of bass being barely perceptible.

In the case of an output stage with negative voltage feedback, or one employing triodes, the circuit impedance is low, and in the limit when the set impedance is zero, an effective capacitance of 50 μF causes a loss of 18 db at 100 cycles. In such cases the value of the capacitors will have to be greatly increased. It is suggested, however, that the aural test should be the deciding factor.

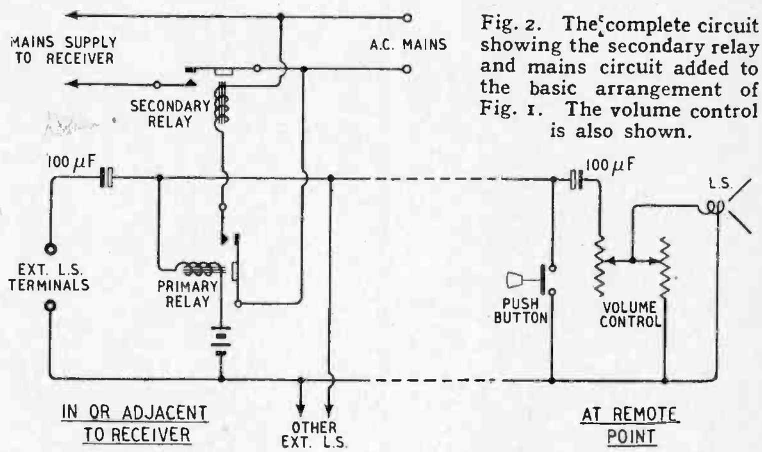


Fig. 2. The complete circuit showing the secondary relay and mains circuit added to the basic arrangement of Fig. 1. The volume control is also shown.

Referring to Fig. 1, in normal use the push-button contacts are open, the battery merely maintains a polarizing voltage across the two capacitors, and the audio signal from the radio set passes through them to the loudspeaker.

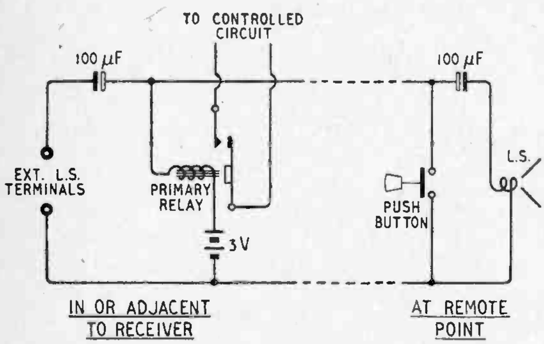


Fig. 1.—The basic remote-control circuit. Closing the push-button switch energizes the primary relay and so closes its contacts.

The relay is of the type which requires not more than, say, 60 mA to operate it, at 3 volts, and is therefore of sufficiently high impedance, with the usual 1½ to 3 ohms extension loudspeaker, not appreciably to by-pass the audio signals. The writer has tried inserting a low-resistance choke in series with the relay, and by-passing the latter with an electrolytic capacitor. This helps, but is not necessary unless a very high audio output is required from the extension loudspeaker. The trouble then is not the attenuation caused by the relay but the fact that low signal frequencies rattle the relay, which may consequently send false signals to the controlled circuits. For normal levels, such a refinement is not needed.

The use of a battery is open to criticism, but the alternatives are complicated and wasteful of power. An ordinary twin-cell cycle-lamp battery usually lasts more than twelve months, and is cheap and easy to replace. The contacts at the loudspeaker are only closed when the actual operation of switching on or off is being performed; no power is taken from the battery at other times.

The relay shown in Fig. 1 is not used to carry out the actual switching operation itself, but to control another relay which performs this function. This secondary relay must alternately make and break a circuit at successive operations. The photographs below show the construction. The core is built up of U-shaped laminations ½ in wide, and outside dimensions 1¾ in by 1¾ in, stacked

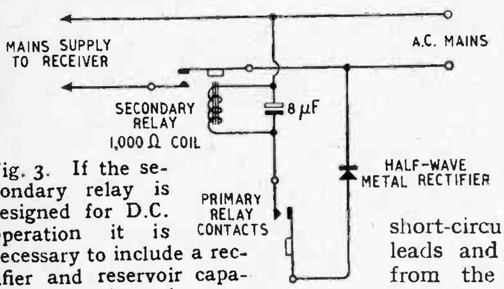


Fig. 3. If the secondary relay is designed for D.C. operation it is necessary to include a rectifier and reservoir capacitor as shown here.

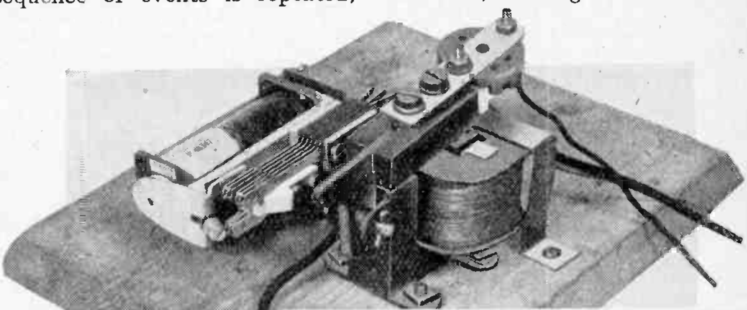
to a depth of 11/32 in. The coil, which is intended to operate on 230 V 50 c/s, consists of 7,000 turns of 38 S.W.G. enamelled-copper wire, and is placed over one limb of the core. It has a resistance of 750 Ω and an inductance, with the armature attracted, of 2 henrys. This value depends, of course, on the air-gap, which has been taken as 1/32 in. The armature is also laminated, and has the same cross-section as the core. It is hinged to the latter by means of a bracket fixed to its outside limb.

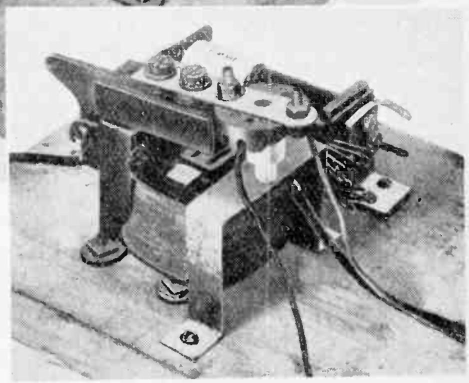
An extension on the armature carries a switch, the plunger of which is arranged to bear against a bridge mounted over the coil. This switch, of the type found on reading lamps, closes a circuit at one operation and opens it at the next. It is wired in one of the mains leads to the receiver, the mains switch on the set being left on, the set tuned to the required station, and its volume control set to the required level. Fig. 2 shows the complete circuit.

The volume control on the extension loudspeaker is of the constant-impedance type, so that its operation does not affect the volume at the set speaker, or at any other extension loudspeakers which may be in circuit. These latter, of course, must be fitted with blocking capacitors, but the volume control and push-button will not necessarily be fitted to them all.

The "local" unit, consisting of the two relays, the battery and 100-μF capacitor can be a separate small unit near the receiver. Sockets can be provided into which to plug the set's mains leads, and flexible leads can be arranged to plug into the "External L.S." terminals on the set and into the power point and "External L.S." sockets in the skirting.

Assuming everything to be off to start with, the sequence of operation is as follows. The act of pressing the push-button short-circuits the loudspeaker leads and completes the circuit from the battery through the primary relay, the contacts of which close and cause the secondary rely to be energized from the mains. The switch on the secondary relay closes, and remains closed even after the push-button has been released, and the relays de-energized. The set is thus switched on, and the volume can be controlled at the remote loudspeaker. To switch the set off, the button is pressed again, the sequence of events is repeated,





Primary and secondary relays are shown above on the left and right respectively, while a close up of the latter appears on the right. Here the mounting of the switch on the armature can clearly be seen.

and the switch operated by the secondary relay is moved to the off position.

If the device which is used as the secondary relay happens to be D.C. operated, it can be powered by the battery, but as the force required to operate the push-on push-off type switch is considerable, it cannot merely replace the primary relay. To obtain say six watts from a three-volt battery (which is possible under pulse conditions) the circuit resistance must be kept down to about 1½ ohms. This means a very low impedance relay which would noticeably attenuate the audio signals. Also the resistance of the loudspeaker extension wires would be important. Even if the primary relay is retained, however, if D.C. is required, a better plan is to supply the secondary relay from the mains through a half-wave rectifier and limiting resistance, as otherwise the battery life will be very much reduced. The coil should then be designed for high-voltage working. The rectifier and resistance, however, need not be designed to carry the required operating current continuously, as the duty cycle is very short; something like one second in an hour or more. The rectifier must, however, be designed to stand the peak inverse voltage; i.e., the peak mains voltage plus the unidirectional voltage developed across the relay coil. This coil should be shunted by an electrolytic capacitor of 8 μF or more to

Receiver Remote Control—

prevent rattle. The arrangement is shown in Fig. 3.

The resistance of the extension leads is in series with the primary relay, but with normal wiring this is small in comparison with the resistance of the relay coil and has little effect on the available current.

Care must be taken to ensure that the voltage across the electrolytic capacitor in the remote loudspeaker is of the correct polarity. Some loudspeaker extension systems employ non-reversible plugs and sockets. This will prevent accidental reversal of polarity in the event of the loudspeaker's being temporarily disconnected. Non-reversible plugs and sockets are not foolproof, however, as the connections between one room and another may be crossed. It is, therefore, necessary to check the polarity at all the sockets and make them uniform. This can easily be done by connecting a battery across one socket, and testing at the others with a voltmeter. If the plugs are reversible, and the chance of wrong connection cannot be avoided, reversible electrolytics can be used, but are not so readily obtainable as the polarized type.

The secondary relay current is about 0.3 A and so the contacts of the primary relay are required to make and break 230 volts A.C. at this current. The telegraph type of relay, which is the natural choice for this purpose, is usually fitted with rather light contacts, but the writer has found that perfectly reliable operation can be obtained if a relay with two pairs of "make" contacts is used, and the contacts wired in series so as to present a double gap when the contacts open. The G.P.O. "3000" type is suitable (see photo), and is available now in many radio shops as Government surplus. One with the required contact arrangement, and a coil resistance of 50 ohms should be selected.

In order to get the full benefit from the remote volume control, it is preferable to arrange for the audio output from the set to be just too loud for normal listening. It is particularly irritating to find that the control on the extension speaker is "flat out," but that the sound level is still not high enough.

For this reason it is desirable to fit a similar volume control to the built-in loudspeaker on the set, so that listeners at both points may adjust the volume to the required level, without affecting each other.

COLONIAL BROADCASTING

Extracts from an Interesting Survey

INFORMATION on the history and development of broadcasting in the Colonies and Protectorates, not readily available from any one source, has been collected by A. R. Burrows and published in the *Bulletin* of the International Broadcasting Union.

The author, who was secretary general of the Union for many years prior to the war, will be remembered by some readers as "Uncle Arthur" of the early days of the B.B.C.

Some of the technical difficulties associated with colonial broadcasting have been discussed in *Wireless World* from time to time, but, as stated in the *Bulletin*, the greatest problems are largely economic.

We give below a few extracts from the considerable amount of information contained in the article.

Prior to the Japanese invasion the broadcasting service in Malaya was operated by the Malayan Broadcasting Corporation, set up in 1941 on the lines of the B.B.C. At the cessation of hostilities it was conducted by the British Military Administration and was later taken over by the Government's Malayan Broadcasting Department. There are medium-wave transmitters in five towns, which are temporarily operating low-power equipment. They will later be equipped with 10-kW transmitters. This service is supplemented by three S.W. transmitters. There are also daily transmissions by four 7.5-kW S.W. transmitters in Singapore operated by the British Far Eastern Broadcasting Service.

The broadcasting service in Hong-Kong is controlled and operated by the Government. Before the Japanese invasion there were three transmitters in the Colony—one S.W. and two M.W. The M.W. transmitters are at present operating on reduced power and the re-establishment of the S.W. service is being considered.

The Palestine Broadcasting Service, started in 1936, was originally part of the Department of Posts and Telegraphs, but in June, 1945, became a separate department of the Palestine Government. There are now two 20-kW medium-wave transmitters at Ramullah, some 20 miles north of Jerusalem, serving the 78,000 licensed listeners.

The Bahama Islands possess a complete telecommunications organization which is controlled by the Government and provides all internal and external radio and telephone services. There is a 5-kW M.W. transmitter and a 600-watt S.W. transmitter for broadcasting to the 1,200 set owners. About 28 community receivers are in use in the outer islands. A weather observation and reporting service is conducted in the islands for the U.S. Weather Bureau. The islands' broadcasting service is utilized for one of radio's primary purposes—the saving of life—for it is the only means available for issuing hurricane warnings to the isolated communities.

In Fiji a M.W. and a S.W. transmitter are operated by Amalgamated Wireless (Australasia) under a Government licence which, after 12 years, expires this year.

Ceylon's 11,000 listeners (1942 figure) are served by a 5-kW medium-wave transmitter and a 7½-kW short-wave transmitter owned and operated by the Government. In addition a powerful S.W. transmitter is operated by the British Army's South-East Asia Command.

Cable and Wireless, Ltd., operates Kenya's four low-power medium- and short-wave transmitters in Nairobi where there are some 7,000 licensed listeners and an ever-growing number of community sets. Public address systems are installed in Mombasa and Nairobi.

It is not possible in our limited space to deal with all the areas covered by Mr. Burrows' survey. In a number of them where there is no broadcasting service a rediffusion system is operated. It is perhaps of interest to note that the number of licensed listeners in some of the areas in which there is not a broadcasting service is considerable. For instance there are some 10,000 in Malta, 8,000 in Trinidad and Tobago and 5,000 in Cyprus.

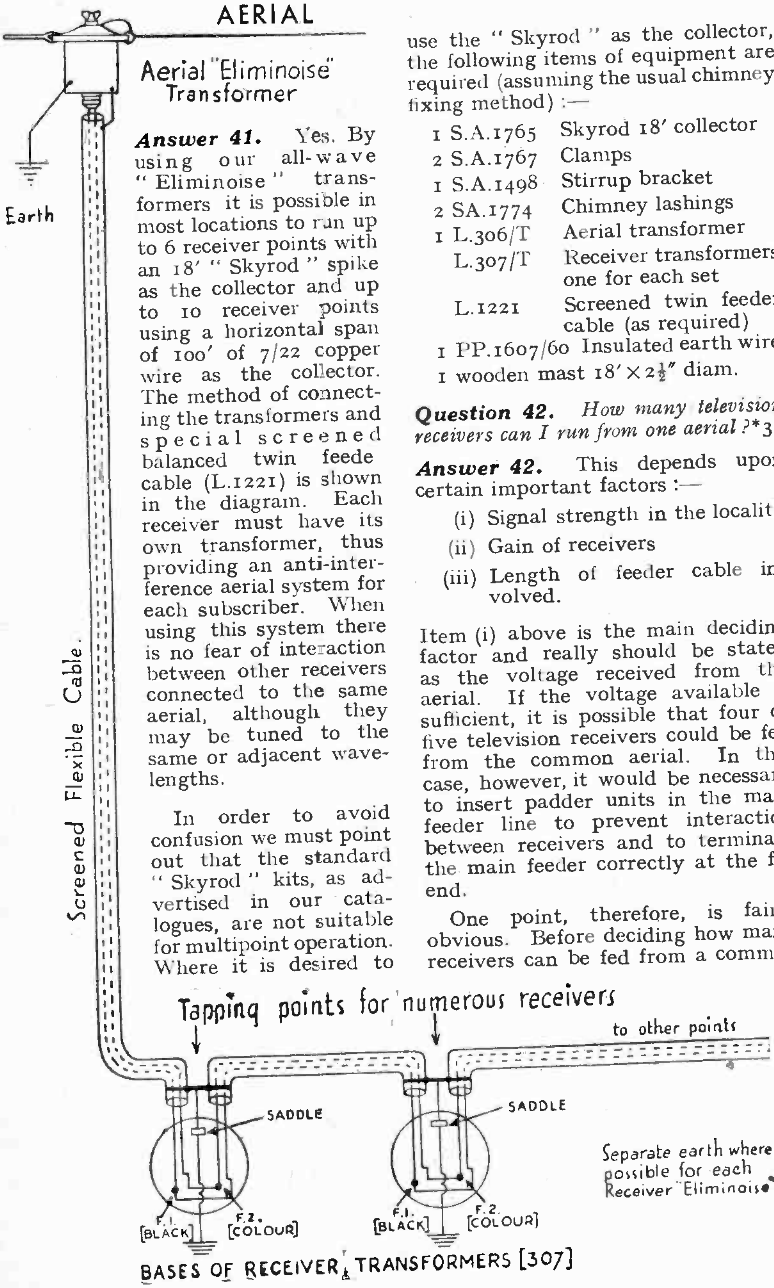
The majority of the areas covered by the report are populated by peoples whose unaided resources are generally insufficient to enable them to buy receivers for themselves and, moreover, many lack an electricity supply.

BELLING-LEE QUIZ (No. 12)

Answers to questions we are often asked by letter and telephone

Question 41. *Can I run more than one broadcast receiver from a "Skyrod"*1 or horizontal "Eliminoise"*2 aerial system*

The "ELIMINOISE" ALL-WAVE ANTI-INTERFERENCE SYSTEM



Answer 41. Yes. By using our all-wave "Eliminoise" transformers it is possible in most locations to run up to 6 receiver points with an 18′ "Skyrod" spike as the collector and up to 10 receiver points using a horizontal span of 100′ of 7/22 copper wire as the collector. The method of connecting the transformers and special screened balanced twin feede cable (L.1221) is shown in the diagram. Each receiver must have its own transformer, thus providing an anti-interference aerial system for each subscriber. When using this system there is no fear of interaction between other receivers connected to the same aerial, although they may be tuned to the same or adjacent wavelengths.

In order to avoid confusion we must point out that the standard "Skyrod" kits, as advertised in our catalogues, are not suitable for multipoint operation. Where it is desired to use the "Skyrod" as the collector, the following items of equipment are required (assuming the usual chimney fixing method):—

1	S.A.1765	Skyrod 18′ collector
2	S.A.1767	Clamps
1	S.A.1498	Stirrup bracket
2	SA.1774	Chimney lashings
1	L.306/T	Aerial transformer
	L.307/T	Receiver transformers one for each set
	L.1221	Screened twin feeder cable (as required)
1	PP.1607/60	Insulated earth wire
1		wooden mast 18′ × 2½″ diam.

Question 42. *How many television receivers can I run from one aerial?*3*

Answer 42. This depends upon certain important factors:—

(i) Signal strength in the locality
(ii) Gain of receivers
(iii) Length of feeder cable involved.

Item (i) above is the main deciding factor and really should be stated as the voltage received from the aerial. If the voltage available is sufficient, it is possible that four or five television receivers could be fed from the common aerial. In this case, however, it would be necessary to insert padder units in the main feeder line to prevent interaction between receivers and to terminate the main feeder correctly at the far end.

One point, therefore, is fairly obvious. Before deciding how many receivers can be fed from a common aerial, it is essential that the aeria be erected (temporarily if necessary) and the vision input voltage measured. Once this figure is known the number of receivers can be determined, and the resistor values calculated for the padder units.

Our installation department would be pleased to advise you on this problem and undertake multi-point installations where conditions are suitable.

ERRATUM

In the May issue of the "Wireless World," centre column, sub-heading 2, 6db should read: minus 6db.

***1 Skyrod** (*Regd. Trade Mark*).

Types **L.355/CK** 12′ collector, down-lead, 2 transformers, pole clamps, and earth wire **£7 7 0**

L.355/LK with chimney lashings and brackets in addition **£8 8 0**

L.370/LK with chimney lashings for 2″ mast in addition to L.355/CK **£8 17 6**

Also supplied with 18′ collector.

***2 "Eliminoise"** (*Regd. Trade Mark*).
Anti-Interference Aerials. (*U.K. Patents* 477218, 479118.)

L.307/T. Receiver Transformer Price **£2 0 0**

***L.306/T.** Aerial Transformer Price **£2 10 0**

***L/308/T.** Pair of Transformers Price **£4 10 0**

***L/308/K.** Complete kit with 60′ Aerial, 50′ screened feeder. **L.1221** Price **£6 6 0**

L.1221 Screened Feeder per yard **1 9**

* Complete with **L350** lightning arrester.

***3 Viewrod** (*Regd. Trade Mark*). Dipole, reflector and cross arm with chimney lashings, **L.502/L.** each **£5 12 6**

Supplied also without reflector and/or chimney lashing .. from **£2 7 6**

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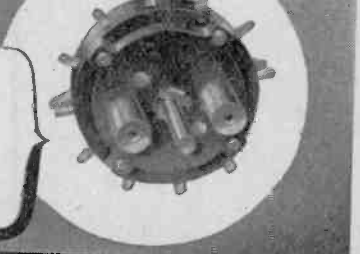

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MARINE NAVIGATION

AMONG the papers presented at the second meeting on Radio Aids to Marine Navigation, which opened in New York on April 28th was one by Capt. R. W. Ravenhill, R.N., Director of Navigation and Direction at the Admiralty, reviewing the mariners' navigational requirements. He stated that in pilotage and coastal waters they were best met by a combination of radar and Decca. So far as an ocean aid was concerned he doubted if the requirements were strong enough to warrant the expense and suggested that they might be met by the use of Consol stations, established primarily for aircraft, which require only an ordinary receiver.

A paper on Decca was presented by W. Ross, Principal Scientific Officer at the Ministry of Transport. To solve the difficulty which would arise should there be a break in transmission or reception a system of lane identification had, he said, been successfully demonstrated. It was achieved by exchanging the frequencies of one or more of the transmitters for a short interval.

The number of ships already fitted with Decca is 74.

TELEVISION RELAY STATIONS

IT emerged from the recent controversy in the House of Commons on the proposed erection of a relay station on the Berkshire Downs that the Post Office is undertaking experiments in relaying television to Bristol and Cardiff by radio link.

It has since been announced by the P.M.G. that the proposed station will be erected elsewhere.

R.C.M.F. REPORT

THE component manufacturer's part in the industrial drive of last year is indicated by the figures given in the annual report of the Radio Component Manufacturers' Federation. Production reached a level during the year of over 20,000,000 components and accessories a month. Some 75 to 80 per cent of the demand placed on the industry was for domestic receivers.

Whilst the value of exports during the year "give grounds for satisfaction" it is pointed out in the report that, owing to the considerable increase in prices, if exports are interpreted in volume of goods rather than value they are not so impressive.

The present membership of the Federation is 118 which brings it very close to its target of 100 per cent representation of component manufacturers.

EXPORT TELEVISION

CONSIDERABLE progress has been made in the development of television transmitters and receivers for the overseas market. E.M.I. is developing 605-line equipment and has prepared specifications for complete transmitting stations with this definition. It is stressed that this equipment is for "export only."

JUBILEES AND ANNIVERSARIES

APART from the Marconi jubilee which is referred to elsewhere in this issue a number of notable anniversaries occur this year.

It was on April 30th, 1897, that Prof. J. J. Thomson (later Sir Joseph Thomson) made his announcement of the existence of the electron. To mark this jubilee the Institute of Physics and the Physical Society, in collaboration with the I.E.E., is arranging a series of lectures in London on Sept. 25th and 26th and an exhibition at the Science Museum which will remain open for about three months.

The silver jubilee of both regular broadcasting in this country and the national radio exhibition will be celebrated this year. The first radio exhibition was held in October, 1922, and the first regular broadcast was radiated in November of the same year.

We are reminded of a number of communications anniversaries by John Young of Cable & Wireless. It is 40 years ago this October that Marconi's opened the long-wave Great Britain-Canadian service. The first phototelegraph service was opened (with New York) in May, 1926—to-day fourteen services are in use. This year is the twentieth anniversary of the opening of the beam services between Britain and Australia (April 8th), South Africa (July 5th) and India (Sept. 6th).

OUR COVER

This month's illustration is from a photograph of Marconi, taken in 1896 with the original demonstration apparatus he brought from Italy to England. On the left is a 1½-metre oscillator and on the right the companion receiver, comprising a copper-strip dipole aerial and (inside the box) a coherer, tapper and relay.

I.E.E. AND INTERFERENCE

IN the section of the I.E.E. annual report dealing with technical investigations reference is made to the work on Codes of Practice.

Among the Codes being prepared are three on the abatement of radio interference from:—

(a) electro-medical and high-frequency industrial equipment,
(b) motor vehicles and internal combustion engines,
(c) neon signs or electric discharge lamps.

The final version of the Code on interference caused by motor vehicles will be published shortly.

The report of the I.E.E. Committee on Radio Interference on means whereby the substantial control of interference could best be brought about has been submitted to the Postmaster-General.

CIVIL AVIATION

THE final report of the first session of the Special Radio Technical Division of P.I.C.A.O. has been issued in English, French and Spanish from the offices of P.I.C.A.O., Montreal. The recommendations contained in the report will be considered by the Council of the organization which will decide upon acceptance in whole or in part.

The report covers the meeting of 180 representatives of 29 nations in Montreal last November which, it will be recalled, was preceded by displays of equipment in this country, the United States and Canada.

The largest section of this 84-page book is Section VIII which deals with radio aids for navigation, communications and radar for search and rescue purposes.

Copies, which cost 3s 9d, may be obtained from E. M. Lewis, P.I.C.A.O. Representative, 7, Fitzwilliam Place, Dublin, Ireland.

AIR OPERATORS' EXAMS

DURING the second half of this year monthly examinations for civil aircraft radio operators' licences will be held in London and Liverpool. Details and application forms, M.C.A. 182 and 183, are obtainable from the Secretary, Ministry of Civil Aviation, Directorate of Telecommunications (Tels 4b), Cornwall House, Stamford Street, London, S.E.1.

Two licences are obtainable—radiotelephony and combined radio-

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telegraphy and telephony. For the first the examination lasts approximately 2½ hours and for the second 3½ hours.

In general the last date for acceptance of applications is the first of the month in which the applicant wishes to sit the examination.

BOY SCOUTS AND RADIO

ARRANGEMENTS have been made by the Postmaster-General whereby up to twenty transmitting licences may be issued to scout groups.

These licences will permit the use of apparatus with a dummy aerial, within a building, for instructional purposes, and portable sets for use at camps and for training schemes, over a radius of ten miles from the radio headquarters shown in the licence.

The licensee will be a responsible Scouter (officer), who need not be technical, but the licence will bear the name and address of at least one qualified operator of the sets, which may be as many as ten.

Transmissions are limited to morse in the 58.5 to 60 Mc/s band. The same frequency must be used for control and mobile sets in any one licensed group.

The total D.C. power input to the anode circuit of the valve or valves energizing the aerial must not exceed 1 watt, apart from one (control) set per group, with which 5 watts may be used.

The provisional licence fee is 10s with which a maximum of ten sets may be used. The arrangement is an experiment for one year.

RAILWAY RADIO

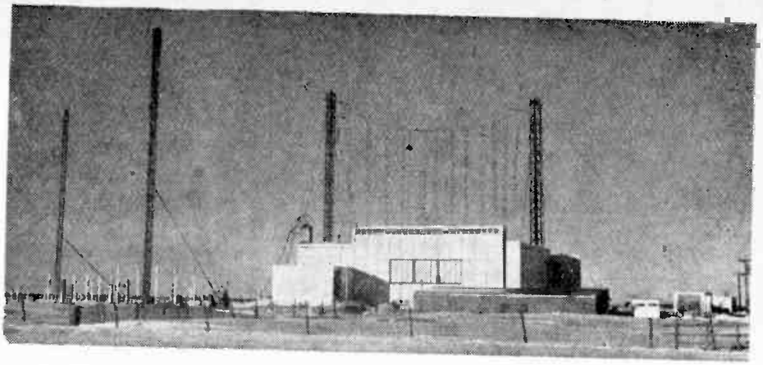
WHEN asked in the House of Commons when he would be able to allocate frequencies to the railways in order that they might undertake trials in radiocommunication, the Assistant Postmaster-General stated that some frequencies would be made available within a few weeks.

It was pointed out, however, that the wavelengths would be liable to alteration as a result of the forthcoming international telecommunications conference.

THIRD PARTY MESSAGES

THE Postmaster-General has asked the R.S.G.B. to draw the attention of amateur transmitters to Condition 8 of their licences whereby they are permitted to send or receive only messages relating to their own or their correspondent's private affairs and prohibited from sending or receiving other messages.

The sending or receiving of messages originated by or about the affairs of third parties, whether for payment or not, is, therefore, a breach of the conditions attaching to the licence and renders it liable to cancellation.



MEASUREMENTS made by the B.B.C. of the transmissions from the international short-wave station of the Canadian Broadcasting Corporation in the 15-Mc/s band show an average signal strength of 400 mV/m. One of the three aerial arrays of the station at Sackville, New Brunswick, which provide six directional beams, is shown in this photograph. The two 50-kW. transmitters are linked to the studios in Montreal by 600 miles of land line. Monthly schedules of the C.B.C. International Service, which was inaugurated two years ago, are sent to listeners sending reports.

AMATEUR FREQUENCIES

SOME of the proposals for frequency allocations being made at the International Telecommunications Conference meeting in Atlantic City were announced just prior to the delegates leaving this country.

In order to give readers an opportunity of comparing the G.P.O. proposals for amateur frequency bands with those put forward by the R.S.G.B., we give below the two lists (Mc/s). The G.P.O. proposals were formulated and substantially agreed to at the recent conference in Paris attended by delegates from the U.K., France, and the U.S.S.R.

G.P.O.		R.S.G.B.
1.715— 2.00	shared	1.715— 2.00
3.50 — 3.60	exclusive	3.50 — 3.80
7.00 — 7.20	,,	7.00 — 7.30
14.00 —14.40	,,	14.00 —14.40
21.25 —21.45	,,	21.00 —21.50
28.00 —29.70	,,	28.00 —30.00
		50.00 —54.00 or
		58.50 —60.00 or
		66.00 —67.50
168— 170	exclusive	166— 170
		220— 225
400— 415	shared	400— 430
1,215— 1,295	exclusive	1,200— 1,300
2,300— 2,450	,,	2,300— 2,450
5,650— 5,850	,,	5,600— 6,000
10,000—10,500	,,	10,000—10,500
20,500—22,000	,,	20,500—22,000

Commenting in the April issue of the *R.S.G.B. Bulletin* on the G.P.O. proposals, the Society states that it has lodged the strongest possible protests with the G.P.O. regarding the 3.5- and 7-Mc/s bands and also the omission of a band around 60 Mc/s.

It will be recalled that S. K. Lewer and John Clarricoats, president and general secretary, respectively, of the R.S.G.B., are attending the Atlantic City conference as delegates of the International Amateur Radio Union.

B.B.C. YEAR BOOK

DISCUSSING the problem of improving the coverage of the Third Programme, Sir William Haley, B.B.C. Director General, writing in the B.B.C. Year Book, 1947, states that the Corporation envisages a chain of F.M. stations to make the programme available to some 96 per cent of the population. A 25-kW experimental transmitter is being built in Kent to serve the south-east.

Among the many interesting articles in the Year Book, which is obtainable by post from the B.B.C. Publications Department, Scarle Road, Wembley, Middx, price 2s 10d, is one by G. Darnley-Smith, R.I.C. chairman, on the radio industry.

PERSONALITIES

Sir Edward Appleton has recently been awarded the honorary degree of D.Sc., by the University of Brussels and has also been elected an honorary member of the Royal Belgian Society of Engineers and Industrialists.

Wilfred Paling has succeeded as Postmaster-General **Lord Listowel,** who is now Secretary of State for India and Burma. Mr. Paling is Labour M.P. for the Wentworth Division of Yorkshire.

J. H. Cotton, M.B.E., has joined the Board of the Dubilier Condenser Co. (1925) as works director. He joined the Dubilier organization in 1930 and has served on several Government missions to the U.S.A. and the Continent during and since the war.

G. D. Deuchars has been appointed United Kingdom Civil Aviation Telecommunications Representative, Cairo.

He succeeds Air Comdre. **W. E. G. Mann,** who is now responsible for overseas telecommunications developments in the Ministry of Civil Aviation.

H. R. Denne has been appointed Television Outside-Service Engineer for E. K. Cole and will operate from Somerton Works, Southend-on-Sea.

H. de A. Donisthorpe was elected chairman of the Radio Industries Club for the eleventh successive year at the first meeting of the new committee. **Guy R. Fountain** is vice-chairman.

C. W. Goyder, C.B.E., who relinquished his appointment as chief engineer of All-India Radio last year, has rejoined the B.B.C. as assistant head of the Overseas and Engineering Information Department.

Major Gen. L. B. Nicholls, a director of Cable and Wireless, is visiting the Middle and Far East to plan the development of civil communications. During the war General Nicholls was General Eisenhower's Chief Signal Officer.

Major L. H. Peter, M.C., has been appointed chief development engineer of the Westinghouse Brake and Signal Co. **L. E. Thompson,** B.Sc., A.R.C.S., has been appointed chief electrical engineer and **K. H. Leech,** B.Sc., chief design engineer.

Andrew Reid has been appointed Press Officer for the Olympia radio exhibition (October 1st-11th). His address is 11, Garrick Street, London, W.C.2. (Tel.: Temple Bar 4844.)

J. H. Williams was elected president of the Radio Industries Club, in succession to **Leslie C. Gamage,** at the sixteenth annual general meeting of the club.

AIR COMDRE. C. S. CADELL, C.B.E., M.A., A.M.I.E.E., who during the war was R.A.F. Director of Telecommunications and Signals, has been appointed managing director of International Aeradio Ltd. This non-profit-making company was recently formed by the three State-owned British airline corporations to install and maintain radio navigational and telecommunications equipment on the world air routes.

IN BRIEF

A record total of approximately 10,780,400 broadcasting receiving licences were in force in Great Britain and Northern Ireland at the end of March. This is an increase of only 2,400 during the first three months of the year. The March total includes 14,550 television licences.

Receiving Licences in force in British India totalled 232,368 at the end of 1946. There was an increase of almost 30,000 during the year.

German Listeners. According to the latest figures available from the International Broadcasting Organization there were 7,686,825 licensed listeners in Germany at the beginning of February. The zonal figures are:—British, 2,886,825; Soviet, 2,500,000; American, 1,800,000; and French, 500,000.

Amateur Exhibition.—The R.S.G.B. is arranging to hold an exhibition of short-wave equipment at the Royal Hotel, Woburn Place, London, W.C.1, from November 18th-21st. A similar exhibition was arranged for 1939, but had to be cancelled on the outbreak of war.

Acoustics.—The proposed Acoustics Group of the Physical Society, to which reference was made in our February issue, has now been formed with H. L. Kirke as chairman and Dr. A. Wood as vice-chairman. Membership of the Group is not confined to members of the Physical Society. Particulars are available from the joint-secretaries, W. A. Allen and A. T. Pickles, The Physical Society, 1, Lowther Gardens, London, S.W.7.

Canadian Loran.—The Canadian Government has announced its intention to build two Loran stations in the Far North this summer for marine and air navigation. A third station is to be built next year.

F.M. in Canada.—By the end of the year it is expected that twelve F.M. stations will be in operation in the Dominion. Three—one in Toronto and two in Montreal—are already operating, with a fourth at Kingston ready to start. The frequency band used for F.M. in Canada is 88-108 Mc/s.

"Wireless World" Index.—Copies of the index to Vol. LII, January-December, 1946, are still available from our Publisher, price 1s 1½d, including postage. Binding cases are also obtainable which, complete with index, cost 5s 10d by post. Our Publisher is able to arrange for the binding of readers' own copies at a cost of 13s 3d, including postage on the return of the volume.

Railway Radar.—Radiolocation is being developed in the Soviet Union for use on railway engines to facilitate driving at night and in fog.

I.S.W.L.—Among the facilities provided by the International Short-Wave League for its members—at present some 600—are a translation service, broadcast station schedule service and a QSL bureau. Details of membership are obtainable from the headquarters, 57, Maida Vale, London, W.9.

I.E.E. Radio Section.—At the Annual Dinner, held in London on April 30th, Prof. Willis Jackson, Section Chairman, announced that the secretaryship of the Section was being taken over by K. W. T. Brown from H. J. Nunn. A presentation was made to Mr. Nunn, who has held the office for 15 years, and has 40 years' service with the I.E.E. The formation of local radio groups has resulted in a noticeable increase in the membership of the Radio Section of the Institution, which is now 3,311.

ERIC E. JONES, manager of the Communications Division of the Mullard Wireless Service Co., which will market the products developed and manufactured by the new company — Electronic Transmission Equipment Ltd., referred to on the next page.

"Proc. R.S.G.B."—The Radio Society of Great Britain is to publish three times a year a new periodical, *Proceedings of the R.S.G.B.* Each issue will contain at least two of the papers read at meetings of the Society.

Engineering Centre.—The I.E.E. and the Brit.I.R.E. are among the bodies sponsoring the formation of the Engineering Centre which will establish branches in various parts of the country. The first will be opened in Glasgow this year. The aims of the organization include the provision of permanent exhibitions of modern engineering products and advice bureaux. The headquarters of the Engineering Centre, Ltd., is 351, Sauchiehall Street, Glasgow, C.2.

High-power F.M.—Permission has been granted to Eitel McCullough, the American valve manufacturers, to establish an experimental 50-kW F.M. transmitter at their works at San Bruno, California. It is planned to erect the station eventually at the summit of the 3,800ft Mount Diablo, near San Francisco.

Jubilee.—To mark the "fiftieth anniversary of the discovery of radio by Marconi" the Italian National Council of Research has organized an international congress to be held in Rome from September 28th-October 5th. The congress is planned to provide a complete picture of the present develop-

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ment of radio in the technical, scientific and industrial fields. Invitations have been extended to many countries to participate in the congress.

An American Book, "Music and Sound Systems in Industry," by Barbara Elna Benson, is the first to attempt to survey in a comprehensive manner the origin, development and present-day applications of "music while you work." Published by McGraw-Hill, price 9s, it includes a 41-page "discography"—classified list of records.

"Research and the Smaller Firm" is the title of the report of the conference on this subject held in Manchester last October under the auspices of the Manchester Joint Research Council. Copies of this 100-page report are available from the M.J.R.C., Chamber of Commerce, Ship Canal House, King Street, Manchester, 2, at 2s 6d, plus postage.

INDUSTRIAL NEWS

Flat-ended C.R. tubes are being produced by the G.E.C. and are a feature of their new table model television receiver which incorporates a 9in tube giving a picture of about 8in × 6½in. These tubes employ pressed screen ends of 1,000 mm radius of curvature.

Radio Industries Club.—The annual report of the club, presented at the sixteenth annual general meeting, shows that membership of the parent club (London) has grown to 645—an increase of 43 during the year. Membership of the two affiliated clubs is: Scotland, 198; Wales and Monmouthshire, 88.

R.C.M.F. Council.—At the first meeting of the new council of the Radio Component Manufacturers' Federation, A. F. Bulgin was elected chairman, and W. A. Jackson, vice-chairman.

Engineering and Marine Exhibition.—Among the radio manufacturers exhibiting at this show at Olympia (August 28th—September 13th) are: Ardente, Automatic Coil Winder, B.I. Callenders, B.T.H., S. G. Brown, Cossor, Ekco, Magneta Time Co., Met-Vick and Rediffusion.

E.M.A. Representatives to the B.S.I. Sub-Committee on Radio Equipment and Components are A. S. Williams (Felgate Radio) and C. Lunt (Central Equipment). R. C. Hitch (New Era) is deputy.

Plessey Co. is the only radio manufacturer exhibiting in the *St. Merriel* floating exhibition visiting South America.

Radio Industries Ball.—During the period of the Radio Exhibition the Radio Industries Club will be holding a ball at the Royal Albert Hall.

Electronic Transmission Equipment, Ltd., is the name adopted by a new company formed by Mullards for the development and manufacture of communications apparatus. It will take over the present communications activities of Radio Transmission Equipment, Ltd. Laboratories and works are at Brathway Road, Wandsworth, London, S.W.18. Equipment will be marketed by the Communications Division of Mullard. Directors of E.T.E. include Air Comdre. A. V. Harvey, C.B.E., M.P., and T. E. Goldup.

Stratton and Co. recently presented the R.S.G.B. with an Eddystone 640 communication receiver for use at the Society's headquarters' station.

S.I.M.A.—An official catalogue of the members of the Electronic Section of the Scientific Instrument Manufacturers' Association who were exhibiting at the B.I.F. was produced by the Association for distribution at the exhibition. The brochure includes a list of members and details of their products.

Mullard has opened a new factory at Gillingham, Kent, for the assembly of the component parts of miniature valves. The sub-assemblies are transported from Gillingham to Mitcham, where the filaments are inserted and the complete assembly sealed into the bulb.

Philips.—A new Philips factory is being built at Hamilton, Lanarkshire, Scotland. It will ultimately employ some 2,500 workers on the production of receivers and components.

B.I. Callender's Cables.—Due to the delay in building the company's new factory on the Kirkby Trading Estate, Liverpool, B.I. Callender's have taken over a factory covering 9½ acres at Melling, near Liverpool, for the production of telecommunication equipment.

Ekco.—The address of E. K. Cole's Scottish Service Depot is now Ekco Works, Duchess Road, Rutherglen, Lanarkshire. (Tel.: Rutherglen 2240/3.)

Moreton Cheyney Co. has moved to new premises in Darkhouse Lane, Deepfields, Bilston, Staffs. (Tel.: Bilston 41778.)

Welwyn Electrical Laboratories, Ltd., have moved their factory and head office to Links Road, Blyth, Northumberland (Tel.: Blyth 668/9). A branch office will be maintained at the old address—70, Bridge Road East, Welwyn Garden City, Herts.

G.W.B. Electric Furnaces, Ltd.—It was inadvertently stated in our April issue that this company's Birmingham office was at 21, Steelhouse Lane, which is the new address of Wild-Barfield Electric Furnaces, Ltd. The address of G.W.B. Electric Furnaces remains unchanged.

CLUBS

Birkenhead.—Meetings of the Wirral Amateur Radio Society (formerly the Wirral Amateur Transmitting and Short-wave Club), which has a membership of over 60, are held twice a month on Wednesdays at the Y.M.C.A., Whetstone Lane, Birkenhead. June meetings will be held on the 11th and 25th. Sec.: B. O'Brien, G2AMV, 26, Coombe Road, Irby, Heswall, Cheshire.

Birmingham.—Details of the meetings of the recently formed South Birmingham group of the R.S.G.B., which are held on the first Sunday of each month at 10.30 a.m. and the third Monday at 7.0 at Stirchley Institute, Stirchley, are obtainable from T. Higgins, G8JI, 391, Rednal Road, Northfield, Birmingham, 31.

Birmingham.—Employees of I.C.I. (Metals), Ltd., Kynoch Works, Witton, Birmingham, have formed the Kynoch Radio and Television Society. They hope eventually to establish their own station and laboratory. Membership is not confined to I.C.I. employees. Sec.: J. W. Harris, Kynoch Works, Witton, Birmingham, 6.

Brighton.—At the meeting of the Brighton and Hove Group of the R.S.G.B. at the Golden Cross Hotel, Western Road, on June 16th at 7.30 a representative of the Automatic Coil Winder and Electrical Equipment Co. will speak on "Test Equipment." Town Representative: Lt. Cdr. J. R. D. Sainsbury, G8HV, 80, Lansdowne Place, Hove, 2, Sussex.

Cheadle.—The Cheadle (Staffs) and District Amateur Radio Society claims the distinction of having a higher ratio of amateur transmitters to the town's population than any other—one to 680. Sec.: V. Hughes, G3AVG, Abbots-Haye, Cheadle, Stoke-on-Trent, Staffs.

Harrogate.—The recently formed Harrogate and District Short-wave Radio Society meets on alternate Wednesdays at 7.30 at the Y.M.C.A., Victoria Avenue, Harrogate. The next meeting will be on June 11th. Sec.: K. B. Moore, Spinney Cottage, 2a, Wayside Crescent, Harrogate, Yorks.

Manchester.—Amateurs in the Manchester, Prestwich, Whitefield and Bury districts are invited to the meetings of the Whitefield and District Radio Society held on Mondays at 7.30 at the Stand Grammar School for Girls, Higher Lane, Whitefield. Morse classes and a short-wave listener section have been started. Sec.: E. Fearn, 4, Partington Street, Newton Heath, Manchester, 10.

Kingston-on-Thames. — Originally formed in 1935 and reorganized last October, the Kingston and District Amateur Radio Society has been meeting twice a month at the Three Fishes Hotel, Kingston, but has now to find other accommodation. Members will be notified when alternative arrangements have been made. Sec.: A. W. Knight, G2LP, 132, Elgar Avenue, Tolworth, Surbiton.

MEETINGS

Institution of Electrical Engineers

Southern Centre.—"Colonial Telecommunication Systems," by C. Lawton and V. H. Winson, B.Sc. (Eng.), on June 4th at 7.0 at 110, High Street, Portsmouth.

"Frequency Modulation," by K. R. Sturley, Ph.D., B.Sc., on June 18th at 7.0 at the Royal Aircraft Establishment, Farnborough.

British Sound Recording Association

"Sound on Film and the Amateur," by D. O. Roe, B.Sc., on May 30th at 7.0 at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.

LETTERS TO THE EDITOR

Reflections from Meteors ✦ Ions and Electrons in Thyratrons ✦ Self-controlled R-C Oscillator

"Whistling Meteors"

CONCERNING the description of the meteor effect in the April *Wireless World*, by G. R. M. Garratt, there are one or two points of interest which I might add. First, one can observe meteor reflections without necessarily hearing the ground wave of the station concerned. In this case it is, of course, necessary for the receiver to be fitted with a B.F.O. and instead of a beat note due to the reflected and ground waves one obtains a normal beat note which, at times, varies in frequency due to the doppler effect. Secondly, one can use frequencies considerably in excess of the 15 Mc/s mentioned by Mr. Garratt. Thirdly, the effect can be observed on stations of 1 kW power and less.

The writer, in the course of V.H.F. propagation observations, frequently observes meteor reflections on stations of the order 40-50 Mc/s. In particular, checks on tropospheric conditions are made on two stations which are situated at a distance which makes the meteor effect quite apparent. These are the Paris television (vision, 46; sound, 42 Mc/s), and an experimental 1-kW transmitter at Eindhoven on 43.2 Mc/s, which are 210 and 177 miles respectively from the writer's station. According to whether tropospheric conditions are good or not, these signals are sometimes audible at good strength or at other times inaudible. Even, however, if the signals are not audible by tropospheric refraction, provided a stable receiver is used and it is left tuned to the frequency of the station one will hear, from time to time, short bursts of signal, seldom lasting more than a second! Due to the short duration of the "bursts" it is nearly impossible to "tune in" the receiver during the time the signal is audible, hence it must be accurately logged beforehand.

When the signal is audible continuously (i.e., by tropospheric refraction), provided it is not too strong, the meteor reflections will show up as sudden marked increases in signal strength. The reflections have been heard at all times of the day and night. Sometimes they occur fairly frequently whilst at other times there may be intervals of five or more minutes between individual "bursts" and for long periods no reflections are heard at all.

During meteor showers amateur transmitters in U.S.A. have, of course, had trans-Continental contacts by this form of reflection on 50 Mc/s.

D. W. HEIGHTMAN.
Clacton-on-Sea, Essex.

IN commenting on this article, I would first remind you that the effect described was reported by me in the *Wireless World* as long ago as April, 1942, when an abstract of Chaman Lal and Venkataraman's original paper was published.

Your contributor is in error when he says that meteors maintain the ionization responsible for *long-distance* communication during darkness. Long-distance communication is effected mainly on short waves, and the ionized region responsible for their propagation at night is the F layer, whose continued existence during darkness can be adequately explained without having resource to meteors. This is not to say that meteors have *no* ionizing effect upon the upper atmosphere, for it has recently been indicated by Sir Edward Appleton that the "residual" night-time ionization of the E layer may be due to their effects. This night-time E layer has, however, little or no effect upon short-wave communication, though it has upon that on the medium and long waves, so that the only long-distance communication effected during darkness by way of an ionized region which may be maintained by meteors is that which is carried out on the long waves.

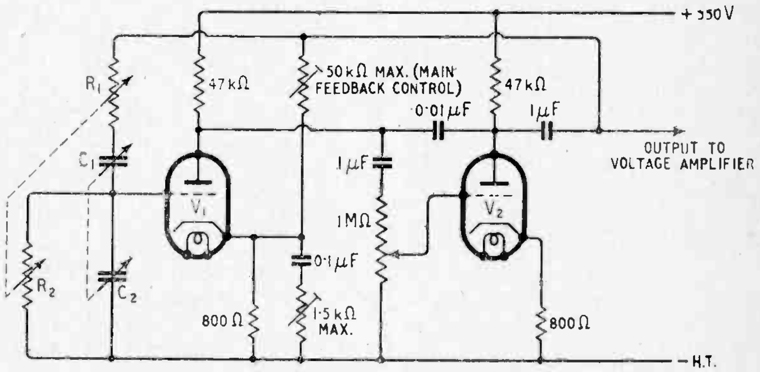
Lastly I would mention that the B.B.C. receiving station at Tatsfield has been observing and recording these "whistles" for many years past—even since before the publication of the Indian paper—with the object of correlating their occurrence with that of the well-known meteoric showers.

T. W. BENNINGTON.
B.B.C., London, W.1.

Amplitude Control in R-C Oscillators

IN the type of resistance-capacity oscillator described by Terman and others (*Proc. I.R.E.*, Vol. 27, p. 649), a non-linear lamp resistance was used in the cathode circuit of the first stage to apply extra feedback to compensate for change in amplitude. The type of lamp required is not readily available in this country, and the following alternative method of control may be found useful.

A condenser of the order of 0.01 μF is connected between the valve anodes to provide feedback that increases with frequency. A second condenser in series with a small resistance is shunted across the normal bias resistor of the first valve. This capacity reduces feedback as frequency rises. By balancing the main feedback control against this variable resistance, settings can be found that give less than 10 per cent variation of amplitude over at least an eightfold frequency range. Waveform is excellent throughout.



R-C oscillator with amplitude control. V_1, MH4. V_2, MHL4. With the obvious exception of R_1, R_2, C_1, C_2, controls may be locked when correct settings have been found.

In this circuit best results seem to be given by low-slope triodes, as the

Letters to the Editor—

settings of controls are then less critical. E. J. B. WILLEY.
London, S.W.5.

Thyratron Action

IN your February issue "Cathode Ray" may have added to existing confusion by his description of the action of ions and electrons in thyratrons.

He implied that electrons leave the cathode in "ones" and release so many electrons by collision and ionization that they enter the anode in "hundreds." In fact, he said that "such a crowd would need an enormous cathode to yield it by thermal emission alone."

That this description is very misleading may be seen easily if one enquires where the electrons get to in the circuit and where they continue to come from in the valve.

Obviously in a sustained discharge, such as occurs in a thyratron, as many electrons must leave the external circuit at the valve cathode as enter at the anode. Also, over a period of time as many electrons must enter the valve at the cathode as leave at the anode. Thus the cathode must release, by thermal emission, the entire current the valve is capable of handling. This is an unfortunate fact, since much power must be wasted in heating the cathode.

The only advantage of having a gas, or vapour, filling in the valve is that the ionized molecules neutralize the space charge effect so that a 10—20-volt drop between anode and cathode can force electrons to cross the valve at a rate of many amperes, whereas in a similar vacuum valve hundreds or even thousands of volts would be required. Since the ionization reduces the anode dissipation of the valve and increases the efficiency of the circuit, it is worth while and is widely used, not only for large currents, but also for low-current precision control equipment.

WM. H. P. LESLIE.
North Farnborough, Hants.

[*"Cathode Ray's" comments on this letter are given below.—Ed.*]

I am grateful to Mr. Leslie for pointing out that my description of conduction in mercury vapour rectifiers and similar valves was misleading in one respect, in that it implied that the electrons emitted from the cathode were only a part of the total electronic current. It is true that the emitted electrons release very many more from the gas molecules, and since all electrons are alike it might seem that those attracted to the anode would be more numerous than those emitted from the cathode. In actual fact, however, ionization takes place a very short distance from the cathode, so that the whole of the remaining space between cathode and anode is filled with a cloud of electrons and ions. This cloud is electrically neutral and is therefore subject to very little potential difference during conduction. It is almost as if, during the conducting phase, a metallic conductor extended from the anode to within a very short distance of the cathode, confining the negative space-charge to a thin layer, across which only a few volts are needed to sustain the process.

The electrons removed from this cloud by the anode are replaced in equal numbers by the cathode. Although it is true to say that a gas-filled valve can carry a given current with less (though not enormously less) cathode-heating power than a vacuum valve, this is due to circumstances other than the one I mentioned. I believe that, except for the question of cathode emission, my original brief description of what is quite a complicated process was, so far as it went, in agreement with Mr. Leslie and authorities generally; and I hope that the above further remarks, in conjunction with his letter, will make the matter clear.

"CATHODE RAY."

"Careers in Radio"

WITH reference to the above article, published in the April *Wireless World*, your readers may be interested to know that, although the school conducted by this company originally catered for those intending to enter aircraft radio engineering, it was extended some months ago to cover all branches of radio engineering and we now train students for any of the recognized professional examinations in radio engineering, including special training in radar theory and technique.

R. J. WOODHAMS,
Air Service Training, Ltd.
Hamble, Southampton.

Television Synchronization

HAVING recently carried out an exhaustive investigation of the circuital aspects of frame time-base synchronization I found W. T. Cocking's particularly lucid and helpful contribution to the subject of considerable interest.

While the various factors causing imperfect interlacing are well known to circuit engineers there is little unanimity among them as to the relative importance of these causes. In this respect is is my own conviction that insufficient attention has been given to the waveform irregularity mentioned by Mr. Cocking; viz., the difference between alternate frames in the duration of the interval between the last line synchronizing pulse and the first pulse of the framing signal. It is significant that this difficulty was taken into account by the formulators of the current American R.M.A. standard transmission in which the irregularity is eliminated by the insertion of a group of equalizing pulses between the last active line and the first framing pulse and of a similar group between the last framing pulse and the first of the unmodulated (i.e., black) lines commencing the following frame. As a result U.S. synchronizing circuits are particularly simple and there is little other evidence that their designers are obsessed by the interlacing problem.

An additional factor in favour of a framing signal centrally disposed between two similar equalizing pulse trains is its greater suitability to the flywheel method of frame time-base synchronization particularly when automatic frequency and phase control is desired.

I would suggest, therefore, that the use of equalizing pulse trains would be worthy of attention when the time comes to revise transmission standards. A. W. KEEN.
Harrow-on-the-Hill,
Middx.

A.R.R.L. 1947 HANDBOOK

THIS annual publication of the American Radio Relay League has acquired a well-deserved reputation as a standard manual of amateur radio communication. Theory and practice are nicely proportioned, with some nine chapters devoted to each and covering, on the theoretical side, such subjects as fundamental principles, valves, transmitter and receiver design, keying, modulating technique and, finally, wave propagation and aerials. The authors have contrived to explain these matters lucidly and adequately without mathematics.

As in previous editions considerable space is given to valve data and in the 1947 edition some fifty pages are devoted to tabulated operating conditions and characteristics of over 1,000 valves.

A selection of miscellaneous formulæ, charts and tables gives an appropriate finish to this useful storehouse of radio information.

The handbook is obtainable from A. F. Bird, 66, Chandos Place, London, W.C.2, the price being 12s 6d plus 8d postage. Alternatively, orders for delivery direct from the U.S.A. can be placed with the Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1. Price 11s 6d, inclusive of postage.

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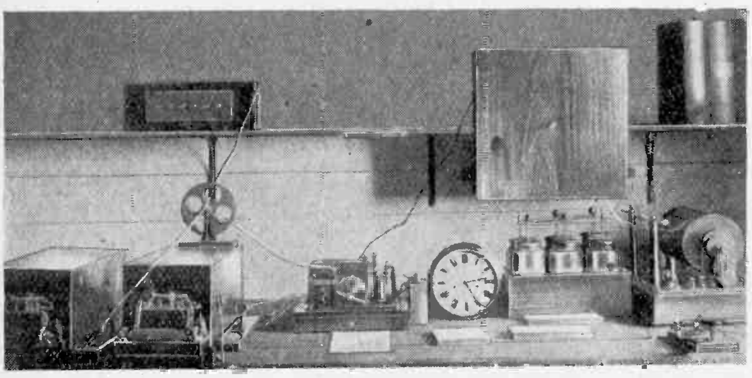
MODERN MARINE RADIO

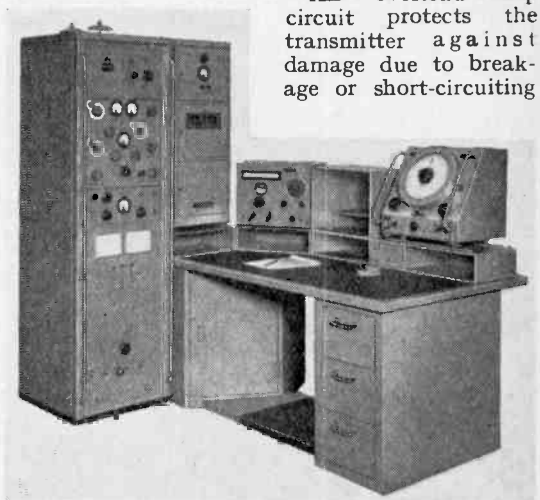
Standardized Marconi Equipment for Merchant Ships

By D. F. BOWERS and E. F. CRANSTON

TO meet the demand for radio equipment created by the intensive shipbuilding programme since the war, the Marconi Company has standardized two types of installation, built on the unit system so that they can be readily fitted in cabins of diverse shapes. Each installation consists of a transmitter, communication receiver, automatic alarm device, and direction finder. The "Trader" transmitter is for medium-frequency working only, but the "Oceanspan" covers both medium- and high-frequency marine bands.



THEN—The Marconi Company is now celebrating the fiftieth anniversary of its foundation. In the photograph above is seen one of the earliest marine installations: that fitted aboard the S.S. *Philadelphia* in 1902, and used by Marconi for experimental work.



——AND NOW → a typical Marconi installation of 1947 built on the unit system and adaptable to different shapes of cabin. The units shown are (from left to right) "Oceanspan" transmitter, auto alarm device, communication receiver and D.F. receiver.

A robust cabinet houses the transmitter together with the aerial switching, transmitter supplies, vibrator supply units for all receivers, battery charging and control circuits. The various units in the cabinet slide in on runners and connect with the cabinet wiring by special spring contacts. Access to the units is obtained by the removal of the front cover, which is interlocked to prevent accidental contact with high potentials. To assist in maintenance and servicing, test jigs supplied with each equipment make it possible to bring any unit out into an accessible position with power on, so that inspection or performance checks may be effected. The "Oceanspan" and "Trader" radio-frequency units are interchangeable, the remaining units being common to both equipments.

At medium frequencies the "Oceanspan" transmitter covers 365-540 kc/s and delivers an aerial current of 4.0 to 5.5 amps on C.W., or 4.5 to 6.0 amps on M.C.W. into an average ship's aerial. In the high-frequency marine bands (between 3.0 and 23.0 Mc/s) the power radiated is 100 watts on C.W. or 110 watts on M.C.W.

The transmitter employs a negative-resistance type oscillator for medium frequencies and a crystal oscillator for high frequencies. Provision is made on the latter for fitting up to ten crystals, giving a total of thirty radiated frequencies, the H.F. marine bands being harmonically related. Separate aerial matching circuits are used for medium- and high-frequency operation, both being capable of coupling to the wide range of aerial characteristics met with on different classes of ships. The circuits are designed to give low harmonic radiation, this being essential to prevent interference on other marine bands.

Colour-coded tuning controls are fitted to simplify operation, and the use of "click" spot-frequency selectors enables predetermined settings to be rapidly and accurately found. For high-frequency operation it is possible to switch from the calling to the working frequency without retuning the transmitter. The circuits and performance of the "Trader" transmitter are identical with those of the "Oceanspan" transmitter on medium frequencies.

An overload trip circuit protects the transmitter against damage due to breakage or short-circuiting of the aerial, failure of drive or mistuning of the final stage.

About 60 watts at 1,000 c/s is developed by a tone oscillator valve acting directly as an anode modulator. The depth of modulation is 80 per cent (100 per cent for M.C.W. operation).

Modern Marine Radio—

The transmitter is keyed by the front contact of the telegraph key, the back contact being used to desensitize the associated receiver for "break-in" operation. No keying relay is used.

The equipment is normally fed from the ship's D.C. supply at 110 or 220 volts. Alternatively, by the operation of a switch, the equipment can be supplied from emergency batteries while still giving the same aerial output. Under this condition the duration of transmission and reception more than complies with statutory requirements for emergency operation.

The "Yeoman" superheterodyne receiver covers continuously a frequency range of 15 kc/s to 25 Mc/s. Gaps in the frequency range are avoided by selecting, according to the signal frequency, either of two intermediate frequencies, i.e., 570 kc/s or 98 kc/s. The receiver employs eight valves including one signal-frequency, and two I.F. stages. A crystal oscillator with a frequency of 690 kc/s (a sub-harmonic of the marine high-frequency calling frequencies), can be used as a calibrator when desired. Four pass-bands are available, the narrowest (100 c/s) being obtained by means of an audio-frequency filter. A logging scale is fitted in addition to the usual frequency calibrated scales. Plugging headphones into one of the jacks provided automatically cuts out the built-in loudspeaker. For "break-in" operation the gain of the receiver is drastically reduced by applying a biasing voltage to the signal frequency and first I.F. valves in the "key down" condition. The degree of desensitizing can be adjusted to suit operating conditions.

The "Vigilant" automatic alarm device provides for the reception of the international alarm signal and by the subsequent actuation of alarm bells indicates the reception of a distress call. The apparatus consists of a receiver which responds to M.C.W. signals on any frequency between 512 and 487 kc/s, and a selector unit which discriminates between the correctly coded distress call and other signals or static. A calibrated oscillator is incorporated for testing both receiver and selector.

The "Lodestone" direction finder covers a frequency band of 250-546 kc/s. The goniometer and superhet receiver are built into a single unit used in conjunction with Bellini-Tosi fixed loops and a separate sense aerial. The receiver employs five valves including one signal-frequency stage and one stage of intermediate-frequency amplification.

Since these equipments have been fitted, reports have been received from the operators regarding general performance and the ranges obtained. These reports state that on medium frequencies (375 to 500 kc/s) ranges up to 900 miles by day and 2,000 miles by night were achieved. At high frequencies world-wide communication was obtained. It has been found that the simplicity and rapidity of band changing and the ability to switch rapidly from calling to working frequencies has materially assisted in the expeditious handling of traffic.

BOOK REVIEW

Principles of Radar (Second Edition). By Members of the Radar School, Massachusetts Institute of Technology. McGraw-Hill Publishing Co., Ltd., Aldwych House, Aldwych, London, W.C.2. Price 25s.

EXPERIENCE with large books composed of the contributions of many writers has not always been entirely happy, and in the present case one may be additionally prejudiced by the facsimile typescript, associated with rush war jobs. So it is a pleasant surprise, on examining "Principles of Radar" more closely, to find a work combining consistency with thoroughness in every part. More remarkable still is the way in which it combines two other qualities that so seldom meet as to seem almost incompatible: this volume is as informative as an advanced work, and as approachable as an elementary one. And these primary qualities are further combined with exceptional accuracy and consistency in presentation. There may be slips or misprints, but in a fairly close examination the reviewer failed to find a single one in the book itself; a result which as far as he can remember is quite unprecedented! It is true that the dust-cover bears a reference to a non-existent Chapter XIII, but it is unlikely that the authors can be blamed for that, and in any case the following extract from the same cover is so true as to be worth quoting:—

"Expositions of circuits and devices provide an unusual combination of technically thorough and accurate treatments with minimum dependence upon mathematics. Emphasis in the treatment of circuits is upon quantitative analysis directly from tube characteristics and physical principles."

The method adopted in explaining each circuit—say a differentiating or oscillator circuit—is to reduce it to its basic equivalent, which is generally familiar. This is admirable, because in contrast to blind-alley memorizing, it gives the student a thorough grasp of underlying principles, combined with the ability to apply them to new situations. The favourite reducing tool is Thevenin's Theorem, which ought to come much earlier in technical instruction than it usually does—or did.

The authors confine themselves to radar in its strictest sense, and wartime radar at that; yet the book can be thoroughly recommended to readers who are not even concerned with radar at all, for its thorough explanations of circuit action with non-sinusoidal waveforms, waveform spectrums and bandwidth, practical design of transmitters and feeders, and theory of lines and cavity resonators, to mention only a few things.

It is no doubt a result of intensive experience in teaching this new science to thousands of mainly non-technical entrants, that almost every possible cause of misunderstanding has been anticipated and guarded against. The uses of symbols and conventions are clearly explained and scrupulously adhered to. To exclude any uncertainty about what is meant when descriptions of circuit action refer to a current or voltage being positive or negative, the positive condition is marked on each diagram concerned—a very helpful convention.

Although the emphasis is on principles, typical values and quantities are given. For example, not only are the usually obscure principles of dipole reflectors and directors clearly and concisely given in a way that enables particular cases to be worked out, but the effect of variables on their performance is shown diagrammatically.

"Principles of Radar" is a model of how to teach theory for practical application.

M. G. S.

CHANNELS OF COMMUNICATION

Why and How They Require Bands of Frequency

By "CATHODE RAY"

IT is interesting to notice how the emphasis shifts during the development of a new art.

When the brothers Wright were attempting to fly, their thoughts were no doubt more concerned with getting their contraption into the air than with the fear that lack of international air traffic regulations might increase the risk of their bumping into some other aviator.

Similarly, fifty years ago the achievement of sending wireless messages at all was too absorbing to leave much time for considering what might happen when overcrowding set in. But when wireless caught on and spark transmitters were installed wholesale, it was soon clear that the risk of one "bumping into" another was far from negligible. The word "jamming" dates from this period. Messages were generally quite brief, however, and a number of ships (for example) could share the same wavelength —or *channel*. If it was completely jammed it was just a case of waiting one's turn.

But when some stations' transmissions came to be more or less continuous, they had to be given exclusive rights to channels. And as they became more numerous the problem arose of packing the channels more and more closely in order to have enough to go round.

At first the solution appeared to be just a matter of making receivers more and more selective. It was true that certain theorists had talked learnedly about "sidebands," but these were dismissed by others as mathematical fictions, devoid of any practical reality or significance. This question came to a head in the great Stenode controversy of 1929-1932. The reality and non-reality of sidebands were both stoutly defended to influential circles, and things got to such a pass that a Government-sponsored investigation was put in hand. Its report settled any lingering doubts about the physical reality of sidebands and the inescapable necessity for spacing transmitters apart by a frequency which depended on the frequency of the "information" they carried.

Meanwhile the growth in the number of transmitters, broadcasting and otherwise, was making an acute international situation of this one-time highbrow scientific controversy. On the one hand the need for a wide frequency channel in order to transmit speech and music faithfully had been established; on the other, all the nations wanted to grab as many channels as they could, and were not always content with frequencies that limited effective range to their own frontiers. And, of course, all sorts of other radio services kept on joining the competition, so the conflict between the irresistible force of commercial and political radio development and the immovable object of necessary channel width gets worse day by day.

But is the channel difficulty so immovable? What exactly is the difficulty?

In the first place, it may be as well to realize that it is not an exclusive radio problem. If the "information"—morse, speech, music, pictures, etc.—were sent over a line channel instead of by radio it would still occupy a frequency band. For the reproduction of reasonably clear speech it is necessary to include all frequencies from, say, 100 to 3,000 c/s. That is a frequency band of 2,900 c/s. Sent directly over a

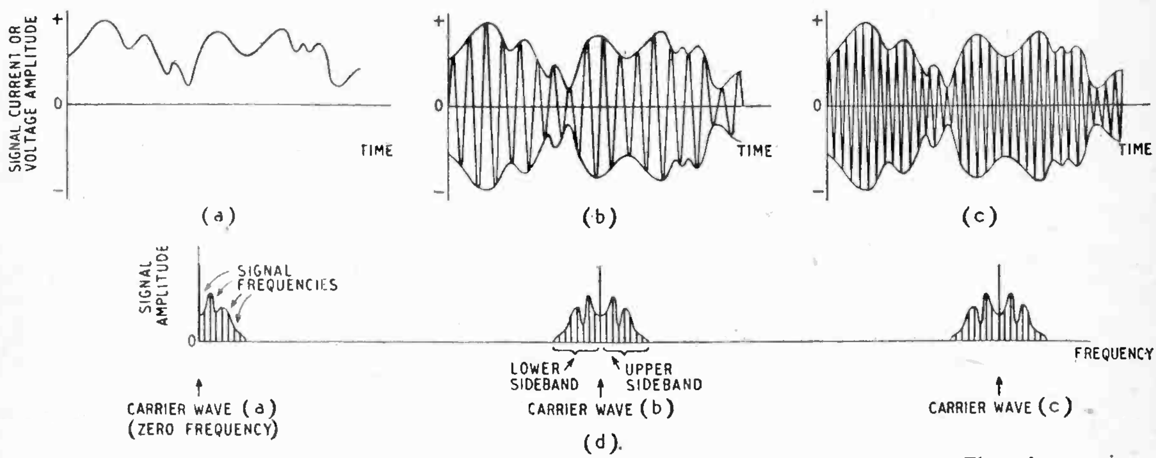


Fig. 1. (*a*) is a sample of audio-frequency programme ; a mixture of a number of frequencies. These frequencies can be individually represented on a frequency scale, as at the left of (*d*). When (*a*) is used to modulate a carrier wave, the result is shown on time and frequency scales by (*b*) and the middle of (*d*) respectively. (*c*) and the right-hand end of (*d*) represent an alternative carrier wave, of higher frequency. (*a*) can be regarded as having a zero-frequency carrier wave. In all cases the programme is fully communicated by one sideband only. (*a*)—(*c*) and (*d*) are two different ways of graphing signals.

Channels of Communication—
line, this band would occupy the position 100-3,000 c/s in the frequency scale (for what that means, see later).

The modulator in a radio transmitter is just a device for shifting this same band into a region of frequencies that can be radiated effectively. If the carrier wave is, say, 1,000,000 c/s, amplitude modulation causes sidebands to appear, from 997,000 to 999,900 c/s and 1,000,100 to 1,003,000 c/s; a total band of 6,000 c/s (including the small gaps extending for 100 c/s each side of the carrier wave). This is more than double the original 2,900 c/s; but it need not be. One sideband and the carrier wave can be suppressed, whereupon what is left occupies exactly the same frequency band as the original. Given a suitable receiver, no more is needed. The difficulty is that this sort of receiver costs more and is much more difficult to tune than the sort that deals with transmissions consisting of carrier wave and both sidebands. So, in broadcasting, where the number of receivers is enormous, it is an unfortunate practical necessity for transmitters to occupy a channel more than twice as wide as in line communication. For point-to-point radio, the extra trouble and cost of single-sideband working is relatively small, and well worth it for the saving in channels.

Whatever carrier-wave frequency is used, the frequency band occupied by the information is, of course, exactly the same. In fact, the original band, 100-3,000 c/s, can be regarded as a sideband of a zero-frequency carrier wave; see Fig. 1.

What is meant by "occupying" a 100-3,000 c/s frequency band? It can hardly mean that there is a signal going on all the time at every frequency from 100 c/s to 3,000 c/s, because the number of such frequencies is infinitely large. (However closely together you number them, somebody can always come along with another decimal place to the right and stick nine more in between every pair of yours!) The nearest approach to complete occupation is "fluctuation noise" caused by the restless movements of electrons, in which the probability is that something will happen sometimes however narrow a frequency band you select. In practice, however, there is no sense in dividing the frequency scale into narrower units than one can select by the sharpest tuning circuits or filters. The band 100-3,000 c/s covers a good many such units, and can be said to be occupied if there is a chance that all the units may be needed some of the time. In any particular spoken message terms of the height of a vertical line on a cathode-ray tube, just as in Fig. 1*d*. With a variable signal such as speech or music these lines keep popping up and down all the time. This type of display is an alternative to the ordinary time-base oscilloscope, which shows Fig. 1*a*-*c*.

The next question is whether it is possible to reduce the frequency bands occupied, so as to make room for more channels. 2,900

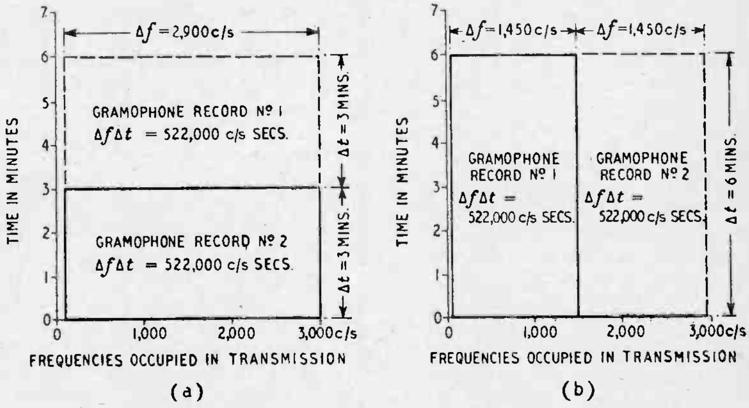


Fig. 2. If a transmission channel 2900 c/s wide is available, two recorded speeches, each lasting 3 minutes, would together occupy it for 6 minutes (*a*). By running the records at half-speed, each occupies only half the band width, and by means of modulators, band-pass filters, etc., both could be transmitted simultaneously along a 2900 c/s channel (*b*); but as each takes twice as long, there is no net advantage, and the process is technically much more difficult. In practice a frequency gap would have to be allowed between the two channels.

or musical programme, some of them may go unused all the time, but you never know. Renting a communication channel is rather like renting an hotel. You have to pay for the whole place all the time, even though some of the rooms may not always be full. In speech or music, the hotel guests are very much of the type referred to in America as "transients." (The U.S.A. must have known I was going to use this analogy!)

Incidentally, a frequency-occupation diagram, such as Fig. 1*d*, is often called a spectrum, as it is, in fact, the extreme low-frequency end of the same thing as is shown by an optical spectroscope. One type of communication-frequency spectroscope consists of an array of filters or resonators, between them covering the whole band of frequencies involved, with an arrangement for showing the response of each in

c/s for speech is already some reduction, because the frequencies actually present in the voice extend considerably higher. It is possible to cut off still more, but in doing so one runs an increasing risk of losing important and perhaps vital parts of the information.

Instead of sacrificing some of the frequencies completely, it is possible to lower them all. By recording the speech and running the record into the transmitter at half-speed, the resulting frequency band (50-1,500 c/s) is half what it was; and by re-recording at the receiving end and reproducing at twice the speed it is restored to 100-3,000 c/s. But although it would be possible in this way to transmit two speech messages simultaneously in a frequency band normally occupied by one, each would take twice as long to transmit, so the arrangement would show no advantage over the much simpler process of sending the two messages straightforwardly one after the other along the full-width channel. This is shown in Fig. 2, where frequency band-widths are denoted by Δf and time periods occupied by Δt. (The Greek capital D, Δ, stands for *difference* between two boundary frequencies or times.)

It seems, then, that what determines the quantity of information that can be transmitted along a channel—line or radio—is not just the width of the channel, Δf, but the width multiplied by the time, Δt, during which it is available. This $\Delta f \Delta t$ is represented on a diagram of the Fig. 2 type by an area. A given message can—theoretically—at any rate—be transmitted in a short time along a wide channel, or in a proportionately longer time along a narrower channel. The unit of the amount of information that can be transmitted might be said to be one cycle per second multiplied by one second, viz., one cycle.

Before this statement can be regarded as fully buttoned-up it is necessary to establish a more definite relationship between information and cycles. This is difficult, because "information" is not readily measurable. Hartley, of oscillator fame, discussed it in America in 1928, and arrived at what has since been named the Hartley Law, which is more or less what we have just said—"the total amount of information which may be transmitted is proportional to the product of frequency range which is transmitted and the time which is available for transmission." Even his fairly advanced argument didn't get the length of fixing a numerical rate of exchange between information and $\Delta f \Delta t$. Not long ago Dr. Gabor tackled this part of the problem.[1] But before going on to his results, is it true that the unit of $\Delta f \Delta t$ is the cycle? It may seem to fit nicely into the Hartley Law, because it is a plausible idea that one cycle is a sort of elementary signal, like a morse dot perhaps; so a whole message can be built up from a suitable number of cycles. A pity, but it is a fallacy. Try sending even a simple message with identical cycles, as many as you want! An infinitely large number would be insufficient.

"How absurd!" you may say. "Give me an audio oscillator and a morse key and I'll soon crack off the message." Yes, but I said *identical* cycles. If you interrupt the flow of cycles you are modulating it, and that creates sidebands, which consist of cycles of other frequencies and therefore not identical.

Whatever one may do in order to convey information necessitates some sort of choice or selection of alternatives, such as the choice of letters in written words, or sequence of dots and dashes in morse or of sounds in speech, and that means variation or *modulation*. And that, as has been proved mathematically and by experiment, spreads out the frequencies, so that it is impossible to send a message with a single frequency. The cycle, as a unit of message capacity, won't do; it is the cycle per second frequency band width multiplied by the second.

So now perhaps the Hartley Law looks less obvious, and the abstruse reasoning behind it more necessary. (This reminds me of the professor who suddenly interrupted his lecture at the words ". . . from which it is obvious that . . .," and saying, "Excuse me, gentlemen," retired into his study for deep and prolonged thought. At length, emerging into the now empty classroom he beamingly announced, "Yes, gentlemen, it *is* obvious!")

After people realized that signalling by *amplitude* modulation necessitated a channel at least as wide as the highest modulation frequency, every now and then some of them who didn't know about the Hartley Law, or didn't believe it, rubbed their hands with glee and said, "Ha! We can get round this by using *frequency* modulation. We have only to keep the depth of modulation down to, say, 100 c/s each side of the carrier wave, and we'll be able to send speech over a 200-c/s-wide channel!" Well, of course, that is too good to be true, but there was some excuse for not realizing it at first—the mathematics this time was beyond all

[1] *Journal I.E.E.*, Part III, Nov. 1946, pp. 429-457.

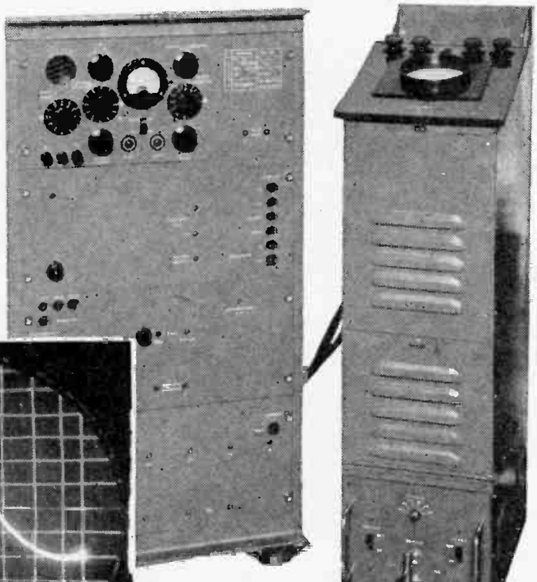
Channels of Communication—

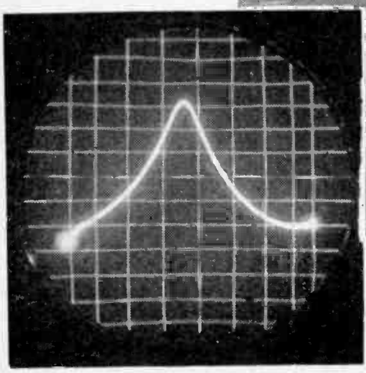
but a select few, of whom J. R. Carson was the first to prove that the sidebands with F.M. were even wider than with A.M., however narrow the frequency deviation.

The pursuit after some way of dodging the Hartley Law seems to be as fruitless as the search for Perpetual Motion; but that is not to say there is no scope at all for progress. A deep, clear, rounded voice is not likely to need quite such a wide frequency band as a very high, squeaky one delivering the same message in the same time. The high voice is less efficient in its use of a transmission channel. On the other hand, the same words can be sent as quickly by high-speed morse through an even narrower channel than the deep voice, and telegraphy is, therefore, more efficient in this respect than telephony, at least if only the mere words are counted as "information." An interesting question is : What is the smallest signal—that is, the smallest time + frequency-band—that is capable of transmitting one elementary item of information? That is the problem Dr. Gabor investigated, and to do so he had to invoke mathematics of many terrifying kinds, and used an analogy with quantum mechanics to make it easier—so you may know! But it is not too difficult to follow the gist of it. In doing so one gets some light on the sort of ideas that are coming into an increasing number of papers on communication nowadays. As the Cathode-Ray screen is just about filled up, however, the shining of that light will have to wait until next month, when we will discuss some of the possibilities.

RESPONSE CURVE TRACER

REDIFFUSION, LTD., of Broomhill Road, London, S.W.18, have produced an automatic curve-tracer of unusual type. Fed with the output of the filter, transmission line or loudspeaker under test it draws the response curve on the screen of a C.R. tube with a long-persistence screen and then automatically draws a graticule in 3-db steps for amplitude and octaves for frequency. The apparatus under test is, of course, fed from a B.F.O. of constant output voltage. It is important to note that no synchronization of the apparatus with the B.F.O. is needed nor any communication channel but the apparatus under test. The frequency range is 39 c/s to 11,000 c/s. The apparatus is known as Redifon Response Curve Tracer, Model M.33.



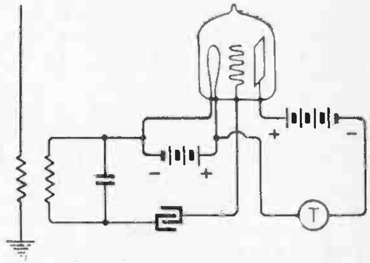


A response curve taken with the equipment is shown on the left with the apparatus itself above and the C.R. unit on the right.

40 YEARS AFTER

IT was in January, 1907, that Lee de Forest filed the patent on the insertion of the grid in the valve.

Dr. de Forest, America's "Father of Radio," addressing the U.S. National Association of Broadcasters, in a letter in a Chicago newspaper, asks, "What have you gentlemen done with my child? He was conceived as a potent instrumentality for culture, fine music, the uplifting of America's mass intelligence. You have debased this child . . . you have made him a laughing stock of intelligence."



This diagram from de Forest's 1907 patent specification "might—except for the absence of a grid leak—be dated 1943."

In a special de Forest anniversary number of our New York contemporary, *Radio Craft*, the inventor, now 73 years old, contributes an article on "How the audion was invented." Describing the building of the first valve containing a platinum plate and carbon filament he writes: "The plate was connected to the positive side of the dry battery; the negative terminal to the filament. In series was a telephone receiver. This device was *not* the Fleming valve. It has always been quite impossible for me to understand the confused idea, in the minds of some otherwise keen thinkers, that the audion differed from the Fleming valve merely by the insertion of a third electrode. *Without the use of the B-battery the valve would be nothing but a rectifier with one too many electrodes.* The employment of the local battery in the plate circuit is just as necessary an element to the success of the device as the grid."

Writing on "Early Radio Inventions" in our sister journal, *Wireless Engineer* (November, 1943), Professor G. W. O. Howe, said of de Forest's insertion of the grid in the valve, "This will surely rank for all time as one of the greatest inventions of radio telegraphy."

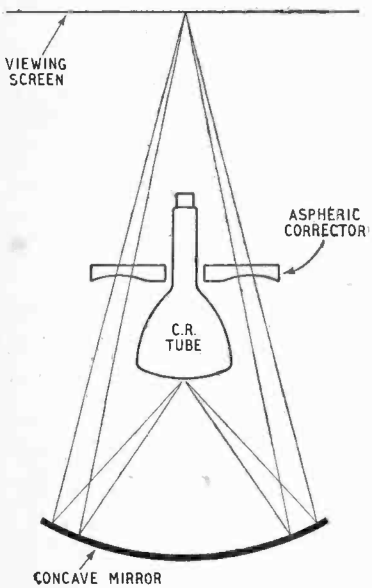
In recognition of the 40th anniversary of his invention, de Forest was awarded the Edison Medal by the American I.E.E.

PROJECTION TELEVISION

Advantages of Plastics for Optical Equipment

THERE is no doubt that the attainment of larger television pictures must depend very largely on projection technique, if only because the convenient maximum in size for a directly-viewed cathode-ray tube has already been reached. The most widely used tube to-day has a screen diameter of 9in and an overall length of about 18in and produces a picture 7½in by 6in; 12in tubes are used and are proportionately bigger in every way. Anything much larger than this becomes impracticable for home use.

It is an attractive idea to produce a small and very bright picture on a small tube and to project it optically on to a viewing screen. By optical magnification any required size of picture can be obtained and the physical dimensions of the apparatus can be kept within reasonable limits. Moreover, the picture can be obtained on a flat surface instead of the rounded end of the tube.



Layout of the Schmidt optical system for projecting television pictures on a screen.

Projection television is by no means new and sets embodying this principle were on the market before the war. However, there have always been certain difficulties which have hitherto prevented it from becoming at all widely used. These have lain in the attainment of adequate brightness and definition.

The brightness required at the tube itself, of course, varies as the square of the linear dimension of the final picture and there is nothing that can be done about this. There is also a loss in the optical system as compared with direct viewing and it is here that serious difficulties have been encountered.

For efficiency an optical system of very large aperture is needed, but with the conventional glass lenses and mirrors a large aperture demands the use of spherical surfaces if the manufacturing cost is not to be prohibitive. Now spherical surfaces result in spherical aberration and a loss of definition and contrast in the final picture. As a result a compromise is adopted between aperture, aberration and cost and the loss of light is quite considerable.

During the war great strides were made in the development of plastic, instead of glass, lenses for optical equipment and this technique is now being applied to television projection. The great advantage of plastic over glass is that it becomes economically possible to adopt surfaces other than spherical and so a large aperture system free from aberration becomes possible. It is true that a suitable mould has to be made and that this is quite as difficult as making a glass lens of the same shape, but one mould can be used for many plastic lenses and with bulk production its proportionate cost per lens is small.

The technique of making plastic optical equipment was discussed recently by D. Starkie in a paper read before the Institute of Physics in which he referred to

Projection Television—
the work of Imperial Chemical Industries. Two suitable materials are available and are known as Transpex 1 and 2; they are respectively especially pure grades of Perspex and polystyrene. They have refractive indexes of 1.49 and 1.59 and the softening temperature is 120° C.

For television purposes the Schmidt optical system is used as sketched in Fig. 1. Two models were shown at the lecture. One used a 2½-in C.R. tube with an 8-in diameter optical system giving a magnification of 8.5 times at a throw distance of 40in. The other had a 3½-in tube with a 14-in optical system and a magnification of 7.5 times at a throw distance of 69in. The resolution is claimed to be adequate for a 1,000-line television system.

As shown in Fig. 1, the C.R. tube on which the picture is formed faces a concave mirror. This is made of Transpex with a surface layer of aluminium deposited in a vacuum chamber. The aperture is f/0.75 and would in itself be sufficient to focus an enlarged picture on the viewing screen if it were not that it introduces spherical aberration. The effects of this are overcome by the aspheric corrector plate mounted around the tube. It is this component of the system which would be so difficult to manufacture if glass were used.

Heavy Duty Converter

DESIGNED for use with television as well as radio receivers the Valradio Model 230/200 vibrator converter operates from D.C. mains and supplies 200 VA at 200/250 V A.C.

The vibrator is of the heavy-duty type having contacts ¼in in diameter. It is spring-suspended to reduce mechanical noise and housed, together with its transformer and R.F. filter circuits, in a ventilated steel case measuring 13in × 6in × 6in.

Frequencies of 50, 65 and 75 c/s can be supplied, and the latter is recommended for television as it avoids any shadow or flicker due to residual hum in the receiver.

The price of the converter is £12 and the makers are Valradio, 57, Fortress Road, Kentish Town, London, N.W.5.

NEW RECEIVING VALVES

First Details of Mazda and Mullard Ranges

MOST of the new types announced by Mazda will be on the B.V.A. type B8A base described in our issue of last November. The A.C./D.C. series, already in production, has a standard heater current rating of 100 mA and includes the following types. Unless otherwise stated the bulb diameter is 20 mm.

10C1. Triode-heptode frequency changer. Performance equivalent to that of the Mazda TH233.

10F9. Pentode R.F. amplifier primarily designed to work in the I.F. stage of a receiver: working mutual conductance, 2.4 mA/V. Similar to the VP133, but is designed to work with the same operating potentials on input grid and screen grid as the 10C1. This enables the number of resistors and condensers in the receiver to be reduced.

10LD11. Double-diode-triode, the triode section of which has a voltage amplification factor of 30.

10P13. Beam power output pentode intended primarily for use in receivers where the saving of space is of the first importance. The 10P13 has been especially designed to enable resistance smoothing to be employed in anode and screen circuits. With 180 volts on the anode and 165 volts on the screen it has a power output of 2.5 watts.

10P14. Beam power output pentode with greater power-handling capacity than the 10P13. It is fitted with an international octal base and has a bulb 28.5 mm in diameter. Typical operating voltages are 165 volts on the anode and 175 volts on the screen, under which conditions the power-handling capacity is 3.3 watts.

U404. Half-wave rectifier designed for input voltages up to 250 volts R.M.S. D.C. output 90 mA.

In the forthcoming A.C. range, 6.3-volt heaters with reduced current consumption will be standardized, and small-bulb construction will be used wherever possible. The types which will be available are as follows:—

6C9. Triode-hexode frequency changer similar to the TH41.

6F15. Variable-mu R.F. pentode designed for operation in conjunction with the 6C9 using common A.V.C. bias and coupled screens.

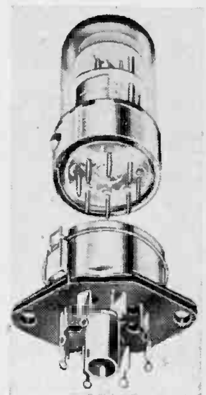
6LD20. Double-diode-triode; amplification factor of triode section 30.

6P25. Beam power output pentode; with 250 volts on the anode and screen, gives a power output of 5.8 watts. It is fitted with an international octal base and has a bulb diameter of 45 mm.

6F13. High-gain screened R.F. pentode for wide-band reception, e.g., in television.

6L18. Triode designed primarily for use as the local oscillator in superhet television receivers. It is an efficient oscillator up to 150 Mc/s.

The new range of Mullard valves to be released later in the year will be fitted with the spigotless version of the B.V.A. type B8A base and will be made by a new low-temperature sealing process in which a special cement is used to join the bulb to the glass base. Advantages claimed for the method are that softening and distortion of the base are avoided and hard connecting pins can be used. There is also less risk of "poisoning" the cathode.



The spigotless type B8A base has been adopted for the new "U40" range of Mullard valves.

The new valves will have a diameter of 22 mm and lengths ranging from 66 to 84 mm. The heater current will be 100 mA and the following details of representative types have been received.

UAF41. Single-diode-pentode: only one diode is included in order to avoid interaction between the diodes in a circuit where two diodes are required. By using two UAF41 valves in a receiver, the diode section of the I.F. valve can be used for detection and the diode section of the A.F. amplifier for A.V.C. In this way the delay voltage of the A.V.C. valve will not be affected by the control of the I.F. amplifier. The slope of the UAF41 is 1.8 mA/V and the anode-grid capacitance is less than 0.002 pF.

UCH41. Triode-hexode: The third hexode grid is connected internally to the triode grid and the valve can therefore be used only as a frequency changer. The heater consumption is only 1.4 watts and the characteristics of the UCH41 are approximately the same as those of the earlier CCH35.

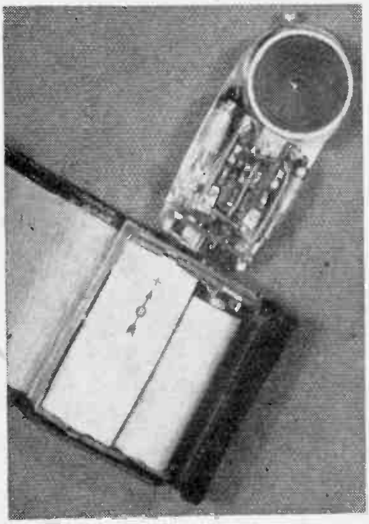
UL41. Output pentode: This valve has a mutual conductance of 9.5 mA/V, and is capable of delivering 4.2 watts of A.F. power into a 3,000-ohm load when operated at anode and screen voltages of 165 V, and with a signal input of 6.2 V. The valve is so designed that, with the obvious exception of the resistance in the heater circuit, the circuit constants, i.e., cathode and screen resistances and anode load are substantially independent of the supply voltage.

UY41. Half-wave rectifier: This valve is designed for input voltages up to 250 V R.M.S. and gives a rectified output current up to 90 mA.

HEARING AID MINIATURE

The Multitone Type MT3

NOWHERE is the cult of "miniaturization" pursued with greater justification than in the production of hearing aids for the deaf. In the latest Multitone design a three-stage amplifier and crystal microphone have been compressed into a case $3\frac{1}{4}$in long, $1\frac{1}{16}$in wide and $\frac{1}{2}$ to $\frac{11}{16}$in thick. A wide variety of battery supply units is available the smallest of which plugs into the base of the amplifier unit and serves as a carrying handle. Clips of the fountain pen type enable the unit



Multitone miniature hearing aid, type MT3.

to be attached to the person in a variety of ways. The weight of the unit is $2\frac{1}{2}$oz; with the smallest battery pack, $6\frac{1}{2}$oz. Running costs range from 1d per hour to 1d for 13 hours, depending on the degree of amplification required, and the type of battery chosen.

The circuit consists of a two-stage R-C coupled voltage amplifier employing a Raytheon type CK510AX double tetrode, followed by a CK506AX pentode output valve, feeding a miniature magnetic earpiece or bone conductor. When a crystal earpiece is used the output valve is connected as a triode, the necessary circuit changes being effected by differences in the wiring of the 3-socket earpiece connector.

Volume is controlled by negative feedback through a differential condenser arranged, when an inductive load is used, to attenuate high frequencies as volume is decreased. The effect of this is to reduce extraneous noise at low volume levels.

The instrument has provision for the connection of an inductive pick-up coil in place of the microphone, so that it can be used in theatres, cinemas, etc., equipped with the "Telesonic" system.

The price of the MT3 with magnetic earpiece is 29 guineas, with crystal miniature earpiece 30 guineas and with bone conductor 31 guineas. The "Telesonic" coil is 2 guineas extra. Makers: Multitone Electric Co., 223/227, St. John Street, Clerkenwell, London, E.C.1.

UNBIASED

By *FREE GRID*

Radiagnosis

SOME of you may have heard of the famous "Abrams box" invented about 1920 by the late Dr. Albert Abrams, of San Francisco. It was sometimes known as the Oscilloclast or E.R.A. ("Electronic Reactions of Abrams"). The doctor claimed to relieve a very large number of the ills to which the flesh is heir, ranging from gin-drinker's liver to housemaid's knee—both of which, by the way, are exceedingly painful conditions and no matter for ribald jesting. Claiming, as he did, to bring about his cures by "electronic reactions" his methods naturally had some interest to those of us moving in electronic circles.

The reason why I am raising the question of "Abrams box" now is that it, or at any rate a modern and very much more electronic counterpart of it, appears to be coming into action again. The main difference is that the new version—like the encephalograph—is more of a diagnostic apparatus than a curative instrument. According to what I have been reading about it, the instrument depends for its effect upon its reactions to the human aura.

No doubt there are many of you who are not quite certain what the human aura is. I am not at all sure that I am myself after all the contradictory statements I have read about it. It is said to be a sort of vapoury or "etheric" cloud surrounding the

Marked and indelicate attention.

body, and more especially the head, rather in the fashion of the halos depicted on paintings and stained-glass windows. People, like Mrs. Free Grid, who possess the necessary psychic gifts claim to be able to see it and they state that it varies in colour being darker in those parts adjacent to any organs of the body which are below par. Hence the expression "off colour" to denote a feeling of ill health. I must confess that although I have always been a sceptic concerning it I invariably feel distinctly uncomfortable when the offensive females who constitute Mrs. Free Grid's psychic circle have directed marked and indelicate attention to the region of my liver, presumably in an endeavour to discover signs of incipient cirrhosis.

Now, however, all this has been changed and the whole thing set upon a scientific basis by the discovery that radio waves of a certain length are affected by the aura. There is a kind of radar effect, the degree of which depends on the condition of any particular part of the aura or in other words upon the health or otherwise of the adjacent bodily organ. This new diagnostic method has, I understand, advanced so far that certain police forces in the U.S.A. are seriously considering its use as a test for sobriety.

Science and Art United

NEXT October when the radio exhibition opens at Olympia we shall be celebrating the silver jubilee of radio exhibitions; the very first exhibition was held at the Horticultural Hall in October, 1922. That year also saw the birth of regular broadcasting—November 14th, 1922, was the exact date—and so we shall be celebrating the silver jubilee of that too.

However, it is not about silver jubilees that I want to talk but about the exhibits which we shall see at Olympia. At the risk of being shouted down by totalitarian technical partisans I am going to take up the challenge implicit in the contemptuous remark made recently by one of them to the effect that he hoped it would not be merely another furniture show. Speaking personally I sincerely hope that the various manufacturers will choose their furniture designer with as much care as they choose their technical designer, for radio has suffered too long from the ugly brown box complex.

Twenty-five years ago a broadcast receiver was a mass of protuberant knobs and valves and quite rightly so, for it was purely and simply a scientific novelty. Nobody in 1922 who had not the clear-sighted vision of myself and a few other pioneers dreamt that it would grow up to the ubiquitous and indispensable home entertainer that it is today. Women in particular were "agin it," and I well recollect Mrs. Free Grid's vain efforts to cleanse the Augean stables which a wireless

Spring cleaning run riot.

set inevitably made of any room in which it was installed. I make no apology for reproducing a photograph, taken in a much later epoch, showing the result of Mrs. F. G. having cleared my room of a much-cherished accumulation, hoarded for many years, of receivers and other apparatus of the period.

Some time after this kindergarten stage, broadcast receiver design seemed to enter into the doldrums of the 2-V-2 era in which the two valves in front of the detector were prevented from active opposition and made into quite docile passengers by the application of positive grid bias. This state of affairs lasted for some time and many manufacturers tried to conceal the poverty of the land in the matter of technical design by over elaborate cabinet work.

Now, however, the broadcast receiver is as much grown up as the automobile, and both innards and outards deserve equal attention from the hands of their respective craftsmen. Some manufacturers have obviously realized this but others quite clearly farm out their cabinet designing to the local undertaker with his somewhat one-track mind. The time will, of course, eventually come when the wireless set is banished to the cellar with the electric light meter, and its functions radio-controlled by a small portable push-button unit.

RANDOM RADIATIONS

By "DIALLIST"

Symbols

IT is growing increasingly difficult to keep pace with the changes in wireless symbols. Take stage gain. In the early days S was often used as the symbol for this. Then we seemed to have settled down to A. But in the February number of *Wireless World* I notice that S. W. Amos uses M. If this is now correct, it is a pity, one feels, for M seemed to have become established as the symbol for mutual inductance—to say nothing of the hard work it puts in as the abbreviation for mega—in MΩ, Mc/s and so on. Talking of symbols, "Cathode-Ray" had something to say recently about the overworking of μ. I am eagerly expecting the appearance of μ-phone in some American publication. It has not come my way yet, but I feel sure that it will one of these days. American publications are pretty bad offenders in their disregard of internationally accepted symbols. One still comes across "mfd" quite often in them. They seem almost to have standardized *u* for μ presumably because few typewriters have a μ; *u* is used instead and it saves time not to bother about adding the extra stroke when correcting a typescript. More curious is *w*, which one finds even in text books such as Terman in place of small omega as the symbol for ohm.

□ □ □

Television Grousers

FROM time to time one comes across disgruntled folk who are more than a little bitter about the proportion of the B.B.C.'s total revenue that is spent on television. There are not, they argue, more than 7,000-8,000 genuine televiewers (private owners, that is, who use their televisors solely for entertainment purposes) amongst the 12,000-odd licencees * who live within the service area of the Alexandra Palace. A good many other people, they point out, who hold television licences live in places so far from A.P. that their interest in the matter must be in the experimental rather than in the entertainment side. They contend that of the 12,000 a very considerable number have no more than a professional or trading interest in television: every concern manufacturing televisors must hold several licences for its own laboratories and for its research workers in their homes: all stores or radio shops dealing in television sets must take out licences. The number, then, of those who own and use televisors at the present time purely for entertainment purposes is very small indeed; how can an expenditure running well into six figures be justified? Is not every holder of a television receiving licence getting many times what he pays for and being heavily subsidized by the holders of "sound" receiving licences?

Wrongs and Rights

Those who hold such views are barking simultaneously up several wrong trees. In the first place the £1 "sound" receiving licence gives no specific undertaking that entertainment programmes will be provided for those who hold it; it does no more than authorize the ownership and use of a wireless set, just as the 10s gun licence authorizes the ownership and use of a gun but does not bind the Government to supply suitable targets. In point of fact a large percentage of the wireless licence revenue is allotted to the provision of broadcasting and there is a kind of gentlemen's agreement that this shall be done. So far as television is concerned, there can be no doubt that it will become in time a major form of home entertainment. It is the clear duty of the authorities to foster its development, even though it may have to run for some time at a loss. My own view is that it is now being subsidized not too heavily, but far too meagrely. Two of the chief reasons why people don't rush to install televisors in their homes are that the transmissions occupy so few hours each day, and that, for sheer lack of funds, the programmes have now to contain such a large proportion of matter that is of little real entertainment value.

More Money Needed

It isn't always realized how costly a business it may be to put on a television item such as a play. In "sound" broadcasting the actors and actresses can read their parts; they needn't be in costume; movements, gestures and facial expressions are of no importance. For a "vision" broadcast matters are very different. Costumes and scenery are necessary and thorough training and rehearsal are required to ensure that everyone is not only

* According to figures published since this was written, the present total is 14,550.—ED.

Random Radiations—

word-perfect, but also movement-perfect and expression-perfect. It costs, therefore, many times as much to televise a play as to broadcast it by sound only. Further, a "sound" broadcast may be recorded and repeated at will for a trifling expenditure; the only way of repeating a television broadcast (unless you film it and televise the film) is to do it all over again. Because the money for an absolutely first-rate service is not there, a great deal of unsuitable matter has to be televised. Who, for example, is going to switch on the television receiver in order to see an orchestra, a pianist or a singer? I've always thought that one of the greatest boons of "sound" broadcast reception is that you can hear singers without seeing their far from beautiful facial contortions!

If the television service is given a lot more money, we shall have better programmes and "televiewing" will soon become popular. But if television funds are to be rationed now according to the number of licences, we shall find ourselves involved in the vicious circle: few licences mean small grants; small grants mean poor programmes; poor programmes mean few licences. . . .

Not Very Likely

The chairman of a manufacturing concern recently raised what, to my mind, is a completely imaginary scare by issuing a warning that, if we didn't pull up our socks we should find our markets inundated with cheap televisors of American make, once the present import restrictions were lifted. I can think of few things more unlikely for four pretty good reasons: (1) You can't profitably dump goods in a foreign country unless they're the left-overs of large home sales; (2) sales in America are not large; (3) American sets would be of no use here (unless extensively modified) since the American systems use 525 lines as compared with our 405 and their modulation is the exact opposite of ours; (4) televisor prices in the U.S.A. are very much higher than they are here. Dumping, then, seems unlikely. Almost equally incomprehensible to me is the statement of another chairman that television sets could form one of our major exports. To whom are we going to export them? At the moment the only other country in which there are yet any kind of regular television services is the U.S.A. For reasons already given we have no possible market there. Television can flourish (owing to the restricted service area of U.S.W. stations) only in countries where there are many densely populated areas. As there is no crystal-set equivalent of the televisor the inhabitants of such areas must be prosperous and well paid as well as numerous. How many countries can you name which fulfil these requirements and are therefore suitable targets for a television export drive!

□ □ □

Shorthand Circuits

THOUGH I intended to refer last month to A. W. Keen's interesting article on "Shorthand Circuit Symbols," I didn't leave myself space enough to do so. Most of us, I imagine, who have had to take notes of lectures on wireless or electricity in general have had in self-defence to invent shorthand systems of our own. You may hold your own pretty well with ordinary symbols if the lecturer draws his circuits on the blackboard; but you're apt to be sunk if he unrolls a wall diagram, all ready drawn, rushes through the explanations of it and then passes on to another of the same kind. Good though Keen's system is in its way, I've a good many criticisms of it to make. First of all resistors and inductors. If resistors are represented just by one "saw-tooth" and inductors by a single curve, you're very apt to make the signs for the two difficult to distinguish when working fast. I make my resistors with two saw-teeth like a capital M, right-way up or sideways according to circumstances, and my inductors with two major curves joined by a little loop (like a copybook capital W). I don't quite like the short straight line for a capacitor—apt to be overlooked. My symbol is a capital X, with its middle point on the lead. Then valves. Keen's idea is attractive; he shows them as polygons with one side per electrode. But can you draw at note-taking pace a hexagon or a heptagon which is unmistakably what it is meant to be?

SHORT-WAVE CONDITIONS

Expectations for June

By T. W. BENNINGTON *(Engineering Division, B.B.C.)*

MAXIMUM usable frequencies for this latitude decreased very considerably during the daytime during April, and increased somewhat during the night. This was according to the normal seasonal trend, and these variations should continue until about the end of June.

There was a considerable amount of ionosphere storminess during the month, though April was less disturbed than March. The most severe disturbances occurred during the periods 4th-6th and 17th-19th, the Aurora Borealis being seen in England and in many parts of Northern Europe on the night of 17th. Other disturbed periods were 2nd, 8th-9th, 12th, 15th and 26th-27th.

Forecast.—During June the daytime M.U.F.s should continue to decrease towards their lowest seasonal value, which should be reached towards the end of the month. The night-time M.U.F.s should be higher than they were during May.

Working frequencies for *long distance* transmission paths should therefore be somewhat lower by day and, except for those to high latitudes in the Southern Hemisphere, somewhat higher by night. Communication on exceptionally high frequencies (like the 28-Mc/s amateur band) is not likely to be very frequent. Daytime frequencies will, of course, remain of use for longer periods than at present—for example, 17 Mc/s should be regularly usable on many circuits till well after midnight. 15 Mc/s may remain usable the night through over some circuits.

For *medium distance* transmission—up to about 1,800 miles—the E or F1 layers will control transmission for considerable periods during the day, and in these cases daytime as well as night-time frequencies should be higher than at present.

Sporadic E is likely to be particularly prevalent, and so on many occasions—which are, however, unpredictable — communication over distances up to 1,400 miles may be possible by way of this medium on frequencies far above the M.U.F.s for the regular E or F layers.

Below are given, in terms of the broadcast bands, the working frequencies which should be regularly usable during June for four long-distance circuits running in different directions from this country. In addition a figure in brackets is given for the use of those whose primary interest is the exploitation of certain frequency bands, and this indicates the highest frequency likely to be usable for about 25 per cent of the time during the month for communication by way of the regular layers:—

Montreal:	0000	15 Mc/s	(22 Mc/s)
	0300	11 ,,	(19 ,,)
	0800	15 ,,	(22 ,,)
	1300	17 ,,	(24 ,,)
Buenos Aires:	0000	17 ,,	(24 ,,)
	0100	15 ,,	(22 ,,)
	0700	11 ,,	(20 ,,)
	0900	15 ,,	(23 ,,)
	1000	17 ,,	(26 ,,)
	1400	21 ,,	(29 ,,)
Cape Town:	0000	15 ,,	(22 ,,)
	0200	11 ,,	(18 ,,)
	0500	15 ,, or 17 Mc/s	(23 ,,)
	0700	21 ,,	(30 ,,)
	1400	26 ,,	(34 ,,)
	1700	21 ,,	(32 ,,)
	1900	17 ,,	(26 ,,)
	2100	15 ,,	(23 ,,)
Chungking:	0000	15 ,,	(20 ,,)
	0600	17 ,,	(23 ,,)
	2000	15 ,,	(21 ,,)

Ionosphere storms are not usually very troublesome during June and relatively stable radio conditions may be expected. At the time of writing it would appear that if any storms do occur they are more likely during the periods 2nd, 8th, 10th-12th, 19th-20th, 25th-27th and 30th than on the other days of the month.

Footnote.—Three items of interest—two of which will answer some queries received—are given below in condensed form.

(1) Newspaper report from Capetown states that at 1430 local time during the afternoon of 26th March H. Rieder, of Three Anchor Bay, picked up amateur PAOUN, Eindhoven, Holland on 6 metres. His test and call sign were heard, signals being "loud and clear."

(2) When signals come in from a direction other than that in which the transmitting station is known to be, it most probably indicates that the working frequency is above the M.U.F. for the path. Over the Great Circle path propagation cannot be sustained by the ionosphere, but energy can still be "scattered" towards the receiver from ionospheric points "off" the Great Circle path.

(3) Summer prospects for *long distance* communication on the higher frequency bands:—

28Mc/s: Not much good in east/west directions till about mid-September except on isolated days. Improving rapidly after that. Fair, but not so good as lately, for communication in southerly directions.

50 Mc/s: No prospects in east/west directions till about October, when the best possibilities for years should open up, reaching a peak in November. Even then, do not expect regular contacts on this frequency.

RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

RADIO-VISION

DISTANT objects are detected and observed by a method which combines the principles of radiolocation with those of television.

Exploring pulses of frequency-modulated centimetre waves are projected through a refracting prism, say of ammonia gas, or of pitch, from which they emerge as a "spectrum," in which the component frequencies are differently dispersed to provide a "static scanning line" of the field under observation. A third dimension of scanning may be added by mechanically moving the beam. Reflected echo signals derived from the different frequency bands are separately detected by receivers which are cyclically tuned. The resulting signals are passed through delay and "coincidence" circuits to give a final image, which may be stereoscopic, of any object located at a given distance from the transmitter. The distance being found by known radiolocation methods.

J. Forman and Pye, Ltd. Application date September 30th and November 21st, 1941. No. 579813.

RADIO COURSE INDICATORS

IN a blind approach system, the correct course is defined by the receipt of equal signals from both beams, the indicator then showing a null or zero reading. The same indication would, of course, be given in the absence of all signals, so that it is usual to provide a separate fault indicator, such as a neon lamp, which ceases to glow if there is any defect in the equipment, or if by an oversight the beams have not been switched on.

According to the invention, the same cathode ray tube is made to serve both as a course and "breakdown" indicator. The received signals invariably contain an appreciable fraction of unfiltered ripple voltage from the 500-cycle tone-modulator. This is diverted, through a suitable bypass circuit, from the first A.F. amplifier on to the X-plates of the C.R. tube. The Y-plates are fed with the amplified signal from the second A.F. stage, from which the ripple is excluded by the intensive coupling. The ripple voltage will then expand the normal "spot" indication into a corresponding "line" trace, so long as the course-marking signals are coming through.

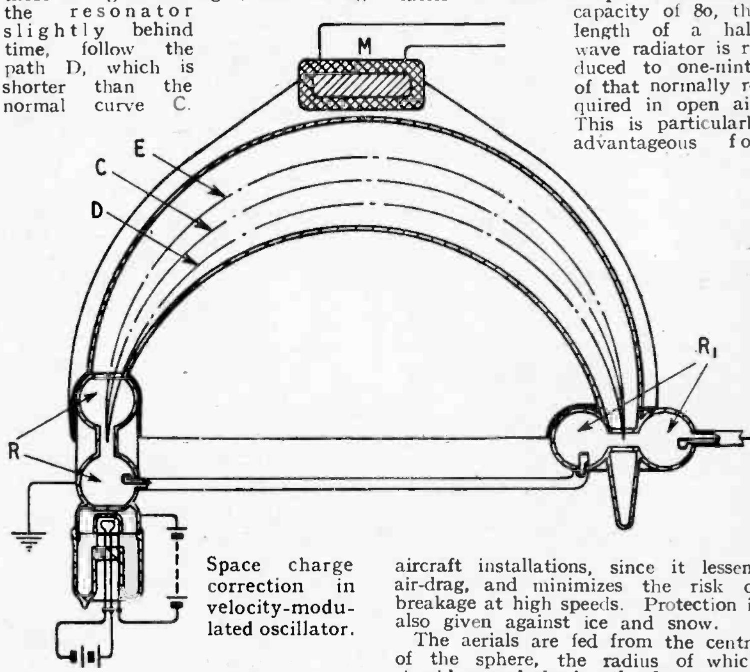
Standard Telephones & Cables, Ltd. and H. P. Williams. Application date May 11th, 1944. No. 579090.

S.W. OSCILLATORS

IN short-wave generators of the velocity-modulating type, the concentration of electrons in the space, following the first resonator, tends to create space-charges which adversely affect the operation of the device.

The electrons in the arrangement shown are passed from the bunching resonator R to the second or load resonator R1 through a crescent-shaped channel under the control of the transverse field from a magnet M.

The R.F. field between the narrow walls of the centre portion of the resonator R imposes on the electron beam a slight lateral vibration, in addition to producing the usual bunching effect. This side-to-side deflection shifts the radius of curvature of the paths taken by the electrons under the influence of the magnet M, so that those swung to the right, and leaving the resonator slightly behind time, follow the path D, which is shorter than the normal curve C.



Space charge correction in velocity-modulated oscillator.

Similarly, when the beam is swung to the left, those emerging first take the longer path E. The correct bunching of the stream is thus preserved until it reaches the delivery or load resonator R1, whilst undue overcrowding in transit is avoided.

Westinghouse Electric International Co. Convention date (U.S.A.) Aug. 20th, 1941. No. 578588.

DIRECTION FINDERS

TO facilitate D.F. operation all transmitters within a given frequency band are first indicated simultaneously on the dial of a cathode-ray tube. A particular transmitter is then selected and bearings are taken on it.

Initially the receiver is coupled to a non-directional aerial, whilst a motor continuously swings the tuning over the given frequency range. All incoming signals appear on the dial as separate radial deflections, against a time base which is derived from a circular potentiometer rotated synchronously with the tuning control.

To take bearings on a particular transmitter, the set is switched over to a directive aerial, and the circuits are tuned manually to the frequency indicated on the C.R. tube. The aerial is then rotated into the zero position, this orientation being ascertained by the fact that the original deflection no longer appears on the indicator dial.

Standard Telephones and Cables, Ltd. (Communicated by International Standard Electrical Corp.) Application date 31st July, 1942. No. 578301.

AERIALS

RADIATING elements, such as rods, cones or cylinders, are arranged radially inside a sphere or hemisphere of insulating material. Assuming the latter to have a specific inductive capacity of 80, the length of a half-wave radiator is reduced to one-ninth of that normally required in open air. This is particularly advantageous for aircraft installations, since it lessens air-drag, and minimizes the risk of breakage at high speeds. Protection is also given against ice and snow.

The aerials are fed from the centre of the sphere, the radius of which should exceed the length of a quarter-wave radiator by an odd number of quarter wavelengths, as measured in the dielectric.

Alternatively, radiation may take place from a half-wave slot cut symmetrically about the centre of a sheet of metal laid over the base of a hemisphere of half-wave radius, the slot being excited at opposite points, at the centre of each edge.

Standard Telephones and Cables, Ltd., and E. O. Willoughby. Application date April 21st, 1944.

The British abstracts published here are prepared with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

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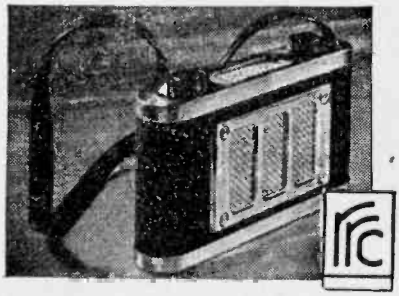

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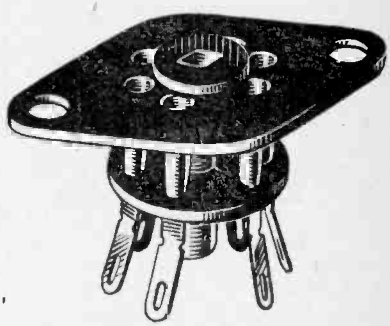

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NEW RECEIVERS AND AMPLIFIERS

R107 communication receiver, brand new, very heavy and massive job, excellent performance; £30.—Box 8514. [7502

COMMUNICATION receivers.—As soon as civilian supplies recommence we shall be at your service.—A.C.S. Radio, 44, Widmore Rd., Bromley, Kent. [4528

SEMI-MIDGET a.c. main 3-waveband superhet receivers; in mahogany wood cabinet; retail price, £14/3/6, plus £3/3 tax; trade and export enquiries invited. PARKER Radio Manufacturing Co., 756, Harrow Rd., N.W.10. Ladbroke 4446. [7254

AMPLIFIERS, 6 watts push-pull output, complete with 10in speaker, for use on ac mains, good quality job, tone control, etc.; call and hear one or send for descriptive leaflet "W." CHARLES BRITAIN (RADIO), Ltd., 2, Wilson St., London, E.C.2. [6835

DEGALLIER'S, Ltd., announcement.—When token imports American receivers is permitted we shall have these; information will be in this column when available, please watch future issues. [7541

OSMOR A.C.-D.C. 3-wave 5v superhet receivers, excellent reproduction and sensitivity, attractive cabinet, early delivery, shipping waveband if required; write for literature; trade enquiries invited.—Morgan, Osborne & Co., Ltd., Southview Rd., Warlingham, Surrey. [7286

OSMOR A.C.-D.C. 5v 3-wave superhet radio heart, includes (fully assembled) chassis, coil pack, calibrated dial, 2-gang, I.F.S., V.C. choke, 8-16, dropper, circuit diagrams, small resistances and condensors only required, cabinets available; trade enquiries invited.—Morgan, Osborne & Co., Ltd., Southview Rd., Warlingham, Surrey. [7287

BAKER'S.—New 7-valve "Wireless World" Quality amplifier with tone control stage, 8 watts push-pull triode output, price includes super Quality triple cone, 12in permanent magnet speaker, with large output transformer and all valves; also as above but with 15 watts tetrode output, ideal for realistic reproduction or public address; 2½d stamp for partics., prices, etc.—Baker's Selhurst Radio, 75, Sussex Rd., S. Croydon. Croydon 4226.

CHARLES AMPLIFIERS.—Announcing a new version of their famous HFA1 amplifier—the HFA3 incorporating a pre-amplifier to enable the use of moving coil pick-ups direct; this amplifier in conjunction with the Lexington moving coil pick-up and the B.A.E.C. twin cone speaker provides the highest obtainable fidelity of reproduction; the complete range now comprises amplifier HFA1 7watt cathode follower output for crystal pick-ups; HFA2 single-ended 3 watt for crystal pick-up; the HFA3 for moving coil pick-ups; full constructional blueprints, 2/6 each; full kits or separate components available or supplied ready assembled; stamp for comprehensive catalogue.—Charles Amplifiers, 1e, Palace Gate, Kensington, W.8.

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1155 receiver, not modified; offers over £10.—M. Stratford, 8, Coxwell St., Cirencester, Glos. [7336

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AMBASSADOR 10watt radio and p.a. amplifier, working order; £12.—T. E. C., The Outgang, Aspatria, Cumberland. [7493

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NATIONAL H.R.O. type M 9-valve power pack, 9 coils, 50 kc/s to 30 mc/s, no spkr.; £55.—29, Pickwick Rd., Corsham, Wilts.

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B.S.R. P.A.20 amplifier, Romac 25/H/11 radio amplifier, 3 G.E.C expo speakers, 2 Meico mics., 1 Lustraphone mic., all in good condition; £90 or offers, will separate.—Bonham, 40, Salisbury Ave., Coventry. [7457

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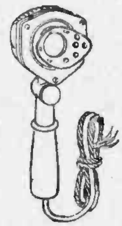

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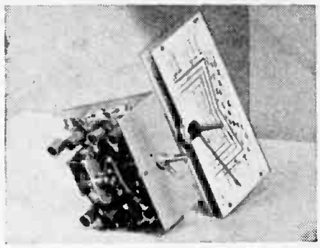

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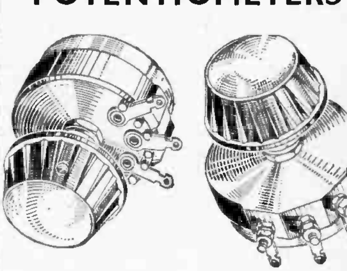

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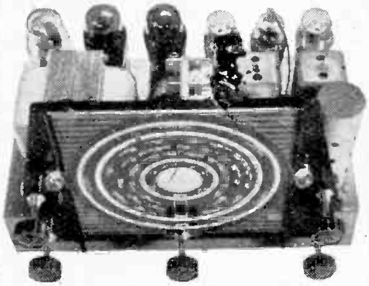

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COILS for W.W. tone control and filter circuits (Brierley and Hartley spec.); high fidelity, mic. line and output transformers; s.a.e. full list.—R. Clark, 30, Langland Crescent, Stanmore, Middx. Wor. 5321. [6971

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RADIOGRAM, walnut cabinet, H.M.V., 8 changer, light weight P.V. (sound sales, 12 watt amp. and tuner, bass and treble lift phase invertor speaker, walnut), record cabinet, mahog., 300 record space, excellent reproduct., perfect cond.; £110.—"Siggers," London Rd., Bracknell, Berks. [7390

PORTABLE recording equipment: M.S.S. recording machine, 20 watt amplifier, new, from stock: Blank discs, cutting needles, trailer needles, microphones, lightweight pickups, matching transformers, speakers, etc.; trade enquiries invited.—Sound Discs (Supplies), Ltd., 83a, Bold St., Liverpool. [6964

1947 quality record reproducers, amplifier and radio chassis, gram motors, pickups, speakers, micrograms, players, etc.; lowest prices in the trade; s.a.e. for detailed list; special this month, Universal amplifiers, 12 watt, 10gns.; 15 watt, £14/10.—Radio Unlimited, 16, Carnarvon Rd., Leyton, E.10.

TECHNIFON, Ltd., manufacturers of direct disc recording equipment and acccessories. Precision built traverse gear complete with first class quality cutting head, £15/15; delivery 3 wks.; s-sided 12in blank discs still available, 3/- each; for all lightweight pickups using push in styli, our h.f. type sapphire stylus now available, 9/2 inc. P.T.; postage and packing extra.—Technifon, Ltd., 99, Belgrave Rd., London, S.W.1. Vic. 8814.

CHARLES AMPLIFIERS welcome lovers of recorded music to their new premises where their high fidelity amplifiers can be heard together with Lexington Connoisseur and Rothermel pick-ups and B. and A.E.C. Vitavox, and Wharfedale speakers, B. and A.E.C. accoustic chambers, infinite corner baffle deflectors, etc.; we like you to bring your own familar records for comparison; this is a service devoted entirely to the high fidelity reproduction of music; one minute from the Albert Hall and Kensington High St. Station; buses 73, 49, stop at the door.—Charles Amplifiers, 1e, Palace Gate, Kensington London, W.8. [6642

TELEVOX playing desks.—We wish to apologise to the large number of our customers who have been obliged to wait several weeks for these units; we are doing all we can to overcome the acute shortages of essential parts that are seriously affecting our production.

THE Televox Sound Service has pleasure in announcing the production of their model P.D.11 playing desk, fitted with a belt-driven turntable and powered by a constant speed induction motor, with speed adjustment; this model will be mounted on the same chassis as our previous models, namely, with black ripple finish, size 14½in×12½in×3½in deep, mounted on 4 rubber feet, with or without pick-up.—For further particulars write to Televox Sound Service, Kings Studios, 37, Albert Rd., Southsea, Hants. Tel. Portsmouth 4982.

THE Televox Sound Service have pleasure in also announcing the early production of a floor model record player, incorporating the above belt-driven turntable unit, mounted in a sliding cabinet, and supported on a modern tubular steel frame with easy access record rack; the top of this player is covered with a substantial black vitrolite (plastic glass) surface, specially designed to support table model radios.—Further particulars from the above address. [7666

SPECIAL offer to experimenters and amateur enthusiasts of moving coil earphones and microphones, combined; these instruments are of the very latest type, issued to the Services, and are all new and boxed, as from the makers; special attractive price to clear, £1 for the complete set, which is less than half their usual value; also small size Westinghouse metal rectifiers, half-wave type, size ⅝in×⅜in., pass approx. 50-60ma, price 2/- each, or £1 doz; full-wave type, size ⅞in×¾in., pass approx. 100ma, 3/- ea., or 30/- doz.; all new and in their original wrapping; counterpoise aerial systems, containing in all 40ft of copper insulated aerial wire, only 2/- each concentric aerial feeder, as used by R.A.F., 1/- yard; please note, we pay all postage and carriage expenses; c.w.o. please.—Pearson, 58, Bain St., Glasgow, S.E., and 263, Gallowgate, C.4. [7673

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374, Kensington High Street, London, W.8

MORSE EQUIPMENT

MORSE practice equipment for classroom or individual tuition; keys, audio oscillators for both batt. or main operation.—Webb's Radio, 14, Soho St., W.1. Ger. 2089. [2291

NEW MAINS EQUIPMENT

MAINS transformers, 750-0-750, 200ma, 4v and 6.3v L.T., 230v input, 65/-; 350-0-350, 100ma 5v C.T. and 6.3v L.T., 230v input, 27/6; aluminium sheet, polished half hard, 22 gauge 1/4, 18 gauge 2/-, 16 gauge 3/- sq ft; duralumin tube, ½in, 10ft, 4/-; all postage extra; transmitter and amplifier racks built to your requirements; enquiries, and stamp for component list.—Fanthrope, 6-8, Hepworth's Arcade, Hull. [7274

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100 watt C.W. 40watt 'phone transmitter, complete with all equipment, also 2 communication receivers, all in perfect working order; s.a.e. for details.—Offers to Thomson, 14, North St., Fowey, Cornwall. [7543

250W ham transmitter, rack built, 6L6-807-813 Mod. 6SJ7-6J5-pp 6A3-ppTZ40, power packs 1,500v, 1,000v and 450v and bias; original cost of parts £260; complete and working on all amateur bands, £180.—G4HV, 16, Keswick Gdns., Ruislip. [7378

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SPECIAL offer headphones, w/lead and jack plug, 5/6 per pair (boxed 2 pairs).

SPEAKERS, P.M. 4in 17/6, 5in 15/6, 8in 22/6, all less transformers; transformers (output) to match, 5/6 ea.

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LINE cord 0.3 amp (60 ohms per ft), 2-way 1/6 per yd, 3-way 2/6 per yd.

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MATT RADIO SERVICE (Kingston 4881), 152, Richmond Rd., Kingston-on-Thames, Surrey. [7168

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AERIAL coupling units, type "A," including 200ma H.F. ammeter, at 35/- each; the R.1124 receiver unit is the ideal base for a television amplifier or f.m. unit; complete with all six valves at £4/10.

VALVES, 1R5, 1T4, 1S5, 1299a, and many other scarce types; spares, components of every make and type; send stamp for lists and remember that the service goes with the sale; terms cash with order or c.o.d. over £2.—Orders to Dept. W.W., Ariel Trust, Ltd., 188, Vauxhall Bridge Rd., London, S.W.1. [7417

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I.F. transformers for 465 kc/s, permeability tuned, 3⅜in high by 1⅜in square, per pair 14/6; Superhet coils, 2/3; T.R.F. pairs, 6/6; mains trans. 350v 80ma, 6 or 4v, 26/6; steel instrument cases, 18in×8in×7in, fully louvred, open one end, 12/6; tuning hearts, coil packs, etc.; 3d stamp for lists and data.—Midland Radio Coil Products, 13a, Silver St., Wellingborough, Northants. [7463

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THIS MONTH'S SPECIALS.

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MIDGET 2-GANG VARIABLE CONDENSERS, size 1¾ × 1½ × 1¼, ceramic insulation. Capacity, .0001 mfd. Price **8/6** each.

MIDGET 2-GANG TUNING CONDENSERS, with trimmers .0005 mfd., size 2¼ × 1¾ × 1½. Price **13/9** each.

ELECTROLYTIC BLOCK CONDENSERS, 32 mfd. 500 v.w., **7/6** each.

MIDGET ELECTROLYTIC CONDENSERS, 4 mfd. 425 v.w., **3/-** each.

CHASSIS MOUNTING ELECTROYLTIC CONDENSERS (single hole fixing), 4 mfd. 500 v.w. Price **4/6** each.

TUBULAR CONDENSERS, 20 mfd. 150 v.w. Price **4/-** each.

BUTTON VALVEHOLDERS to fit 1T4, and 1R5, etc. Ceramic **1/-** each; **9/-** doz.

AMPHENOL, **9d.** each; **7/6** doz.

EF50 CERAMIC VALVEHOLDERS, **1/-** each; **9/-** doz.

MIDGET 1.4 VALVES, 1T4 and 1S5. Price **11/-** each.

6L6 metal, **12/6** each; 5Z3, **12/6** each; 6K7, metal, **10/-** each; 6V6 gt, **10/-** each; 6SJ7, **10/-** each. Brand new ex-Govt.

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Very large stock of Radio Valves. All types. British and American. A.C.; Battery; All-dry; Universal; Metal; Glass; Midget, etc., at B.O.T. prices.

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LATEST ex-Government purchase: Rotary transformer, brand new, ex-Government stock, 12v input, 480v output, D.C., 17/6 each, plus 2/6 carriage and packing; 28v input, 280v output, 25/-, plus 2/6.

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CHARGER kits for small radio store, guaranteed one year, for one to 20 cells at one amp. ..rises 150 watt transformer, selenium rectifier and ballast bulb and holder, £4/15; ditto 1 to 20 cells at 2 amps, £6/15, transformer and rectifier specially designed; ammeters, flush mounting, reliable and accurate 0-6 amp, ../-, post 6d; transformer and rectifier for 2v ..cle charger, 13/6, post 7d; fluorescent chokes, 80 watt, boxed and bitumen filled, 230v .., and tapped 200-250v 21/-, postage 1/2.

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TUNGSRAM.—5Z4, 6B8, 6J5, 6V6, 6X5, 25Y5, 807, APP4c, APP4G, DD13, DD818, ECH2, EF12, EH2, EL5, EL11, EM4, EZ4, HL13, HP13, HP1018, HP1118, HP2018, HP2118, HP4106, HR210, MH1118, MH4105, LD210, LL2S, P2018, PP6E, SP2BS, SP4B, SP4S, SS210, VP4S, HL4, HP211C, LL4, LP220.

AMERICAN.—OZ4, 1A4, 1A5, 1B4, 1C5, 1D7, 1E5, 1E7, 1F4, 1F5, 1F6, 1F7, 1G6, 1H4, 1H5, 1H6, 1J6, 1LC6, 1LN5, 1N5, 1S4, 1S5, 1T4, 1T5, 2A6, 2A7, 2B6, 2B7, 5U4, 5V4, 5Y3, 5Z3, 5Z4, 6A4, 6A6, 6AE5, 6AE6, 6AG6, 6B7, 6B8, 6C5, 6C6, 6D5, 6D6, 6D8, 6E6, 6F5, 6F6, 6F7, 6G6, 6H6, 6J5, 6J7, 6J8, 6K5, 6K6, 6K7, 6K8, 12K7, 6L5, 6L6, 6L7, 6N7, 6Q7, 6P5, 6R7, 6SA7, 6SC7, 6SF7, 6SJ7, 6SN7, 6T7, 6V6, 6X5, 6Y5, 7A6, 7A7, 7B5, 7B6, 7B7, 7B8, 7C5, 7C6, 7H7, 7S7, 7Y4, 10, 12A 12A5, 12A6, 12B7, 12J5, 12K8, 12Q7, 12SA7, 12SF5, 12SR7, 12Z5, 14A7, 15, 17, 18, 20, 22, 25, Y5, 25Z4, 31, 32, 33, 34, 35Z5, 37, 38, 46, 48, 49, 50, 53, 55, 57, 59, 71A, 77, 79, 80, 81, 82, 83, 89, 807, 954, 955, 956, 117Z6, 1299A, 9001, 9002, 9003, 9004, 9005.

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ILH4, 6A3, 6AG5, 6AG7, 6AK5, 6B4, 6C8, 6E7, 6F8, 6SK7, 6SL7, 7C7, 12SJ7, 12SK7, 12SN7, 12SQ7, 25Z5, 26, 29, 78, 18, 37, 39/44, 41, 42, 43, 76, 84.

and 101 more types.

Order C.O.D. above listed numbers or equivalents (subject to stock). Please enquire for any valve you require, even if not listed. We may have it. Old and new types are arriving daily.

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Avo All-wave Oscillator, battery operated, with 2 dummy aerials	£12	0	0
Also all other AVO instruments in stock from	£4	4	0
Service Sheets, British or American per doz.		10	6
Amplion "Convete" Mains Set	£4	19	6
P.M. Moving Coil Speakers, 3 ohm, 5in.		18	9

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SURPLUS radio and electrical components, list free.—11, Salisbury St., Gateshead, 10

A LIST not to miss; unsurpassed bargains in components; send 1d stamp for list.—Watts, 38, Chapel Av., Addlestone, Surrey.

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MANUFACTURERS and exporters, we offer the following brand new components and high quality tropicalized paper block condensers at bargain prices for bulk purchase:—

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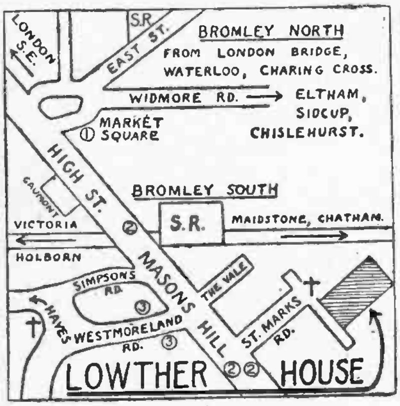

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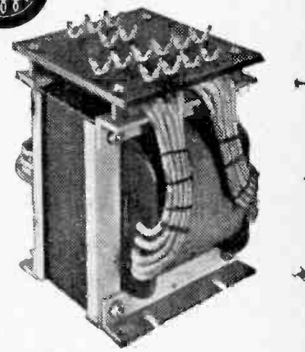

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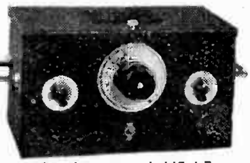

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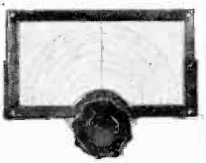

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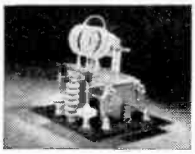

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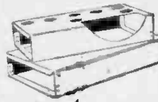

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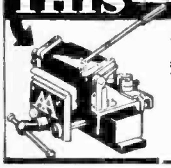

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Reliable results. Guaranteed.
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BOROUGH of Fulham. Electricity department.

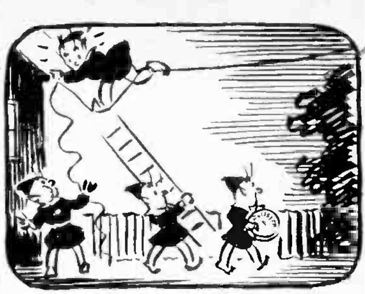
TRAINEE radio mechanic. Applicants should have had training in the use of simple workshop tools and have elementary knowledge of general principles of electricity and magnetism. The successful applicant will be required to continue his studies at a technical institute and, if necessary, will be allowed one day from work per week without pay for this purpose. The position is progressive and on the successful completion of his training and studies the applicant should be eligible for the position of a radio mechanic. The rates of pay are £1/12/1 per 44 hour week at 14 years of age, rising annually to £4/8/2 per 47 hour week at 20 years of age.

TERMS of employment will be in accordance with N.F.E.A. agreements.

FORMS of application for above position may be obtained upon application to the Borough Electrical Engineer, 587, Fulham Rd., S.W.6.

MINISTRY of Civil Aviation.—Appointment of radio operators.

APPLICATIONS are invited for appointments as radio operators at Civil Aviation Radio Stations. Applicants must be at least 21 and under 40 years of age on 1st May, 1947. Candidates for appointment to Grade II must possess the Postmaster General's Second-Class Certificate of proficiency in radio telegraphy or the Air Operator's Licence with practical experience as a wireless operator in H.M. Forces, the Merchant Navy, civil aviation, etc. Ex-Service candidates not possessing these qualifications will be considered if they possess the Service "trade" qualification combined with suitable practical experience. Opportunity exists for suitably qualified officers to be promoted to Grade I, and candidates already qualified may be appointed direct to that grade. Qualifications required for Grade I are similar to those laid down for Grade II except that candidates must possess the Postmaster General's First-Class Certificate of proficiency in radio telegraphy or the Air Operator's Licence, and have had practical experience in direction finding work. Rates of pay on entry to Grade II range from 98/- a week at age 21 to 106/- a week at age 25 or over, rising by annual increments to a maximum of 130/-. Rates for Grade I range from 104/- a week at 21 to 120/- a week at 25 or over, rising by annual increments to a maximum of 165/- a week. These rates include consolidated bonus addition. When final complements are settled establishment will be offered within those complements to suitable operators. Candidates should apply by postcard for a form of application to the Ministry of Civil Aviation, Establishment Division (B), 10 Fleet St., London, E.C.4, quoting reference Est./351. The latest date for the receipt of completed application forms is 7th June, 1947. Applications from candidates serving in the Forces overseas, if not received by that date, will be considered in connection with vacancies which will arise during the next few months, provided that they are received by 16th August, 1947; such applications may be by letter, giving date of birth and full details of qualifications and experience. [747



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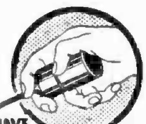

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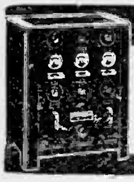

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JUNIOR Radio Engineers required by the Government of the Bahamas for a tour of three years in the first instance; salary £500, rising to £600 a year. On salary of £500 a cost-of-living allowance of £150 a year is payable. Free passages. Candidates, not over 40 years of age, must have had good basic training in radio engineering for vacancies (A), (B) or (C), or in electrical engineering for vacancy (D), and possess one or other of the following qualifications:—

(A) For radio receiver maintenance. A good knowledge of radio receiver design, construction and maintenance, fault finding procedure, and high frequency and vhf receivers. (M/N/17500.)

(B) For radio transmitter maintenance. A good knowledge of radio transmitter circuit design and operation and experience in the maintenance of telegraph and radio telephone transmitters up to 5kw on broadcast, high frequency and vhf. Mechanical ability in the use of tools essential. (M/N/17501.)

(C) For general radio maintenance. Good experience with antennæ and antennæ construction, and ability to maintain and operate teletype machines. A good knowledge of the use of workshop facilities, test equipment, small machine tools, and the method of construction of small equipment essential. (M/N/17502.)

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BOROUGH of Fulham. Electricity department.

RADIO mechanic. Applicants must have had experience in the servicing of all types of radio receivers, alignment of superhets, use of all types of instruments and a sound knowledge of radio theory. Television circuitry knowledge an advantage. Rate of pay 2/9 per hour or £6/9/3 per 47 hour week.

TERMS of employment will be in accordance with N.F.E.A. agreements.

FORMS of application for above position may be obtained upon application to the Borough Electrical Engineer, 587, Fulham Rd., S.W.6.

BOROUGH of Fulham. Electricity department.

RADIO diagnoser. Applicants must have had experience in fault tracing in all types of radio receivers, alignment of superhets, use of all types of instruments and a thorough knowledge of radio theory. Television circuitry knowledge an advantage. Rate of pay 2/11 per hour and £6/17/1 per 47 hour week.

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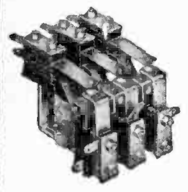

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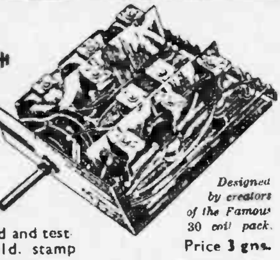

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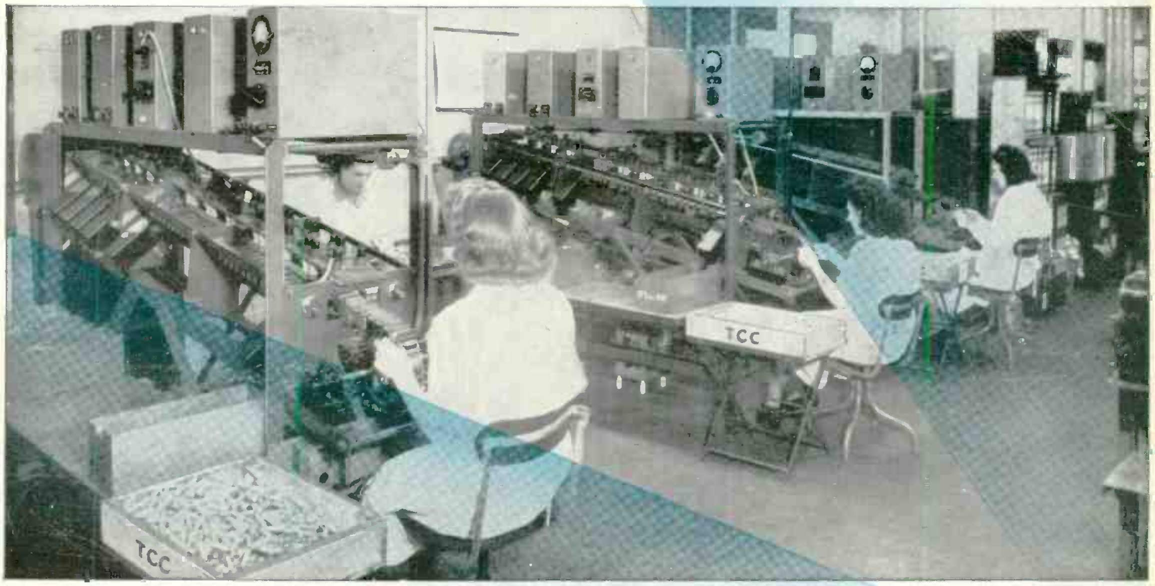
SEARCHLIGHT on *Quality Control*



Quality Control, in its broadest and widest application, is a never-relaxed feature of every stage in the production of T.C.C. Capacitors

From raw-material acceptance to final Capacitor test, a keen-eyed team of technicians and operatives, backed by the most modern test equipment, is engaged in the application of scientifically-based control methods with one purpose in mind, that of maintaining the highest attainable standards of quality

Periodical examination, by statistical analysis, of the collated data ensures the effective application of the control systems employed.

TCC Capacitors

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