Wireless World

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Encouraging Technical Writers

THERE can be no doubt that the prestige of British radio was gravely harmed when, during the period immediately following the end of the war in 1945, publication of information on wartime developments was deliberately delayed by concerted official and semi-official action. The whole technical world was hungry for details of the developments, but, for a year or more, all the information released came from non-British sources. As an indirect result of this "hangover" from wartime censorship, technical writers were discouraged; indeed, the impression became current—and is to some extent still current— that it was almost improper to write on any subject that was not already safely in the textbooks. These feelings, coupled with a widespread idea that technical writing was mildly frowned upon by employers in industry, has certainly restricted, or, at the best, delayed, publication of information on many important British developments. All too often, detailed information is released so late that it is no longer topical.

Wireless World hopes and expects that these harmful ideas will be dispelled by the wise and generous action of the Radio Industry Council in establishing a "premium" scheme for the active encouragement of technical writing. Starting from 1st January, 1952, the R.I.C. will award premiums of 25 guineas each, up to an average of six per year, "to the writers of published articles which, in the opinion of a panel of judges, deserve to be commended by the industry." Eligibility is restricted to articles by any non-professional writer published in papers or periodicals which can be bought by the public from bookstalls or by subscription. Journals of learned or professional societies and those circulating exclusively to members of a trade are barred.

In broad principle the scheme seems entirely commendable, and wisely no attempt has been made at this stage to fill in all the details. That can be done as the scheme develops; what really matters is that it has now been made clear that the industry as a body looks on technical writing by its employees and others as meritorious and worthy of reward. The judges "are to be given the greatest possible freedom in choosing articles for awards, but they will be asked broadly to take into consideration: Value of the article in making known British achievements in radio and electronics; originality of subject, technical interest; presentation and clarity."

We hope that an incidental result of the premium scheme will be to establish the principle that there is merit in exposition of the work of others. Not all those responsible for technical developments have cultivated the art of clear writing; sometimes, too, they tend to be unsympathetic towards non-specialist readers with less knowledge of their subject than themselves.

Propaganda—and the Reverse

Obviously, it is not the object of the R.I.C. premium awards to encourage the writing of tendentious propaganda; that would spell failure from the start. But equally we think it is desirable that technical writers should realize that most foreign readers do not understand our queer national characteristic of denigrating the British way of life in all things. A particularly bad example of this appeared in the American journal *Audio Engineering* for October, where a British author, H. A. Hartley, paints a gloomy, misleading and damaging picture of the backwardness of this country, especially in the field of sound reproduction. The author is entitled to air his opinions, but should verify the facts purporting to support them. As it is, all too many of the points capable of verification are wrong. One example will serve: in the very first paragraph, Mr. Hartley, deploring what he considers to be the loss of British leadership in television, cites the arrival of the 12-in tube as the feature of this year's radio show. He is more than a year behind the times; even at the 1950 show there were more 12-in tubes than smaller ones. At this year's show the 12-in tube was commonplace, with many of 15 and 16in. And, going back to the pre-austerity era, the sight of a 12-in tube was not a matter for amazement even in 1937.

RADIO FEEDER UNIT

High Quality Pre-tuned Receiver with Gramophone Pre-amplifier

By J. F. O. VAUGHAN

THIS feeder unit is intended to provide an output of the high quality necessary to do justice to the several new amplifiers which have been described in *Wireless World* in the past few years. It provides switched selection of four stations (normally local ones), three on the medium waveband and one on the long, and an input for gramophone of sufficient gain for light-weight low-output pickups.

Except for the rectifier, which is a standard type on an octal base, B7G-type valves are used. This is done largely because of the convenience of single-ended valves for the r.f. stages from the point of view of screening. Apart from the miniature types most single ended valves are either obsolescent or have unsuitable characteristics.

From the circuit diagram it can be seen that there are two r.f. stages, V_1 and V_2, a diode detector, V_3, an a.f. amplifier, V_5, to compensate for the loss caused by the tone control circuits, and a separate amplifier, V_4, for gramophone input. A.g.c. is not provided as it is difficult to arrange a simple system which is quite free from distortion; the unit is intended primarily for the reception of local stations, where fading is negligible, and so the absence of a.g.c. should be no disadvantage.

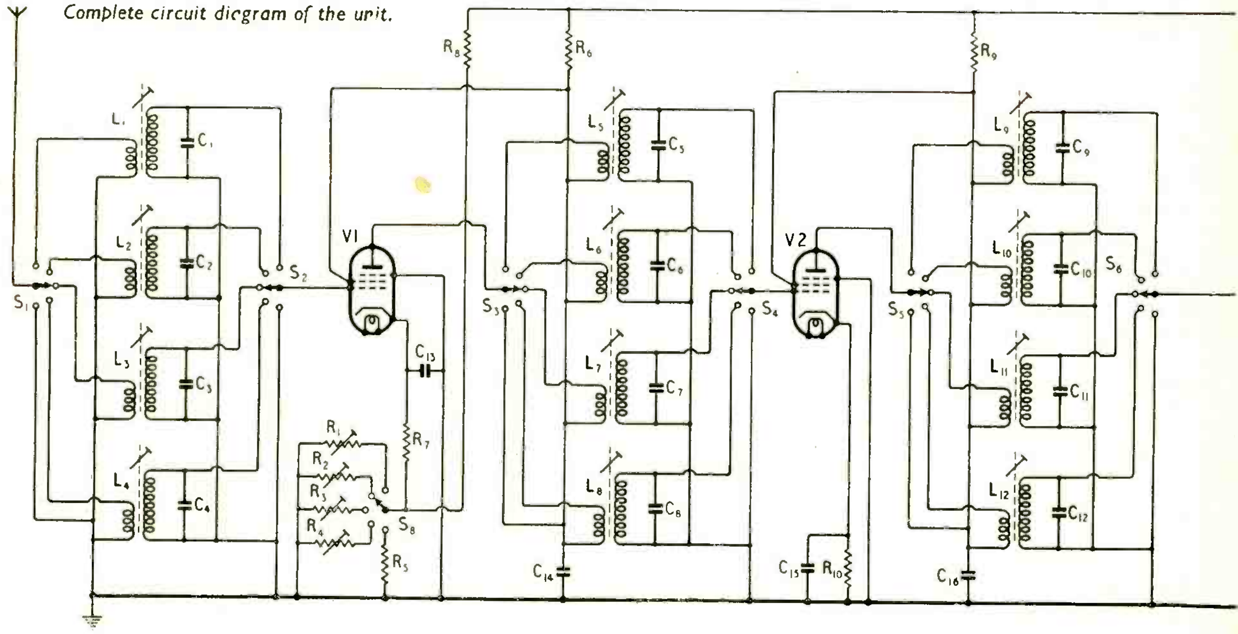
The local stations will not, of course, be received all at the same strength and for this reason provision has been made for adjustment of the r.f. gain at each position of the station-selector switch. Four pre-set resistors, R_1—R_4, one for each switch position, are provided in the cathode circuit of V_1 to enable the output from the four stations to be made the same. The resistor R_8 from the switch S_8 to h.t.+ provides additional biasing current through these resistors, so increasing the range of gain variation available. R_5 biases V_1 when the gramophone input is in use. The switch S_8 is a make-before-break type so that at no time is the cathode of V_1 subjected to full h.t. potential.

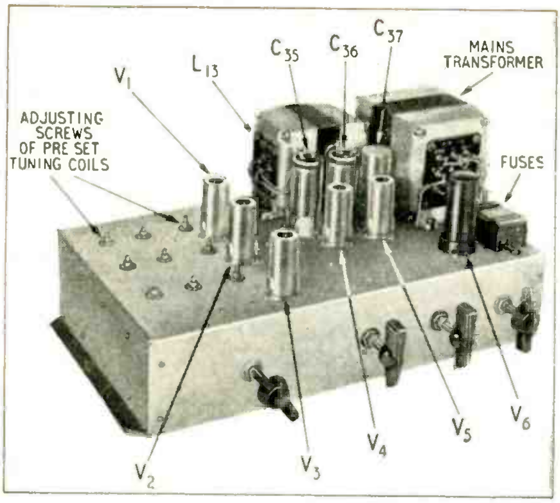
The tone control circuit is the one in this year's *Wireless World* Diary and was designed to avoid the use of inductors. The pickup input circuit gives bass compensation of 6 db per octave and is intended for pickups with a fairly level bass response. Most special pickups require a particular form of compensation and the circuit recommended by the makers can be substituted for the one shown.

The detector circuit is straightforward and it will be found that even with a value of only 1 MΩ for the volume control the a.c. load resistance is quite high enough compared with the d.c. load resistance to avoid appreciable distortion. (See "Diode Detector Distortion" by W. T. Cocking in the May 1951 issue of *Wireless World.*)

The high gain obtainable from the two r.f. stages makes the mechanical layout of this part of the circuit

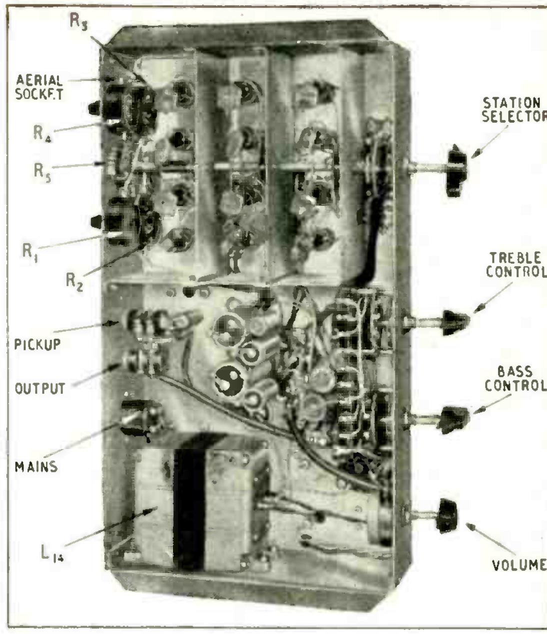
Complete circuit diagram of the unit.





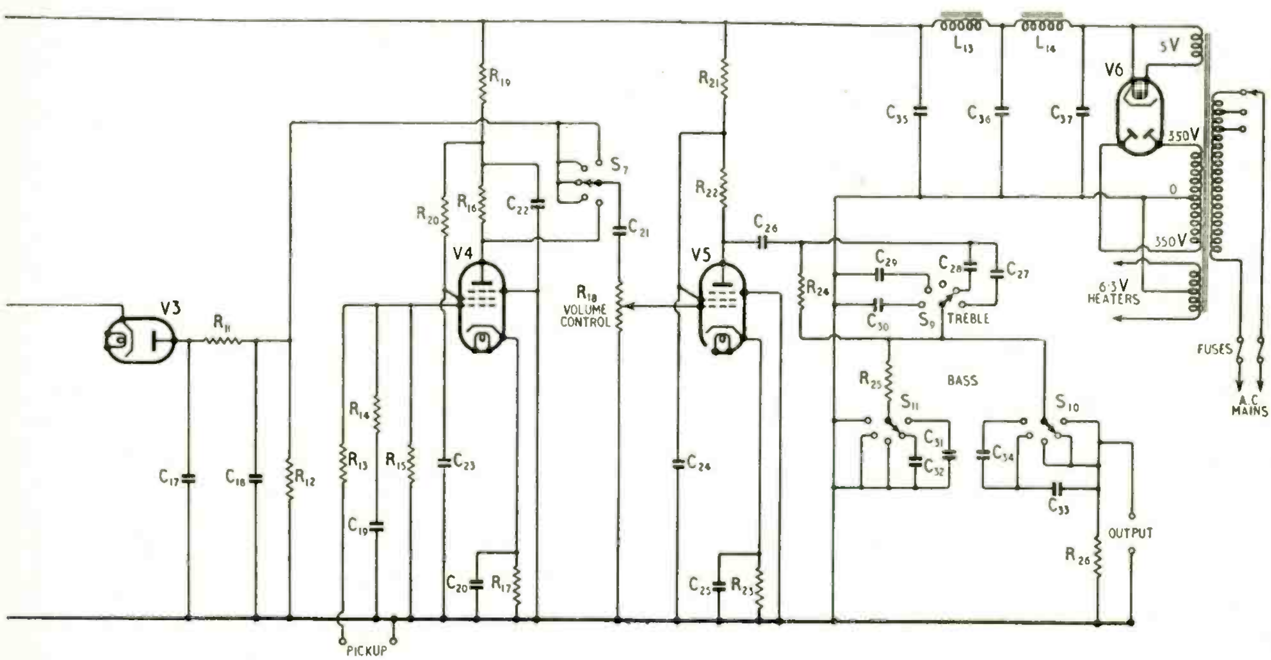
Top view, showing the adjusting screws for the pre-set tuning coils.

Right : General underside view of the unit.



very difficult if stability is to be achieved. The photographs show that each set of coils and associated switch wafer is mounted on a separate sub-chassis. The sub-chassis are like inverted boxes having only two sides. They nest together, the other two sides being formed by the adjacent sub-chassis and the main chassis. They are mounted " bottom " upwards against the top of the main chassis. The coils are mounted on the " bottom," the main chassis having clearance holes for the coil-fixing nuts. One side of each sub-chassis forms a screen across the holder of the appropriate valve, except in the case of the detector. These screens and the rear of the main chassis must have holes large enough to prevent the switch shaft from being able to touch them where it passes through them. This has a very considerable effect on stability.

The switch shaft consists of sections in convenient lengths joined by couplers—these are made of copper sheet rolled to the shape of the shaft and soldered and are fixed to the shaft by 6 B.A. screws tapped into it. Copper was chosen because it can be soldered and because it provides a slight degree of flexibility. It is not known whether it will prove too soft for continual use, but it has not yet given trouble after many operations. Standard ¼-in flexible shaft couplers are too big and they do not line up the shafts with sufficient accuracy. Wafer switches are normally purchased assembled on rods and must, of course, be dismantled

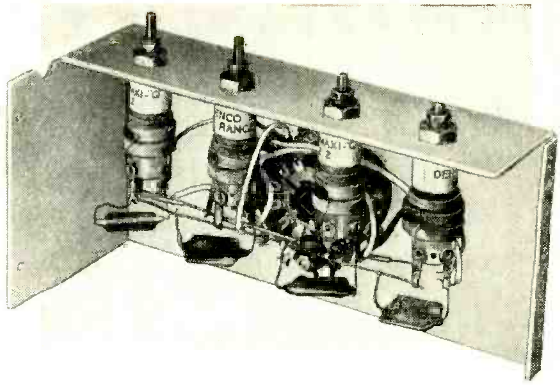


for this particular application. It is essential to line up the wafers on the various screens very accurately before inserting the shaft, as otherwise contacts will be damaged and the life of the switch will be greatly reduced.

Each sub-chassis is wired up as a separate unit, leaving only three leads to be connected when it is fixed to the main chassis. These are: (a) the lead which goes to the screen-grid pin on the valve-holder (to earth in the case of the aerial coils), (b) the lead to the valve anode (to the aerial socket in the first stage), and (c) the lead to the grid of the next valve (to the detector cathode in the third stage).

The valveholder wiring for the first and second stages is arranged so that it does not interfere with the insertion and removal of the sub-chassis. The only components on the holder are cathode and screen-cum-anode by-pass capacitors, for which metallized types are used to save space, and the cathode-bias and h.t. decoupling resistors.

The tone-control components are also assembled on to a separate unit. In this unit two switches are used, each having 2-pole 5-way contacts. In the case of the treble control, only one half of the wafer,



One of the sub-chassis taken out of the unit, showing the tuning coils and capacitors and the switch wafer.

shown as S_9 in the diagram, is used. The circuit for the bass control demands the use of the whole wafer, shown as S_{10} and S_{11}. The two halves must be wired so that when the wiper of S_{10} is at the top, so is the wiper of S_{11}; i.e., either C_{31}-C_{32} is in circuit or

LIST OF COMPONENTS

Capacitors

C_1 to C_{12}	tuning capacitors, protected silvered mica; see text.	Hunts
C_{13} to C_{16}	0.01μF metallized paper	Dubilier
C_{17} and C_{18}	500pF silvered mica	Hunts
C_{19}	0.02μF paper	„
C_{20}	50μF electrolytic, 12V working	„
C_{21}	0.01μF paper	„
C_{22}	8μF electrolytic, 450V working	„
C_{23}	0.1μF paper	„
C_{24}	8μF electrolytic, 450V working	„
C_{25}	50μF electrolytic, 12V working	„
C_{26}	0.15μF paper	„
C_{27}	0.001μF mica, moulded	„
C_{28}	250pF mica, moulded	„
C_{29}	500pF mica moulded	„
C_{30}	1,500pF mica, moulded	„
C_{31}	0.05μF paper	„
C_{32}	0.15μF paper	„
C_{33}	1,500pF mica, moulded	„
C_{34}	0.001μF mica, moulded	„
C_{35} to C_{37}	16μF electrolytic, 450V working	„

Resistors

R_1 to R_4	10kΩ pre-set	Colvern
R_5	10kΩ ½W	Erie
R_6	3.3kΩ ½W	„
R_7	220Ω ½W	„
R_8	0.1MΩ ½W	„
R_9	3.3kΩ ½W	„
R_{10}	470Ω ½W	„
R_{11}	50kΩ ½W	„
R_{12}	220kΩ ½W	„
R_{13}	220kΩ ½W	„
R_{14}	22kΩ ½W	„
R_{15}	1MΩ ½W	„
R_{16}	220kΩ ½W	„
R_{17}	1.8kΩ ½W	„
R_{18}	1MΩ variable, tapered	Reliance
R_{19}	47kΩ ½W	Erie
R_{20}	1.2MΩ ½W	„
R_{21}	22kΩ ½W	„
R_{22}	10kΩ ½W	„
R_{23}	330Ω ½W	„
R_{24}	0.15MΩ ½W	„
R_{25}	10kΩ ½W	„
R_{26}	1MΩ ½W	„

Valves

V_1	EF92	Mullard
V_2	EF91	„
V_3	EF91	„
V_4	EF92	„
V_5	EF91	„
V_6	5Z4	Cossor

Coils and Chokes

L_1 to L_3	Range 2 blue	Denco Maxi Q
L_4	Range 1 blue	„
L_5 to L_7, L_9 to L_{11}	Range 2 yellow	„
L_8 and L_{12}	Range 1 yellow	„
L_{13} and L_{14}	20H at 60mA	Woden

Switches

S_1 to S_8	5 wafers, each 2-pole 5-way	N.S.F.
S_9, S_{10} and S_{11}	1 wafer, 2-pole 5-way	„

Mains Transformer

Primary:	10-0-200-220-240V	Woden
Secondaries:	350-0-350V at 80 mA 5V at 2A 6.3V at 3A	

Chassis Fittings

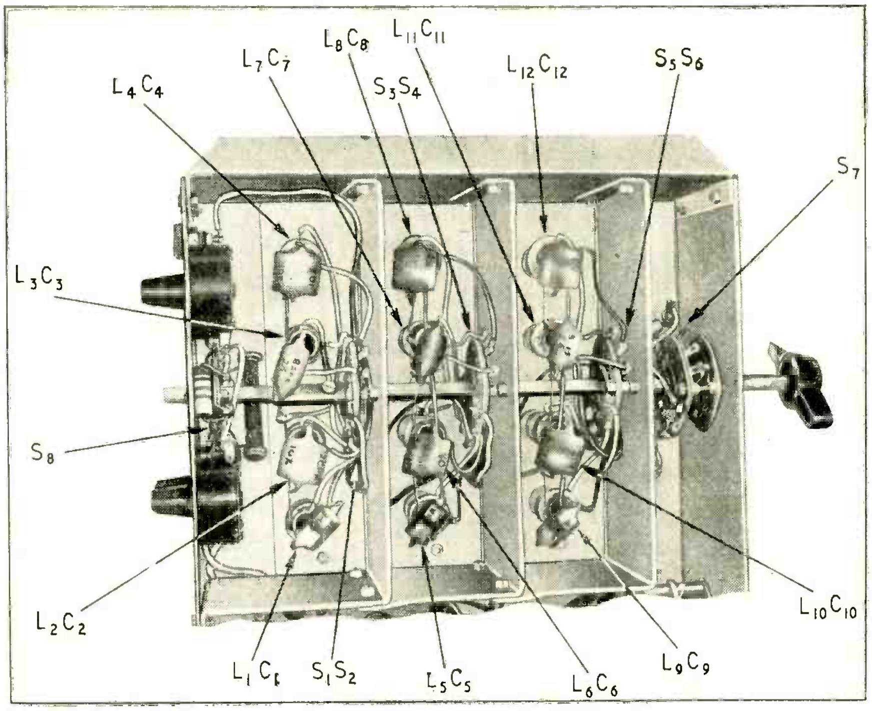
2 telephone jacks, 2-point	Igranic or Bulgin
Mains connector	Bulgin
Twin fuseholder	„
1 octal valveholder	„
5 B7G valveholders with cans	Belling & Lee
2 telephone-type plugs, 2-point	Bulgin
Aerial socket and plug	Belling & Lee

C_{33}-C_{34}—not, for instance, C_{32} and C_{33} together. These switches are often fitted with earthing strips which short-circuit some of the contacts not in use. If these are fitted they must be removed, as they upset the tone-control connections.

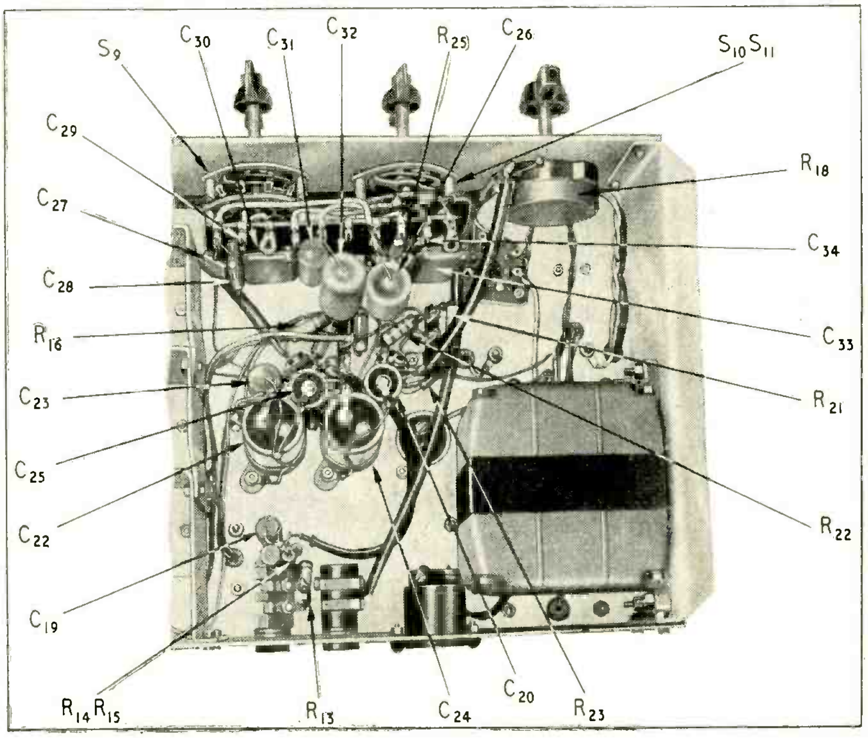
To assemble the unit the spacer tubes on the screws holding the switch wafers to the click-plates are removed, sawn in half and replaced with the switch wafer between the halves. The ends of the screws in question are then passed through holes in a suitable tag-board and the nuts replaced. The components are mounted on the tag-board and wired to the switches and the whole is then fixed to the main chassis by the panel-fixing nuts. As the switches are rigidly fixed to each other by the tag-board, the locating tags provided to prevent rotation on the panel need not be used. C_{26} and R_{26} are also mounted on the tag-board, so the only connections to this unit are from the anode of V_5 and from the output jack. This latter lead should be screened and the screening joined to the jack sleeve terminal and earthed at one point only. The earth connection on the unit is taken to one of the screws holding the switches to the tag-board.

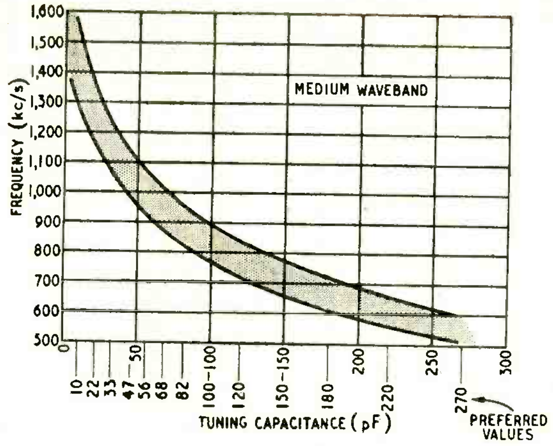
The r.f. coils are tuned by dust-iron cores, suitable fixed capacitors being chosen to bring the desired frequency within the range of adjustment. The whole range can be covered by preferred values of capacitance with a selection tolerance of ±10%. The two curves for the medium and long wavebands show frequency versus capacitance for the upper and lower limits of inductance and give preferred values of capacitance assuming 40pF strays. In the present case the values selected are 47pF for the 1,214-kc/s Light Programme (C_1-C_5-C_9), 82pF for the 908-kc/s Home Service (C_2-C_6-C_{10}), 220pF for the 647-kc/s Third Programme (C_3-C_7-C_{11}) and 220pF for the 200-kc/s long-wave Light Programme (C_4-C_8-C_{12}), and have all been found to tune in the station without difficulty.

The three circuits for each station are normally tuned for maximum signal, but the sensitivity is such



Underside of the r.f. end (above) and a.f. end (below) of the chassis



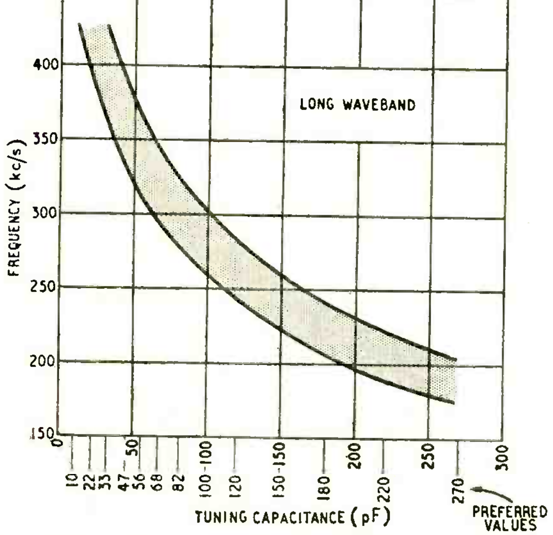


These two curves enable preferred-value capacitors to be selected for tuning on the medium waveband. They represent the upper and lower limits of inductance of the adjustable tuning coils, so the shaded area between indicates the range of adjustment.

that the improved bandwidth obtained by stagger-tuning can be taken advantage of, provided that interference from neighbouring stations is not troublesome. It may, in fact, be found that the circuits cannot be aligned exactly without trouble from instability, particularly where the tuning capacitors are small and there is a very high circuit Q. In the first stage this can be overcome by adjustment of the appropriate pre-set resistor in the cathode circuit of V_1, but if the second stage is unstable it may be necessary to increase the value of R_{10}. It must be pointed out that small changes in layout have a very considerable effect on stability and each separate case will need different treatment.

Adjusting the Coils

If stations other than those mentioned above are better received in a particular locality, the capacitance values for them can be selected from the curves—



Curves for tuning by preferred values on the long waveband.

and of course there is no reason why two stations should not be on the long waveband and two on the medium; alternatively the long waveband can be cut out altogether and all four stations selected from the medium waveband.

Incidentally, the coils as supplied do not have any means of locking after adjustment and there is a danger of the cores shifting and so upsetting the tuning. This can be avoided by securing the adjusting screw of each coil with a 4 B.A. brass lock-nut. The best way to do it is to slide the nut on to the shaft of a thin screwdriver, use this for adjusting the coil, then, holding the adjusting screw steady with the screwdriver, run on the nut and finally tighten it against the coil-fixing column. This method ensures that the tuning is not disturbed when the lock-nut is tightened.

A separate power-pack is included in this unit to avoid the difficulties which might arise in obtaining h.t. and l.t. from the amplifier with which it is to be used. The mains transformer has a 350-0-350-V winding because, although such a high voltage is not really necessary, its use is no disadvantage and it enables a standard transformer to be used. Two stages of smoothing are incorporated to keep hum to a minimum. No mains switch is fitted as it is assumed that the supply to the whole equipment will be controlled by one switch.

COMPONENT SPECIFICATIONS

TWO new specifications covering air and mica dielectric pre-set capacitors have recently been issued by the Radio Industry Council. In common with other specifications of this kind the components are classified into three main groups, red, yellow and green respectively, which indicate the climatic conditions, in this descending order of severity, for which they are suitable. The specified tests are also based on this colour classification.

Sections 1 and 2 only are available covering performance requirements and production tests for all three groups. Section 3 of each dealing with types, values and sizes will follow later.

Specification RIC/143 deals with variable pre-set mica dielectric capacitors and covers single- and multiple-plate types. It is specified that the single-plate type shall be variable between limits of 2-15 pF, 3-30 pF or 4-40 pF. Actual values of the multiple-plate type will be defined in section 3 when issued, but the largest capacitance has been fixed at 3,000 pF. The maximum working voltage is 150 d.c.

Variable pre-set air dielectric capacitors are dealt with in RIC/142 and covers rotary flat-plate and concentric-vane types. Ranges, values and voltage ratings will be given in section 3 when issued.

Now available is section 3 of RIC/131 covering paper dielectric tubular capacitors. Four varieties are listed, type C, ceramic cased: type M, metal cased; type S, metal cased with one terminal connected to case and type W, wax coated.

Intended for use within the radio industry, copies of these specifications are obtainable from The Radio Industry Council, 59, Russell Square, London, W.C.1, and they cost 7s 6d for sections 1 and 2 of RIC/142 and 5s for RIC/143, sections 1 and 2. Section 3 of RIC/131 costs 2s. All prices include postage.

Continental Gramophone Records

New Long-playing and Variable Groove Pitch Types

From a Correspondent

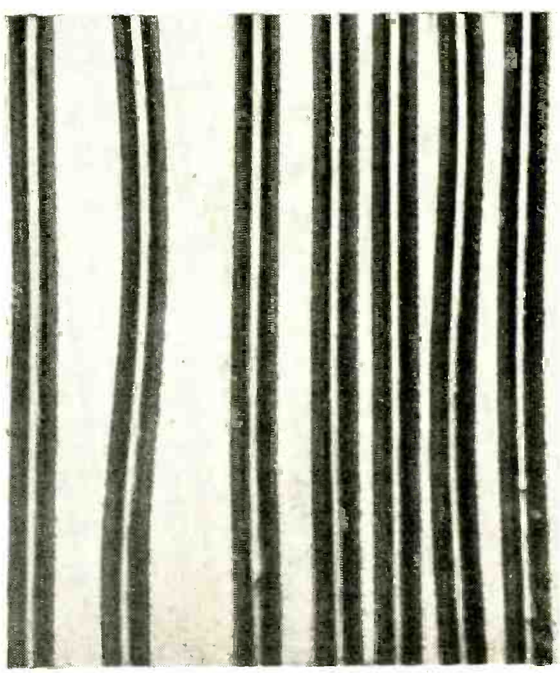
IF an analysis were made of the amount of research into the various aspects of gramophone recording and reproduction, it would probably be found that the time devoted to the economics of record production and material cost is very much less than that of any other aspect of the art. It is only within the last few years that any serious attempt has been made to overcome the large bulk and high cost of records, notable examples being the American R.C.A. 45-r.p.m. records, giving a playing time of approximately five minutes on a 7in disc, the American Columbia L.P. and the British Decca, 33⅓-r.p.m., giving playing times of over 20 minutes on a 12-in disc, against approximately five minutes for the 78-r.p.m., 12-in disc. The long-playing records have the added advantage of greater signal-to-noise ratio, but unfortunately the higher cost of the vinyl resin compared with shellac does militate against the use of low-noise unloaded resins for 10in or 12in, 78-r.p.m. discs.

The long-playing record at 33⅓ r.p.m., using a 0.001in radius stylus, has been available in this country for some time, and is now finding ready acceptance among enthusiasts. Philips of Holland have recently announced long-playing records with the same characteristics as the American Columbia L.P.s. On these records the pre-emphasis above 3 kc/s is somewhat greater than the British Decca. They are pressed from the same type vinyl resin as the American and British records

The long-playing records just mentioned require a turntable speed other than the standard 78 r.p.m., and this considerably increases the cost of the gramophone turntable system, apart from special compensating networks for a different type of recording characteristic. One solution to the economics of the situation is provided by the new 7-in "Minigroove" records produced by Philips of Holland. These are 78-r.p.m. vinyl pressings with a fine-groove recording, requiring a 0.001-in radius stylus. They give a playing time of approximately 4½ minutes, and are cut to effectively the same characteristics as the standard 78-r.p.m. records produced in this country. The diameter of the inner groove is only 3¼in, but in view of the small stylus diameter (0.001in) and the high lateral groove speed, tracing distortion is no worse than the best 78-r.p.m. standard records. The recordings sound very clean, and the absence of background noise is a decided advantage over the shellac pressings. The recording level is about 3 to 6 db lower than standard commercial records available in this country, but is usually sufficient to load fully the average radio receiver or amplifier. One disconcerting feature of the small-diameter inner groove is that on some record players the automatic stop mechanism trips before the end of the record, and in a few cases, where a positive stop is provided for the tone arm, the unfortunate groove gets chewed up! In spite of the high cost of the vinyl plastic, the small size of the record results in the selling price being no greater than that of a 12-in shellac record of the same playing time.

It has been contended that space is wasted on normal recording systems because the groove pitch must be such that no over-cutting occurs in the loudest passages, which occur only for a small fraction of the total playing time. One solution is to use a vari-

Photomicrograph showing variable groove pitch in a Deutsche Grammophon Gesellschaft recording of a violoncello sonata. (Photo by C. E. Watts.)



able groove pitch, with the grooves close together on soft passages and wider apart on loud passages.

In order to obtain a variable groove pitch which is dependent on the amplitude of the recording, two requirements must be fulfilled: (a) an infinitely variable gear ratio (giving pitches between 90 and 300 grooves per inch) between the turntable and lead screw, and (b) a means of anticipating high recording amplitudes by at least one revolution of the turntable.

In the simplest system, the gear ratio is varied manually, together with the master gain control in such a manner that on crescendos and loud passages, the groove pitch is increased. This requires that the control engineer has a score, is able to read it, and has an extra knob to twiddle in anticipation of the loud passage. In an ideal automatic system, the variable gear ratio should be controlled directly from the signal current by means of a servo system with some electronic or mechanical means for anticipating the variations in signal strength. The practical interpretation of a system is to record on magnetic tape and to use two playback heads, spaced in time one revolution of the record apart, the first playback head providing the control current of the servo system operating the variable gear ratio (and thus the groove pitch), and the second head providing the recording signal with the necessary delay.

As most of the original recording is now done on tape and then dubbed on to the disc, this system is not really so complicated as may seem at first sight, the only extra apparatus required on the tape reproducer being one playback head together with the necessary amplifier and servo system.

Two Continental series, "Deutsche Grammophon Gesellschaft" and "Archiv," are being recorded with variable groove pitch, and a playing time of $7\frac{1}{2}$ minutes is obtained for a dynamic range of 36 db with 12-in discs. These records have some pre-emphasis approaching the Decca "ffrr" characteristic. They are pressed on shellac, which unfortunately is not always of the high quality to which we are accustomed in this country, and some of the pressings exhibit a rather high surface noise.

One useful feature with the "Archiv" discs is the information sheet which is supplied with each record, giving all details of the particular record. It is a procedure which, if extended to give technical details, such as pre-emphasis, top "roll-off," dynamic range, maximum level, etc., can be commended to the British record companies.

LONG-DISTANCE RADIO JUBILEE

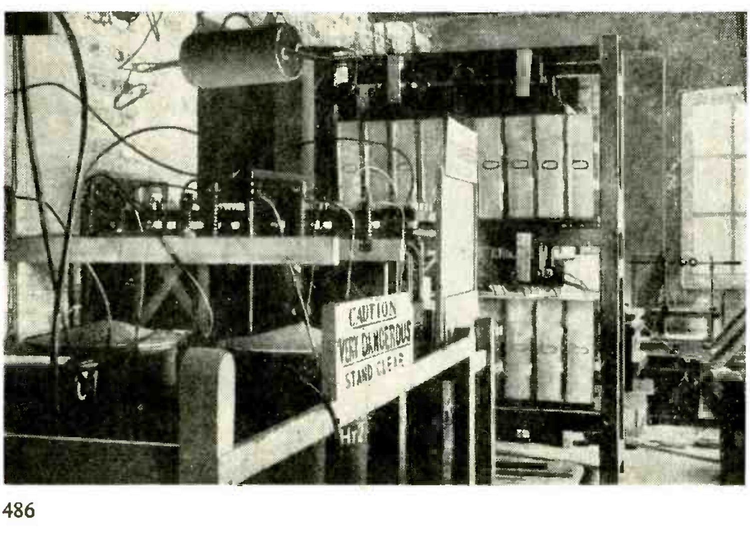
FIFTY years ago this month the possibility of long-distance radio communication was proved by the success achieved by Marconi in the first transatlantic wireless transmission. It was on December 12th, 1901, that young Guglielmo Marconi, then only 25 years old, received in Newfoundland, with the simplest possible apparatus, single-letter signals transmitted from Poldhu, Cornwall.

The story is so well known that it hardly needs repeating—the building of the 12-kW station at Poldhu (many times more powerful than that used in earlier experiments), the wrecking of the transmitter aerial by a gale shortly before the experiment, the kite receiving aerial at Signal Hill, Newfoundland, and the reception of the prearranged signal, the letter "S" in morse.

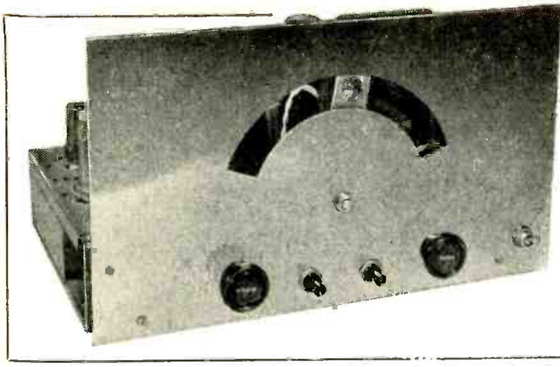
Marchese Luigi Solari, who is believed to be the only survivor of Marconi's original band of collaborators, has sent us some interesting reminiscences of the experiments, during which he was present at Poldhu. It was, in fact, a Solari mercury coherer, connected in series with a telephone and the aerial, which was used by Marconi for the reception of the signals.

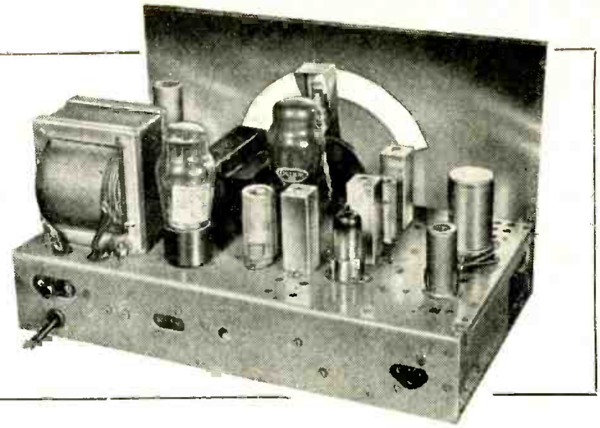
It has often been asked why the letter "S" was used as a test signal for the experiments instead of the letter "V," which is normally employed as a test signal. According to the Marchese, the consecutive dots were more readily distinguishable from the atmospherics, which produced sounds "like that of long dashes."

Within a few weeks of Marconi's initial success he received on board the American liner *Philadelphia* complete messages transmitted from Poldhu at a distance of 1,551 miles and of single letters up to 2,099 miles. He was then on his way to Canada to erect the Marconi Wireless Telegraph Co.'s station at Glace Bay, which was used for the first commercial transatlantic service. Incidentally, Marconi's experiments at Signal Hill came to an abrupt end when, to quote from his article in *Wireless World* on the 25th anniversary of his successful experiments, "I was notified on behalf of the Anglo-American Telegraph Company that, as they held a charter giving them the exclusive right to construct and operate stations for telegraphic communication between Newfoundland and places outside the Colony, the work upon which I was engaged was a violation of their rights."



POLDHU. Some of the early apparatus at the Marconi station at Poldhu. On the extreme left are the transformers; the banks of condensers are carried in metal containers in the wooden rack and the spark gap consisting of two steel spheres mounted on insulating rods is visible on the right.





DESIGN FOR AN

(Concluded from page 444 of previous issue)

F.M. Receiver

By
J. G. SPENCER*

2.— Circuit Alignment and Performance Specification

A DESCRIPTION of the receiver and details of the coils and transformers having been given in the first part of this article, attention can now be turned to the important subject of aligning the various circuits.

Alignment of the I.F. Amplifier.—The nominal intermediate frequency is 8.2 Mc/s but this is not critical and any value between 8.0 Mc/s and 8.5 Mc/s is satisfactory. The two i.f. transformers are adjusted for critical coupling and this should be obtained with the coil spacing given in the winding data. It is possible that with slight differences in chassis wiring the stray external coupling capacitances will differ and it is worth checking the response curve of each transformer to ensure that the coupling is correct.

For the i.f. output meter the most suitable device is a microammeter connected in series with R_{15} at its earthy end, but if no meter sufficiently sensitive to give an accurately readable deflection on 10 μA is available, the output valve can be pressed into service as a d.c. valve voltmeter. To do this, remove V_5 and connect the grid of V_6 to the junction of R_{13} and R_{14}. The i.f. output can then be measured with a voltmeter connected across R_{29}.

When using V_6 in this way it is advisable to keep the input voltage within the range of $\pm$ 4 V, in order that the cathode voltage shall be linearly proportional to the input. A change of grid voltage of 4 V gives a change of cathode voltage of approximately 1.8 V.

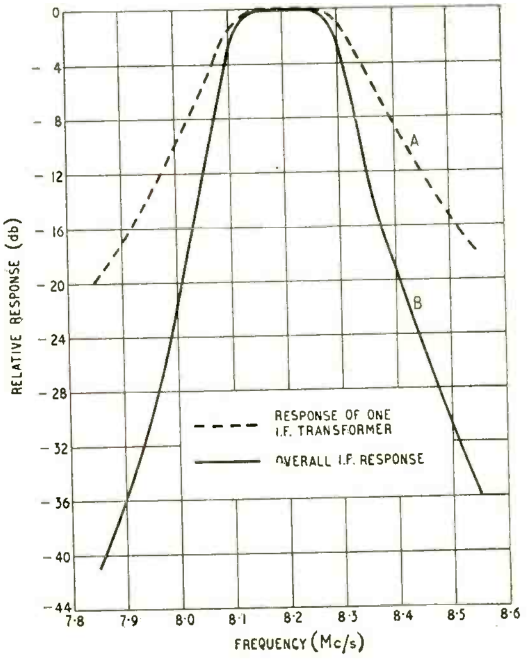
Disconnect C_7 at its junction with R_5 and connect a 1,000 $-\Omega$ resistor between the control grid of V_2 and earth. Connect the output of the signal generator across this resistor.

Set the signal generator to a frequency of 8.2 Mc/s and adjust the cores of L_6, L_7, L_8 and L_9 for maximum output.

Then connect a 2.2 $-$kΩ resistor across L_6 and a similar resistor across L_7, this will damp these circuits to such an extent that they are substantially flat over the pass band, increase the signal generator output until a readable output-meter deflection is obtained and plot the response curve of the second i.f. transformer.

If the coupling between L_8 and L_9 is correct the curve of Fig. 4(A) will be obtained, substantially flat topped and 3 db down at approximately $\pm$ 120 kc/s. If the coupling is too great the curve will be wider and will show two "humps," conversely if the coupling is too weak the curve will be narrower. If any adjustment of the spacing between L_8 and L_9 is necessary

Fig. 4. I.F. response curves centered on 8.2 Mc/s. Curve A is response of one transformer (L_8, L_9); curve B is overall response when correctly aligned.



*Research Department, B.B.C.

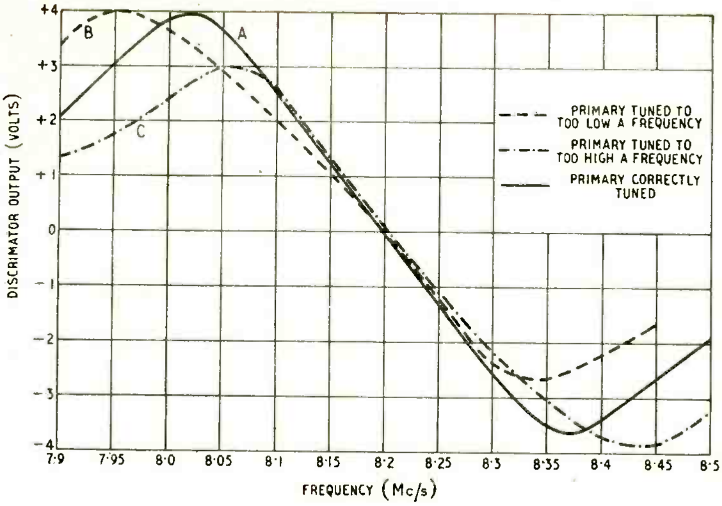


Fig. 5. Form of curves produced by various adjustments of discriminator transformer (L_{10}, L_{11}). Curve A shows correct tuning, Curves B and C mistuning of secondary circuit.

both circuits should be retuned after such adjustment. This process should be repeated for the first i.f. transformer with L_8 and L_9 each damped with 2.2 kΩ.

For this part of the alignment the d.c. output from the grid of V_4 should not be more than figure 1 V to avoid overloading V_3. The response curve obtained should be similar to that for the second i.f. transformer.

Finally, remove the damping resistors and plot the i.f. overall response curve. This should be ±100 kc/s wide at the 3-db down points as shown in Fig.4(B).

The Discriminator.—(1) Disconnect C_{26} from L_9 and connect signal generator output between the free side of C_{26} and earth. Set signal generator to 8.2 Mc/s and output to figure 1 V.

(2) Disconnect h.t. supply to V_5 and short circuit R_{26}.

(3) Connect voltmeter across R_{29}.

(4) Connect junction of R_{21} and R_{22} to grid of V_6 through a 500-kΩ resistor.

(5) Adjust trimmer of L_{10} for maximum downwards deflection of voltmeter.

(6) Remove 500-kΩ resistor from junction of R_{21} and R_{22} and connect to junction of R_{21} and R_{23}.

(7) Adjust trimmer of L_{11} for zero output (i.e., earthing the grid of V_6 gives no change of voltmeter reading).

(8) Repeat steps 4 to 7 once more.

The discriminator response curve of output against frequency should now be plotted and if the alignment is correct it will be similar to that shown in Fig. 5(A) linear over a range of ± 120 kc/s and with the positive and negative peaks of approximately equal amplitudes situated ±170 kc/s from the centre zero. If the bandwidth is narrower than this the coupling between L_{10} and L_{11} should be increased and vice versa.

The effect of primary mistuning is to shift both peaks of the curve in the same direction, so that they are unequally spaced from the zero point, and also to make their amplitudes unequal. This effect is shown in Fig.5(B) and (C). Mistuning of the secondary will shift the frequency of zero output.

R.F. and oscillator circuits.—To check that the oscillator is functioning insert a milliammeter between the low potential end of R_8 and the cathode of V_2 and measure the oscillator grid current. This should be of the order of 40 μA. If no grid current is observed check that L_4 is connected in the correct sense and reverse the connections if necessary. A signal generator covering the 90-Mc/s band will facilitate the r.f. alignment but it is not essential as almost any generator whose oscillator fundamental frequency goes up to 10 Mc/s or above will generate harmonics in the required range and of sufficient amplitude for the purpose.

First set C_{17} to mid scale and C_{18} to minimum capacity, adjust the cores of L_2 and L_3 to the middle of their travel and *switch the receiver to a.m.*

If the harmonic method is used set the signal generator to the highest available integral sub-multiple of 91.2 Mc/s, switch on modulation and adjust the oscillator trimmer, C_{18}, until the signal is heard. Then adjust L_2 and L_3 for maximum output, reducing the signal generator output if necessary to prevent the action of a.g.c. from masking the effect of the tuning adjustments.

If a low frequency fundamental is being used it may be possible to align the receiver on the wrong harmonic and to check this rotate the signal generator tuning until the next harmonic reponse is heard. Note the frequencies at which these two adjacent responses occur. Let these two frequencies be f_1 and f_2 and the frequency to which the receiver is tuned be f_0, then

$$f_0 = \frac{f_1 \times f_2}{f_1 - f_2}$$

Two points must be borne in mind when aligning on harmonics. In the first place only the fundamental ranges of the signal generator should be used. It is quite common practice for the highest range to be on a harmonic of the fundamental oscillator frequency and if this is employed the formula given will not hold good.

Secondly, care must be taken to avoid confusion from image responses in the receiver, the local oscillator frequency is *below* that of the carrier and the image frequency is therefore 16.4 Mc/s *lower* than the signal.

When the r.f. circuits are lined up there is little possibility of error since they attenuate the image frequency by some 30 to 40 db, but if the r.f. circuits are off tune in the initial stages of alignment the image response may be comparable in amplitude with that of the primary signal.

Aerials. — The B.B.C. experimental v.h.f. transmitter at Wrotham radiates f.m. and a.m. on frequencies of 91.4 Mc/s and 93.8 Mc/s respectively, both transmissions being horizontally polarised. It has a nominal service area of approximately 60 miles radius, but at these frequencies the intensity of the field at any point is greatly influenced by local topography and areas of low field strength may occur within this distance.

Generally speaking, however, a horizontal dipole, 5 ft. 1 in long, erected at roof height and broadside on to the transmitter should give an adequate input to the receiver, even at the edge of the service area. If any difficulty is experienced, the aerial should be tried in different positions, since the field strength can

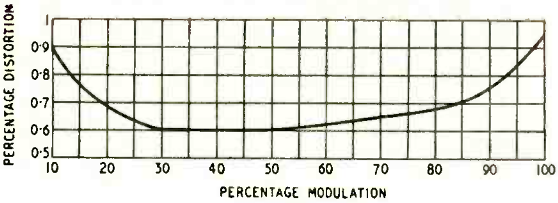
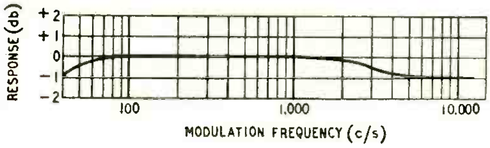


Fig. 6. Curve showing harmonic distortion with depth of modulation.

Fig. 7. Curve showing modulation frequency response when corrected for pre-emphasis.



differ considerably between points only a few feet apart.

In many cases there will be no need for more than a simple indoor aerial, such as a length of twin flex connected to the receiver and opened out at the far end to form a dipole, which can be laid along the picture rail or on the floor.

At a receiving site rather more than 20 miles from the transmitter the receiver has been found to work quite satisfactorily with a length of wire 30 in long connected to one aerial socket and hanging vertically downwards. In view of the complex standing wave pattern set up inside a building at v.h.f. it is even more important with indoor aerials than with those erected in the open to try the effect of varying the position of the aerial.

Test Instruments.—The essential test instruments required for aligning the receiver are a d.c. voltmeter reading 0-10 volts and a signal generator covering the intermediate frequency of 8.2 Mc/s.

The absolute frequency accuracy of the latter instrument is not important but it must be capable of being adjusted in small increments of frequency, not more than 50 kc/s, with a fair degree of accuracy. This facility is essential for taking response curves of the i.f. transformers and discriminator.

A microammeter with a full-scale deflection of the order of 100μA and a signal generator covering the 90-Mc/s band are of great assistance if available but they are not essential provided harmonics in this band can be obtained from the signal generator used for the i.f. alignment.

Performance Specification

The following results of performance tests made on the prototype receiver will be of interest as a final check on performance. All measurements of signal-to-unwanted-response ratio were made with a square-law meter preceded by an aural weighting network, a method which has been found to give results in close agreement with subjective assessments†.

Absolute sensitivity.—Carrier input required with 40 per cent modulation to produce 50 mW output = 19 μV.

Maximum deviation sensitivity for 10 *per cent harmonic distortion.*—Carrier input required to produce 10 per cent distortion with 100 per cent modulation at 400 c/s and with 50 mW output = 60 μV.

Sensitivity for 40 *db signal to noise ratio.*—Carrier input required with 40 per cent modulation to produce 40 db output signal to noise ratio = 40 μV.

The three foregoing sensitivity measurements were all made at the mid-band signal frequency and will be some 6 db worse at the limits of the tuning range due to the drop in response of the r.f. circuits.

Signal to hum ratio.—Modulation depth required to produce 40 db signal to hum ratio with a carrier input of 10 mV = 0.9 per cent.

Harmonic distortion, variation with modulation depth.—See curve Fig. 6. For this test the gain control setting is fixed at a level which gives 50 mW output with 40 per cent modulation.

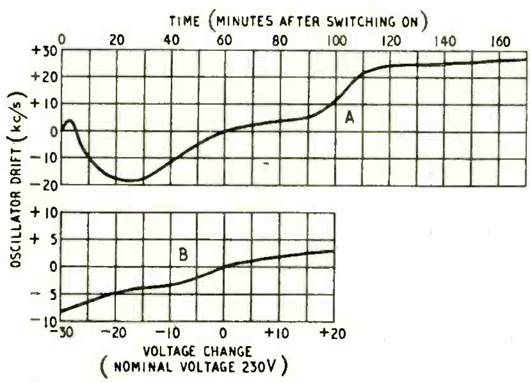
Maximum output power for 10 *per cent harmonic distortion.*—Carrier modulation 100 per cent at 400 c/s = 2.0 watts.

Modulation frequency characteristics.—(Output level of 50 mW.) See curve Fig. 7.

Adjacent channel suppression ratio.—Ratio of amplitude of interfering carrier, modulated 40 per cent, situated on the adjacent channel to that to which the receiver is tuned, i.e. spaced by ± 200 kc/s which produces a signal to interference ratio of 40 db to the wanted carrier, latter modulated 40 per cent :—
+ 200 kc/s = − 10 db ; − 200 kc/s = + 3.5 db.

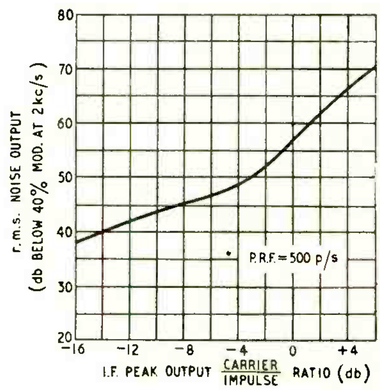
Second and third channel suppression ratio.—As

† "Electrical Noise"; Maurice, Newell and Spencer. *Wireless Engineer*, January, 1950.



Left: Fig. 8. Local oscillator frequency stability; curve A initial drift with temperature compensation; curve B drift due to mains fluctuations.

Right: Fig. 9. Impulse interference performance curve.



above but with the interfering carrier spaced ± 400 kc/s and ± 600 kc/s from the wanted carrier :—

+ 400 kc/s = + 14.5 db
− 400 kc/s = + 23.5 db
+ 600 kc/s > + 30 db
− 600 kc/s > + 30 db

Image channel suppression ratio.—As above but with interfering carrier at image frequency = + 13 db.

Intermediate frequency suppression ratio— as above but with interfering carrier at i.f. = + 29·4 db.

Spurious frequency suppression ratio.—As above but with interfering carrier at any frequency likely to produce a spurious response, *e.g.* by beating with local oscillator harmonics etc. Two spurious responses were found, at signal frequency plus and minus intermediate frequency respectively and both required the interfering carrier to be + 22 db relative to the wanted carrier.

Local oscillator drift.—See curve (A) Fig. 8.

Dependence of local oscillator frequency upon mains voltage.—See Curve (B) Fig. 8.

Co-channel suppression ratio.—As for adjacent channel but with interfering carrier adjusted to within ± 1 kc/s of the wanted carrier = − 11 db.

Amplitude modulation suppression.—Ratio of output due to f.m. to output due to a.m. when the receiver is tuned to a carrier simultaneously amplitude and frequency modulated to depths of 40 per cent = 30 db.

Impulsive interference performance.—See curve Fig. 9 in which the output signal-to-noise ratio is plotted against the peak impulse to carrier ratio at the output of the i.f. amplifier.

SHORT-WAVE CONDITIONS

October in Retrospect : Forecast for December

By T. W. BENNINGTON*

DURING October the average maximum usable frequencies for these latitudes increased considerably during the daytime, and decreased considerably by night, which variations were in accordance with the normal seasonal trend.

Daytime working frequencies were fairly high, 22 Mc/s being consistently usable over east/west paths under undisturbed conditions. On very few occasions, however, were higher frequencies than this usable. Over north/south paths frequencies up to 26 Mc/s were usable during undisturbed days. At night 7 and 6 Mc/s were generally the highest usable frequencies after midnight.

There was a further small decrease in the amount of sporadic E recorded.

There was a considerable decrease in the average sunspot activity during the month. Since the big decrease in the general level of sunspot activity which occurred in the autumn and winter of 1950, the decrease has been much more gradual, with the result that the level of activity is not very greatly lower than it was at this time last year.

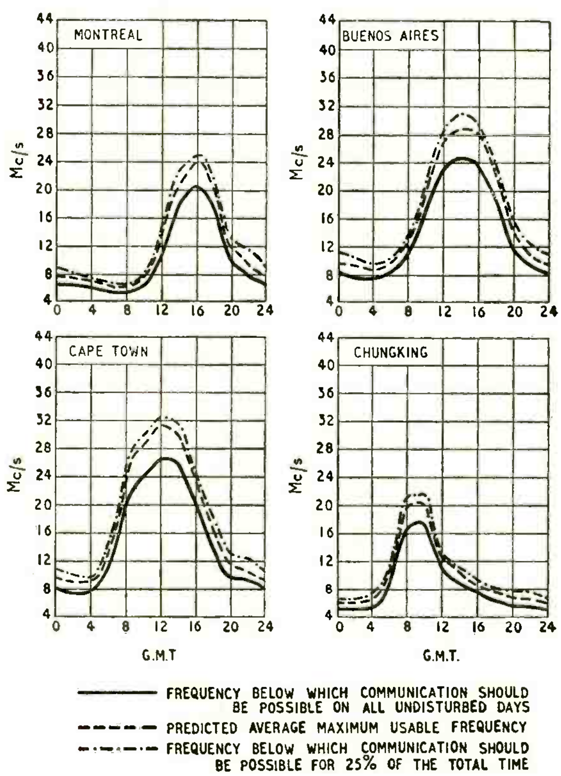
Though less disturbed than September, October was yet a very disturbed month. The ionospheric storms were accompanied by severe magnetic storms and by auroral activity in this country, and "great magnetic storms" were recorded on 17th and 28th. The most disturbed periods for short-wave conditions were 8th-11th, 13th-14th, 16th-23rd, and 28th-29th. No Dellinger fadeouts have, as yet, been reported.

Forecast: During December a small decrease in the daytime m.u.f.'s for these latitudes is to be expected, as compared with those for November. At night there should be a further considerable decrease in m.u.f.'s, and perhaps the lowest values for the coming winter season will occur during the month.

Working frequencies should, therefore, be reasonably high during the peak day period and very low by night, whilst over a considerable part of the daily period only medium-high frequencies will be usable. On east/west circuits frequencies up to about 20 Mc/s should be regularly usable, and those a few megacycles higher sometimes so. At night low frequencies will be necessary, and after midnight even 6 Mc/s may be often too high. Over north/south circuits frequencies up to 26 Mc/s should be regularly usable during the daytime, and 7 Mc/s be about the highest usable frequency after midnight.

Sporadic E capable of propagating very high frequencies is unlikely to be prevalent, and medium-distance communication on high frequencies is, therefore, unlikely to occur.

The curves indicate the highest frequencies likely to be usable over four long-distance circuits from this country during the month.



*Engineering Division, B.B.C.

Radio for Taxis

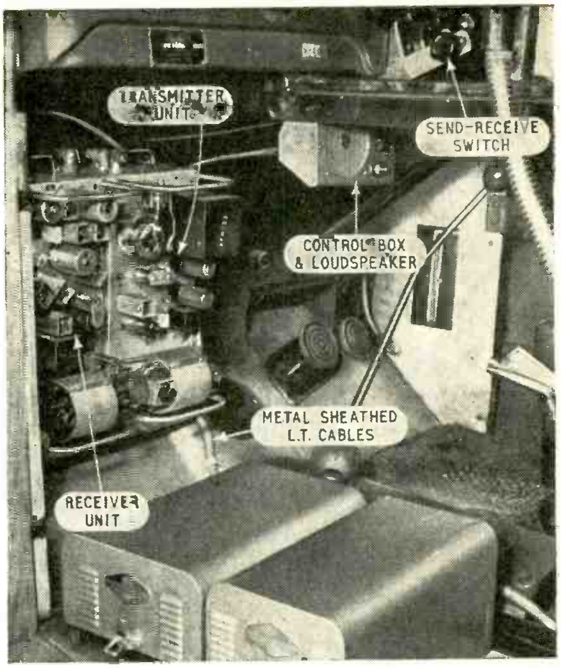
Ambitious Scheme for the London Area

THE use of radio-telephones in private hire vehicles is not a new departure, neither is its extension to taxicabs, but installations of this kind can often provide some interesting technical problems. A case in point is the somewhat ambitious scheme launched recently for fitting a large number of London's taxicabs with two-way v.h.f. radio-telephones. An initial target of 1,000 cabs is visualized, with a single radio centre handling all line and radio traffic. The scheme is well under way and taxis participating in it can be identified by the short vertical aerial, little more than a foot in length, mounted well forward on the roof of the cab.

Radio equipment for this scheme is supplied by Pye Telecommunications, but it was not necessary to design equipment especially for the purpose as their existing v.h.f. mobile sets Type PTC115, with a few modifications, meet the requirements of the taxis and the Type PTC704 that of the radio centre.

These two equipments are for operation in the band 100-184 Mc/s, the actual frequencies employed being 172.8 and 182.8 Mc/s. Although two frequencies are available a duplex system is not used since all messages are brief.

Despite the use of such a high carrier frequency no difficulty has been experienced from attenuation in the vast built-up area of London and although the scheme has now been in operation for several months not a single blank area has so far been encountered. One transmitting site only is used, but it is located on very high ground on the northern outskirts of the metropolis.



Early stage in fitting Pye Type PTC115 v.h.f. radio in one of London's taxis. Covers are not yet in place and the partition between driver and luggage space has not yet been replaced. Below: Experimental corner reflector type aerial under test for standing wave ratio on feeder. A slotted section of feeder is used.

Amplitude modulation is employed and the r.f. power output from the fixed and mobile equipments is approximately 12 watts. This gives a good solid signal anywhere in the London area and quite sufficient to override all traffic noises in the taxis, which have to be fitted with loudspeakers in order that the driver's attention should not be distracted from his primary function of driving, which might well be the case if a calling device in the form of a buzzer or lamp were used and the driver required to search for and pick up a hand telephone set.

This requirement gave rise to two other problems; one was how to operate the send-receive switch without removing the hand from the driving wheel, and the other the positioning of the microphone. These two are really a single problem as in most mobile equipments using hand telephone sets the send-receive switch is embodied in the handgrip when a simplex system is used.

Speaking into the microphone from any distance is quite impractical on the road as the voice will more often than not be drowned by the noise of passing traffic. A little ingenuity was required to avoid the necessity to pick up the microphone and at the same time have it sufficiently close to the mouth.

In the case of these radio-equipped taxis the microphone it carried by a horizontal swivelling arm attached to a vertical rod mounted on the glass partition which divides the drixers' compartment from the luggage space. This arm can be moved up or down and clamped in any position and also swung to or away from the glass partition. In the operating position it is adjacent to the driver's mouth and slightly to his left. He can speak into it without actually turning his head and taking his eyes off the road.

The difficulty of the change-over switch was overcome by mounting a press-to-talk switch on an arm extending out from the instrument panel in the driver's compartment and terminating just below the rim of the steering wheel on the left-hand side. The knob of the switch projects outward, that is, to the left, and by extending the first two fingers of the left hand it is quite easy to operate the switch without relaxing the grip on the wheel.

As the equipment is remotely controlled, it is possible to accommodate the bulk of it anywhere in the vehicle. The only items that must be convenient to the driver are the remote-control box (with built-in speaker), send-receive switch and microphone.

The taxis we saw fitted were Austins and the radio transmitting and receiving units are mounted in a small recess in the front part of the luggage compartment. Owing to its awkward position and shape it is not very useful for luggage, so that fitting the radio here leads to no worth-while loss of luggage capacity. The space is just large enough to take the two radio units and their anti-shock cradle mounted on end, as shown in one of the illustrations, and it is then enclosed by a stout metal panel to protect the sets from possible damage. This had not been fitted when the photographs were taken, neither had the partition between the driver's cab and luggage compartment been reinstated as it was desired to show as much of the apparatus as possible. For example, the control unit is included and so is the arm carrying the send-receive switch, also the armoured cable connecting the radio units to the battery, which in these taxis is accommodated below the driver's seat.

With a 12-volt supply the receiver consumption is about 4.5 A; current rises to 6 A when the transmitter valve heaters are switched on; that is to say, when the whole equipment is in the "stand-by" condition and ready for immediate use. With the transmitter in operation the consumption rises to 14 A, but this latter demand is for only very short periods. Nevertheless, a larger-capacity battery than usual is desirable and so is a dynamo giving a somewhat greater charging rate.

The receiver of the PTC115 is a double-superheterodyne having 11 valves in all. They are miniature types, and so the sets can be kept reasonably small; the two units together measure $16\frac{3}{4}$ in wide, $15\frac{1}{2}$ in deep and 8 in high, and the total weight is 40 lb. The valve arrangement of the receiver is, briefly: one r.f. stage; first mixer with local oscillations fed from the frequency multiplier of a crystal oscillator; second mixer with local oscillations fed in from the crystal oscillator stage; two i.f. stages with eight tuned circuits at about 3 Mc/s (2nd i.f.); signal detector and a.g.c.; noise limiter, a.f. and output stages. Grid bias for all valves is taken from a resistor connected in the h.t. negative lead in preference to separate cathode resistors. This is a widely used system in commercial radio equipments, and also in many Service sets, and no doubt the saving effected in cathode resistors and capacitors, especially where a fairly large number of valves is used, accounts for its popularity.

A signal to noise-operated muting circuit with three valves and a relay, for suppression of all receiver noise in the absence of a carrier, can be included in the receiver if required.

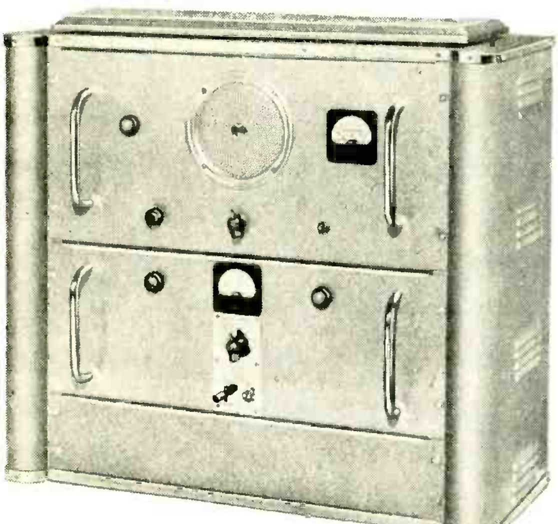
In the companion transmitter there are seven valves, in this case a mixture of octal, miniature and special types. The first stage is a crystal oscillator and combined frequency doubler, the second is a frequency tripler, the third (two valves) a push-push (anodes parallel, grids push-pull) doubler and the fourth a push-pull r.f. power amplifier, the valve used here being a double tetrode, the American type 832. The remaining two valves are a pair of 6V6s operated as a push-pull modulator with the microphone output applied to their grids via a step-up transformer. There is no intermediate amplifier.

High tension for both units is supplied by small rotary generators, one machine being used for the receiver and part of the transmitter, and the other for the remaining valves in the transmitter.

A point of interest regarding the installation in the taxi is that all permanent wiring for the radio, such as l.t., microphone input, loudspeaker output, and relay circuits, terminates at the anti-shock cradle. The "take-off" from the cradle to the transmitter and receiver units is by means of self-aligning plugs and sockets, so that either unit can be easily removed for replacement in the event of a fault, or for a routine check-up in the maintenance department without disturbing a single wire with the exception of the aerial cable.

The fixed station (Pye Type PTC704) is entirely automatic in operation and is controlled over Post Office lines from a radio centre near King's Cross. Transmitter and receiver are duplicated and should a fault develop the stand-by set comes into operation immediately. As a further insurance against breakdown, a stand-by set is installed at the radio centre with an aerial on a 100-ft mast.

Circuit layouts are very similar to those of the respective mobile equipments, with the exception that as the whole station is operated from the a.c. mains,

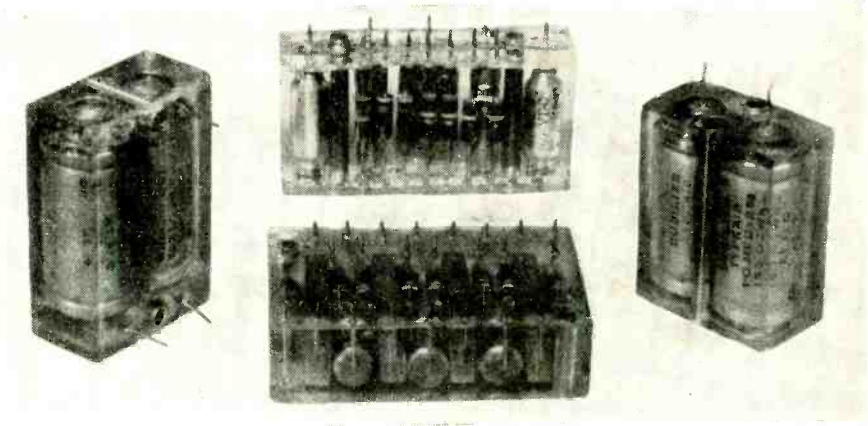


One of the Pye Type PTC704 v.h.f. radio telephone equipments used at the fixed station and as stand-by at the radio control centre.

size, weight and consumption are not important and several refinements can be included. For example, a moving-coil microphone is used which demands a few extra audio stages in the modulator, a signal-noise operated muting circuit is permanently built-in and not optional and the receiver is capable of giving a larger audio output.

It is expected that before very long the amount of radio traffic to be handled will exceed the capacity of a single transmitter and that some form of multiple-station operation for the London area will have to be adopted. Some investigation has been carried out along these lines and the possibilities of limited-coverage aerials are also being studied. One of the illustrations here shows a corner reflector aerial being lined up by measuring the standing wave ratio on a slotted section of transmission line. The dipole is not visible, but it is in the angle of the reflectors.

Potted Circuits



New Development in Miniaturization of Equipment

THE technique of prefabrication has been applied to a good many unlikely things, including houses and pork pies, but one would never have thought it could enter into anything so complex as the manufacture of radio circuitry. Component sub-assemblies were probably the first move in this direction, then followed printed circuits, and now another important advance has been made in the sub-assembly idea. This is the breaking-down of apparatus into groups of wired-up components and embedding them in blocks of protective resin. The process is known variously as "potting," "moulding," "packaging," or—to be really highbrow—"encapsulating," and is the outcome of work done by the Telecommunications Research Establishment of the Ministry of Supply. At the moment it is largely confined to equipment being made for the Services.

The technique has two main advantages. First, it permits quick and easy servicing in the field by unskilled men—when a fault develops the cube in question is simply taken out, thrown away and replaced by another one. Secondly, equipment can be made much smaller and lighter. Not only are tag-strips and other fixing devices unnecessary, but the components can be sealed off and protected *en bloc* in much less space than if they were treated individually—there is no need for cumbersome devices such as pressurized boxes. As an example, 38 components have been enclosed in a block measuring only $2\frac{3}{4}$in × $1\frac{1}{4}$in × $\frac{11}{16}$in.

Potting is quite a simple affair and no special equipment is required. The components are assembled—sometimes between two plates of Perspex—and placed in a mould, then the resin is poured in and allowed to set. The resin (known as "Marco," and made by Scott, Bader & Co.) is already in liquid form, so it does not have to be melted and there is no danger of damaging the components by heat. It does, however, require a catalyst to make it set and an accelerator to speed up the process, and these are added just before use. When finished, the blocks are proof against temperature and pressure changes, moisture, fungi and heat (they cannot be melted away). Months of immersion in water has no ill effect on them. They are also very rigid and there is little danger of anything shaking loose as a result of mechanical shock or vibration.

One difficult problem in the technique is getting rid of the heat generated internally by the components. Various methods have been tried, but the most convenient seems to be to load the resin with mica (25 per cent proportion) as this increases the thermal conductivity. The mica also improves the dielectric strength of the resin and lowers its coefficient of linear expansion which is, unfortunately, rather high. T.R.E. do not favour the American practice of encapsulating the valves as well since they only make matters worse—not to mention the extra expense when faulty units are thrown away.

In practice a single potted circuit usually accommodates three or four sub-miniature valve stages, or the equivalent. All the connections are brought out on one face so they will be easily accessible when the blocks are packed together and into the chassis. For fixing purposes a couple of tubes are embedded into the resin to take fixing screws. Incidentally, the resin can be coloured, and this provides a very convenient means of identifying the circuits.

R. F. Chokes

"They are most interesting little components . . . ."

says **"CATHODE RAY"**

ALTHOUGH r.f. chokes are not so conspicuous as they once were, they do have their uses, so it is as well to know how they work. From the almost total absence of detailed information on them the reader might suppose that there is not much to it. He would be making a great mistake. They are most interesting little components, quite capable of exercising the inquiring mind. It is usual, for example, for the manufacturer of an r.f. choke to claim that it is "all-wave"; that is to say, that it is effective as an r.f. rejector over such a wide band as 150—20,000kc/s. Yet if the same manufacturer produces tuning coils he will probably claim for them just the opposite, that they tune very sharply! Does then the construction of a choke coil differ fundamentally from a tuning coil's, and if so how? What and why are the dead-spots one may have heard of? Why is it sometimes an advantage to put a short-wave choke (which is a low-inductance coil) in series with a long-wave one (which has a high inductance)? Could not the slight increase of inductance be obtained equally well and much more conveniently by winding a few more turns on the bigger coil? Why have so many different shapes and styles been put on the market? Which is the best type of winding? What decides the right inductance for the job? And so on.

The ideal r.f. choke would act as a complete open-circuit at all radio frequencies, and a short-circuit at zero (and perhaps audio) frequency. Since it consists of an inductive coil of wire, one might expect it to act like a tuning coil and respond more or less sharply to a particular frequency. And in fact it does do so at some frequency or other. The essential difference between a tuning coil and a r.f. choke is that the resonant frequency of the tuning coil (by itself) is higher than any of the working frequencies, whereas the resonant frequency of a r.f. choke is lower than any (or most) of the working frequencies. To appreciate what this means we have to be clear about the meaning of "resonant frequency (by itself)," which I shall denote by f_s.

Elementary theory teaches us that resonance takes place when the inductive reactance is matched by a equal capacitive reactance. So tuning coils, which are designed to provide the inductance, are used in conjunction with tuning capacitors, which are designed to provide the capacitance. Sometimes the inductance is fixed and is tuned by a variable capacitor; sometimes (especially in i.f. circuits and others for working on one fixed frequency) the capacitance is fixed and is tuned by a variable inductor—e.g., screwing an iron-dust core in or out. Even when there is no visible capacitor, there is inevitably a certain amount of capacitance in parallel with the coil, due to the wiring valve electrodes, etc. Even if you were to disconnect the coil altogether, so as to remove all such added capacitances, you would still find that it would resonate at a particular frequency, detected by the sudden increase in absorption from a tunable circuit very loosely coupled to it. That particular frequency could then reasonably be called the resonant frequency of the coil by itself. Knowing the inductance of the coil, you could use the usual formula to calculate the capacitance that it needed to tune it to that frequency (f_s) and the result would be what is called the self-capacitance of the coil, C_s. So any isolated coil can be represented theoretically as in Fig. 1. For most r.f. coils C_s is between 1 and 15pF. If you like you can add a resistance in series with L to represent the resistance of the wire and any other losses at the resonant frequency.

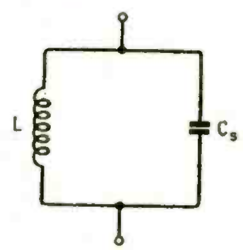


Fig. 1. Approximate theoretical equivalent of a choke or other coil, neglecting resistance.

Note that we are not entitled, merely on the strength of the foregoing experiment, to represent the coil in this way, with the same value of C_s, at any other than the resonant frequency. If we use the coil in any practical tuning circuit, there is bound to be some added capacitance due to the circuit wiring, etc., and probably a tuning capacitor as well. So the working resonant frequency or frequencies are bound to be lower than f_s. Seeing that the self-capacitance is not really a single lump, as in Fig. 1, but is distributed in and mixed up with the inductive turns of wire, it is perhaps surprising that if we make very careful measurements of added capacitances and resulting resonant frequencies we find that at frequencies below f_s the coil does continue to behave as if its self-capacitance were one practically constant lump.

We know that at the resonant frequency a parallel combination of L and any C (a rejector circuit) behaves as a high resistance; so that is an alternative to Fig. 1 as a representation. The lower the actual (series) resistance of the coil, the higher this representative resistance. No inductance or capacitance appears because they have balanced one another out. But unlike Fig. 1 this resistance representation does not hold even approximately good at other than the resonant frequency. The inductance of the coil has a reactance increasing steadily from zero at zero frequency. And the reactance of the capacitance in parallel with it decreases from infinity at zero frequency, as shown in Fig. 2. The resonant frequency is that at which the two reactances are equal. At any other frequency, either inductance or capacitance prevails. Since we are considering them in parallel, the prevailing element is the one that offers the lower reactance, because most of the current goes that way. At frequencies below resonance the combination is, on balance, inductive; and at higher frequencies is capacitive. Calculating the combined reactance at various frequencies we get graphs like Fig. 3. Note that at frequencies far from resonance they are much the same as in Fig. 2. (I hope the more knowledgeable readers are not getting too bored with all this familiar stuff, but the recapitulation is just about over.)

Fig. 3, with its reactance curves disappearing into infinity, is not perhaps very helpful or convincing to the practical man; but we can express the same thing in more easily graspable terms as the capacitance which, on its own, would produce the same reactance (Fig. 4). The inductive reactance is covered by this representation; it appears as a negative capacitance. Exactly at resonance, the infinite reactance is very conveniently represented by zero capacitance.

If you have been following this you will see that at frequencies very much higher than resonance the reactance of L is so much greater than that of C that it is more or less negligible as a path, and it is fair to represent the whole outfit by the capacitance alone. The higher the frequency above resonance, the fairer. So we see that by making the inductance of a coil large enough to put the resonant frequency well below any of the working frequencies, the coil behaves at all those working frequencies as if it were nothing but C_s, which as I said is normally only a few pF, so can be relied upon to offer a pretty high impedance, and in some circuits merges into the general circuit capacitance without making much difference. At lower frequencies, down to and slightly below resonance, the equivalent capacitance is even smaller. Being negative below resonance, it begins to neutralize the circuit capacitance, and only after it has done so completely does the circuit as a whole become inductive and its reactance start to fall. So we see that over a very large frequency range, from something below resonance to an indefinite amount above, a choke coil can behave almost as an open circuit—at worst, as a slight increase in the stray capacitance. A tuning coil, on the contrary, generally has a relatively low inductance, and is shunted by a relatively large capacitance, so that except at or near the resonant frequency either L or C provides a low-reactance path.

In practice there are also r.f. losses. They are represented in Fig. 5 by R, which is preferably too large to form much of a path. C is the imaginary variable capacitance shown in Fig. 4, comprising L and C_s.

So far, then, we conclude that the aims in an r.f. choke design are to make its inductance high enough to put f_s somewhere near the low end of the working frequency range, and (notwithstanding this) to make C_s as small as possible. Minimizing C_s is not only desirable for its own sake, by raising the reactance, but also because it generally raises the resistance R. An "all-wave" choke is evidently satisfactory if f_s is about 200 kc/s; and if C_s is as low as 3pF that means L has to be over 200,000μH. The more successful one is in keeping C_s low, the higher L must be to keep f_s right. So the problem appears to be one of getting a high inductance with a very low self-capacitance. There are various well-known ways of promoting this object, such as winding the coil narrow and deep, or lattice-wise, and perhaps dividing it into several sections.

Judging from many of the r.f. chokes I have come

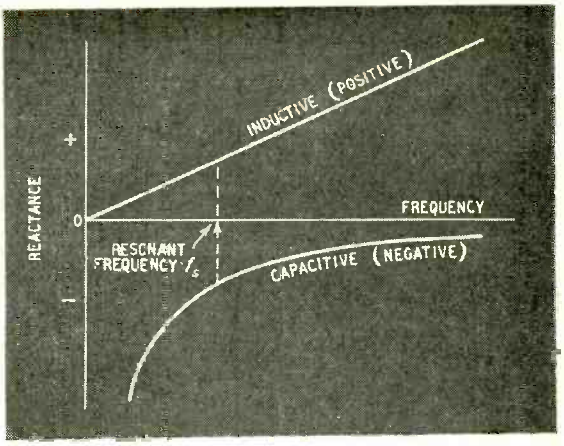


Fig. 2. Reactance graphs of inductance and capacitance such as those of a coil (Fig. 1) showing how their magnitudes are equal at one (the resonant) frequency.

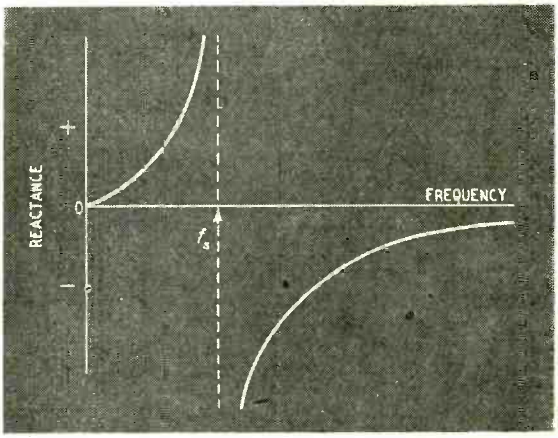


Fig. 3. Combined reactance of the two in parallel showing how it goes to infinity at the resonant frequency.

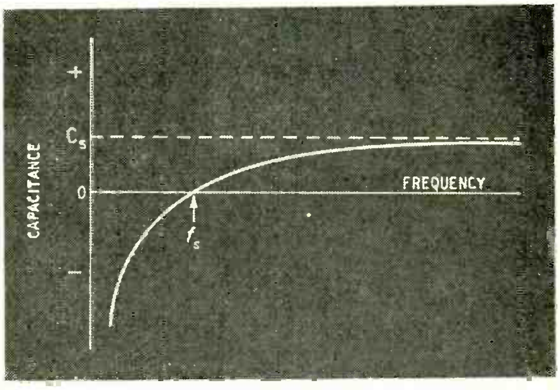
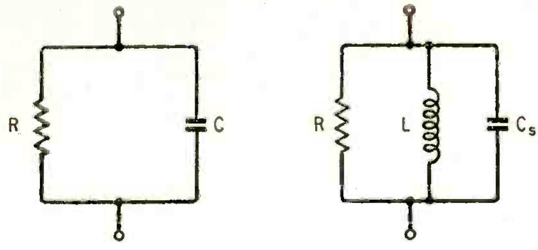


Fig. 4. If the reactance of the Fig. 1 combination were supposed to be due entirely to a capacitance, that capacitance would have to vary with frequency in the manner shown here. At the highest frequencies, it would be practically equal to C_s.



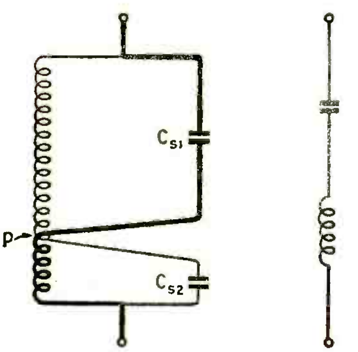
(a) (b)

Fig. 5. The variable C in Fig. 4 can be assumed to account for the reactance of a choke (a): it represents the more or less fixed L and C_s in Fig. 1, (b). In both, the resistive component can be represented by a parallel resistance R.

across in my time, their designers must have imagined that the matter was as simple as that. Unfortunately it is not. The mistake is to assume that Fig. 1 holds good at frequencies above resonance as well as below. One way of seeing how this is unlikely to be so is to consider Fig. 4. At a given frequency, a coil large enough for its f_s to be lower is equivalent to a small capacitance—rather smaller than its C_s. At the same frequency, a coil small enough for its f_s to be higher is equivalent to an inductance. Now consider any point near one end of the winding of an r.f. choke, such as *p* in Fig. 6(a). It divides the choke into two unequal parts, one of which can be regarded as the large coil just mentioned and the other the small coil. Their single equivalents are therefore respectively a capacitance and an inductance, as in Fig. 6(b). It may well happen that there exists a point and a frequency such that the reactances of these two are not only opposite but equal. If so, they form a tuned *acceptor* circuit, which is precisely what is not wanted, for it means that the choke offers an impedance consisting of nothing more than the series r.f. resistance of the two parts.

If you test a choke over a wide range of frequency above f_s the odds are in favour of your finding several such frequencies where the resistance R dips downwards. At the same frequencies the measured capacitance C fluctuates from the smooth and almost level curve at the right-hand end of Fig. 4. Some chokes I have tested dip as low as 10,000 Ω (from a normal level of perhaps 250,000 Ω), and since a usual position for an r.f. choke is in parallel with a tuning circuit it is not hard to imagine why such occurrences are called " dead spots " ! The damping effect on a high-Q circuit is of course catastrophic. If a medium-wave tuning circuit by itself had a Q at 1Mc/s of 180, a choke resistance of 250,000 Ω would reduce it to 105, and a 10,000 Ω resistance to 9.5 ! The associated violent fluctuation in equivalent capacitance is likely to be very upsetting, particularly if the tuning is supposed to be ganged.

These statements may be more convincing if backed by some actual examples. And it may be as well to say something about the method of measurement. One way of measuring the values of R and C is by means of a bridge, but a bridge covering a wide range of radio frequencies is a rare and expensive thing. Humbler experimenters can get the results by making up a special oscillator with carefully arranged tuning and oscillation controls. The effect of putting capacitance in parallel with an oscillator tuning circuit is to shift the frequency and if it is brought back again by reducing the capacitance of a parallel tuning capacitor calibrated in pF the value of the added capacitance can be read off. The effect of putting resistance in parallel is to shift the point on the oscillation control at which oscillation just stops or starts, and by making a preliminary trial with a number of known resistors the control can be calibrated in resistance at each frequency. So the drill is to set the oscillator so that it just oscillates, with the calibrated capacitor at zero on its scale. The choke is then clipped across the tuned circuit terminals and the oscillation control reset to restore oscillation (the amount of the adjustment showing the choke resis-



(a) (b)

Fig. 6. Showing how at a certain frequency one part of a coil can be capacitive and another inductive (a), forming a series resonant circuit (b).

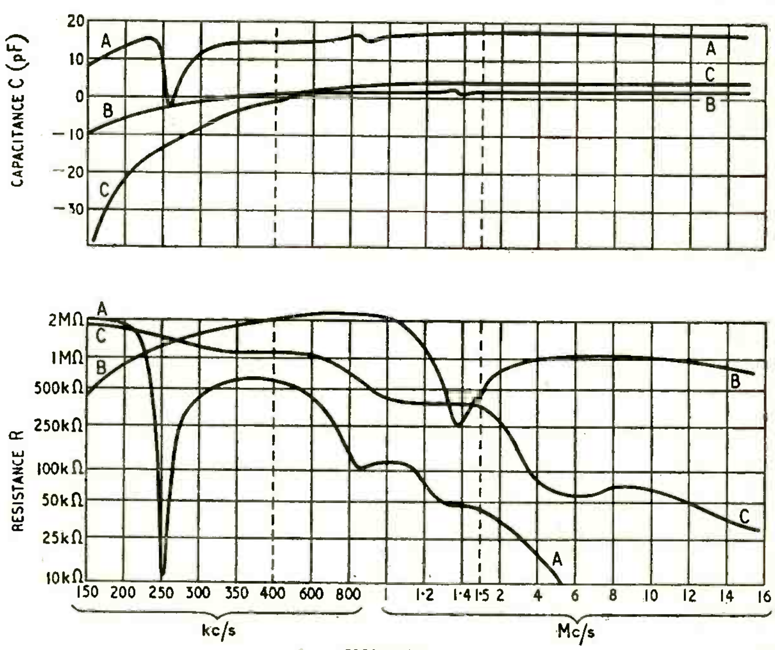


Fig. 7. Equivalent resistance and capacitance, R and C in Fig. 5 (a), graphed for three actual r.f. chokes over a wide range of frequency.

tance), and the calibrated capacitor is reset to restore the original frequency (the amount of the adjustment showing the choke capacitance). The test is then repeated at sufficient frequencies to provide data for a graph. To cope with both positive and negative capacitance the calibrated capacitor should have a centre zero, reductions in its capacitance being marked positive and increases negative.

One of the misconceptions about r.f. chokes is to suppose that dead spots are necessarily caused by the separate sections of divided windings resonating on their own. As a matter of fact the worst offenders are usually single-section types. "A" in Fig. 7 is an example; $\frac{1}{2}$in internal diameter, $1\frac{1}{8}$in external diameter, $\frac{1}{4}$in wide. It has an inductance of about 150,000μH which, with such a large C_s as this choke has, is enough to bring its rejector resonance well below the measured range of frequency. As you see, there is a violent acceptor resonance at 250kc/s. You can imagine what would happen to a parallel-fed tuned circuit in which this choke was used as the feed path! Note the accompanying fluctuation in capacitance. And the very low resistance and large capacitance at high frequencies.

I checked the Fig. 6 theory in a rather interesting way be feeding a choke at a pronounced dead-spot frequency from a powerful oscillator. After keeping it on for some time I found that a comparatively small part of the winding had become hot while the rest was cool. The hot section was, of course, the one forming the inductance, through which the full r.f. current had flowed.

While narrowing a single coil is some help by reducing C_s, a serious long-wave dead spot is likely to persist unless the winding is divided into sections. Doing this does not in itself guarantee that there will be no appreciable series resonances. Design by theory is so difficult that most of us work by trial and error. Obviously one takes care about such things as keeping the terminal leads from running close together, as that would quite unnecessarily increase C_s. Apart from dodging dead spots, the main difficulty is that success in reducing C_s brings f_s higher, so that the steep negative fall-off in Fig. 4 comes into the working range of frequency and it is necessary to raise the inductance. This means more turns, more series resistance, and more inductive coupling and risk of introducing hum and undesired feedback.

With the object, presumably, of reducing inductive coupling, it was once a practice to enclose chokes in screening cans. But these, while possibly of some value for cutting out *capacitive* coupling, are almost completely ineffective as magnetic screens at power or even audio frequencies. And at the working (radio) frequencies, at which the screening might be effective, the choke does not act as an inductance anyway. Moreover the screen largely spoils the performance of an otherwise good choke, by increasing C_s and reducing R and L.

Another scheme is to have two oppositely-wound coils side-by-side—the so-called binocular choke. This is very effective in directions equidistant from the two halves of the choke, but much less so where one half is nearer than the other (Fig. 8(a)). Personally I prefer to have the two halves end-to-end on the same axis, as in Fig. 8(b).

In these anti-coupling schemes each half of the choke opposes the other, reducing the inductance. So by now the number of turns required is becoming really formidable, unless one eases the situation by using an iron core (or a pair of them for a twin choke). Fortunately the effectiveness of the core at the higher radio frequencies is unimportant—if anything it would be an advantage if it fell right off—so one is free to choose a grade that has a high permeability in the region of 150kc/s (assuming that to be the lowest working frequency). The core is likely to increase C_s, but with suitable design it need only be very slightly; and the increase may well be more than wiped out by the reduction in the size of winding due to the core.

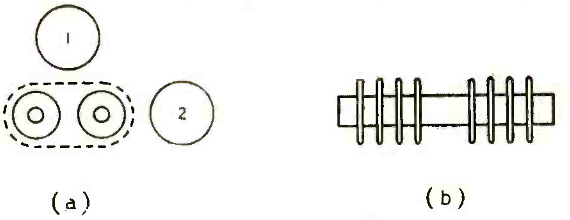
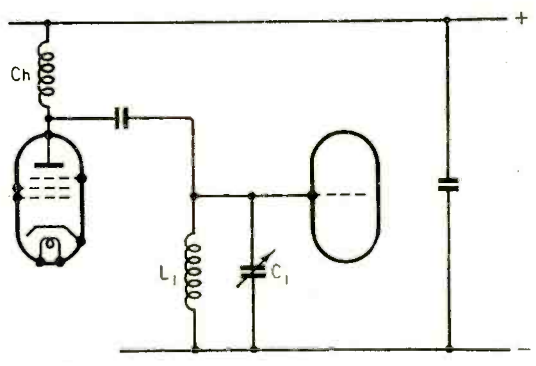


Fig. 8. At (a), coupling between a binocular choke and a coil in position 1 may be zero, but in position 2 can be quite considerable. An alternative method of winding two halves of a choke to counteract coupling is end-to-end, as at (b).

Fig. 9. Parallel-feed intervalve coupling circuit. The detuning effect of the choke has to be counteracted by trimming L_1 as well as C_1.



Type A in Fig. 7, a one-time commercial model, is an example of how bad a choke can be. Curves B refer to an experimental attempt to show how good a choke can be. No doubt even this could be improved upon, for it dates from a time when suitable iron-dust cores were not readily available, and they were in fact made of thin rolled-up iron tape, one in each end of a Fig. 8(b) pair. The fall-off is decidedly in evidence at 150kc/s, and there is one rather nasty dip in the resistance at about 1.4Mc/s.

The third example, C in Fig. 7, is a present-day type of simple and inexpensive construction, without the anti-coupling (or astatic) feature. It is remarkably free from violent series resonances. The inductance is rather on the low side, so that if it were used in parallel with one tuned circuit in a gang it would upset the tuning at the low-frequency end unless suitable precautions were taken. Fig. 9 shows the elements of a tuned r.f. intervalve coupling (L_1 and C_1) parallel-fed via an r.f. choke Ch. So far as r.f. is concerned, Ch is in parallel with L_1C_1, which is not only damped by R in Fig. 7 but detuned by the varying C. If C consisted solely of C_s (L being infinitely large), then the detuning due to the choke would be removable by adjusting the trimmer capacitor in parallel with C_s, reducing its capacitance by an amount equal to C_s. But since any real choke has a finite inductance L, which causes an effect equivalent to the imaginary varying C in Figs. 4 and 7, something more is needed to counteract the detuning effect of Ch. Putting L in parallel with L_1 is equivalent to reducing L_1. So we need only increase L_1 by that amount to bring it to the correct value.

The rule for calculating inductances in parallel is the same as for resistances. Let us denote the increased tuning-coil inductance by L_1'. To get things right, the inductance of L_1' in parallel with L must be equal to the original L_1. Putting it in algebra:

$$\frac{1}{L_1'} + \frac{1}{L} = \frac{1}{L_1}$$

With a little manipulation this can be worked around to

$$L_1' = \frac{LL_1}{L - L_1}$$

For instance, if L_1, the normal tuning coil inductance, is 2,200μH, and L, the choke inductance, is 50,000μH, the adjusted tuning coil inductance must be 2,200 × 50,000 divided by 50,000 − 2,200, which is 2,300—a rise of about 4½%. If the tuning coil is fitted with an adjustable iron core this should be easy.

I hope that by now most of the questions at the beginning may be deemed to have been answered, directly or indirectly; but there is perhaps one exception—the question about putting a short-wave choke in series with an "all-wave" type to make it rather more all-wave than it would otherwise be. This question chiefly concerns the self-capacitance, C_s. If the choke is in parallel with other capacitances, as in Fig. 9 for example, then a picofarad more or less is neither here nor there, because it can be taken up on the trimmer. The main object in keeping C_s low in such circumstances is as a means of keeping R high. But if the purpose of the choke is to prevent r.f. currents from taking a certain path, then C_s becomes vital on its own account at the higher frequencies. A value of, say, 5pF would be generally satisfactory at low r.f. (reactance 160,000Ω at 200kc/s) and perhaps fair enough at medium r.f. (32,000Ω at 1Mc/s.). But at 20Mc/s it is down to 1,600Ω, so it would be pointless to strive to keep R up in the megohm region. By winding a comparatively few turns of small diameter in one of the low-capacitance styles, it is possible to keep C_s down to less than 1pF, with great advantage at the high-frequency end. But of course the inductance would be quite inadequate for low r.f. So if both have to be covered, both chokes can be connected in series and placed so as not to couple with one another. At the h.f. end we have perhaps 0.7pF in series with 5pF. This is not at all the same thing as a few more turns on the big choke, where they would couple closely with the others and the type of winding (being designed for high inductance) would be unsuitable for very low capacitance. At low r.f. the small choke would hardly influence the situation at all; it would merely be a relatively small series inductance.

BUSINESS RADIO

A Review of the Present Position

CONSIDERABLE criticism has recently been levelled against the Post Office from certain quarters for its so-called tardiness regarding the development of Business Radio. This criticism is, we believe, largely due to a misinterpretation of the facts and also to the reluctance of the Post Office to give undue publicity to the Service for fear of an avalanche of requests for frequencies for "frivolous" purposes. We are, therefore, grateful to the officers of the Overseas Telecommunication Dept. (the section of the Post Office responsible for the licensing of Business Radio) for facts regarding the Service.

It will be recalled that, as stated in our September issue, the P.M.G. announced in the House that 400 licences, covering 392 fixed and 1,902 mobile stations, had been issued by the Post Office for mobile radio services (excluding police and fire) at the end of July. This tells only half the story. Whilst this is, of course, the correct number of licences in force, no mention was made of the hundreds of applicants to whom frequencies had been allocated, but whose licences were held up until equipment was delivered. Had these been added to the totals they would have been increased by some 50 per cent. In fairness to the Post Office it should, moreover, be stated that every application for a mobile Business Radio licence has been met—except, of course, where it was considered the line telephone service met the need.

It is perhaps worth commenting on the relative positions in this country and the United States. In the U.S. Business Radio is largely confined to taxi and car-hire services, and, as they have only four channels below 450 Mc/s, as many as 400 taxis operate in the same channel in some of the larger cities. In this country any applicant—from bookmaker to builder, doctor to dairy farmer, and taxi-owner to towage company—is accommodated within one of the existing Business Radio bands.

With, however, the growth of the demand for this service, the available channels in the 71.5-88 and 156-184 Mc/s bands are, so far as London is concerned, liable to become overcrowded. There is, of course, the 460-470 Mc/s band, but the utilization of this band is hampered by the lack of suitable equipment.

Readers may like to have exact details of the bands in which Business Radio is accommodated:—(a) 71.5-72.8, (b) 76.7-78.0, (c) 85-88, (d) 156-184, and (e) 460-470 Mc/s.

Frequencies in (a) and (b) are paired with those in (c) for duplex operation. Channels are 50 kc/s wide in (a), (b) and (c), and 100 kc/s wide in (d). So far, of course, there is no service in this country comparable with the American "Citizen's Radio"—a mobile radio-telephone service for John Citizen. Provision has, however, been made by the Post Office for the operation of land mobile services in the 460-470 Mc/s band, where the Post Office point-to-point service is also accommodated.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents.

Pulse Power

IN his article "Mystery Broadcasting" your contributor Thomas Roddam refers in your October issue to a transmitter of 1-kW mean power sending 1-μs, 33-kW pulses 30,000 times per second and states that this would be received as a 33-kW transmitter.

This is erroneous, since the signal-to-noise ratio, the proper basis of comparison, would be no better than in the 1-kW condition. Let us take, for example, a transmitter sending pulses of a certain duration. These pulses are then reduced to one-fourth of their former length and, for the same mean transmitter power, the pulse power can be increased four times. This doubles the signal voltage in the receiver, but to handle these shortened pulses, the receiver bandwidth must be increased four times. Since the noise voltage is proportional to the square root of the receiver bandwidth, it is now double its former value, so that there is no net gain; signal volts and noise volts having increased equally. There is no way round this problem which is fundamental to all pulse systems; any attempt to reduce noise by increased selectivity would only deform the shape of the signals and sacrifice the pulse energy residing in that part of its sideband spectrum which lies outside the pass-band of the receiver.

These points are not made to discredit pulse transmission systems which, as your contributor correctly states, afford substantial signal-to-noise ratio improvements, but to demonstrate that altering the duty cycle of the transmitter cannot, in itself, affect the signal-to-noise ratio of the system as a whole. Basically, pulse modulation gets its advantage by sending all audio levels at full power in the manner explained by your contributor "Cathode Ray" in another part of the same issue. S. COOK.

Taunton, Somerset.

Earls Court Television

WHILE watching the various television demonstrations at Earls Court, it occurred to me that it is possible for many prospective buyers of television sets to be sadly disappointed when they compare the picture they will be shown in their local dealer's shop with the one they saw at the Show.

In Earls Court a high level television signal, amplitude 1mV ± 3db in 70Ω, was available at each outlet from the feeder system. This signal was completely free both from fading and interference and hence any television set should be capable of being set up to resolve it into a nearly perfect picture. Except in localities very close to the television transmitting stations nothing like such ideal conditions could possibly exist, since:—

(a) According to the field strength diagrams published by the B.B.C., the high signal level of 1mV/metre is only found within a radius of some 25-30 miles of Alexandra Palace or 40-50 miles of Sutton Coldfield.

(b) As soon as a metre-wave radio broadcast path is employed, interference becomes apparent, its effect on signal-to-noise ratio being normally dependent on the distance from the receiver to the transmitting station, though it may often be sufficient to spoil the picture in an area of nominally high signal level.

Surely, therefore, for demonstration purposes, it would be better to employ a signal which approximates more nearly to the one met with in practice, that is to say, one which is subjected to fading, aeroplane effect and a varying amount of man-made and atmospheric static. I would suggest for the latter a suitable interference level would be equivalent to that obtained in a suburban area fairly close to a main road. Such a test signed would be a check both of the efficiency of the receiver and of any interference suppression circuits incorporated therein, which is surely the purpose of a competitive demonstration such as that in "Television Avenue." I. G. BENBOUGH.

Reading, Berks.

Redundant Word?

AS one of the technical people whose education has been advanced by reading *Wireless World* may I point out to R. L. Hackworth (November issue, p. 458) that when we speak of voltage, amperage and wattage we are conveying something more than the simple ideas of p.d., current and power; namely, the order of magnitude of the quantities, and the units in which they are measured. One does not speak of the "service obtainable from a motor tyre in terms of the distance traversed in miles" but of the mileage (milage)—a word Mr. Hackforth can look up in the Oxford Dictionary: at the same time I suggest he also looks up the definition of another word with the same termination, i.e., verbiage.

Hindhead. HENRY MORGAN.

Legitimizing the "Puff"

WHILST Mr. Mayes' proposal to introduce a prefix for 10^{-9} (October issue) is logically sound on a broad basis and would go a long way towards easing the situation, the fact remains that the farad is an inconveniently large unit from a practical aspect. It seems unfortunate that having at last been presented by Giorgi with a much-improved system of absolute/practical units, we still cannot use the unit of capacitance as it stands and must, in effect, take 10^{-6} absolute units as our practical unit (i.e., the microfarad). Furthermore, we find it necessary to invent new prefixes to avoid decimal points and long strings of noughts. I suspect that "pico-" was born solely to help with the unit of capacitance, whilst we are now considering a prefix for 10^{-9} and it seems unlikely that these prefixes will have much use elsewhere (unless, for instance, we can persuade the physicists to abandon the angstrom—10^{-10} metres—and use instead the picometre, with appropriate numerical adjustments!)

Incidentally, it may be of interest to observe that the original value of the farad, as specified as a practical unit by the British Association for the Advancement of Science between 1861 and 1867, was equal to what we now call the microfarad. The latter was considered a convenient size for practical purposes in the telegraph field (at that time virtually the only practical application of electrical science).

I do not regard the "puff" as a new practical unit, having an arbitrary relationship with the absolute unit, in the way that the ampere is fixed at 10^{-1} absolute c.g.s. units, but rather as a re-naming of an existing submultiple of the absolute (and practical) unit of the m.k.s. system. Splitting hairs, perhaps, but the "puff" is already used fairly widely (and unofficially) and would no doubt remain even if a new sub-multiple were introduced.

Mr. Mayes' specification for metric prefixes is sound, but should include the requirement that the prefix be not liable to ambiguity in conjunction with contractions of the names of units. The suggestion is that 10^{-9} farad could become 1 lillifarad or 1 lF—by the way, Mr. Mayes, may we please at least have consistency as to capital or lower-case letters—but let us not overdo the humour by coining a prefix which, if the small letter is used (as it should be), stands an excellent chance of being misread for the figure "1," whilst the capital letters form a common abbreviation! Quite apart from the phonetic similarity between "lilli-" and "milli-".

If we must have a 10^{-9} prefix, then "nano-", referred to in the editorial footnote to Mr. Mayes' letter, seems to meet the specification.

I am pleased that "Diallist" is apparently not horror-stricken at the thought of a "new" unit, but I disagree that the "puff" would be too small. Certainly a larger unit (replacing the microfarad) would be nearly as good, but the "puff" would be quite big enough for ordinary purposes and has the advantage of current usage. It is agreed that a "micro-puff" is unlikely to find a wide use, but so is a "micro-ohm." As to the typing of μ, I know that a "u" with a manually-added tail gives the right answer, but it tends to be overlooked when it occurs many times in a draft, and "uuF" looks wrong. Besides, a typist will often try to fabricate the thing from a "u" plus a displaced oblique stroke, with (usually) awful results!

A. C. KAY.

Brookmans Park, Herts.

"Decentralized" Broadcasting

I DO not think *Wireless World* need apologize for venturing to put its nose outside the field of pure technology—alluding to the first two paragraphs of the November editorial—in a matter which is so closely associated with radio as the content of what is broadcast. Taking the liberty of a correspondent to go a little farther than editorial etiquette permits, I should like to say that, although I grumble a good deal at B.B.C. programmes, I know, underneath, that they are far better than the mercenary and small-minded drivel which local magnates would inflict on us if they could get at the microphone—and the dangerous rubbish they would pour out at times of social unrest and national danger. Neither financial ability to hire a broadcasting station and its technical personnel, nor success in vote-catching, are proofs of good taste, intelligence, or even sense of social responsibility. May we be saved from the boring nonsense sponsored by sales departments and local provincial big-wigs, which is such a feature of broadcasting in the U.S.A. and in the less "free" countries of Europe and Asia!

W. H. CAZALY.

Huntingdon.

"Jointing Aluminium"

IN reply to P. A. Raine's letter (October issue), I would emphasize the following facts.

The scratch brush method can, of course, produce a semblance of a completely tinned surface, but if the aluminium is reheated and the surface wiped it will be found that a series of fine scratches have been produced in the oxide layer in which the solder has bonded to the aluminium. The continuous film of solder then floats over the surface of the remaining oxide and is keyed by the bonding achieved in the scratches.

Ultrasonic abrasion caused by cavitation in the molten solder occurs on a semi-molecular scale and after tinning by this means the wiping of the metal will reveal an unbroken surface of solder.

While I do not wish to cast any reflection on the scratch brush method advocated by Mr. Raine, it will be realized from these comments that the ultrasonic method will produce a stronger joint with better electrical properties. In the jointing of cable sheaths, no great strength of joint is required nor are its electrical properties of interest. There are, however, many operations where these factors are of the utmost importance and mechanical abrasion cannot be considered satisfactory in these cases.

Mullard Ltd.
London, W.C.2

A. E. CRAWFORD.

Bad Radio Teaching

"DIALLIST" (*Wireless World*, August number) will find that Prof. Sandiford has devoted a chapter to the teaching and learning of elementary mathematics (the root of the trouble about "maths") in his "Educational Psychology" (Longmans, Green and Company). The trouble is that very few teachers know enough about psychology either to perceive the use it can be to them or to apply it intelligently and efficiently in their work; most of them drift into teaching as a means of livelihood on the strength of their technical exam-passing abilities and regard teaching as a fairly easy job requiring only that they "say it very loud and clear."

Not only the teaching of mathematics, but the teaching of that group of subjects lumped under the heading of "radio" is so badly done, by people who may know something about radio but practically nothing about teaching, especially the teaching of radio, and, moreover, have resentment, probably arising out of their ignorance of what teaching means and conceit about their small fund of specialized technical skill, against being told what bad teachers they are, that there need be no surprise or mystery about the shortage of really well-trained younger radio technicians to-day.

It is usual to blame the youngsters and dub them stupid. In fact, only the native wits, as good as ever they were, and the pathetic keenness of intelligent youngsters to grasp the "go" of some of the exciting stuff of their modern electromechanized civilization, prevents radio, amongst much else, becoming a kind of magic beyond the comprehension of any but wizardlike creatures muttering mathematical mumbo-jumbo, in the view of the average citizen. If the technical experts would be content with a little less attention to erudition and a little more to the psychology of explanation, we should soon find the shortage of good technicians markedly lessening.

MARK OWNEY.

Valve Standardization

I CANNOT believe the majority of your readers will agree with Mr. J. R. Hughes who, in your report of the Brit. I.R.E. Convention, is stated to have said that "the main obstacle to standardization is the valve user." I would remind him of the side-contact base series, the Mazda Octal series and that recent "achievement" the B8A series—all of which were "sold" to the user by the valve makers themselves. And, of course, history usually repeats itself!

T. L. FRANKLIN.

Broxbourne, Herts.

Crystal Menace?

REFERRING to the recent correspondence on the radiation of harmonics from crystal sets, surely there is no disadvantage in transposing the aerial series capacitors and their associated inductances. The theoretical 6db reduction per number of harmonic is worth having.

Reading, Berks.

F. A. RUDDLE.

Diathermy Interferance

H. WILLAN CRITCHLEY, in your November issue, "doubts if diathermy is the source of the interference" (causing herring bone or oak-grain bands on Holme Moss Television transmissions). May I say that my tests have established that it definitely is the cause. In this area we have been in touch with the hospital engineer, and have, with his co-operation, watched a television receiver while the diathermy equipment was switched on and off. The interference band only appeared when the equipment was in use, and disappeared immediately on switching off the equipment.

The variation of the pattern is most probably due to the different applications of the diathermy.

P. L. EVERETT.

Chester-le-Street, Co. Durham.

WORLD OF WIRELESS

U.K. Frequency Standards ✦ Aeronautical Radio Aids ✦ Mobile Television Stations ✦ B.B.C. Expenditure ✦ December Meetings

Standard Frequencies

AN experimental service of standard frequency transmissions from the Rugby station MSF was inaugurated under the auspices of the National Physical Laboratory some twenty months ago. Various changes having recently been introduced in the schedule, we give below revised details of the transmissions.

The frequencies, which are maintained within two parts in one hundred million of their nominal value, are monitored at the N.P.L., Teddington, Middlesex, to which all correspondence relating to the transmissions should be sent. The transmitter has a power of 10 kW.

The revised schedule (G.M.T.) is 0544-0615 on 5 Mc/s; 0629-0700 on 10 Mc/s; and 1029-1130 and 1429-1530 on 60 kc/s. The first minute of each transmission period is devoted to the call sign in slow morse and a speech announcement; then the following fifteen-minute cycle is repeated: carrier modulated with 1,000 c/s for five minutes, one cycle-per-second timing pulses for five minutes, the carrier unmodulated for four minutes and the call sign and announcement for one minute.

The low-power transmissions on 2 Mc/s from the Royal Observatory station (GMT) at Abinger, Surrey, which were introduced as an interim measure in 1948, have been discontinued for some time.

Television Exhibition

THE annual exhibition of the Television Society, which is expected to be on a larger scale than in past years, will be held at the invitation of Mullards in the basement of Century House, Shaftesbury Avenue, London, W.C.2, on December 28th and 29th. On the first day it is open to members only from 6.0 to 9.30 p.m., but on the following day the public will be admitted by invitation ticket from 10.30 a.m. to 5.0 p.m.

Exhibitors will be limited to members of the Society, and a number of manufacturers invited by the Society. All exhibits will be associated with some phase of television engineering or production. Some of the manufacturers will be exhibiting equipment for which a member of the Society has been responsible, either in design or production.

Further particulars are available from the Society's lecture secretary, G. T. Clack, 10, Tantallon Road, London, S.W.12.

Teaching Teachers

PREPARATORY to the commencement of the scholastic year, a week's course for full-time and part-time teachers of radio and television servicing was held at the Regent Street Polytechnic in September under the direction of H. W. French, B.Sc., H.M. Inspector of Schools.

Organized jointly by the Ministry of Education and the Radio Industry Council, the course was particularly valuable for the interchange of ideas between those concerned with technical education and representatives of the radio industry.

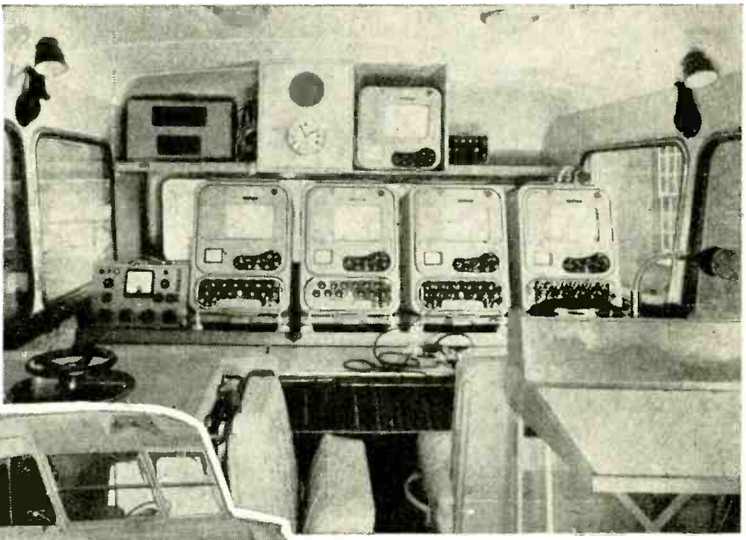
Flight Log Navigation

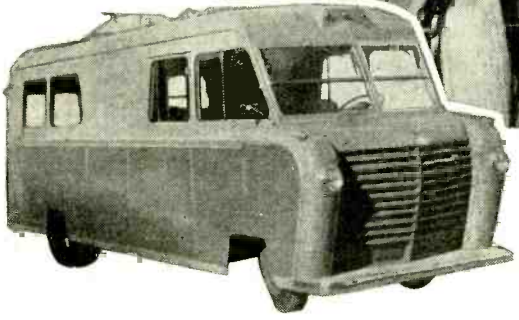
FOLLOWING a recommendation by the International Civil Aviation Organization, the Ministry of Civil Aviation has recently undertaken a series of trials with the Decca flight log navigational aid. This automatic device, described in our April, 1951, issue (p. 143), is an adjunct to the ordinary Decca system, giving a continuous plot on a map of the exact position of the aircraft.

According to the Ministry, the results so far obtained suggest that the Decca system and flight log may be able to provide European air routes with a better navigational service than any at present in use or contemplated, and at much lower cost than for any comparable system. It is thought, too, that the flight log will be of particular value for navigation in jet aircraft. Representatives of European civil aviation have been collaborating in the trials.

Television O.B. Units

WE recently had an opportunity of inspecting one of the two mobile O.B. television units which Marconi's are supplying to the Canadian Broadcasting Corporation.





COMPLETE mobile television station. Above the four control monitors is the receiver monitoring the radiated picture.

Each vehicle is a self-contained three-camera station with its own microwave radio link, the parabola for which is stowed on the roof. As will be seen in the interior view reproduced, four monitors are provided—one for each camera, and that on the right as a master control and mixer. These monitoring units are designed for ease of servicing—the camera control unit (the lower section of the monitor) can be withdrawn revealing all the wiring, which, incidentally, is on the topside of the chassis.

Intercommunication between members of the crew is a major problem in O.B. units and provision is made so that all members can hear, in their headphones, both the transmitted programme and, superimposed, all instructions. Camera operators can speak to the camera control positions and the producer, whilst the latter (whose desk is on the right in the photograph), and the technical director, can speak to all the crew.

Commemorative Plaques

DURING the recent unveiling of the commemorative plaque to Baird on the wall of 22, Frith Street, Soho, where he first demonstrated television, reference was made to the proposal to commemorate the London residence of Marconi. It appears, however, that two difficulties arise. First, Marconi lived in a number of houses in London, and secondly, will the L.C.C. again break its rule that plaques are not erected until at least twenty years after the death of the celebrity they wish to honour—Marconi died in July, 1937.

Having broken away from usual practice in the case of Baird, it would be unreasonable for the Council to adhere to the rule in the case of Marconi, upon whose foundation Baird built. December 12th, the fiftieth anniversary of the spanning of the Atlantic, would have been an ideal date for the dedication.

International Television

THE first issue of the *Bulletin* of the Comité International de Télévision has recently been received. In it is outlined the constitution of the C.I.T. which was set up in 1947 for the purpose of encouraging international collaboration in the field of television technique. The 182-page *Bulletin* includes a number of papers—in English, French, German and Italian—read at the Milan International Television Congress.

Among the British radio personalities on the Study Committees are Dr. R. C. G. Williams (chief engineer, Philips Electrical), vice-president of the Commercial Committee, and T. M. C. Lance (chief engineer, Cinema-Television), president of the committee responsible for organizing congresses and exhibitions.

The headquarters of the C.I.T. are at 41, Gloriastrasse, Zurich, 6, Switzerland, and the general secretariat at 92, Avenue Champs-Elysées, Paris, France, from whom details can be obtained of the journal.

Electronics and Films

A NEW company, High Definition Films, Ltd., of which Norman Collins (at one time B.B.C. Controller of Television) is chairman and managing director, has been formed to develop the use of electronic apparatus in the film industry. An advantage of the electronic film camera is that it enables the film director and technicians to see on monitors during the filming the shots exactly as filmed and, moreover, it is more sensitive.

T. C. Macnamara, technical director of Scophony-Baird, will be in charge of the company's technical operations, which will be conducted at Cambridge in collaboration with Pye. Other directors of the company, the address of which is 24, Old Bond Street, London, E.C.2, are Sir Robert Renwick and C. O. Stanley (chairman of Pye Radio).

Comparative Costs

FROM a perusal of the financial statements published in the "B.B.C. Yearbook, 1952," some interesting conclusions can be drawn. It is particularly interesting to note that, whereas in the Home "sound" services the revenue expenditure on engineering and programmes is respectively 23.5 and 57 per cent of the total; in television it is 35.5 and 44.6 per cent respectively. Plant maintenance in television accounts for 10 per cent compared with 2 per cent for sound, despite the fact that the hours of operation are vastly different—television 6,610 hours, Home "sound" 203,178 hours in 1950.

So far as the Overseas Services are concerned, which were on the air for 166,830 hours in 1950, the expenditure on engineering was 26.3 per cent and programmes 55.9.

The rate of depreciation of television gear, compared with sound equipment, is considerably higher, when the hours of operation are taken into account. For the year 1950/51, the figures are "sound" £108,000; television £74,000.

On the revenue side the income from "sound only" licences was £10,680,906, and from television fees £1,413,292, whilst the expenditure on the Home "sound" service was £7,860,883 and on television £1,718,578. The Corporation's income from publications was £955,230.

Radio and Power Cuts

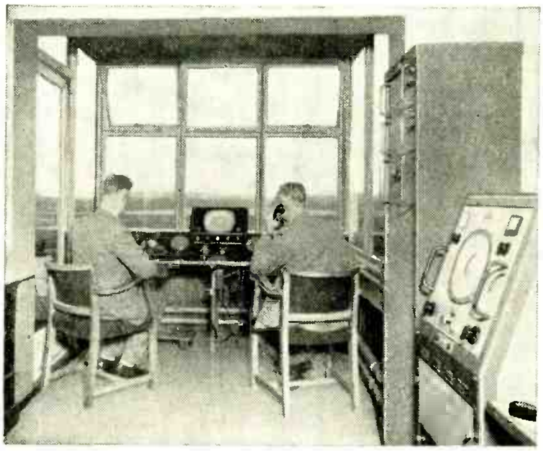
IN our last issue reference was made to the use of broadcasting as a means of conveying warnings of impending load-shedding to consumers. The B.B.C. has since issued detailed plans which, as suggested by our contemporary *Electrical Review*, include the transmission of a 1,000c/s tone for three seconds preceded by the word "caution." These warnings will be transmitted on 1,500 metres between 7.30 a.m. and 12.30 p.m., and from 3.0 to 6.0 p.m. on Mondays to Fridays.

The B.B.C. is further co-operating in the fuel economy campaign by delaying the start of the children's television programme on week-days until 5.30, as was suggested by our contributor, M. G. Scroggie.

V.H.F. Direction Finder

A NEW v.h.f. direction finder, incorporating a number of novel features, has been developed by the Marconi Company for the 118-132-Mc/s band used by civil aviation. It is the Type AD200 and is capable of giving a first-class "sensed" bearing immediately on request, a valuable feature in view of the high speeds now attained by jet-engined aircraft.

The direction finder is largely automatic in operation and can be controlled either locally or from a distance of up to 30 miles over ordinary telephone lines.



V.H.F./D.F. installation in the control tower at the de Havilland airfield, Hatfield. Master control console and twin receivers are on the right with the remote bearing indicator on the control desk.

Two d.f. channels, each with its own display units, may be operated simultaneously from a single aerial system, one pair of telephone lines being required for each when remotely controlled. Bearings are automatically corrected for sense and are read off an 8-in circular meter scaled directly in degrees.

In addition to local and remote d.f. consoles, desk-type bearing repeater units are available for extending the d.f. information to points such as a control tower where space may be limited.

PERSONALITIES

N. C. Robertson, M.B.E., will be responsible for the production of all radio, radar, telecommunication and electronic equipment as Director-General of Electronics Production in the Ministry of Supply—an honorary post. The creation of this Directorship was announced in the House of Commons in July. Mr. Robertson, who is 43, and has been in the radio industry since 1924, joined E. K. Cole, Ltd., in 1930. He has been successively chief inspector, production manager, works manager and since 1945 deputy managing director in the company. He is an Associate of the I.E.E. and was made an M.B.E. in 1944.

N. C. ROBERTSON, M.B.E.

S. S. C. Mitchell, C.B., O.B.E., M.I.Mech.E., the new Controller of Guided Weapons and Electronics in the Ministry of Supply, will be in charge of all work in research, development and production of guided weapons in Britain. He will also undertake the responsibility for the direction of the Ministry of Supply's work on electronics research, development and production. During his naval career he specialized in gunnery. Since 1945 he has been Chief Engineer, Armament Design, at the Ministry of Supply. He is 49.

G. E. Condliffe, O.B.E., B.Sc., M.I.E.E., who has for some time been managing director of Emitron Television, Ltd., has been appointed to a similar post with the associated concern, E.M.I. Research Laboratories, Ltd. He joined the research laboratories of the Gramophone Co. in 1929, and during the war was concerned with Government radar projects.

S. A. Hurren, Head of the Department of Radio and Musical Instrument Technology at the Northern Polytechnic, Holloway, London, N.7, since 1935, is retiring at the end of the year. Mr. Hurren, who has spent 32 of his 44 years of teaching at the Northern Polytechnic, has been chairman of the Radio Trades Examination Board since its inception, and is a past president of the Brit.I.R.E.

John C. G. Gilbert, Assoc. I.E.E., M.Brit.I.R.E., who has been lecturing at the Northern Polytechnic, Holloway, since 1934, and for the past year has been senior lecturer in the Department of Radio and Musical Instrument Technology, has been appointed Head of the Department in succession to S. A. Hurren.

IN BRIEF

Receiving Licences.—If the rate of increase in television licences recorded during September (25,450) has been maintained during the following two months, the number will have reached a million by the time this issue appears. The September figure was 958,500. The total number of broadcast receiving licences (sound and vision) in force in the U.K. at the end of the third quarter was 12,391,350, which was a reduction of 52,500 on August.

Faraday Lecture.—This year's I.E.E. Faraday Lecturer is Dr. G. F. Dutton, of E.M.I. Engineering Development, Ltd., who has chosen as his subject "Sound Recording—Home, Professional, Industrial and Scientific Applications." The lecture will be delivered first at the Town Hall, Birmingham, on December 18th, and subsequently on December 19th at Leicester; January 10th, Cardiff; February 12th, London; March 11th, Newcastle-upon-Tyne; March 13th, Leeds; March 17th, Liverpool; March 20th, Belfast; April 7th, Southampton; April 22nd, Glasgow; April 24th, Aberdeen.

Amateur Show.—The R.S.G.B. Amateur Radio Exhibition opens at the Royal Hotel, Woburn Place, London, W.C.1, at 11.0 a.m. on November 28th, although the official opening ceremony by Charles I. Orr-Ewing, O.B.E., M.P., is not until noon. Admission to the exhibition, which will be open from 11.0 to 9.0 p.m. daily until December 1st, is sixpence.

Patent Office Library.—It has been decided to continue the extended hours of opening of the Patent Office Library at 25, Southampton Buildings, Chancery Lane, London, W.C.2, until December 28th. The hours are 10 a.m. to 9 p.m. Monday to Friday, and 10 a.m. to 5 p.m. Saturday.

Photos for Publication.—Whilst not of direct interest to readers of *Wireless World*, the book "Cash From Your Camera," issued by our associate journal, *Amateur Photographer*, will be found extremely useful by those who aspire to take photographs with a view to publication. It has 140 pages and costs 7s 6d, or by post from our publisher, price 7s 10d.

Technical Register.—The office of the Technical and Scientific Register of the Ministry of Labour and National Service is now at Almack House, 26-28, King Street, St. James' Square, London, S.W.1 (Tel.: Trafalgar 7020).

Training Courses for service technicians have been started by E.M.I. in Scotland. Particulars of the ten-day courses, which will cover basic television theory as well as specialized receiver circuitry, are obtainable from A. J. Lillicrap, Training Division, E.M.I. Sales & Service, Sheraton Works, Wadsworth Road, Greenford, Middx.

"Facts and Figures" is the title of a 20-page extract from the B.S.R.A. Diary giving basic data and useful formulæ relating to recording on disc, magnetic tape and film. It is available from the Hon. Librarian, British Sound Recording Association, 8, Stanton Road, London, S.W.20, price 1s 3d.

Grommets.—Minimum physical test requirements and dimensions for a standard range of grommets for use in various industries, including telecommunications, are given in BS.1767:1951, "Grommets for General Purposes." This British Standard, which costs 2s, is confined to rubber, synthetic rubber and rubber-like materials such as P.V.C.

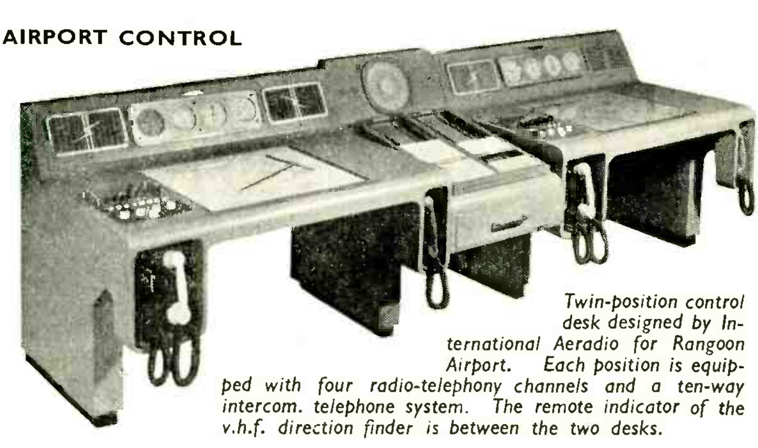
Finland.—A booklet has been issued by the Finnish Association of Technical Traders giving the names and addresses of member firms in various branches of industry with whom manufacturers wishing to market their products in Finland are invited to communicate.

"Toute la Radio," our Paris contemporary, has produced another overseas edition (November), in which summaries of the main articles are given in English and Spanish.

E.I.B.A. Ball.—Manchester's Annual Electrical Industries Ball, in aid of the Electrical Industries Benevolent Association, will be held on December 7th at the Midland Hotel at 7.15. Applications for tickets should be made to Claude Brookes, Salford Electrical Instruments, Ltd., Peel Works, Silk Street, Salford, 3.

Aerial "Whys and Wherefores."—Preparatory to the opening of the Kirk O' Shotts television station, Belling and Lee are arranging three meetings for dealers at which there will be talks on the "whys and wherefores" of different types of aerials. Details of the meetings, which will be held in Edinburgh

AIRPORT CONTROL



Twin-position control desk designed by International Aeradio for Rangoon Airport. Each position is equipped with four radio-telephony channels and a ten-way intercom. telephone system. The remote indicator of the v.h.f. direction finder is between the two desks.

(December 10th), Dundee (12th) and Glasgow (14th), are obtainable from Belling and Lee, Cambridge Arterial Road, Enfield, Middx.

"A Guide to Plastics," by C. A. Redfarn, B.Sc., Ph.D., F.R.I.C., which is issued by our associate journal *British Plastics*, price 7s 6d, deals with the subject of plastics from the basic raw material, through the stages of manufacture to finished products.

Plastics Exhibition.—The success of the Plastics Exhibition and Convention held at Olympia in June has prompted the organizers, *British Plastics*, to make preparatory arrangements for a similar exhibition in 1953.

Antipodean Radio-telephony.—The Hong Kong-Australia radio-telephone service has now been extended to New Zealand.

INDUSTRIAL NEWS

Tannoy sound-reinforcing equipment, similar to that installed in both Houses of Parliament and Church House, Westminster, has been provided in the Parliament Chamber, New Delhi. The installation, which includes sixteen microphones and over 400 reproducers, was undertaken by Union Radio and Appliances, Ltd., New Delhi, India.

E.M.I. Service Depot for the Northern television area has been opened by E.M.I. Sales & Service at Regent House, Cannon Street, Manchester (Tel.: Deansgate 2315). H. A. H. Kelsey, previously with the organization at Perivale, has been appointed manager of the depot.

Londex, Ltd., have opened a third factory—in Croydon. The main offices and research section remain at the Anerley Works, Anerley Road, London, S.E.20 (Tel.: Sydenham 6258), and the Progress and Buying Departments at Howard Road, S.E.20 (Tel.: Sydenham 2431).

Edison Swan Electric Co. announce that they have ceased to handle Plessey components suitable for the "Viewmaster" television receiver.

Grampian Reproducers, Ltd., announce that G. Fidler, who was in charge of their experimental department, has resigned. He has joined Avimo, Ltd., of Taunton, as chief engineer.

Altron is the trade name adopted by Allied Electronics, Ltd., of 28, Upper Richmond Road, London, S.W.15 (Tel.: Vandyke 1856), manufacturers of communications and industrial electronic equipment. They previously traded under the name of British Electronic Industries.

Osmor Radio Products, Bridge View Works, Borough Hill, Croydon, Surrey, manufacturers of coils and coil assemblies, have changed their telephone number to Croydon 5148.

Barker Loudspeakers.—Owing to the loss of a quantity of correspondence received between October 1st and 12th, Barker's ask correspondents to write again should they not receive a reply.

MEETINGS

Institution of Electrical Engineers

Radio Section.—"An Investigation into the Mechanism of Magnetic-Tape Recording" by P. E. Axon, O.B.E., M.Sc., on December 5th.

Informal Lecture on "What Practical Benefits can Communication Engineers expect from the Modern Information Theory?" by E. C. Cherry, M.Sc. (Eng.), on December 17th.

Ordinary Meeting.—"Technical Colleges and Education for the Electrical Industry" by H. L. Haslegrave, M.A., Ph.D., M.Sc.(Eng.), on December 6th.

Education Circle.—Discussion on "Activity Methods in Technical Education"; opener R. D. Watts, B.Sc., at 6 on December 12th.

The above meetings will be held at 5.30 (except where otherwise stated) at the I.E.E., Savoy Place, London, W.C.2.

East Midland Centre.—Faraday Lecture on "Sound Recording—Home, Professional, Industrial and Scientific Applications" by G. F. Dutton, Ph.D., B.Sc. (Eng.), at 7.15 on December 19th at De Montford Hall, Leicester.

Cambridge Radio Group.—Informal Lecture on "What Practical Benefits can Communication Engineers expect from the Modern Information Theory?" by E. C. Cherry, M.Sc.(Eng.), at 8.15 on December 4th at the Cavendish Laboratory, Cambridge. (Joint Meeting with the Cambridge University Wireless Society.)

Mersey & North Wales Centre.—"The London-Birmingham Television-Cable System" by T. Kilvington, B.Sc. (Eng.), F. J. M. Laver, and H. Stanesby, at 6.30 on December 3rd at the Liverpool Royal Institution, Colquitt Street, Liverpool.

North Eastern Radio Group.—"The Life of Oxide Cathodes in Modern Receiving Valves" by G. H. Metson, Ph.D., M.Sc., S. Wagener, Dr.Phil., M. F. Holmes, B.Sc., and M. R. Child, at 6.15 on December 3rd at King's College, Newcastle-upon-Tyne.

North Midland Centre.—Discussion on "The Devising of Examination Questions"; opener Prof. G. W. Carter, M.A., at 6 on December 4th at the Lighting Service Bureau, 24, Aire Street, Leeds.

North Western Centre.—"Technical Colleges and Education for the Electrical Industry" by H. L. Haslegrave, M.A., Ph.D., M.Sc.(Eng.), at 6.15 on December 4th at the Engineers' Club, Albert Square, Manchester.

South Midland Centre.—"The Sutton Coldfield Television Broadcasting Station" by P. A. T. Bevan, B.Sc., and H. Page, M.Sc., and "The Vision Transmitter for the Sutton Coldfield Television Station" by E. A. Nind, B.Sc. (Eng.), and E. McP. Leyton, at 6 on December 3rd at the James Watt Memorial Institute, Great Charles Street, Birmingham.

Faraday Lecture on "Sound Recording—Home, Professional, Industrial and Scientific Applications" by G. F. Dutton, Ph.D., B.Sc.(Eng.), at 6 on December 18th at the Town Hall, Birmingham.

Western Centre.—"The Life and Work of Oliver Heaviside" by Prof. G. H. Rawcliffe, M.A., D.Sc., at 6 on December 10th at the South Wales Institute of Engineers, Park Place, Cardiff.

British Institution of Radio Engineers

London Section.—"Electronic Analogues of Physiological Processes" by W. Grey Walter, M.A., Sc.D., and H. W. Shipton (Burden Neurological Inst.) at 6.30 on December 13th at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

Scottish Section.—"Automatic Precision Temperature Recorders incorporating the Electronic Potentiometer" by C. H. Offord (Honeywell, Brown & Co.) at 7 on December 6th at the Institute of Engineers and Shipbuilders, Glasgow.

Merseyside Section.—"Multi-Station V.H.F. Communication Systems using Frequency Modulation" by W. P. Cole, B.Sc., and E. G. Hamer, B.Sc. (G.E.C. Research Laboratories) at 7 on December 6th at the Electricity Service Centre, Whitechapel, Liverpool.

South Midlands Section.—"Improvements in and relating to Loudspeaker Design" by R. T. Lakin (Whiteley Electrical) at 7.15 on December 12th at the Corporation Street Civic Restaurant, Coventry.

West Midlands Section.—"Design and Application of Industrial H.F. Heaters" by F. W. Budge at 7 on December 18th at Wolverhampton and Staffordshire Technical College, Wolverhampton.

Institution of Electronics

N. Western Branch.—"The Use of Cathode-Ray Tubes in Digital Computing Machines" by T. Kilburn, M.A., Ph.D., A.M.I.E.E., at 7 on November 30th at the College of Technology, Manchester.

Southern Branch. — "Germanium Crystal Valves: Their Characteristics and Applications" by B. R. Bettridge (G.E.C.), at 6.30 on December 5th at Southampton University College.

"Ionization and Nuclear Bombardment" by Inst. Lt. Cdr. R. E. Ward, A.C.G.I., Wh.Sch., R.N., at 7 on December 12th at H.M.S. Phœnix, Stamshaw, Portsmouth.

Television Society

"Television Receiver Design for British and European Systems—a Comparative Study" by Bryan R. Overton, B.Sc., (Mullard Research Labs.) at 7 on December 6th at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

Leicester Centre. — "Wide - Angle Scanning Circuits," by A. J. Thoroughgood, at 7 on December 3rd at the Leicester College of Technology (Room 104), The Newarkes, Leicester.

British Sound Recording Association

London Section.—Members' Night: Short papers given by members on Hot stylus technique, Pickup design, Pickup tracking and Magnetic tape problems, at 7 on December 21st at the Royal Society of Arts, 6, John Adam Street, London, W.C.2.

Portsmouth Centre.—"Building High-Fidelity Amplifiers" by S. Goodsell, at 7.30 on December 20th at the Central Library, Guildhall Square, Portsmouth.

Radio Society of Great Britain

Annual general meeting at 6.30 on December 18th at the I.E.E., Savoy Place, London, W.C.2.

Engineers' Guild

Metropolitan Branch. — Films: "Voices under the Sea" (Cable & Wireless), and "The Port of Manchester," at 6 on December 6th at Caxton Hall, London, S.W.1.

Institution of Works Managers

Glasgow Branch.—"Electronics" by a representative from Ferranti, at 7.15 on December 17th at the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2.

VALVE CATHODE LIFE

By C. C. EAGLESFIELD, M.A. A.M.I.E.E.*

New Explanation for Apparent Deterioration—and a Remedy

IT is generally supposed that the lives of oxide-coated cathodes are only moderate; it may therefore come as a surprise that, in an investigation of the life records of repeater valves made by Standard Telephones and Cables, no evidence could be found to put a definite term to the cathode lives. The conclusion seems to be that the emission continues indefinitely.[1]

However, an effect has been found that could easily be mistaken for a drop in the emissivity. This is the formation of a resistive barrier between the cathode core and the coating, which causes a feedback and thereby a change in the measured characteristics. The effect seems to occur so universally that the study of cathode life almost becomes a study of this resistance. When the life history of a valve shows a deterioration in working current, bias, or mutual conductance, it is perfectly feasible to postulate such a cathode resistance of sufficient magnitude to explain the change. If this be done, one would expect the required resistance to be inversely proportional to the cathode area.

In Fig. 1 is shown the life history of three valve types in terms of such a cathode resistance. The resistance is brought on to a common basis, i.e., for a cathode area of one square centimetre, and is derived from the observed change of mutual conductance during life. Two of the types are small r.f. pentodes and the third is an r.f. pentode of somewhat greater rating—it has a 5-W cathode (triple-carbonate on 0 nickel) and a mutual conductance of 6.5 mA/V at its usual working anode current of 38 mA. All three can be regarded as normal receiving-type valves.

It will be seen that the resistance builds up to a saturation value of about 40 ohm-square-centimetres for all three types, with a surprisingly sharp angle where the rise meets the saturation level.

The resistance grows in a similar way for many other types; the three valves shown have been chosen because it happens that the tests have been continued long enough to show the saturation level clearly. All the life histories that have been examined can be explained by the hypothesis that a cathode resistance builds up to 40 ohm-square-centimetres and then stays constant.

It is important to realize that the suggestion is that no change takes place in the emissivity of the cathodes, but that in all valves the resistance grows to a certain value and then stays constant. It may, or may not, change the measured characteristics appreciably, according to the design of the valve. But all valves grow the resistance and then stay without change indefinitely.

Are there any reasons for supposing that such a resistance exists physically?

A way of detecting it is to measure the mutual conductance at a high frequency (greater than about 5 Mc/s) as well as at a low frequency (less than about 50 kc/s). With a new valve, there is no difference but with an aged valve the high-frequency mutual conductance is the greater. Such a difference is only to be explained by a resistance shunted by a capacitance having been formed at the cathode.

The double-frequency method has been used to measure the cathode resistance of a number of valves that had deteriorated during life, supposedly for a drop in emission. In every case, a resistance was found and the resistance was approximately that required to explain the change in characteristics.

Growth of Cathode Resistance

Two possible causes have been suggested for the growth of the resistance: a mechanical theory by Raudorf and a chemical theory by Eisenstein.

Raudorf's theory[2] is that with age the coating shrinks away from the core, leaving contact between coating and core only at minute discrete spots. The reduction of contact area explains the resistance, which is localized round the contacts, and the high capacitance is explained by the close spacing between the core and the body of the coating. Raudorf associated the shrinking of the coating with a network of fine cracks that he observed on the outer surface of the coating of aged cathodes, and stated that he found flat cathodes much superior to round cathodes.

Eisenstein's theory[3] is that a resistive film is formed at the interface of core and coating by the formation of compounds of barium and core impurities. These impurities are deliberately included in the core metal as reducing agents to promote activation: the most usual are silicon and magnesium and their effect is to

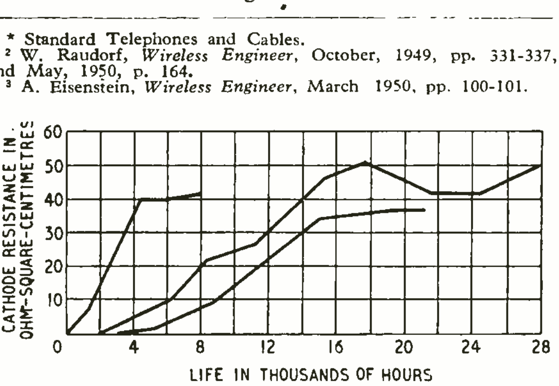


Fig. 1. Growth of cathode resistance during life for three types of valves.

[1] C. C. Eaglesfield, *Electrical Communication*, June, 1951, pp. 95-102.

* Standard Telephones and Cables.

[2] W. Raudorf, *Wireless Engineer*, October, 1949, pp. 331-337, and May, 1950, p. 164.

[3] A. Eisenstein, *Wireless Engineer*, March 1950, pp. 100-101.

release free barium. Eisenstein regards barium-orthosilicate as the most important cause of the resistance.

To the writer it seems that Eisenstein's theory is more probable and contains fewer inconsistencies.

It is doubtful whether the resistance could be cured in the manufacturing process—and in any case every trial experiment would take many thousands of hours to complete, as can be seen from Fig. 1. This being so, it is worth while considering what can be done in the design of apparatus to reduce the effect of the resistance, on the assumption that all present valves have it and all future valves will have it, for an indefinite time ahead.

The known facts can be summed up by saying that within six months to two years running, valves will change from their initial state to a final state in which they have a cathode resistance shunted by a capacitance.

Remedy in Circuit Design

Measurements on valves in their final state suggest average figures of 40 ohm-square-centimetres for the resistance and 0.005μF per square centimetre for the capacitance. It has been verified that the resistance is linear up to a loading of 40mA per square centimetre. The resistance is temperature dependent, but as there is little difference between the cathode temperatures of one valve type and another, this need not concern the user.

The user will probably not know the coated area of the cathode of any particular type of valve, but he may estimate it from the rated heater power, on the basis of 3W per square centimetre.

The easiest way to deal with this problem is to concentrate on the two states of the valves: if the apparatus is satisfactory for both states, it seems a fair deduction that it would be satisfactory during the period of growth. The designer may proceed with a trial design, based on the valves in their new state. He then estimates the resistance and capacitance that will grow at each cathode and, by experiment or calculation, tests whether the design is still satisfactory.

It is hardly possible to give very general instructions on how to choose circuits that will prove satisfactory: each case must be considered on its merits. However, consideration suggests that a liberal use of feedback gives the best chance of success. The reason is that the feedback produced by the life-impedance depends on the valve's effective mutual conductance and a permanent feedback effectively reduces the mutual conductance. A rough rule is that the permanent feedback should swamp the life-impedance feedback.

Take, first of all, a rather simple case, a single valve used for Class A amplification at high radio frequencies. Since the life-resistance is adequately bypassed by the life-capacitance, it will cause no feedback, but will only alter the bias conditions. This is easily allowed for by using a cathode resistor large compared with the life-resistance to provide bias. This usually gives excess grid bias, so the grid is returned, not to earth, but to a positive point. By this very simple device the valve's running conditions can easily be kept almost the same for its two states.

Now consider an amplifier for audio frequencies. It is not likely that the valves for this service will show particularly large changes during life, as there is little need for a high ratio of mutual conductance to heater power. The feedback due to the life-impedance will be constant over the audio-frequency band. To reduce distortion, it is customary to provide a strong feedback from the output of the amplifier to an early stage and this would probably swamp the life-feedback. It seems likely that little modification would be needed to most audio-frequency amplifiers to make them satisfactory.

It thus seems that where the application involves frequencies either very high or very low there should not be any great trouble. A more difficult case is the video-frequency amplifier, partly because the life-feedback then varies over the band and partly because the valves likely to be used are just those most susceptible to the effect.

Such amplifiers are normally required to have a flat frequency characteristic, and it is therefore necessary to compensate for their natural tendency to fall off at the higher frequencies. This is often done by increasing the effectiveness of the inter-stage coupling at the higher frequencies, but another way is to provide a frequency-dependent feedback, and this seems a better way for our present purpose.

Considering a single stage, the compensating feedback may be a resistance and capacitance in shunt in the cathode lead. Now there is usually a range of feedback for which the overall result is much the same, i.e., the same stage gain and frequency characteristic can be got by using high forward gain and high feedback or low forward gain and low feedback. It may thus be possible to swamp the life-feedback.

Where there are a number of stages, it must be considered whether to use feedback over several stages, at each stage, or a combination of both.

If great linearity is required in the input-output voltage characteristic, then feedback will be needed for this purpose. Such a requirement arises in multi-channel carrier amplifiers. For this case, it may prove best to use frequency-dependent feedback at each stage and frequency-constant feedback over the whole chain.

STANDARDS FOR DRY BATTERIES

A NEW British Standards specification, BS1766, dated 1951, recently issued, prescribes the dimensions and performance of dry batteries for use in domestic radio receivers. The performance tests recommended are for their use in a temperate climate, such as prevails in the United Kingdom, and will not be applicable to tropical or arctic conditions. The need for this specification has arisen as experience has shown that the provisions in BS397, "Leclanché-type Primary Cells and Batteries" do not fully meet the present-day requirements for domestic radio batteries. To avoid misunderstanding, definitions are given of the type of primary cell covered by the specification.

In the section devoted to tests it is laid down that for h.t. batteries the end-point, which determines the life of the battery, shall be at 55 per cent of the nominal voltage, and for l.t. batteries when the voltage per cell falls to 1.0 V. An alternative of 1.1 V is mentioned also.

Provisions are made, *inter alia*, regarding "shelf life" and the types of terminal connections, sockets and otherwise, to be used and their position.

Copies are obtainable from the British Standards Institution, 24, Victoria Street, London, S.W.1, and the price is 2s, including postage.

Oscilloscope "Hum"

Some Power-supply Troubles

By W. TUSTING

IN the course of constructing an oscilloscope the writer met with considerable difficulty from mains hum of a kind which is rarely referred to in print, and it is thought that an account of the steps which led to its removal may be of value to other experimenters. The difficulty arose out of the stray field of the mains transformer and, in spite of the presence of a well-made screen around the tube, an unwanted deflection of no less than 0.75 in was found! It is, of course, very well known that the leakage field of a mains transformer is liable to cause such an unwanted deflection and it is commonly stated that it is necessary either to space the transformer widely from the cathode-ray tube or to fit the tube with a mumetal screen. The phrasing usually adopted leads one to believe that if a mumetal screen is used the position of the transformer is unimportant. There is, too, an idea existing that all tube screens are mumetal or its equivalent.

The oscilloscope was built on the stripped chassis of an ANP4 Loran Indicator Unit using the 5CP1 tube of this unit with its screen. This tube is a 5-in type with a post-deflection accelerator. It is rated for 2 kV on the final anode and an additional 2 kV on the post-deflection electrode. However, in this instance the final anode and the post-deflection electrode were joined together and operated at a little under 2 kV, since this was found to give adequate brightness.

An h.t. supply of some 350 V was needed for amplifiers, time bases, etc., and as a suitable transformer was available it was decided to take the e.h.t. supply from this also, through a voltage-multiplying circuit using metal rectifiers. This saved the provision of a separate e.h.t. transformer or, the alternative, rewinding the general transformer to include an e.h.t. winding.

The basic circuit of the power-supply unit is shown in Fig. 1 and is of a type discussed by A. H. B. Walker.[1] Since it was intended to use direct coupling between the amplifiers and the deflector plates the final anode of the tube had to be taken to a point about 250 volts above earth. The total voltage available for the tube is thus about 250 volts more than the output of the voltage-multiplying rectifier.

The chassis of the Indicator Unit takes the form of a steel tray of 2 in under-chassis depth. There is a steel front panel carrying the mounting for the front end of the tube and two upper sub-chassis. These are at about 1 in below the level of the tube axis and one on each side of it. They are shaped roughly to the tube contour on one side and have attached vertical pieces which bolt to the lower chassis. At the rear they carry the back tube mount. The tube has a metal screen fitting it which is quite elaborately and solidly constructed. The general form of the chassis is sketched in Fig. 2.

In view of this screen no hum trouble was expected, but as a precaution the mains transformer was mounted as far from the tube as possible. A rectangular hole was cut in the lower chassis at the back and the transformer mounted beneath the chassis with only the upper half of the bobbin projecting through The clearance between the bobbin and the underside of the c.r. tube was about 4 in.

Initially, the tube was operated at 1.75 kV and a vertical deflection of 0.75 in was found and was due solely to the external field of the mains transformer. It is very easy to determine whether or not a deflection is produced by a magnetic field. If the deflection is unaffected by rotating the tube it is due to a magnetic field, whereas if it rotates with the tube it is caused by a voltage on the deflector plates. Of course, if the screen around the tube is not symmetrical and it is rotated with the tube the pattern will vary somewhat even when only a magnetic field is present.

A spurious deflection of 0.75 in is, of course, intolerable. The most that could be allowed would be about 1 mm, and even this is too great.

Operation with no tube screen at all was tried. The deflection was then 1.35 in. The screen was thus giving only 2.5 db attenuation of the stray field and was, practically speaking, useless. A mumetal screen was then tried. This was one made for a VCR97 tube and did not fit the 5CP1 properly. However, it covered the tube from the base up to the side-con-

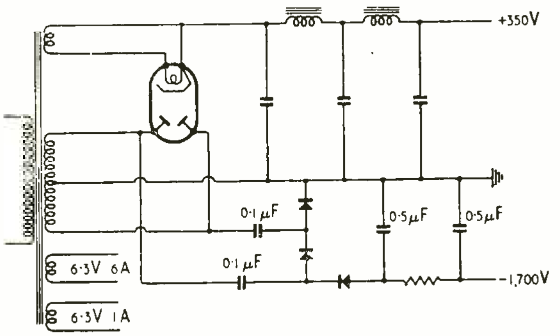


Fig. 1. Circuit of power supply unit.

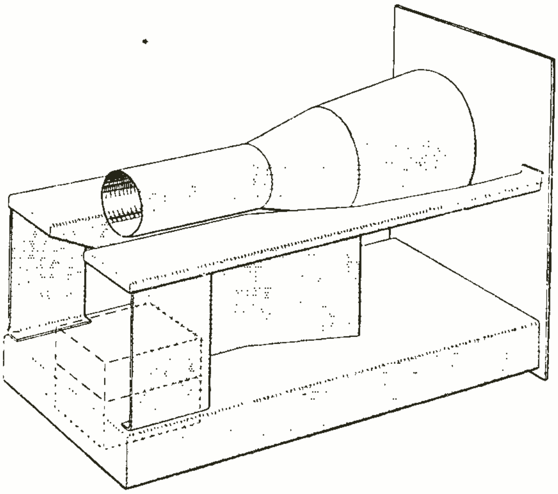
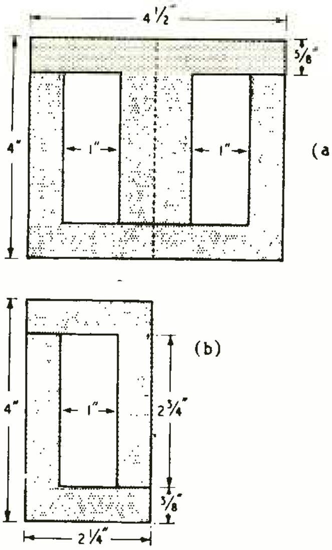
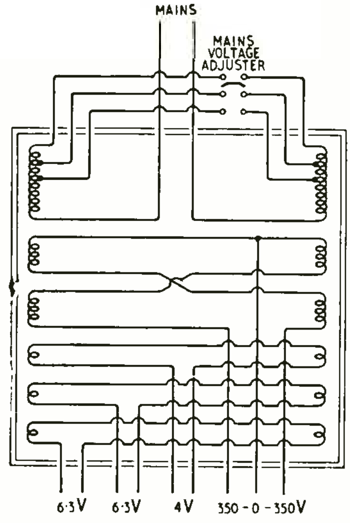


Fig. 2. General form of oscilloscope chassis.

[1] "Television E.H.T. Supply," *Wireless World*, April and May 1948, pp. 120 and 169





Left: Fig. 3. Transformer laminations (a) T and U pieces; (b) cut into L pieces. Right: Fig. 4. Connections of astatic transformer.

nector on the flare. This brought the deflection down to ⅛ in only, making its attenuation about 23 db.

This screen is made in two pieces, as two half-cylinders with attached flares. The two halves overlap for about ½ in, but it was found that the joins affected the screening and that the screening was best when the two joins were in the horizontal plane. This is reasonable, because with a vertical spurious deflection the magnetic field is horizontal.

The enormous difference between the two tube screens made it obvious that the original one was not mumetal at all, and that it was quite useless for screening against a 50-c/s field. A second mumetal screen was obtained and fitted outside the first one in the hope that the deflection would again be reduced by a factor of the same order. However, this merely gave an improvement of some 25 per cent and reduced the deflection to $\frac{3}{32}$ in.

There were indications that some field was passing through the unscreened part of the tube in front of its side-connector. A screen for this was, therefore, fabricated out of a VCR97 screen. This was cut with shears and a flare made from four overlapping pieces. These were held together by narrow strips of mumetal passed through pairs of holes and turned over, rather like the wire staples used for holding papers together. The new flare was held on to a normal VCR97 screen by six screws and nuts.

This screen gives almost complete coverage of the tube, save, perhaps, for an inch back from the screen. It is probably not as effective as one made for the job because of the number of joints. Also mumetal needs heat treatment after working. It was thought, however, that the small amount of gentle bending, cutting with shears and drilling which the metal received would not seriously affect its properties.

This new screen reduced the deflection to $\frac{1}{16}$ in, some 29 db less than that with no screen; the screen was 26.5 db better than the original one. This was a great improvement and brought the oscilloscope to the state of being usable although the deflection was still too great to be satisfactory. It was estimated that a further reduction by a factor of at least 5 was necessary.

In view of the fact that some other oscilloscopes were free from this trouble, in spite of there being no greater spacing between the tube and transformer, it was thought that the particular form of the chassis might be responsible. The two sub-chassis on either side of the tube were of steel and connected through vertical steel supports to the main chassis on either side of the transformer. The erection resembled a pair of pole pieces and it was thought that they might be acting as such. However, their complete removal and also the removal of the front panel made no measurable difference.

It was now evident that something would have to be done to the transformer. Experiment was made difficult by the fact that no alternative tube supply was available and, since trouble had not been expected, all the other components had been mounted on the chassis around the transformer.

The original mounting was with the laminations horizontal and in contact with the chassis, the core lying fore-and-aft. With some trouble the transformer was turned through a right angle so that the core lay across the chassis. The only effect of this was to turn the deflection from a vertical to a horizontal trace, the magnitude being hardly altered.

Transformer Stray Field

The puzzle of why this unwanted deflection did not occur in other oscilloscopes remained and one of them was examined in some detail. This oscilloscope had two transformers, one for the h.t. and the other for the e.h.t. supplies. They were similar in size and symmetrically disposed with regard to the tube. It occurred to the writer that their external magnetic fields might be in opposition in the region of the tube and the experiment of reversing the primary connections of one of the transformers was tried. This at once produced a spurious deflection of the same order of magnitude as that in the other equipment.

It is clear, therefore, that with transformers of normal construction it is better to use two than one and to pole their primaries so that their external fields are in opposition. It is clear, too, that for maximum effect the two transformers should be physically as alike as possible and have equal magnetizing currents, but the secondary turns need not be the same. The transformers should be mounted symmetrically with regard to the tube and as close together as possible.

The use of two transformers instead of one bigger one is definitely an advantage from the point of view of hum from their magnetic fields. Even with identical transformers, however, complete cancellation of the field cannot be obtained unless they occupy the same physical position and this is impossible.

In practice, the use of two identical transformers (identical save for their actual secondary turns) is inconvenient and usually takes up a great deal of space. If the transformers are dissimilar the hum reduction is less and their placing may be critical.

It is better, therefore, to use a so-called astatically wound transformer. This has a rectangular core with a single window and is built up from L laminations instead of the usual T and U or E and I pieces. The windings are in two bobbins on opposite limbs of the core and all windings are split equally between the two. They are connected in series to be series-aiding around the core, but the external fields are in opposition.

The properties of such a transformer are obviously better than those of two ordinary ones because the two sets of windings can be much closer together. Moreover, the total volume required is less. It was decided, therefore, that the proper thing to do was to make an astatic transformer in spite of the labour involved. No suitable laminations were found in the lists—the nearest would have made the transformer at least an inch too big for the available space. It was decided, therefore, to use the existing laminations (M. & E. No. 60) cut in half. They are as shown in Fig. 3 (a) and by cutting along the dotted line a set of L pieces (b) is obtained. The cut edges all come on the outside and so any irregularities do not affect the joint in the magnetic circuit.

The stack height is double that of the existing transformer so that the volume of iron is unchanged as are also the length of the magnetic path and the core area. The same turns per volt are thus needed for the same flux density in the core. The window area is unaltered, so that the same turns can be accommodated. However, with two bobbins instead of one there is rather more waste space needed for insulation between coils and between coils and the iron.

The existing bobbins had rather a large clearance between the outside of the coil and the iron, however, and being wound in sandwich form there was a lot of waste space from the end cheeks of sections. It was felt, therefore, that there would be no difficulty in accommodating the turns. The mean length of turn came out somewhat greater and was reflected by an increase of the copper losses. This would tend to increase the working temperature, but to offset this the surface area of the windings was rather greater.

The transformer was rewound on these lines, there being two identical bobbins with the primary on the inside and the h.t. secondary outside this and the l.t. windings outside the lot. The h.t. winding in each bobbin was split into two sections. Since the two halves of a 350-0-350 V winding carry current alternately and not simultaneously a balance in the external field is only obtained if each half is split into two sections of which one is on each bobbin. (See Fig. 4.)

Both bobbins were wound identically and one was turned around in assembling them on the core so that the coils were in series-aiding when the outer of one winding on one bobbin was joined to the outer of the corresponding winding on the other bobbin.

From the point of view of stray field this transformer was completely successful. With the mumetal screen there was no observable deflection of the spot. Without any screen around the tube at all the deflection was only about $\frac{5}{32}$in high.

The form of the hum on the screen was not the same with the two transformers, however. With the original one it took the form of a vertical or horizontal line according to the position of the transformer. With the astatically-wound component it formed a rectangle about 4 mm high and 1.5 mm wide. This is obviously due to two fields in different directions with a phase displacement between them, the rectangular picture being due to waveform distortion. The precise mechanism is a little obscure.

Taking the diagonal, 42.5 mm = 0.168in, as a measure of the hum amplitude, the improvement due to the astatic transformer is 1.35/0.168 = 8 times, or 18 db. As compared with the starting point a total improvement of 44.5 db in the hum level had been achieved—26.5 db from replacing the original tube screen by one of mumetal and 18 db by replacing the original transformer by one wound astatically. The hum deflection, which is too small to measure, should thus be 44.5 db below 0.75 in, or 0.75/168 = 0.0045 in = 0.1 mm. This is considerably less than the spot size and is entirely satisfactory.

Although not strictly relevant to the subject of this article it may be worth mentioning that considerable difficulty was experienced from leakage between the heater winding for the c.r. tube and other windings. The full e.h.t. voltage exists between them and as the e.h.t. supply is of high impedance quite a small leakage reduces the voltage greatly. It was found essential to impregnate the windings to keep down the leakage.

MANUFACTURERS' LITERATURE

Ediswan Valve Manual in two loose-leaf books; Volume I for Mazda receiving valves and cathode-ray tubes, Volume 2 for transmitting, industrial and special types. Available from the Edison Swan Electric Co., Ltd., 155, Charing Cross Road, London, W.C.2, at 7s 6d complete.

Industrial Timers described in leaflets from Allied Electronics, Ltd., 28, Upper Richmond Road, Putney, London, S.W.15.

Holme Moss Mast; constructional details given in an illustrated brochure from British Insulated Callender's Construction Co., Ltd., 21, Bloomsbury Street, London, W.C.1.

Coin-operated Radio equipment for hotels, blocks of flats, etc., outlined briefly in a leaflet from Hadley Sound Equipments, Ltd., Cape Hill, Smethwick, Staffs.

Geiger Counter and **Oscilloscope** tubes; technical details in a leaflet from 20th Century Electronics, Ltd., Dunbar Works, Dunbar Street, West Norwood, London, S.E.27.

Quartz Crystals in evacuated glass envelopes; a leaflet giving brief details of the types made by Standard Telephones & Cables, Ltd., Connaught House, Aldwych, London, W.C.2.

Aluminium Wire data sheets in a folder from Aluminium Wire & Cable Co., Ltd., 37, Thurloe Street, South Kensington, London, S.W.7.

Time Switch with electrically wound spring giving eight hours' running, described in a leaflet from Venner Time Switches, Ltd., Kingston-By-Pass, New Malden, Surrey.

Soldering Irons and Crucibles, with elements claimed never to need replacement, described in a brochure from The Automatic Coil Winder & Electrical Equipment Co., Ltd., Winder House, Douglas Street, London, S.W.1.

Aerials for sound, television and car radio in a 1951-52 catalogue from Aerialite, Ltd., Castle Works, Stalybridge, Cheshire.

Meter Making illustrated in a booklet published to mark the Golden Jubilee of Everett Edgcumbe & Co., Ltd., Colindale Works, London, N.W.9.

Car Aerial, telescopic turret type, described in a leaflet from E. K. Cole, Ltd., Ekco Works, Southend-on-Sea, Essex.

"How to Choose a Television Set," a booklet intended for non-technical would-be viewers, from The Edison Swan Electric Co. Ltd., 155, Charing Cross Road, London, W.C.2.

Electrolytic Capacitors

Principles of Operation and Some Recent Developments

By G. W. A. DUMMER, M.B.E., M.I.E.E.

IT is strange to think that it is nearly seventy years since the first electrolytic capacitor was made in Germany and nearly ninety years since the principle was first noticed. The oustanding advantage of the electrolytic capacitor is its large capacity in a small volume. Looking at a modern compact electrolytic capacitor, a capacity of 8μF at 450 volts (working) in a container ¾in diameter and 2¼in long seems incredible when the paper equivalent is considered, and at low voltages the capacity comparison is many times greater. Even this does not compare with results now being obtained on new developments such as the tantalum electrolytic capacitor described later in this article.

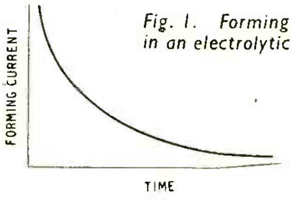
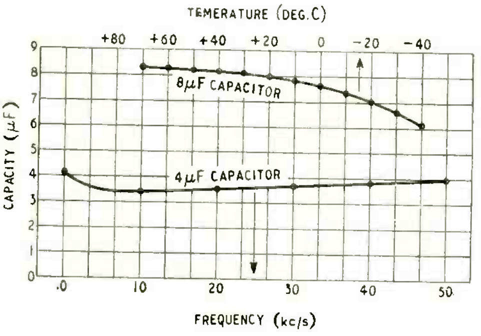
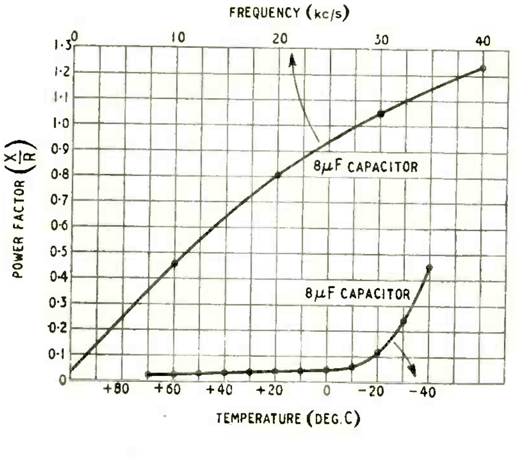


Fig. 1. Forming current for constant voltage in an electrolytic capacitor.

Below: Fig. 2. Effect of temperature and frequency on capacity.



Below: Fig. 3. Variation of power factor (ratio of reactance to parallel resistance) with temperature and frequency.



The large capacity comes from the very thin film of dielectric used—of the order of 10^{-5} cm (or a few millionths of an inch). Capacity is determined by the well-known formula:

$$C = 0.0885 \frac{KA}{T} \mu\mu F \text{ (for a flat plate capacitor)}$$

where K = dielectric constant (about 12 for electrolytic capacitors)
A = area of one plate in sq cm.
T = distance between plates in cm.

Hence if T is very small the capacity will be very large. The method of making this thin film is by anodic oxidation. Certain metals, notably aluminium, tantalum, vanadium, magnesium, bismuth and antimony are readily coated with a film of dielectric by an electrolytic "forming" process. If an aluminium electrode is placed in a solution of ammonium borate and a constant voltage applied, the initial current will be high but will gradually drop as the dielectric film forms (see Fig. 1).

The forming process consists of the deposition of a thin film of aluminium oxide on the surface of the plate. In modern practice the anode foil enters a tank of electrolyte with a constant voltage applied and continues passing through the tank until the required thickness of film is produced.

The strength of the film is remarkable. A p.d. of 100 volts across a film of 10^{-5} cm represents a dielectric strength of 10 million volts per cm, which is beginning to approach the theoretical strength predicted by the ionic theory of crystals, which otherwise has never been approached in practice. The maximum capacity obtainable with a given anode surface area is inversely proportional to the voltage used in the forming process, i.e. the film thickness depends on the forming voltage. Low-voltage capacitors have thinner films and therefore a higher capacity/volume ratio than high-voltage capacitors. The thickest film is formed at about 600 volts, which sets a limit to the maximum working voltage obtainable of about 500 to 550 volts (at room temperature), as the working voltage is approximately 90 per cent of the forming voltage. Ripple voltage must be included in this where the capacitor is being used for rectifier smoothing. It can also be seen from this that the surge voltage is limited in this type of capacitor.

Present Types

There are three main types of dry electrolytic capacitor in use today, those using a plain foil anode.

those with an etched foil anode and those with a sprayed gauze anode. The latter two have greater capacity in the same volume because the anode surface is roughened, thus providing greater area. The essential parts of an electrolytic capacitor are:—

1. The aluminium foil—Positive or anode.
2. The oxide film—Dielectric.
3. The electrolyte (usually a paste of glycol and ammonium tetraborate—Negative or cathode.
4. Spacers—Necessary to separate the negative electrode and anode film from direct contact.
5. A second aluminium foil—A contact electrode to the electrolyte.

A plain-foil dry electrolytic capacitor is made by first forming a coating of aluminium oxide on both sides of an aluminium foil about 0.002in thick. Two strips of aluminium foil are used (the formed foil as anode and the plain as contacting electrode for the electrolyte cathode) separated by two layers of porous paper soaked with electrolyte. This assembly is rolled up, the ends closed with wax and then sealed into a metal container.

Reversible electrolytic capacitors are also made by pre-forming both the aluminium foils and bringing out separate contacts. Each film is effective during the half-cycle that the other is ineffective.

The etched foil type is similar in construction, but the anode foil is mildly acid-etched before forming. This increases the surface area, and as the electrolyte is a paste it can adhere closely to the anode contour. It is essential to control the etching process closely so that "thin" spots are not left on the foil and also to ensure that no acid is left which might contaminate the foil.

The sprayed gauze anode type consists of a fine cotton gauze on which is sprayed pure aluminium from a metal spraying pistol. The effective area is still further increased by this method, but again careful control is needed.

The principal characteristics may be considered as:—

1. Capacity and the effect of temperature and frequency.
2. Power factor and the effect of temperature and frequency.
3. Leakage current and the effect of time, temperature and voltage.

Taking a typical capacitor, Fig. 2 shows the variation in capacity due to temperature and frequency. It is interesting to compare this curve with that given later for a tantalum capacitor (Fig. 6).

The safe working voltage of the capacitor is determined by the leakage current/voltage characteristic. It will be seen from Fig. 4 that the limit of safe working occurs at about 400/450 volts in this case. Over this voltage the leakage current rises rapidly and breakdown soon sets in.

The leakage current also increases with increase of temperature and becomes very large as breakdown is approached. The leakage current/temperature curve is similar in shape to the leakage current/voltage curve.

In general, the disadvantages of electrolytic capacitors may be summed up as the high power factor (about 10 times that of an average paper capacitor), the variation in capacity (selection tolerances of −20% to +50% of the nominal value may be possible) the small safety factor, and the high leakage current.

The great advantage of electrolytic capacitors is, of course, the very high capacity/volume ratio and for smoothing, decoupling and bypass capacitors this advantage may outweigh all the disadvantages.

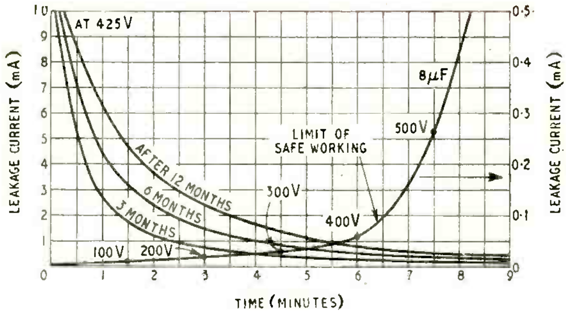


Fig. 4. Leakage current-variation with time and applied voltage.

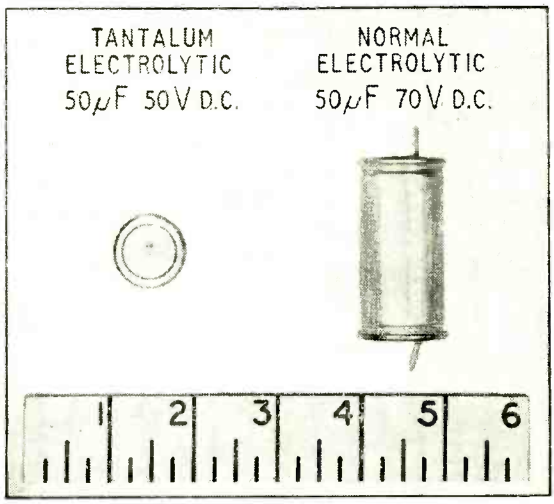


Fig. 5. Comparative size of conventional and tantalum electrolytic capacitors. (Plessey Company.)

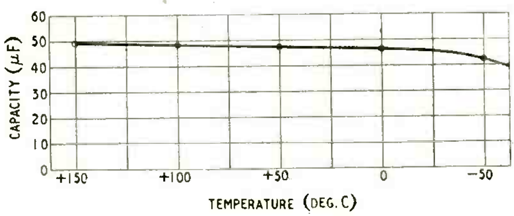


Fig. 6. Capacitance-temperature curve for the tantalum capacitor.

New Developments

During the last few years considerable experimental work has been done in obtaining greater surface area on the anodes and on the use of new anode materials and new electrolytes. It has been known for some time that an increase in the purity of the aluminium foil used would improve the life of the capacitor, but the effect of the various impurities present in the metal has yet to be fully investigated.

One of the most promising new developments is the tantalum electrolytic capacitor A photograph of one of the units is shown in Fig. 5 showing a comparison with a modern electrolytic capacitor of similar capacity. The capacitor is made by vacuum sintering a capsule of pressed powdered tantalum and mounting it inside a silver cup containing sulphuric acid as electrolyte. These capacitors are therefore essentially "wet" electrolytic capacitors. The tantalum is the anode and the silver cup the cathode. The unit is sealed by pressing cathode and anode together over a ring of polytetrafluorethylene (P.T.F.E.), which serves as an insulating washer. P.T.F.E. is necessary owing to the very wide working temperature range of the capacitor, ordinary plastics would freeze or melt at the temperatures at which this capacitor is capable of working. The capacity/temperature characteristic is given in Fig. 6 and it is interesting to compare this with Fig. 2.

The power factor is approximately 0.08 and the leakage current is very small indeed, of the order of 10μA at room temperature. They should not normally need reforming during their life. The price of the capacitors will necessarily be high owing to the high cost of tantalum.

Dry tantalum capacitors (using tantalum in foil form) are now available commercially in the U.S.A. They are rated at 150 volts and are made in values from 0.02μF to 1.0μF. They are extremely small (1.0μF is $\frac{9}{32}$in dia. by 1.0in long) and the have an operating temperature range of $-55°$ to $+85°$C.

There is no doubt that both these capacitors represent an outstanding advance in technique, but it will be some time before prices become comparable with normal types, if ever! There are, however, occasions when extremely small, efficient and reliable capacitors must be used and it is in these fields that the tantalum capacitor will become indispensable.

PHONETIC ALPHABETS

IN view of the introduction by the International Civil Aviation Organization on November 1st of a new phonetic alphabet for use in aeronautical radiotelephony, we feel readers will be interested to be able to compare this with those used in the Services and that agreed at Atlantic City for the maritime mobile radiotelephone service.

The pronunciation of the words in the new word-spelling alphabet, which is the first listed below, is generally as in English, but, as is indicated by heavy type, in one or two cases the stressed syllable differs from normal practice. Where the pronunciation differs from normal English it is shown in parentheses.

This list replaces in civil aviation the well-known Able-Baker list (shown in the second column) which, incidentally, may still be used on request by aircraft until next October. It will be recalled that these spellings, which differ slightly from those used before 1939, were employed by the Allied Forces during the war and have since been approved by the North Atlantic Treaty Organization. The Able-Baker list is, of course, that authorized for use between British ships and coast stations and, for that matter, all "wireless installations licensed by the P.M.G." It should be pointed out that the Atlantic City Convention permits stations of the same country to use "when communicating between themselves, any other table recognized by their administration."

There is also a third variation—that agreed at the 1947 Atlantic City Conference for international use in radiotelephony when it is necessary to verify a letter by analogy, and this is given in the last column.

One change from existing practice in the pronunciation of numbers is introduced in the new I.C.A.O. procedure. The number 3 is to be pronounced "tree" instead of "thuu-ree."

	I.C.A.O.	Services	Atlantic Cy.
A	**Al**fa	Able	Amsterdam
B	**Bra**vo	Baker	Baltimore
C	**Co**ca	Charlie	Casablanca
D	**Del**ta	Dog	Danemark
E	**Ech**o	Easy	Edison
F	**Fox**trot	Fox	Florida
G	Golf	George	Gallipoli
H	**Ho**tel	How	Havana
I	**In**dia	Item	Italia
J	**Ju**liett	Jig	Jerusalem
K	**Ki**lo (Kee-lo)	King	Kilogramme
L	**Li**ma (Lee-ma)	Love	Liverpool
M	**Me**tro	Mike	Madagascar
N	**Nec**tar	Nan	New York
O	**Os**car	Oboe	Oslo
P	Papa	Peter	Paris
Q	**Que**bec (Kibbeck)	Queen	Quebec
R	**Ro**meo	Roger	Roma
S	Sierra (See-erra)	Sugar	Santiago
T	**Tan**go	Tare	Tripoli
U	**Un**ion	Uncle	Upsala
V	**Vic**tor	Victor	Valencia
W	**Whis**key	William	Washington
X	**Ex**tra	Xray	Xanthippe
Y	**Yan**kee	Yoke	Yokohama
Z	**Zu**lu	Zebra	Zurich

TELESCRIBE IN CIVIL AVIATION

THE experimental air traffic control unit, established by the Ministry of Civil Aviation at London airport to try out new ideas in handling aircraft movement information, is investigating the possibilities of the Mullard Telescribe system for this purpose.

A rapid and accurate means of transmitting details of the movement of aircraft between units of a control organization such as exists at London airport is essential for the efficient operation. Owing to the density of air traffic, telephones are becoming too slow and alternative methods are being sought.

The advantage of the Telescribe is that written messages, printed matter, plans, photographs or sketches can be transmitted with equal facility to a distant point and reproduced on a cathode-ray tube, or tubes.

The material to be transmitted is written, or placed, on a sheet of glass which is scanned from below by a spot of light projected from a small c.r. tube in conjunction with an optical system. The light reflected from anything placed on the glass screen is picked up by a photocell, and the electrical signals produced are amplified and passed to the distant point where they are used to modulate a television-type receiving tube and so reproduce an exact replica of the original. Written messages are actually transmitted letter by letter as they are written on the glass. Speed and accuracy are assured. Synchronized, or common, time bases are used for both c.r. tubes.

Ringing-Choke E.H.T. Systems

Part 2 — Voltage Doublers and Regulators

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

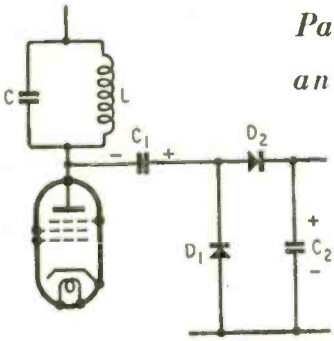


Fig. 6. Voltage-doubler rectifier connected to a ringing choke.

IT appeared in Part 1 that, using a half-wave rectifier and for a given required voltage regulation, the input power needed is proportional to the output power. When good basic regulation is required, the ratio of stored energy to output energy per cycle must be large. In addition, on account of the unavoidable circuit capacitance the stored energy is proportional to the square of the output voltage and at a high voltage may become greater than is necessary for the required regulation.

An economy of input power can then be achieved by using a voltage-multiplying rectifier. With a doubler, for instance, and the same circuit capacitance, the stored energy need be roughly one-quarter only of that with the half-wave rectifier. The regulation will, of course, be four times as bad, but this may or may not be important. If it is, a voltage-regulating circuit can be provided with any form of rectifier.

The use of a regulator has the advantage of permitting the design to be carried out for maximum economy without regard to the basic regulation. It is not suggested, however, that the use of a regulator is always necessary or advisable. It necessarily contains quite a few components and so increases not only the cost but the chances of a fault. If the basic regulation is nearly good enough, therefore, it may be better to improve it by increasing the input power.

The basic circuit of a doubler is shown in Fig. 6 connected to the ringing-choke circuit. As before, we assume that the rectifiers are perfect and that C_1 and C_2 are infinitely large; these capacitors are charged in operation to the steady voltages V_1 and V_2 with the polarities indicated on the diagram. As in Part 1, the peak voltage on the tuned circuit is V_m and the circuit has stored energy $W_s = \frac{1}{2}Li_p^2 = \frac{1}{2}CV_m^2$.

The right-hand side of the diode D_2 is above earth by V_2. The left-hand side is above earth by the tuned-circuit voltage plus V_1; D_2 conducts when the two become equal; that is, when the voltage across C reaches $V_2 - V_1$. The energy then stored in C is $\frac{1}{2}C(V_2 - V_1)^2$ and so the energy lost by L to the capacitors of the rectifier circuit is

$$\tfrac{1}{2}C\,[V_m^2 - (V_2 - V_1)^2]$$

This is on the first positive half-cycle and C is left with energy $\frac{1}{2}C(V_2 - V_1)^2$ when D_2 ceases to conduct and the voltage falls because L has lost all its energy. The energy in C is transferred to the inductance and then back to C again, this time charging it negatively for the first negative half-cycle of oscillation. When the voltage reaches $-V_1$ the diode D_1 conducts. The energy then stored in C is $\frac{1}{2}CV_1^2$ and the energy in L, which is

$$\tfrac{1}{2}C[(V_2 - V_1)^2 - V_1^2]$$

passes to C_1. The total energy passed to the reservoir capacitors is the sum of the two; that is,

$$\tfrac{1}{2}C(V_m^2 - V_1^2)$$

The load takes current i_o at voltage V_2 for the time τ, so we have

$$\tfrac{1}{2}C(V_m^2 - V_1^2) = i_o V_2 \tau$$

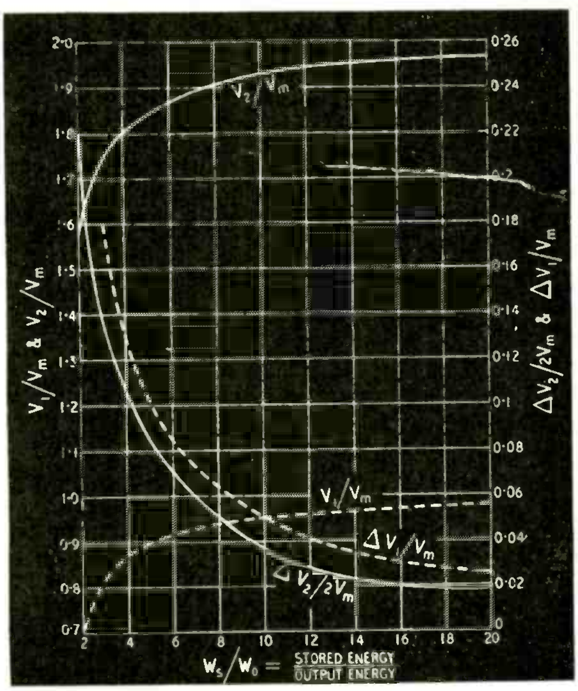
This leads to the expression

$$\frac{V_1}{V_m} = \sqrt{1 - \frac{W_0}{W_s}} \qquad \ldots \quad \ldots \quad \ldots \quad (7)$$

which is the same as equation (3) for the half-wave rectifier, except that V_1 is no longer the output voltage but is merely the voltage across C_1. As before, W_o and W_s are the output and stored energies.

We have now to find the relation between V_2 and V_1, or between V_2 and V_m, whichever is the more convenient. We do this by considering the charge q

Fig. 7. Variation of V_1/V_m, V_2/V_m with W_s/W_o. The curves for $\Delta V_1/V_m$ and $\Delta V_2/2V_m$ represent the fractional voltage regulation of V_1 and V_m. The curves for V_1 apply also to a half-wave rectifier.



conveyed around the circuit. The energy supplied to C_1 is $\frac{1}{2}CV_2^2(1 - 2V_1/V_2)$ and is equal to qV_1 (see Appendix); therefore

$$q = \tfrac{1}{2}CV_2(V_2/V_1 - 2)$$

This charge is conveyed into C_1 when D_1 conducts and removed from it to C_2 when D_2 conducts. The load energy W_o is equal to the supply to C_2 and this is qV_2 and so

$$W_o = \tfrac{1}{2}CV_2^2(V_2/V_1 - 2)$$

Re-arranging and substituting from (7) we get

$$\frac{V_m^3}{V_2^3} \cdot \frac{W_0}{W_s} + 2\frac{V_m}{V_2} - \frac{1}{\sqrt{1 - W_o/W_s}} = 0 \quad .. \quad (8)$$

Being a cubic this equation is an awkward one and we cannot easily see the relation between $V_2/2V_m$ and W_o/W_s. However, if the latter term is very small the relation is approximately

$$\frac{V_2}{2V_m} = 1 + \tfrac{1}{2}\frac{W_0}{W_s} \quad .. \quad .. \quad .. \quad .. \quad (9)$$

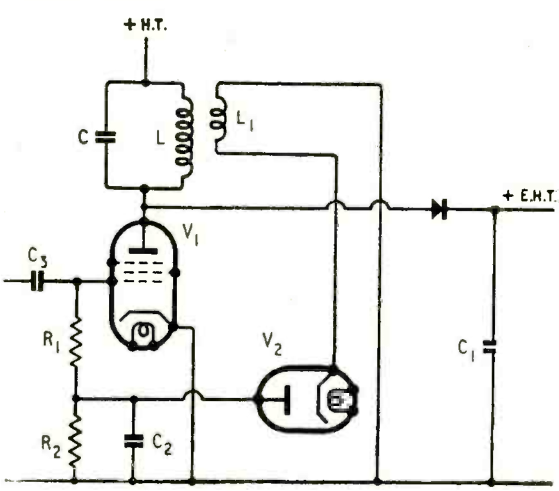
so that on light loads the regulation is the same as that of the half-wave rectifier.

Voltage-Doubler Regulation

The precise relation of equation (10) is shown in Fig. 7, where the solid-line curves show $\Delta V_2/2V_m$ and V_2/V_m as functions of W_s/W_o, while the dotted-line curves show $\Delta V_1/V_m$ and V_1/V_m. These apply for the half-wave case and also for the voltage across C_1 for the doubler.

The term ΔV_2 is defined by the relation $V_2 + \Delta V_2 = 2V_m$ and represents the difference between the output voltages on load and on no load. Examination of these curves reveals what seems at first a surprising thing. The regulation of the doubler is better than that of the half-wave rectifier. The reason for this is that the energy is withdrawn from the tuned circuit during two half-cycles of oscillation instead of only during one. The regulation of the voltage V_1 across C_1 is precisely the same as in the half-wave case for it is fed from the tuned circuit under conditions dictated by the maximum energy loss. When D_2 conducts to transfer charge to C_2, however, the tuned circuit has to supply only part of the total energy and the regulation here depends on this part only and must be better than in the case of V_1. The total regulation is therefore better.

Fig. 8. Half-wave rectifier circuit with the basic form of a voltage regulator.



Let us now see how the voltage-doubler fits into the design of a regulated supply for 10 kV at 100 μA; as before, $\tau = 100$ μsec and we aim at a regulation of 2%. Let us assume that without the regulator a regulation of 10% will suffice. Reference to Fig. 7 shows $W_s/W_0 = 4.3$ and $V_2/V_m = 1.81$ while equation (7) gives $V_1/V_m = 0.88$.

At full load ($W_0 = 10^{-4}$ joule) $V_m = 10/1.81 = 5.5$ kV and $V_1 = 4.84$ kV and the stored energy is $W_s = 4.3 \times 10^{-4}$ joule. The capacitance C should, therefore, be $2W_s/V_m^2 = 8.6 \times 10^{-4}/5.5^2 \times 10^6 = 2.86 \times 10^{-11}$ F $= 28.6$ pF. The inductance L is $2W_s/i_p^2 = 8.6 \times 10^{-4}/0.15^2 = 3.82 \times 10^{-2}$ H $=$ 38.2 mH. Let us make $E_{HT} = 250$ V and taking 90 V for the minimum permissible anode voltage, we can make $E_L = 160$ V $= Li_p/\tau_c$; therefore,

$$\tau_c = 38.2 \times 0.15 \times 10^{-3}/160 = 3.59 \times 10^{-5} \text{ sec} = 35.9\ \mu\text{sec}.$$

Therefore $i_a = 75 \times 35.9/100 = 26.9$ mA. The input power is $250 \times 0.0269 = 6.7$ W of which $6.7 - 4.3 = 2.4$ watts is anode dissipation in the valve.

These conditions are much more satisfactory than those for the half-wave rectifier. The capacitance needed is practicably large and because of the lower value of V_m the input power needed is quite small. The regulation is poor, however, so that we now have to consider how a regulator may be provided to improve it.

For simplicity, we first of all consider the half-wave case, although most of what is said applies equally to the doubler.

One form of regulator is shown in Fig. 8 added to the circuit of Fig. 4. The coil L has an additional winding L_1 and ideally the voltage across L_1 is $1/m$ of the voltage across L. This voltage is applied to the diode V_2 which acts as a peak rectifier and produces across its load circuit R_2C_2 a mean voltage nearly equal to V_1/m. In polarity the voltage makes the diode anode negative to its cathode. This cathode is returned through L_1 to earth, but in practice it may be necessary to return it to some fixed point above or below earth to obtain the correct mean grid bias on V_1.

The grid leak R_1 of V_1 is returned to the diode anode. Therefore, the grid-cathode voltage V_{gk} of V_1 is negative by V_1/m. Now V_1 depends on the load on the e.h.t. circuit. Increasing the load makes V_1 fall and as a result V_{gk} becomes less negative. If the input drive to V_1 is fixed, the instantaneous peak grid voltage also becomes less negative and the peak anode current rises. In its turn this increases the stored energy and so V_m. Although V_1 is still a smaller fraction of V_m than at a lighter load the increase of V_m makes the fall of V_1 smaller than it would be without the regulator. The circuit is in its essentials an a.g.c. circuit.

Now let us consider the precise effect of varying the grid bias on V_1. In Fig 9(a) the lines v_0 and v_c represent the zero and the cut-off grid-bias voltages. If the input saw-tooth wave is ABC applied about a grid bias v_3 the valve conducts only for the period for which the wave is above the dotted line v_c and the peak current corresponds to B. The anode-current wave is shown in Fig. 9(b) by 1.

Now if the bias is reduced and becomes v_2 the whole grid-voltage wave is moved upwards in (a) and becomes DEF. The valve conducts for a longer period and the peak current at E is greater. The current wave in (b) is 2.

The mean anode current is $i_a = \frac{i_p}{2}\cdot\frac{\tau_c}{\tau}$ where i_p is the peak current, τ_c is the conduction period and τ is the duration of one cycle of the input waveform. Because τ_c increases as well as i_p, i_a rises more quickly than either. In fact, τ_c is proportional to i_p and hence i_a is proportional to the square of i_p.

This goes on with reducing bias until the valve runs into grid current or bottoms or both. The first is shown by GHKL in Fig. 9(a) and the resulting anode current by 3 in (b). Once the flattening of the top of the current wave occurs no further reduction of bias can increase i_p and the regulator will cease to function. Reducing the bias then merely shifts the region of changing current to the left and increases the width of the flat top. The mean current, however, increases rapidly. If τ_1 and τ_2 represent the regions of increasing and constant current, the mean anode current is

$$i_a = \frac{i_p}{2}\cdot\frac{\tau_1}{\tau} + i_p\frac{\tau_2}{\tau}$$

Reducing the bias beyond a certain point thus has the effects of making the regulator cease working and making the anode current very large.

It is not difficult to work out the improvement due to the regulator. As before, let V_1 be the output voltage on full load, W_0 and W_s be the stored energy, while V_m is the peak voltage on no load with that same stored energy (that is, the no-load peak voltage without the regulator). The peak anode current will be i_p. On no load with the regulator in action let the output and peak voltages both be V_m' and the peak anode current i_p'. Let the mutual conductance of the valve be g_m, and let m be, not simply the turns ratio of the transformer, but the ratio of the peak voltage across C_1 to the regulator-diode mean output voltage. Ideally, this would be the same as the turns ratio, but in practice the value of m is always larger than the turns ratio, partly because of leakage inductance and partly because of rectifier losses.

The change of output voltage from no load to full load is $V_m' - V_1$ and this causes a change of regulator-diode output voltage of $-(V_m' - V_1)/m$ and this is the change of grid voltage. The resulting change of anode current is

$$i_p' - i_p = -g_m(V_m' - V_1)/m$$

Now $i_p = V_m\sqrt{C/L} = V_1\sqrt{C/L}/\sqrt{1 - W_0/W_s}$ and $i_p' = V_m'\sqrt{C/L}$.

Making the substitutions and collecting terms we get

$$\frac{V_1}{V_m'} = \frac{\frac{g_m}{m} + \sqrt{C/L}}{\frac{g_m}{m} + \sqrt{\frac{C}{L}}\Big/\sqrt{1 - W_0/W_s}}$$

Let $\frac{V_m' - V_1}{V_m'} = \frac{\Delta V_1'}{V_m'} = 1 - \frac{V_1}{V_m'}$, and from equation (3) $\frac{V_1}{V_m} = \sqrt{1 - \frac{W_0}{W_s}}$

then $$\frac{\Delta V_1'}{V_m'} = \frac{\Delta V_1}{V_m}\cdot\frac{1}{1 + g_m\sqrt{\frac{L}{C}}\left(1 - \frac{\Delta V_1}{V_m}\right)\Big/m} \quad (10)$$

The new regulation is equal to the old regulation divided by the denominator of the second term. This term

$$1 + g_m\sqrt{\frac{L}{C}}\left(1 - \frac{\Delta V_1}{V_m}\right)\Big/m \quad .. \quad .. \quad .. \quad (11)$$

is the improvement factor of the regulator.

For the doubler under the conditions developed earlier we have a basic regulation $\Delta V_1/V_m$ of 0.1 and we require the final regulation to be 0.02. The improvement factor is thus to be 5. So from (11)

$$m = \frac{g_m}{4}\sqrt{\frac{L}{C}}(1 - 0.1)$$

which leads to $m = 8.3\,g_m$ (mA/V). If g_m is 14 mA/V, therefore, $m = 112$.

The bias voltage developed by the regulator is thus 5100/112 = 45.6 V on no load and 4840/112 = 43 V on full load. The change of grid voltage is thus 2.6 volts.

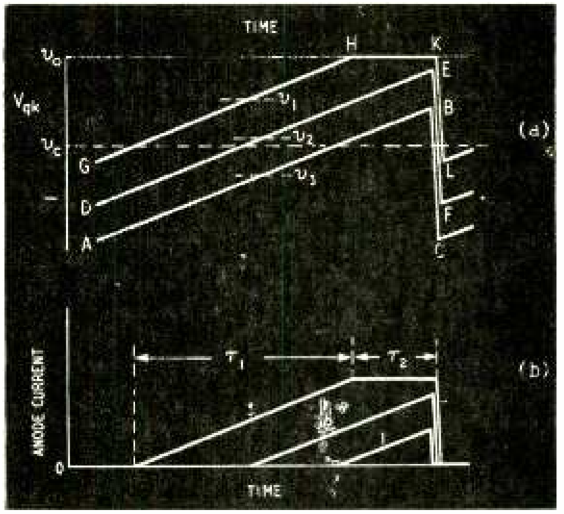


Fig. 9. The effect of varying the grid bias of the driving pentode is shown here. The relation between the driving wave and the cut-off voltage appears in (a) and the anode current waves in (b).

Safety Devices

At this stage in a practical design it would be necessary to refer to the valve curves in order to determine the mean grid bias required. We found τ_c earlier to be 35.9 μsec and as i_p = 150 mA, if we take g_m = 14 mA/V, the change of grid voltage during τ_c must be 15/14 = 10.7 V. The peak-to-peak saw-tooth input voltage needed is $10.7\tau/\tau_c = 10.7 \times 100/35.9 \approx 30$ V. From the valve curves the grid bias corresponding to i_p must be determined (say it is − 4V). The mean bias must be this value plus one-half of the peak-to-peak input or − 19 V.

The regulator develops − 43 volts and so the diode circuit must be returned to 43 − 19 = 24 volts positive to obtain the proper bias. The final arrangement is shown in Fig. 10. The positive bias is obtained from the potential divider R_3, R_4 and R_5.

The cathode bias to V_1 and the diode V_{2B} are points that need explanation. They are safety devices and are not otherwise necessary. If they are omitted a failure in the drive to V_1 will result in the grid potential of V_1 rising to about zero volts and the resulting anode current will be excessive. To counter this, the cathode-bias resistor R_1 is included to limit the current to a safe value if the grid rises to earth potential.

Since the regulator V_{2A} is returned to a point positive to earth it is necessary to include V_{2B} to prevent the grid of V_1 rising appreciably above earth if the drive fails. In normal operation V_{2B} is kept cut-off by the voltage developed across R_2 by the regulator.

TABLE I

	Calculated (1)	Measured (2)	Calculated and corrected for i_p (3)	Calculated and corrected for C (4)	Calculated and corrected for τ_c (5)
L (mH)	63	63	63	63	63
C (pF)	36	40	36	40	40
τ_c (μsec)	45.5	49.5	43.7	43.7	49.5
i_p (mA)	130	125	125	125	125
i_a (mA)	29.5	39	28.4	28.4	32.2
V_0 (kV) at $i_o = 100\mu$A	10	7.9	9.6	9.1	9.1

The cathode-bias resistor has one adverse effect. It reduces the effective mutual conductance of V_1 in so far as the regulator action is concerned. If the resistor is 100 Ω and g_m is 14 mA/V the effective value becomes $14/(1 + 14 \times 0.1) = 5.8$ mA/V only, so that m must be reduced to 1/2.4 times; in the example from 112 to $112/2.4 = 47$. In its turn this affects the positive bias needed from R_3.

As has already been pointed out, m is not the turns ratio of L to L_1 and because of leakage inductance and rectifier efficiency the actual turns ratio may well have to be determined experimentally. If L is air-cored, and m is around 50, the actual turns ratio may well be around 25 : 1.

It should be pointed out that when a voltage-doubler is used the regulator diode should be so connected that it operates on the first *negative* half-cycle, since the amplitude of this is more affected by the load than that of the first positive half-cycle. With the circuit of Fig. 10, this is obtained if both windings are in the same direction and their starts are both made their earthy ends.

Reverting to the basic circuit itself, some measurements have been made in order to find out how well the very simplified theory given here agrees with actual practice. Close agreement cannot, of course, be expected. Some of the discrepancies are due, not to the method of calculation, but to the practical values being rather different from those assumed for the calculation. In Table 1, column 1 represents the design figures, in which C was an initial guess. Column 2 represents the performance of the supply unit as built and the figures are, of course, subject to measurement errors.

As it turned out, the drive was not quite enough to provide 130 mA peak current and it was rather difficult to increase it. Column 3 shows the figures of column 1 corrected for a peak current of 125 mA only and column 4 shows them further corrected for the actual capacitance of 40 pF instead of 36 pF. Column 5 shows a further correction for the practical value of τ_c.

The remaining discrepancies between measurement and calculation, columns 2 and 5, are only in i_a and V_0. The current is in practice 17% higher than theory indicates and the voltage is 13% lower. The voltage agreement is remarkably good in view of the simplifications that have been made in calculation. The difference of current is more surprising, but may well be largely due to errors of measurement, for it is not easy to determine precisely the point at which the driving valve starts to conduct.

It should be noted that no attempt was made to adjust the drive and bias voltage of V_1 precisely. There is little doubt that had more drive and more bias been used τ_c would have been smaller and, in consequence, i_a would have been less.

On the basis of these results, and certain others which are not quoted here, it is considered that the method of design described in this article is a satisfactory one for practical purposes. In order to allow for losses in the coil and in the rectifier it seems that one should design for an output voltage about 15% greater than is actually needed.

APPENDIX

Let charge δQ be added to a capacitance C which already carries a charge Q, so that the charge becomes $Q + \delta Q$.

The initial potential difference is $V = Q/C$ and the final is $V + \delta V = (Q + \delta Q)/C$; therefore, $\delta V = \delta Q/C$.

The stored energy is initially $\frac{1}{2}QV$ and finally

$$\tfrac{1}{2}(Q + \delta Q)(V + \delta V) = \tfrac{1}{2}(QV + Q\delta V + V\delta Q + \delta V\delta Q).$$

The increase of energy is, therefore,

$$W = \tfrac{1}{2}(Q\delta V + V\delta Q + \delta V\delta Q)$$
$$= \tfrac{1}{2}(CV\delta V + V\delta Q + \delta V\delta Q)$$
$$= \tfrac{1}{2}(2V\delta Q + \delta V\delta Q)$$
$$= \delta Q(V + \delta V/2)$$
$$\therefore \delta Q \approx W/V \text{ if } V \gg \delta V/2$$

When $C \rightarrow \infty$, $\delta V \rightarrow 0$ and so, if C is large enough, the relation $\delta Q = W/V$ holds for any magnitude of δQ, provided only that V is not itself infinitesimal.

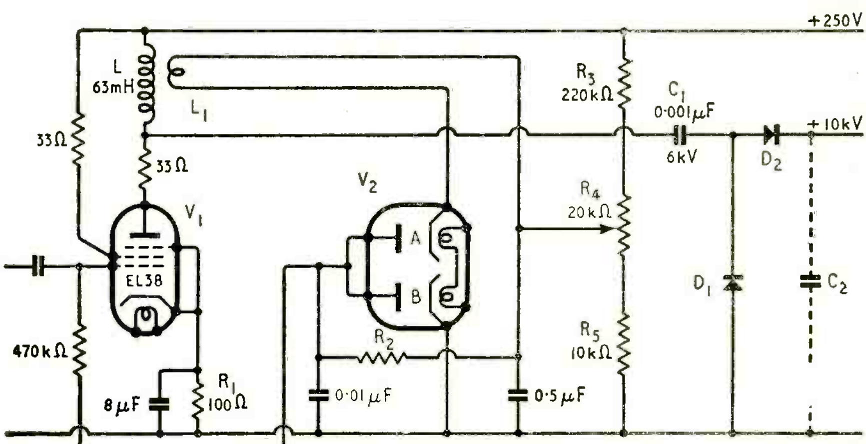


Fig. 10. Circuit of a practical ringing-choke e.h.t. unit with regulator and voltage doubler e.h.t. rectifier.

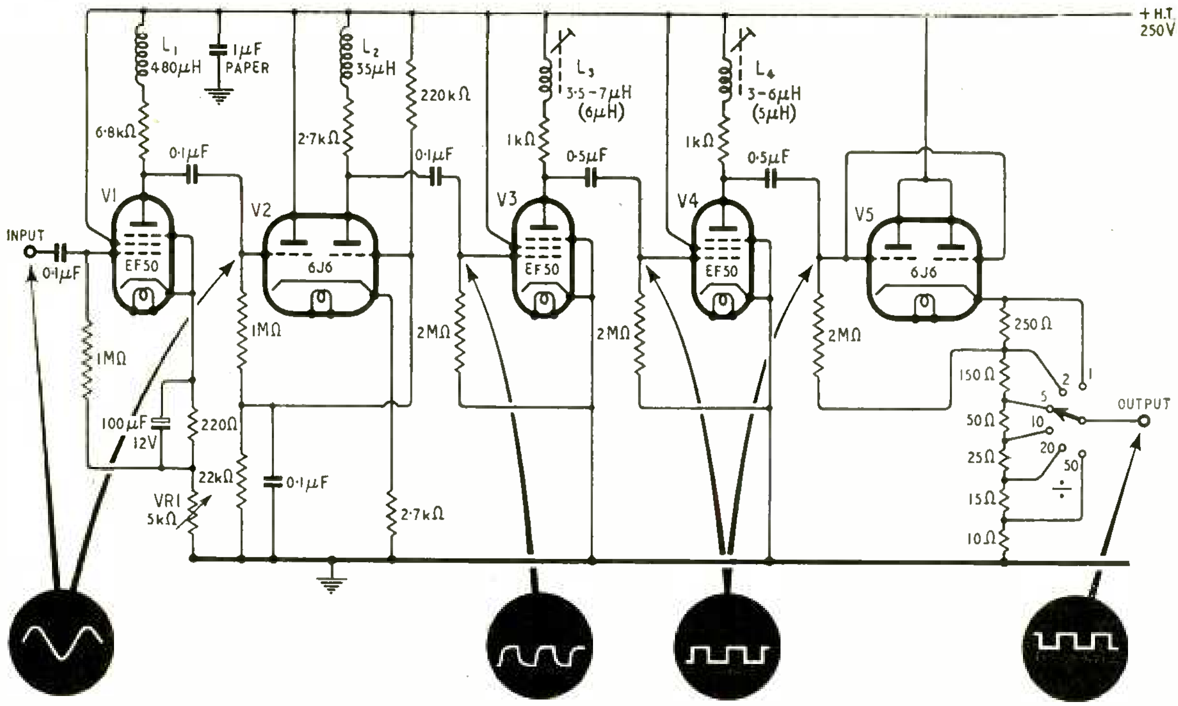


Fig. 1. Circuit of square-wave shaper, showing waveforms at various points.

Wide Range Square Wave Shaper

A Unit Giving Fast Rise Time for Video Amplifier Testing

By J. E. ATTEW

THE writer has recently designed a square wave generator for use in the testing of video amplifier chains for flying spot scanning experiments. The aim was to produce a square wave of frequency from 20c/s to 300kc/s at least, with as small a rise time as possible, and an output of approximately 10 volts peak-to-peak.

The first method tried was a multivibrator using pentodes, with a clipper stage, but this was found to be inconvenient in use, due to synchronizing troubles and to the large number of controls.

Finally it was decided to shape sine waves from an audio oscillator for low frequencies and from an r.f. signal generator for higher frequencies. This allowed precise frequency setting and there were only two controls.

The Circuit

In Fig. 1 the first valve V1 is a pre-amplifier with a gain of approximately 40 up to 1Mc/s. VR1 controls the output into V2, the squaring stage, which requires approximately 24 volts r.m.s. to produce a square wave of unity mark/space ratio, across the anode load. Choke L_2 is for high-frequency compensation. This method of squaring was described by J. McG. Sowerby in *Wireless World*, August 1948 issue. The output signal passes through two overdriven clipping stages V3 and V4, each progressively increasing the rise time. Both stages are shunt compensated for higher frequencies by chokes, which are of the value $L = mR_L{}^2C_0$, where L = inductance in μH, R_L = anode load in kΩ, C_0 = valve and circuit capacities across R_L in pF and $m = 0.25$, a value which produces no overshoot but increases the high-frequency response by 1.4 times the original -3db value. These two chokes have been made adjustable to give precise settings and are adjusted to the value where no overshoot occurs at 500kc/s square wave output.

As f_{-3db} is the frequency where the value of R_L equals the reactance of C_0, and C_0 in the last stage is approximately 16pF (valve capacities + 10pF strays), then f_{-3db} equals approximately 10Mc/s, and, with compensation, 14Mc/s.

$$\text{Rise time is given as } \nu = \frac{0.35}{f_{-3db}}\ \mu \text{ secs.}$$

$$\therefore \nu = \frac{0.35}{14} = 0.025\,\mu \text{ secs.}$$

The measured rise time does approach this value,

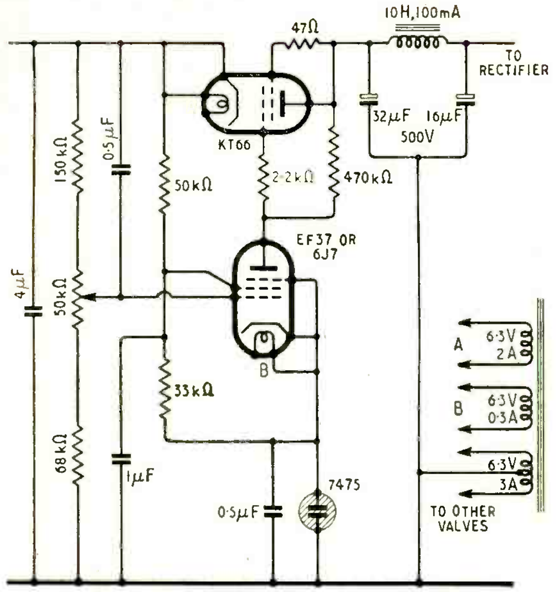


Fig. 2. Stabilizing section of power pack. Mains transformer, 350-0-350V, 80mA.

being of the order of 0.034 ; fall time 0.038, with 75pF across the output.

A cathode follower V6 consisting of a 6J6 with the two halves in parallel was used, as this combination gives a high mutual conductance of approximately 10mA/V (so a low output impedance) and a large initial current which preserves the decay or fall time of the square wave. If the cathode is looking into a comparatively large capacitive circuit, it may not follow the grid voltage when a rapidly increasing negative voltage is applied. The valve would then cut off, and the output time constant would be R_kC_0 and not R_0C_0 (where R_k = cathode resistance, C_0 = capacity across output and R_0 = output impedance). Therefore, the decay time would increase. The rise and fall times are approximately equal with this output circuit, and the output impedance is of the order of 85 ohms in maximum output position.

A step attenuator is fitted, the highest output impedance occurring in the ÷2 position, where it must be used with caution when producing high-frequency square waves if large circuit capacities to earth are present.

The low-frequency response is taken care of by large coupling time constants and a stabilized power supply (Fig. 2), so preventing any droop of the square wave. 20c/s square waves show negligible droop. The regulated power supply could possibly be replaced by a supply with a 100 to 200μF capacitor or more across the output, but this has not been tried.

L_3 and L_4 consist of 16–17 turns of 36 s.w.g. on an "Aladdin" former type F804 with dust core. L_2 consists of 55 turns of 36–38 s.w.g. on a ⅜in diameter former.

The final unit was built in the form of a strip similar to the vision chain of a television set. Screens were fitted between each stage across valveholders, and coupling components mounted on valveholder tags, as is good practice for wideband construction to keep circuit capacities to a minimum.

A particular make of condenser used to couple V3 to V4, produced a pronounced ringing effect at high frequencies, no doubt due to it having an inductive component. This, although it was marked N.I., was replaced by a more suitable type.

The required minimum input for a good square wave is 0.6 volt r.m.s., but the sensitivity could be increased by the addition of another stage similar to V1 between V1 and V2. Maximum output voltage is 11.5 volts peak-to-peak.

As a point of interest it is possible to produce a pulse output by replacing L_2 with a larger inductance, the repetition frequency being dependent on the input frequency, and the pulse width on the value of inductance.

The excellence of the square wave from the unit has been found more than adequate for the original purpose, and good square waves up to 1Mc/s can be produced.

CLUB NEWS

Brighton.—The programme for the December meetings of the Brighton & District Radio Club, which are held at the Eagle Inn, Gloucester Road, Brighton 1, on Tuesdays at 7.30, includes demonstrations of Pye telecommunication gear, by W. E. Rees, of Business Radio, Ltd., (December 4th) and of a home-constructed tape recorder. The club transmitter, G3EVE, is on the air on 80 metres c.w. one Tuesday a month. Sec.: R. T. Parsons, 14, Carlyle Avenue, Brighton 7, Sussex.

Cleckheaton.—"Police Radio" is the subject of the talk to be given by Supt. Dewhirst of the Bradford City Police to members of the Spen Valley Radio & Television Society on December 5th. The club meets at 7.30 on alternate Wednesdays at the Temperance Hall, Cleckheaton. Sec.: N. Pride, 100, Raikes Lane, Birstall, Nr. Leeds, Yorks.

Exeter.—Meetings of the Exeter Radio & Television Club (previouly the Exeter & District Radio Society) are held on Thursdays at 7.30 in the Exeter Hobbies Association Hut, Haldon Road, Exeter. On December 6th the club will hold a servicing competition and on the 13th there will be a demonstrated talk on "The A.F. Amplifier Stage." Sec.: L. R. Jenkin, 16, South Avenue, Exeter, Devon.

Harrogate.—With the opening of the Holme Moss television station, it has been decided by the Harrogate Radio Society that at the monthly lecture meeting at the Y.M.C.A., the emphasis will be on television. Sec.: J. Coleby, 19, St Winifreds Avenue, Harrogate, Yorks.

Ilford.—At the December meeting of the Ilford & District Radio Society Mr. Pratt (Avo) will talk on "Instruments." Meetings are held every Thursday in St. Albans Church Hall, Albert Road, Ilford, at 8.0. Vice-president and Sec.: H. T. Stott, 10, Gordon Road, Chadwell Heath, Romford, Essex.

Two Calls.—Details of the British Two-Call Club, membership of which is open to amateurs who have operated under an overseas call-sign and one in this country, are obtainable from G. V. Haylock (G2DHV), 63, Lewisham Hill, London, S.E.13.

World Friendship Society of Radio Amateurs will have an information stand at the exhibition, organized by Mullards, to be held at the Church Hall, Bellwood Road, Waverley Park, London, S.E.15, on December 1st. During the evening a selection of Mullard film-strips will be shown. Tickets are obtainable from A. H. Bird, G6AQ, 35, Bellwood Road, London, S.E.15.

Manufacturers' Products

New Equipment and Accessories for Radio and Electronics

Multi-range Meter

THE new multi-range meter produced by Taylor Electrical Instruments, model 77A, is notable for its good mechanical design and satisfying appearance. The movement is fitted with sprung jewels to give resistance to shock and postpone the onset of sticking and has been generally designed to reduce sluggishness—it has a sensitivity of $41\,\mu A$. Silver-plated contacts are used in the single range-switch, which has a firm and definite action.

Taylor multi-range meter

On the switch there are five voltage ranges (both both d.c. and a.c.), five d.c. current ranges, two resistance ranges going up to a maximum of $5\,M\Omega$, and a position which puts an internal buzzer and battery in series with the test prods. There are also two extra d.c. ranges, 0-3,000 V and 0-15 A and provision for measuring a.c. output voltage.

The meter is available from the makers at 419-424, Montrose Avenue, Slough, Bucks, price £16.

Television Signal Generator

THE thing that strikes one most about the new W90 television signal generator recently introduced by Waveforms, Ltd., is its unusual versatility. First of all it has two variable r.f. oscillators (40-70 Mc/s), one for vision and the other for sound, then both of these can be modulated in a variety of different ways. The v.f. modulation, which is available also at a separate output, has the usual sync and blanking pulses and provides eight different patterns which can themselves be combined to give complex patterns. In addition the complete sync waveform is brought out separately. The r.f. output for sound can be internally modulated (400 c/s), externally modulated, or used without modulation. Each of the two outputs, vision and sound, has its own amplitude control but after the two are combined they go through a common stepped attenuator.

The W90 is available from the makers at 26, Oakleigh Road, New Southgate, London, N.11.

Miniature Coil Turrets

MORE than usual interest attaches to the introduction by Denco of a range of miniature coil turrets. This method of coil switching is probably the most efficient as unused coils are completely removed from the circuit.

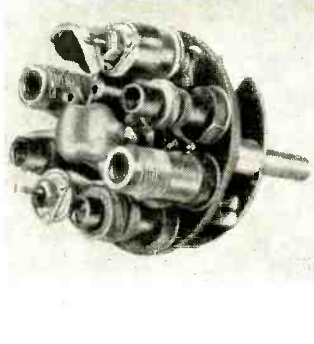
These turrets measure 2 in in diameter and $1\frac{3}{8}$ in deep and are intended for use in small superhets. The type CT10 is for a 3-band receiver and it covers 150-410 kc/s, 520-1560 kc/s and 6-9 Mc/s respectively when tuned by a 2-gang capacitor of 534 pF and using an i.f. of 465 kc/s.

The other unit (type CT9) is also for a superhet and provides the choice of four pre-tuned stations, three in the medium and one in the long waveband.

Dust cored coils are used throughout with provision for inductance as well as capacitance trimming. Each turret is accompanied by full instructions for fitting, wiring and alignment, also by a circuit diagram of a suggested receiver. Alignment instructions are very well prepared.

The turrets are obtainable from Stern Radio, Ltd., 109-115, Fleet Street, London, E.C.4, and cost 52s for the CT10 and 39/6 for the CT9, including U.K. purchase tax.

Waveforms television signal generator and (right) miniature coil turret for 3-band superhet obtainable from Stern Radio.



RANDOM RADIATIONS

By "DIALLIST"

International Standardization

A READER TELLS ME that soon after reading my note on the lack of standardization that prevails even in mathematical signs he was able to ask a Danish friend about the use of ÷ for *minus* in his country. He confirmed that it was so used, but added that the practice was confined to text books (I've seen it in others, nevertheless) and that in the ordinary way Danes use "–" just as we do. The Danish division sign is a colon, which I have come across in French books as well. There is a relic of this in our old "rule of three" signs, for 3:4::6:8 amounts to 3÷4=6÷8. It seems queer that we cannot reach international agreement in a matter so apparently simple and straightforward as the signs associated with elementary arithmetic—but there it is I am waiting for a reader to tell me that in the course of his travels in Yugotoblazia, or Lunibinia or some such land, he has found that × indicates division, ÷ multiplication, – addition, and + subtraction! Do you know, by the way, how the *plus* sign was evolved? It was at first a handwriting sign, the cursive form of the printer's "ampersand" (and *per se* and), which was itself a contracted outline of the Latin *et*; the same sign, in fact, with a vertical downstroke and a looped cross-stroke that most of us use for "and" to save time in writing notes or letters. It was used by early mathematicians to mean "added to," and, when the printers came to setting their manuscripts in type, they evolved the + sign to represent it.

Nation-wide Television

THOUGH WE HAVE HAD a regular television service for some fifteen years now (except for the wartime gap), it was a rather restricted one until Holme Moss came on the air. The population of these islands being concentrated, as it is, perhaps unfortunately, round the "Great Wen" of London, the Alexandra Palace station (of modest power by to-day's British standards) serves more than a quarter of our people. Sutton Coldfield added about another eighth of them and Holme Moss something like a further quarter to the total of those within range of a television transmitter. Reception has thus become possible in about eight million homes. Though we had a lot of leeway to make good when the war ended, the problem has been so well and so energetically tackled that we have already achieved a television service which covers a higher percentage of homes than that of any other country.

Viewing Hours

WE cannot, of course, compete with the United States in the number of hours each day in which televiewing is possible, or in the matter of alternative programmes, but I am not at all sure that we should benefit greatly, could we do so. Take the question of alternative programmes. There seems to be only one way of making these available, by getting advertisers to sponsor them—and that, so the many American friends from whom I hear assure me, is a blessing so mixed that it ceases to be a blessing. Since, for a variety of reasons, a television programme costs many times as much as one of the "sound only" kind, there is no other way of providing them here at the present time (short of a £10 television receiving licence, which is unthinkable). And what of the number of hours each day during which reception is possible? We must, I feel, realize that viewing by wireless is a much more expensive pastime than listening by wireless. Until a system has been invented and developed which uses receiving gear that is much less expensive to buy, operate and maintain, television reception must remain something of a luxury; that is why I do not feel that any great increase in the number of programme hours would be justified. Not everyone, though, will agree with that view!

Australia's "Pedal Wireless"

UNTIL I READ "Flying Doctor Calling," by E. Hill, I had not fully realized how vast a land Australia is (nearly as big as the whole of Europe this side of the Urals) or how completely isolated settlements can be in the "Outback." Or rather, how isolated they could be, until the advent of the pedal radio set. It was this transceiver, with its pedal-operated generator, that made it possible for the "flying doctor" service, founded by the Very Rev. John Flynn, O.B.E., to develop into the marvellous system which now covers all of those huge lonely tracts. Until quite recently, days or even weeks of travelling might be needed to reach the nearest place where medical help was available. Now any dweller in the outback who invests £40 or so in one of these sets and makes a landing-strip near his home has the flying doctor service available in emergencies completely free of charge. The operator at the medical centre nearest his home listens for calls at a certain number of minutes past every hour of the twenty-four. Any urgent call is put through to the doctor, who tells the caller what immediate treatment he should give. "Got a landing-strip?" asks the doctor; "Good; I'll be with you about . . . " and he names a time. The flying doctor comes in an ambulance 'plane and within a few hours of the pedal wireless call the patient is lying in a comfortable hospital bed. A magnificent service. What a different world it would be if man always used wireless and the gifts that he receives from other branches of science for such worthy purposes!

Fine Abrasives

A KIND READER, who read my note a month or two ago on cleaning rotary switches of the leaf-contact type by treating them with fine abrasive paper, has sent me sheets of two grades of crocus paper and of rouge paper. It is invaluable not only for the job I described, but for cleaning up the travelling arms of wire-wound potentiometers and variable resistors, valve pins, the bared ends of fine wires, the tips of terminal binding screws and a whole lot of other electrical contacts which may give trouble by becoming dull or dirty. Other readers may care to have particulars of them, so here they are. The two crocus papers are made by Huber, of Paris. They are marked No. 1 and No. 2 and the latter is a good deal the finer. The rouge paper is made by W. Canning & Co., of Birmingham.

B.B.C. ACTIVITIES

"UNDER the most favourable conditions the change [from m.w. to centimetre-wave broadcasting] must inevitably be gradual. But the sooner it can be begun the better," writes the Director-General in his article on the "Fourth Decade" in the "B.B.C. Yearbook, 1952."*

Among the articles of technical interest in the Yearbook are "Engineering Research," by H. T. Greatorex, "Television Goes Further Afield," by M. J. L. Pulling, and a review of the work of the Engineering Division. The Reference Section of the Yearbook will be found particularly useful giving, as it does, details of the services provided by the B.B.C.

* Published by the B.B C., price 3/6.

UNBIASED

By FREE GRID

Cavalcade of P.A.

IT is a thousand pities that no attempt ever seems to be made by inventors and other pioneers to make some sort of public record when any particular thing is done and exactly what it is that is being done; if they did so the task of historians would be made so much easier. I have been endeavouring to piece together a history of radio and its offshoots and very hard going I have found it.

At present I am engaged on p.a. and let me forestall the flood of letters by saying that I am perfectly well aware that it is not an offshoot of radio but existed in the form of the megaphone long centuries before Marconi was born. But all the same, I intend to include it in my proposed history of radio, for nobody can deny that it is the a.f. technique developed by radio designers that has brought home to us the full horror of unbridled invention.

I am at the moment seeking to find out when and by whom p.a. was first used in an election and who first coined the term "Public Address." I am, of course, acquainted with the fact that regular broadcasting in this country began by the reading of election results on November 14th, 1922. I am aware, also, that a monstrous stentorphone, using air-blast technique in more senses than one, was installed long before that date on New Brighton Pier by one of our great dailies. It was, as a matter of fact, used in August, 1921, for election purposes—actually the choice of a Beauty Queen. I can personally vouch for the accuracy of this, as I was roped in as a member of the electoral college—at that time I had some reputation as a judge at fat stock shows. But my line of enquiry at present is directed to finding out when a parliamentary or municipal candidate first used a microphone, amplifier and loudspeaker to bludgeon his views into the addled and sound-drunk pates of his befuddled audience.

Election of a Beauty Queen.

One of the pioneers in the use of p.a. for election purposes was, of course, Sir Ian Fraser, but I doubt if he was the first. I should be very surprised if p.a. were used even in rudimentary form in the General Election at the end of 1918, while I am quite sure it wasn't used in the previous one, which was at the end of 1910. Subsequent to 1918 we had general elections in 1922, 1923 and 1924, but don't forget the bye-elections. By 1928 p.a. was well established on a commercial basis and was extensively used in that year at a local election in St. Marylebone, as I well remember.

In the U.S.A. they used it much earlier than we did over here and I recall standing in Fulton Street, New York, in November, 1920, gaping in wonderment at the meaningless and mumbled mouthings coming from a loudspeaker which an interpreter informed me were in support of the presidential candidature of Harding; despite this handicap, he was elected by a large majority.

If, therefore, any of you know of any outstandingly early and well authenticated instances of the use of p.a. at an election in this country, I hope you will let me have them.

Receiver of the Future

DOES it ever occur to any of you what sort of broadcast receiver we shall all be using in a few years' time? Until recently I had seriously thought that we should all be back to the crystal set as, according to the modern disciples of James II, power cuts are going to get more and more severe as the years go on. It is quite useless thinking of the popular mains/battery set as a solution. The gaps in the power supply cannot be filled in that way, for the same "Dismal Jimmies" tell us that there will not be enough raw material to spare for making batteries in sufficient quantities for listeners' needs.

However, after reading the informative article by R. W. Hallows in the October issue, it is obvious that we are saved. It will only be necessary to get one of the battery reactivation units he mentions and remove the gaseous sludge which gathers around the positive element and clogs up the works, thus bringing our dry cells to a premature end. Incidentally, I was surprised that he was content merely to hazard an intelligent guess at the *modus operandi* of this device and did not confirm it by the equally intelligent use of a tin opener, as, of course, I did immediately I read his article.

"Intelligent use of a tin-opener"

Of course, these "reactivators" cannot remain as untidy units outside our receivers; they must eventually become an integral part of set design. There must also be an automatic switch to put the batteries "on activation" for the correct period of time after each bout of listening. Such a device should not be a tame time-switch but should depend for its functioning on the internal resistance of the batteries and keep the latter coupled to the rejuvenator unit until this falls to the correct fraction of an ohm.

Transoceanic Jubilee

IT is exactly half a century (December 12th) since Marconi first spanned the Atlantic by wireless and was, for his pains, called by many an impractical visionary. He had been called that when he first mooted the idea in 1899. It is somewhat surprising, however, to learn that Sir William Preece, the famous Chief Engineer of the G.P.O., who had taken such a great practical interest in young Marconi's experiments and helped him so much, had little faith in the commercial future of the inventor's work.

According to the late R. D. Blumenfeld, one of the most famous figures in Fleet Street's Valhalla and an erstwhile editor of the *Daily Express*, Sir William Preece stated unequivocally that "Wireless telegraphy is not and cannot be a commercial success. . . It may be used under exceptional circumstances by the Army and Navy, but commercially it is impossible."