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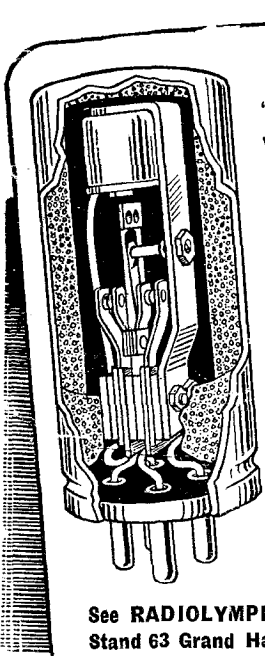
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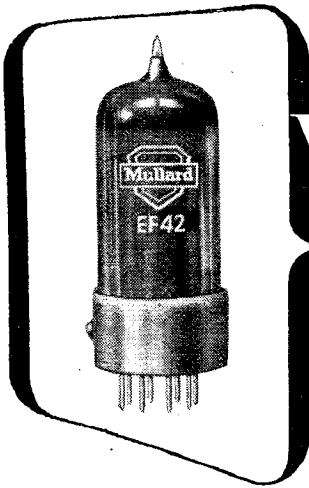
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Valves and their applications

A Linear Time-base Generator for an Oscillograph using the EF42

The design of a broad band Amplifier for an Oscillograph has already been discussed in previous articles*, and a linear time base waveform generator may be found useful in complet-

ing the design of a general purpose oscillograph using EF42 valves.

The time-base generator is designed to operate with an ECR35 Cathode ray tube operating at 1.2 KV. overall accelerating voltage. The total signal required under these conditions will be 350 volts (peak to peak) or 175 volts per valve from two EF42's in push-pull, when the X plates are used. Allowing for 25% over-deflection this output voltage must be increased to 420 volts (peak to peak).

To obtain this large output from two EF42 valves a 300 V. H.T. Line is found desirable, although the circuit described may still be made to oversweep the C.R. tube with only 250V. H.T. Some non-linearity is to be expected when operating at this high output level, but this may be considerably reduced by the use of negative feedback. A resistive feedback network from the anodes of the output valves proves effective in providing the required degree of linearity.

Figure 2 shows a linear sawtooth generator providing the input to the pair of EF42 valves. The sawtooth voltage waveform is generated at a lower voltage level (approx. 25 volts peak to peak); the pair of EF42 output valves serves to

amplify and paraphase the output from the sawtooth generator.

The d.c. connection to the deflector plates prevent drifting of the trace with variation of the time base amplitude.

The circuit of the sawtooth generator is shown in figure 1. This is a circuit of the self-running 'Miller' integrator type; it differs from the 'transitron' in the omission of the coupling capacitor between the screen and the suppressor grids. The 'switching' or 'flyback' is provided by accumulated charge on the suppressor grid and is thus independent of the time constants in the screen grid circuit.

The 'Miller' capacitor C_1 is switched to provide coarse increments in the variation of the time-base velocity, the fine control being provided by a d.c. potential (V_1) derived from a potentiometer (R_1). The amplitude of the waveform will remain constant, with constant H.T. to the waveform generator, but the output may be preset to any desired value by the adjustment of the network arm R_5 .

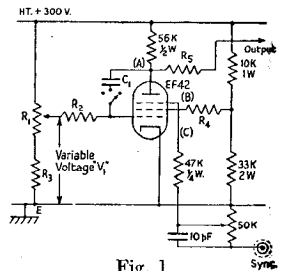


Fig. 1

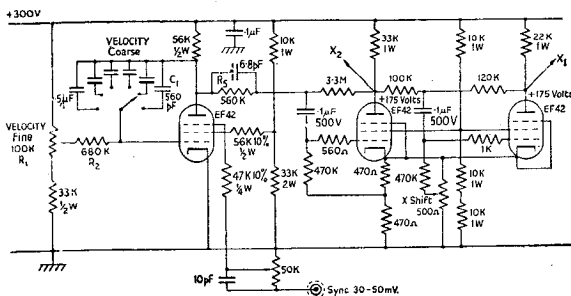


Fig. 2

* See "Wireless World" January and April 1949.



Reprints of this report from the Mullard Laboratories, together with additional circuit notes and details of the power supply may be obtained free of charge from the address below.

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AUGUST 1949

RADIO AND ELECTRONICS

Comments of the Month

BROADCASTING FOR EXPORT

FOR a long time there has been growing dissatisfaction over the low field strength provided by the broadcasting service in certain areas of the country, notably the South Coast. Last month a reader made what seems to be an eminently practical suggestion: that the Kingston station, near Brighton, should be used, at such times as it is not carrying out its normal function of distributing the Third programme, for reinforcing the Home and Light programmes over an area that is notoriously badly served.

Many readers now protest that this suggestion, though useful, offers merely a palliative. It is pointed out that the supplementary service would not be available at night-time, when, during the summer, atmospherics are most likely to spoil reception of the long-wave station. The real cause of the trouble, it is contended, is that the B.B.C. is using two of its medium-wave channels exclusively for broadcasting to Europe, and not for the internal service. Here it should perhaps be added that one of the channels in question is "borrowed" and is not one of those officially allocated to this country under the Lucerne Plan. But, as a reader whose letter is printed elsewhere in this issue points out, the avowed intention of the B.B.C. is to use two of the medium-wave channels given to Great Britain under the Copenhagen Plan, including one of our three exclusive (non-shared) frequencies for the European Service. Thus it would seem that medium-wave broadcasting for export is to become a semi-permanent activity.

The general idea is, of course, one with which we have become uncomfortably familiar of late years: the exporting of something we need ourselves. The parallel is not quite perfect, and in any case, most of the issues raised cannot be commented upon here. It is permissible, however, to say that our correspondent is probably right in assuming the frequencies given to us at Copenhagen were for home consumption: it seems unlikely that the delegates of

all the countries represented there agreed on our having extra channels, over and above our domestic requirements, for propagating our ideas abroad. And it also seems to follow that, at future conferences, we shall find it difficult to sustain claims for the number of channels enjoyed at present if it can be shown we evidently can do without some of them for home consumption.

One conclusion is clear. If the Government decides that medium-wave channels that are in fact necessary for a good home service are to be permanently used for other purposes, it is more than ever desirable that the development of a supplementary e.h.f. service should proceed at all speed. As to whether a.m. or f.m. will be used for the service will presumably depend on the results of the B.B.C.'s forthcoming full-scale tests.

TELEVISION PICTURE QUALITY

AN article elsewhere in this issue will serve to draw attention to the fact, of which there is growing recognition, that definition as expressed in the number of scanning lines is not the only quality that goes to make a satisfactory television picture. One of the novel views put forward is that, so far as reproduction of moving objects is concerned, it might be better to reduce the number of lines and increase the number of frames. This and other suggestions of the author, though ingenious, call for experimental verification before they can be accepted.

In view of our editorial comments last month on the relative merits of British and American television standards, we were particularly interested in our contributor's suggestion that the U.S. practice of using 60 frames per second (as opposed to our 50) might give less distortion of rapidly moving images. If he is proved to be right, we may have to modify our statement, though we stick to our original contention that the 60-per-second rate was chosen to fit in with the standard American supply frequency.

HIGH-QUALITY AMPLIFIER

Since the "Williamson" amplifier, as it has come to be called, was first described in our issues of April and May, 1947, it has aroused world-wide interest. In the Australian *Radiotronics* (Nov.-Dec., 1947) it was described as "by far the best we have ever tested. . . . It not only gives extraordinary linearity and lack of harmonic and intermodulation distortion, but is comparatively simple. . . ." The present article repeats the original design data, with slight modifications, and deals at length with special precautions to be taken

SINCE the publication in the April and May, 1947, issues of this journal of an amplifier design suitable for high-quality reproduction of sound, correspondence has revealed that a more complete explanation of

mand exists for a pre-amplifier unit to enable the amplifier to be used in conjunction with gramophone pickups and microphones of low output. In the present article it is proposed to deal with the amplifier, and in a subsequent

necessity for frequent reference to the May, 1947, issue, the circuit of the amplifier and the list of component values are printed again. These differ in minor detail from the originals. In the circuit previously printed a potentiometer was provided in the penultimate stage to enable the signal to be balanced. Due to the use of common unbypassed cathode resistors for the push-pull stages, the amplifier is largely self-balancing to signal, and it is permissible to dispense with this adjustment. Accordingly, revised values and tolerances are shown for resistors R_5 , R_7 , R_{11} and R_{13} .

A transitional phase-shift network consisting of R_{26} and C_{10} ,

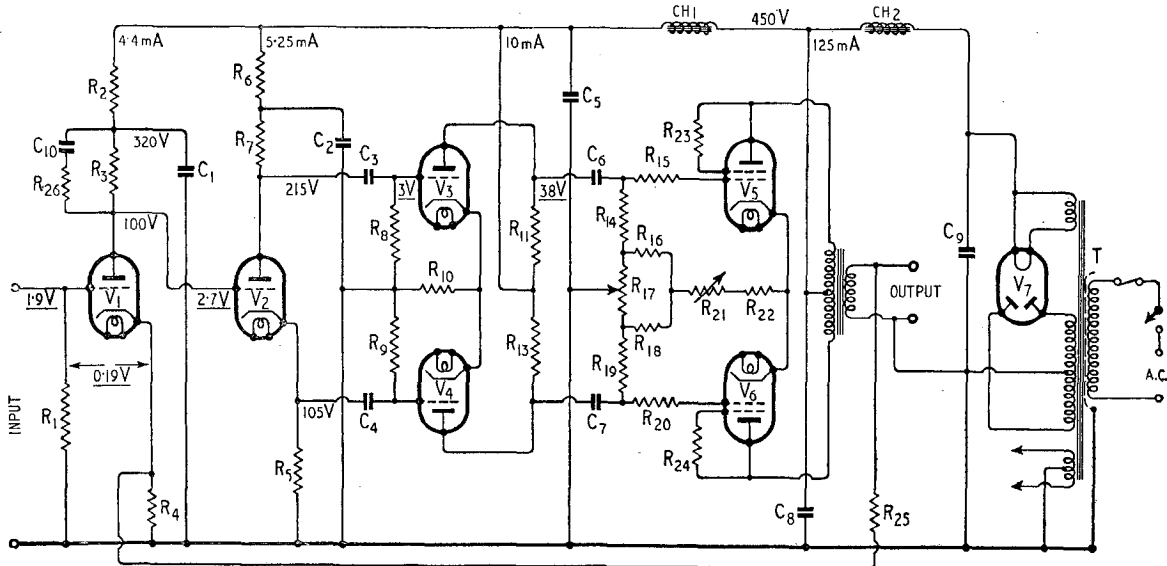


Fig. 1. Circuit diagram of complete amplifier. Voltages underlined are peak signal voltages at 15 watts output.

R_1	1M Ω	$\frac{1}{4}$ watt \pm 20%
R_2	33,000 Ω	1 watt \pm 20%
R_3	47,000 Ω	1 watt \pm 20%
R_4	470 Ω	$\frac{1}{4}$ watt \pm 10%
R_5, R_7	22,000 Ω	1 watt \pm 5%
	(or matched)	
R_6	22,000 Ω	1 watt \pm 20%
R_8, R_9	0.47M Ω	$\frac{1}{4}$ watt \pm 20%
R_{10}	390 Ω	$\frac{1}{4}$ watt \pm 10%
R_{11}, R_{13}	47,000 Ω	2 watt \pm 5%
	(or matched)	

R_{14}, R_{15}	0.1M Ω	$\frac{1}{4}$ watt \pm 10%
R_{15}, R_{20}	1,000 Ω	$\frac{1}{4}$ watt \pm 20%
R_{16}, R_{18}	100 Ω	1 watt \pm 20%
R_{17}, R_{21}	100 Ω	2 watt wirewound
		variable
R_{22}	150 Ω	3 watt \pm 20%
R_{25}	1,200	$\sqrt{\text{speech coil impedance}}$
		$\frac{1}{4}$ watt (see table)
R_{26}	4,700 Ω	$\frac{1}{4}$ watt \pm 20%
C_1, C_2, C_5, C_8	8 μ F	500V wkg.
C_3, C_4	0.05 μ F	350V wkg.

C_6, C_7	0.25 μ F	350V wkg.
C_9	8 μ F	600V wkg.
C_{10}	200pF	350V wkg.
CH ₁	30H	at 20mA
CH ₂	10H	at 150mA
T	Power transformer	
	Secondary 425-0-425V	150 mA, 5V, 3A,
		6.3V 4A, centre-tapped
V_1, V_2	2 \times L63 or 6J5, 6SN7 or B65	
V_3, V_4	do.	do.
V_5, V_6	KT66	
V_7	Cossor 53KU, 5V4	

some of the features of the design, with the addition of some information about construction, would be of interest. The correspondence also shows that considerable de-

article to present the design of auxiliary equipment to form a domestic sound-reproducing installation.

Circuit Diagram. To avoid the

which was previously recommended as a temporary measure, has been added as a permanent feature to increase the margin of stability at high frequencies. This

New Version

Design Data : Modifications : Further Notes

By **D. T. N. WILLIAMSON** (*Ferranti Research Laboratories*)

will be discussed later when the stability of the amplifier is considered.

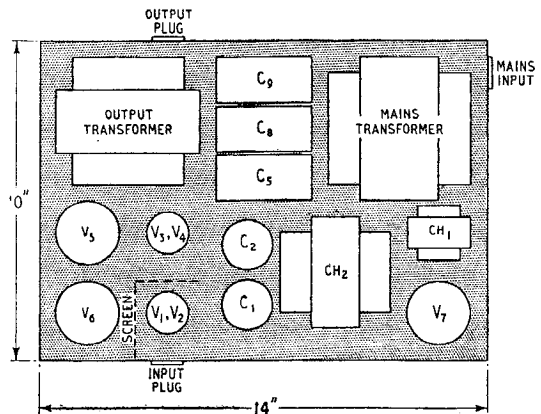
Finally, an indirectly - heated rectifier has been substituted as this prevents a damaging voltage surge when the amplifier is switched on. No suitable type was available when the circuit was originally published. A list of alternative valve types is also shown.

Amplitude and Phase/frequency Response. A curve showing the transmission and loop gain of the amplifier at frequencies between 1 c/s and 1 Mc/s is shown in Fig. 2. Although only the section between 10 c/s and 20,000 c/s is useful for sound reproduction, the curves outside this range are included as they may be of interest to those who may wish to use the amplifier for other purposes. They may also serve to emphasize that, in a feedback amplifier, the response must be carefully controlled at frequencies very remote from the useful range if stability is to be achieved.

Many different arrangements have been used satisfactorily to suit differing circumstances. An excellent plan is to construct the power supply and the amplifier on separate chassis, as this gives greater flexibility in accommodating the equipment in a cabinet.

The following

Fig. 3. Suggested layout of principal components of combined amplifier and power pack.



precautions should be observed:—
1. The output transformer core should be positioned at right angles to the cores of the mains transformer and the main smoothing choke.
2. The output transformer and loudspeaker leads should be kept

able gain at low radio frequencies, and care is necessary to avoid oscillation.

3. Signal wires, especially grid leads, should be kept as short as possible, and the stopper resistors associated with the output stage must be mounted on the valve-holder tags, and not on group panels.

4. A bus-bar earth return formed by a piece of 12 or 14 s.w.g. tinned copper wire, connected to the chassis at the input end, is greatly to be preferred to

the use of the chassis as an earth return.

5. Electrolytic and paper capacitors should be kept away from sources of heat, such as the output and rectifier valves.

Figs. 3 and 4 show the positions of the major components in two

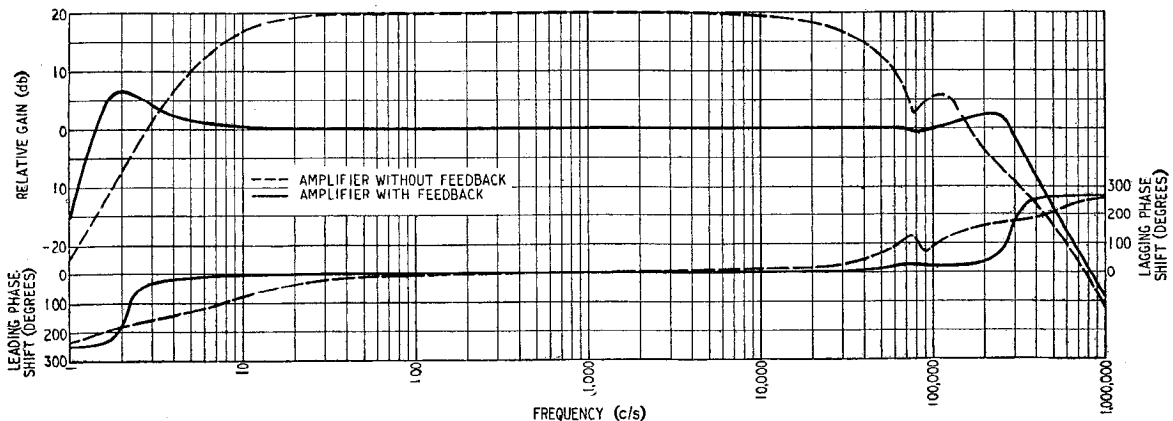


Fig. 2. Loop gain and phase-shift characteristics of the amplifier.

General Constructional Data. The layout of the amplifier is not critical, provided that a few simple precautions are observed.

at a reasonable distance from the input leads, which should be screened. As the response curve shows, the amplifier has consider-

alternative layouts which have been used successfully.

Initial Adjustments. Before the amplifier is put into service

High-Quality Amplifier—

there are a few adjustments which require to be made. These concern the balancing of the standing currents in the output stage, and (with the original circuit) balancing of the signal currents in the push-pull stages.

Accurate balance of the standing currents in the output stage is essential, as the low-frequency characteristics of the output trans-

put voltage about half maximum.

(d) Adjust R_{12} for minimum output in the detector.

The Output Transformer. As stated previously, the output transformer is the most critical component in the amplifier and satisfactory performance will not be obtained with a component differing substantially from the specification. The effect of de-

it is considerably larger than the transformers which are usually fitted to 15-watt amplifiers. The fact that the peak flux density of 7,250 gauss for maximum output at 20c/s lies on the upper safe limit for low distortion is sufficient comment on current practice.

Some confusion arose regarding the method of connection of the transformer secondary windings to match loads of various impedances, whilst utilizing all the secondary sections. The correct primary load impedance is $10,000\Omega$ and as the turns ratio in the original design is 76:1 the impedance of each secondary section is $10,000\Omega/76^2$ or 1.7Ω . When secondary sections are connected in parallel, the turns ratio, and hence the impedance ratio, remains unchanged. If now two secondary sections, or sets of paralleled sections, are connected in series the turns ratio is halved, and the secondary impedance, being proportional to the square of the turns ratio, becomes $1.7 \times 2^2 = 6.8\Omega$. Similarly if three sections are connected in series the impedance becomes $1.7 \times 3^2 = 15.3\Omega$. Thus the available secondary impedances, keeping a $10,000\Omega$ primary load impedance, are 1.7, 6.8, 15.3, 27, 42.5, 61, 83 and 109 Ω . The connections to obtain these values are shown in the table.

Should it be necessary, in an emergency, to match loads of other impedances to the amplifier, it is permissible to reduce the primary load impedance to $6,000\Omega$ giving another series of secondary impedances, namely 1, 4, 9, 16, 25, 36, 49 and 64 Ω . Under these conditions the power output will be increased slightly and the distortion will be doubled. The value of the feedback resistor R_{25} must remain unaltered, as the turns ratio is unchanged. The values of R_{25} are given in the table.

Winding data for an output transformer to match loads in the region of 3.5 Ω are given in the Appendix and the connections and other data are included in the lower section of the table.

The two outer layers of the output transformer primary should normally be connected together to form the centre tap, the inner sections of the winding being taken to the valve anodes. This gives

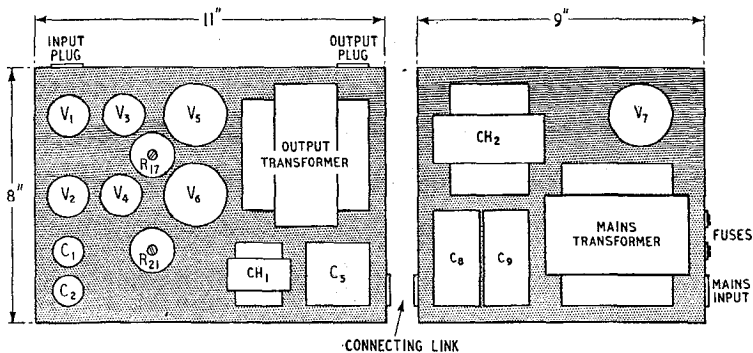


Fig. 4. Layout when using separate power pack.

former deteriorate rapidly with d.c. magnetization. The procedure to be adopted for static and signal balancing is as follows:—

Static Balancing.

(a) Connect a suitable milliammeter in the lead to the centre tap of the output transformer primary.

(b) Set the total current to 125 mA by means of R_{21} .

(c) Connect a moving-coil voltmeter (0-10 V approx.) across the whole of the output transformer primary and adjust R_{17} , until the reading is zero, indicating balance. Random fluctuations of this instrument may be noticed. These are due to mains and valve fluctuations and should be disregarded.

Signal Balancing.

(a) Connect the low-impedance winding of a small output transformer in the lead to the centre tap of the output transformer. Connect a detector (headphones or a cathode-ray oscillograph if available) to the other winding, earthing one side for safety.

(b) Connect a resistive load in place of the loudspeaker.

(c) Apply a signal at a frequency of about 400 c/s to the amplifier input to give an out-

creasing the primary inductance will be to produce instability at low frequencies, which can be cured only by altering the time constants of the other coupling circuits, or by decreasing the amount of feedback. At high frequencies the situation is more complex, as there are more variables. The leakage inductance, the self-capacitance of the windings, the capacitance between windings and the distribution of these parameters determine the transmission of the component at high frequencies, and great variations are possible.

In the output transformer specified, the only parameter which is likely to vary appreciably is the inductance of the primary at low signal levels, due to the use of core material with a low initial permeability, or to careless assembly of the core. The high-frequency characteristics are not dependent on the core material to a substantial degree. They are dependent only on the geometry of construction, and to some extent upon the dielectric properties of the insulants used, and are therefore reproducible with a high degree of accuracy.

Comments are frequently expressed about the size of the output transformer. It is true that

the minimum external electric field.

Stability with Negative Feedback.—Much has been written about the stability of amplifiers under conditions of negative feedback, and the criteria for stability are now widely appreciated. The article by "Cathode Ray" in the May, 1949, issue, states the matter simply and with characteristic clarity.

Continuous oscillation will occur in a feedback amplifier if the loop gain—that is the transmission of the amplifier and the feedback network—is greater than unity at any point where the phase shift of the amplifier has reached 180°. It is also possible for an amplifier to be unstable in the absence of continuous oscillation if these conditions should occur in a transient manner at a critical signal level. This latter condition is particularly likely to occur in badly designed amplifiers with iron-cored components, where the inductance and, therefore, the time constant

than those of the fixed coupling circuits, an increase in its value due to a high signal level may be sufficient to render the system unstable. In order to avoid this condition the fixed time constants must be made much longer than that of the variable stage. This condition would lead to undesirably large interstage couplings if good low frequency response were required. Alternatively, the variable time constant must be chosen in relation to the fixed time constants, such that its minimum value is sufficiently longer than the fixed values to produce stability. An increase in its value then serves only to increase the stability margin. This method is used in the amplifier under discussion.

To ensure a wide margin of stability, whilst at the same time preserving the high loop gain necessary to reduce the effect of transformer distortion at frequencies of the order of 10-20 c/s, would require a transformer with

to the lowest practicable value.

When the amplifier is reproduced, the "spread" in tolerance of components will normally be such that changes in characteristics due to departure from the nominal value of one component will be balanced by opposite changes produced by departure in another component, and the amplifier as a whole is likely to have characteristics close to the average. Individual amplifiers may, however, have characteristics which differ substantially from the average, due to an upward or downward trend in the changes produced by component deviations. If the trend is in a direction such that the loop gain is reduced, no instability will result, the only effect being a slight degrading of the performance. If, on the other hand, the loop gain is increased by an amount greater than the margin of stability, oscillation will occur. It should be emphasized that this will happen only very

OUTPUT TRANSFORMERS. TABLE OF CONNECTIONS.

		No. of secondary groups of sections in series	1	2	3	4	5	6	7	8
		Connections								
Original Output Transformer 10,000/1.7Ω	Correct secondary impedance (ohms)		1.7	6.8	15.3	27	42.5	61	83	109
	Minimum secondary impedance permissible (ohms)		1	4	9	16	25	36	49	64
	Feedback resistor R ₂₅ (ohms)		1,500	3,300	4,700	6,800	8,200	10,000	11,000	12,000
	Turns ratio		76	38	25.4	19	15.2	12.6	10.8	9.5
Alternative Output Transformer (See Appendix) 10,000/3.6Ω	Correct secondary impedance (ohms)		3.6	14.4	32.5	57.5	90	130	176	230
	Feedback resistor R ₂₅ (ohms)		2,200	4,700	6,800	9,000	11,500	13,500	16,000	18,000
	Turns ratio		52.5	26.25	17.5	13	10.5	8.75	7.5	6.5

controlling the phase and amplitude characteristics of one or more stages may increase by as much as a factor of five between zero and maximum signal levels. If this variable time constant is shorter

a very large initial primary inductance. This would necessarily be expensive, and a compromise must be drawn between the three factors. Because of this, the margin of stability must be kept

rarely, and when it does the remedy is obviously to reduce the loop gain to its correct value.

To assist the unfortunate few who experience instability, the following procedure is recom-

High-Quality Amplifier—

mended. If oscillation should occur at a low frequency (about 2c/s) the first step should be to disconnect the feedback resistor R_{25} . If the oscillation continues the decoupling circuits should be checked and any faulty components replaced. The amplifier should also be examined to ensure that it is operating correctly balanced in push-pull, and not in an unbalanced manner due to the failure of some component.

Primary Inductance

Assuming that the amplifier is, or has been rendered, stable with the feedback disconnected, the next step should be to check the phase and amplitude characteristics at low frequencies. It is not practicable to make direct measurements of these characteristics without very special equipment, as inspection of Fig. 2 will show that the interesting region lies below 10c/s. It is therefore necessary to arrive at the desired result by indirect means, namely by measurement of the component parameters which determine the characteristics. The parameter which is most likely to show a large deviation from specification is the initial primary inductance of the output transformer, since the quality of the core material is not easy to control accurately, and careless assembly of the core may cause considerable variations in its permeability.

The initial primary inductance should be checked by connecting the primary winding across the 5-V, 50-c/s rectifier heater winding of the mains transformer and measuring the current in it. The secondary windings should be open circuit. The current, which can just be read on the 10mA a.c. range of a Model 7 Avometer, should be 150 μ A or lower. The component should be rejected if the current exceeds 200 μ A.

If the output transformer is satisfactory the values of the other components should be checked, particular attention being paid to the coupling components. Should the time constants of the couplings, that is their RC product, be higher than the nominal values by more than 20 per cent, the resistors should be adjusted to give the correct value.

The trouble will probably have

revealed itself by this time, but, if upon reconnecting R_{25} the oscillation is still present, it is very likely to be due to the use of valves with mutual conductances higher than average, and it is legitimate to increase the value of R_{25} to reduce the loop gain. If instruments are available, the loop gain may be measured by disconnecting R_{25} from the cathode of V_1 , and reconnecting it via a $470\Omega \pm 10$ per cent resistor to chassis. The voltage gain, measured from the input grid to the junction of R_{25} and the 470Ω resistor, should be 10 at frequencies between 30c/s and 10kc/s. Care must be taken not to overload the amplifier when this measurement is being made.

The adjustment of the loop gain to its correct value at medium frequencies should render the amplifier stable at high frequencies. It is unlikely that the phase characteristic at high frequencies of individual amplifiers will deviate appreciably from normal unless the layout is very poor or the transformer is not to specification.

Capacitive Loads

The amplifier is absolutely stable at high frequencies with a resistive or inductive load, but it is possible for oscillation to occur when the load impedance is capacitive at very high frequencies, for example, when a long cable is used to connect the amplifier and loudspeaker. To avoid this possibility, and to give an increased margin of stability, a transitional phase-shift network consisting of R_{26} and C_{10} in conjunction with the output resistance of V_1 , has been included in the circuit. This has the effect of reducing the loop gain at frequencies from 20kc/s upwards without affecting the phase shift in the critical region.

The use of a phase advance network consisting of a capacitor shunting R_{25} has been advocated as a means of stabilizing this amplifier. The effect of such a network is to increase the loop gain at high frequencies, at the same time reducing the amount of phase lag. It is sometimes possible by this means to steer the phase curve away from the 180° point as the loop gain is passing through unity, thus increasing the margin of stability.

The connection of a capacitor across R_{25} , however, will not stabilize this amplifier if it has been constructed to specification, although it may produce improvement if oscillation is due to some large departure from specification, such as the use of an output transformer with completely different high-frequency characteristics. The writer has no information about this.

The use of separate RC bias impedances for the output valves has also been suggested. This procedure is not endorsed by the writer, as there are numerous disadvantages in its use and no redeeming features whatsoever. If the time constant of the bias network is made sufficiently long to ensure that the low-frequency performance of the amplifier is unimpaired, the phase shift of the bias network will have its maximum at or near the lower critical frequency and may provoke oscillation. If, on the other hand, it is made sufficiently short to avoid this, the ability of the amplifier to handle low frequencies will be impaired. The use of separate bias impedances destroys the self-balancing properties of the amplifier, and if two dissimilar valves are used in the output stage "motor boating" is likely, due to the presence of signal in the h.t. line. The performance of the output transformer may be seriously affected by the out-of-balance current caused by valves whose anode currents lie within the manufacturer's tolerance limits. Finally, there can be little justification of this modification on economic grounds, as the costs are roughly similar. Indeed, if the question of replacement due to failure is considered, the common bias arrangement shows a definite saving.

It is to be hoped that these remarks on stability will not have the effect of frightening those who already possess amplifiers of this type or are contemplating acquiring them. Their purpose is to help the occasional "outer limit" case where instability is experienced, but if they serve to impress upon the reader that negative feedback amplifiers are designed as an integral unit, and that any modifications, however insignificant they may appear, may seriously affect the performance or

stability, a useful purpose will have been accomplished. Such modifications should be attempted only by those who are confident that they know what they are doing, and who have access to measuring equipment to verify results.

APPENDIX

Output Transformer with 3.6-ohm Secondaries

Winding Data

Core: 1½in. stack of 28A Super Silcor laminations. (M. & E.A.) The winding consists of two identical interleaved coils each 1½in. wide on paxolin formers 1½in. × 1½in. inside dimensions. On each former is wound :

5 primary sections, each consisting of 440 turns (5 layers, 88 turns per layer) of 30 s.w.g. enamelled copper wire interleaved with 2 mil. paper.

alternating with

4 secondary sections, each consisting of 84 turns (2 layers, 42 turns per layer) of 22 s.w.g. enamelled copper wire interleaved with 2 mil. paper.

Each section is insulated from its neighbours by 3 layers of 5 mil. Empire tape. All connections are brought out on one side of the winding, but the primary sections may be connected in series when winding, two primary connections only per bobbin being brought out. Windings to be assembled on core with one bobbin reversed, and with insulating checks and a centre spacer.

circuit is to connect two receivers to one aerial. Then $n = 2$ and $R = Z_0/3 = 24 \Omega$ if $Z_0 = 72 \Omega$ as is usual. Each receiver input is 6 db below the aerial output. The resistors can be the ordinary small composition type and in this instance it would be convenient to use for each two 47- Ω components in parallel, since this would permit the use of standard-value components.

The matching unit can be connected at any convenient point. Where it is desired to operate several receivers simultaneously in the same room, as in a demonstration showroom, the unit would obviously be fitted where the aerial feeder enters the room and short lengths of feeder run from it to each set. On the other hand, a pair of semi-detached houses might decide to share an out-door aerial. It might then be desirable to fit the matching unit fairly close to the aerial and run separate long feeders from it into the separate houses. In this case the unit must be carefully weather-proofed.

The unit can equally well go

SHARED TELEVISION AERIALS

Methods of Feeding Several Receivers

It is not always realized that it is a simple matter to operate more than one television receiver from a single aerial. There is, of course, a loss of signal, for in the ideal case the signal power provided by the aerial is divided equally among the receivers connected to it. The loss is rarely a serious one, however, except in areas of low field strength

The most obvious way of connecting several sets to a common aerial is by means of a transformer, for then there is no loss in the network, apart from some unavoidable transformer loss. This is shown in Fig. 1 and if each receiver is designed for a feeder impedance Z_0 and the aerial feeder impedance is also Z_0 the trans-

turns ratio of $1 : N = 1 : \sqrt{1/n}$. Ignoring transformer losses, the input to each individual receiver is to log n db below the aerial output.

Where only a few sets

are used it is much simpler to use a resistance matching network, but it is rather less

efficient. The arrangement is shown in Fig. 2. It can be seen by inspection that for proper matching it is necessary to have

$$Z_0 = R + \frac{Z_0 + R}{n}$$

whence

$$R = Z_0 \frac{n - 1}{n + 1}$$

The aerial current divides equally among the receivers, there-

fore the input power to each is 20 log n db below the aerial output. The power lost in the resistors is as much as that fed to the receivers.

The commonest use of this

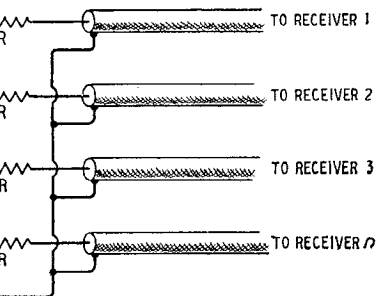


Fig. 2. Here a resistance network is used for matching several receivers to an aerial.

in the middle of a cable run. Thus, two flats on different floors might share an aerial, and the obvious place for the unit is at the entry point of the cable into the upper of the two.

Since the loss of signal for two sets is 6 db the scheme may be inapplicable in fringe areas. There is, however, the possibility that if two neighbours combine they could for the cost of two separate aerials, erect one more elaborate and lofty structure which would provide an increase of more than 6 db in signal. However, the transformer matching system

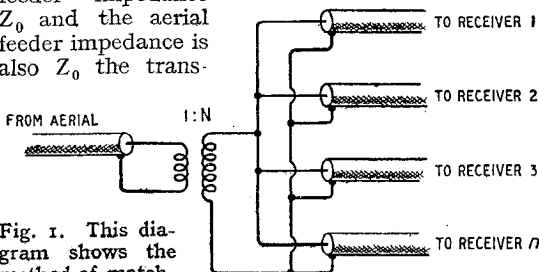


Fig. 1. This diagram shows the method of matching a feeder to several receivers by a transformer.

former must have an impedance ratio $Z_0 : Z_0/n$ where n is the number of receivers. This is a

Shared Television Aerials—

is likely to be more satisfactory under this condition.

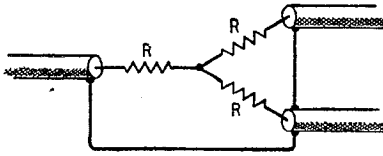
For two receivers the unit has the form shown in Fig. 3 (a). An alternative form which is exactly equivalent is shown in Fig. 3 (b). By the star-delta transformation

since it is obviously inapplicable to coaxial feeders. One resistor R_1 is still needed. The aerial feeder is properly matched without it and as it is connected to points of equal potential there is no current in it and no power loss in it. It is needed to retain proper

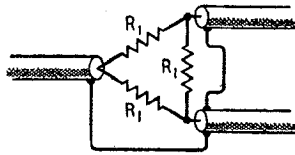
vides a 1,000-c/s modulating tone for calling the shore station. A simple code will be used to distinguish between stations operating in the same channel.

The coast stations are assembled in the standard 19in wide racks and give about 50 watts r.f. output. Unit construction is adopted for ease of maintenance and a complete unit, transmitter, receiver or power supply, can be quickly replaced if a failure occurs.

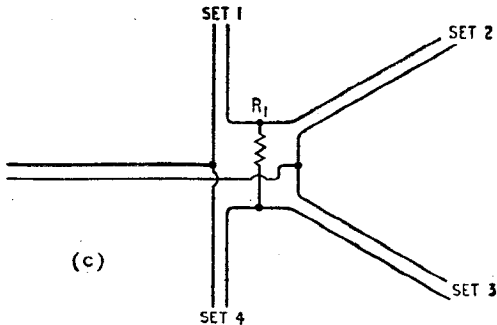
Under development is a further set intended for installation on board ships. It will give about 10 watts r.f. output and provide a considerably greater range than the lightweight portables. It will be



(a)



(b)



(c)

Fig. 3. When two receivers only are fed from a common aerial the circuit of Fig. 2 reduces to (a) and this has the exact equivalent (b) in which R_1 equals the feeder impedance. If twin feeders are used two of the resistors can be replaced by feeders (c) and four sets fed without extra loss.

theorem $R_1 = 3R = Z_0$. Therefore, the resistor and the feeder impedances are the same. Hence, two of the resistors could be replaced by feeders and so four sets could be operated without any loss.

This scheme is sketched in Fig. 3 (c) for twin-wire lines,

matching looking in from the receiver feeders.

It should be noted that none of the receiver feeders is balanced to earth in this arrangement, but the aerial feeder is. Such a unit should, therefore, be used only when but short connections to the receivers are needed.

HARBOUR RADIO

Supplementary Aid to Radar Navigation

A v.h.f. radio telephone system is being installed by the Mersey Docks and Harbour Board in order to provide direct communication between the port radar station* or docks and the pilots on board ships entering or leaving the river.

Initially 150 portable sets and 10 fixed shore stations will be employed. The portable sets are battery operated, weigh just under 20lb and are designed to provide a working range of up to 25 nautical miles.

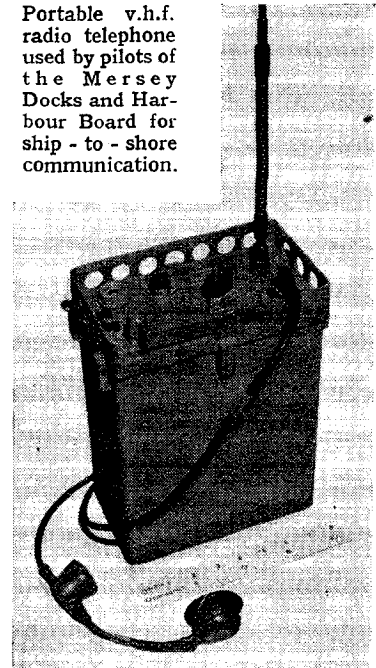
Twelve radio channels have been allocated to this service, six for the portable sets in the band 158.6 to 159.1 Mc/s and six for the land

stations covering 163.6 to 164.1 Mc/s.

The portable sets are crystal controlled and any channel can be selected merely by turning a switch. A 5-Mc/s i.f. is used and as this is arranged to be the difference between the transmitting and receiving frequencies of each set the same crystals can be used for both the transmitter and the receiver. A 4-volt accumulator powers the set and the r.f. output to the aerial is 0.25 W, amplitude modulation being employed.

An important feature of the set is its simplicity of operation. There are three controls only, a channel selector, combined on-off and send-receive switch and a ringing key. The last mentioned is a novelty for this type of equipment and it pro-

Portable v.h.f. radio telephone used by pilots of the Mersey Docks and Harbour Board for ship - to - shore communication.



flexible enough in design to cover the United Kingdom harbour requirements as well as general radio-telephone communications between ships and from ship to shore in foreign harbours.

The equipment is designed by British Telecommunication Research and made by the Radiogramophone Development Co.

"High-Quality Audio Amplifiers"

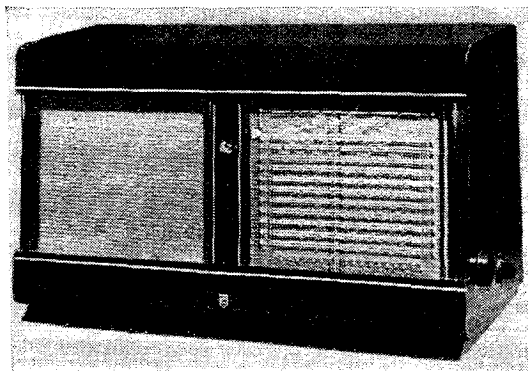
THIS 20-page booklet containing reprints of five *Wireless World* articles on amplifier design is now available from our Publisher, price 2s 6d (postage 2d). The circuits included are "W.W. Quality Amplifiers," "A.C./D.C. Quality Amplifier," Jeffrey's "Push-Full Phase-Splitter," Baxandall's "High-Quality Amplifier Design" and Woodville's "Economical 50-watt Amplifier."

* See "Harbour Radar," *Wireless World*, September, 1948, pp. 317-320.

TEST REPORT

PHILIPS MODEL 681A

Double Frequency Changing on Short Waves



UNUSUAL care has been taken in the design of this table model receiver to provide ease and stability of tuning on short waves. In addition to the usual medium- and long-wave ranges and two short-wave ranges covering 11 to 110 metres, which are covered by the basic superheterodyne circuit consisting of r.f. amplifier, frequency changer, i.f. amplifier, detector and a.f. stages, there are eight selected short-wave broadcast bands of about 0.5 Mc/s which are each expanded to the full width of the 7-inch horizontal tuning scale. A double superheterodyne principle has been applied to the bandspread circuits in such a manner that the local oscillator on each band works at a single fixed frequency and is therefore easier to stabilize.

On the bandspread ranges the section of the main ganged tuning condenser associated with the input to the r.f. stage is discon-

FEATURES
 Waveranges:
 Normal Tuning:
 11.1—34.2 m.
 34.2—110.5 m.
 192—560 m.
 900—2,000 m.
 Bandsread ; 11, 13, 16, 19, 25, 31, 41 and 49 m. bands.
 Power Output : 8.9 watts.
 Mains Supply ; 100-250 V., 50-100 c/s.
 Consumption ; 85 watts at 220 V.
 Price (including tax) £48 8s 9d.

of the auxiliary frequency changer. The r.f. stage is fixed-tuned to a point in the middle of the band and will accept, without appreciable attenuation, signals up to 250 kc/s on either side of the centre frequency. The oscillator section of the first frequency changer is also fixed-tuned to a frequency 3 Mc/s higher than the centre point of the r.f. tuned circuits. Other signals in the band produce a spectrum of frequencies, centred on 3 Mc/s, and this first intermediate band is

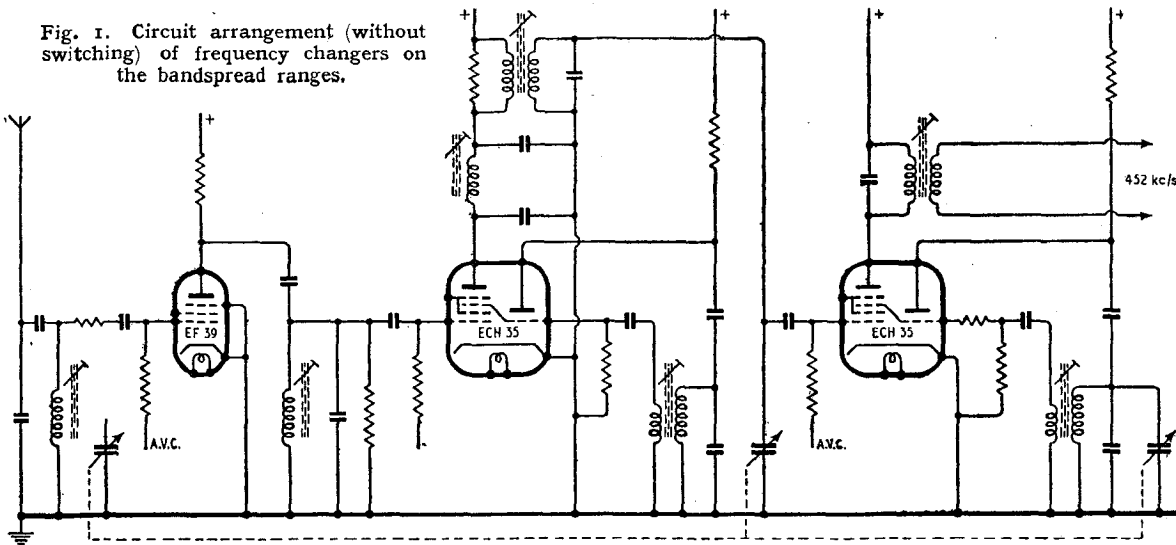
signals follow the same course as on other wave ranges.

Fig. 1 shows the circuit arrangement of the two frequency changers on the bandspread ranges. The filter circuit in series with the primary of the first i.f. transformer is included for whistle suppression. Fig. 2 shows the progress of the signal through the receiver on the bandspread ranges.

As the first oscillator is higher in frequency than the signals, the calibration of the scales on the bandspread ranges is opposite to that on the normally tuned broadcast ranges. Wavelength decreases as the pointer moves from left to right, instead of increasing as on the long-, medium- and general-coverage short-wave bands.

The i.f. amplifier, detector and

Fig. 1. Circuit arrangement (without switching) of frequency changers on the bandspread ranges.



nected, and the second section tuning the intervalve coupling is transferred to a first intermediate-frequency transformer in the anode circuit of the mixer section

explored by the tuned secondary circuit connected to the grid of the second frequency changer. Here the conversion is made to the main i.f. of 452 kc/s and the

a.v.c. stages follow standard practice and a cathode-ray tuning indicator, controlled by the a.v.c. bias, is included.

A centre-tapped auto-trans-

Philips Model 681A

former couples the triode a.f. amplifier to the push-pull pentode output valves, and Fig. 3 gives the circuit arrangement of the stage. To balance out hum in the push-pull circuits R_1C_1 is introduced to offset RC. Feedback is applied from the secondary of the output transformer to one side of the phase-inverting circuit.

Tone control is effected by feedback through a capacitance from the anode to the grid of the first a.f. stage. A potential divider, which includes the tone control resistance, is connected across the phase-splitting inductance, and values are chosen so that the point X is at the same a.f. potential as the grid of the valve. When the slider is at this end of the control there is no feedback, and maximum high-note response is obtained.

Performance.— On the bandspread ranges the set handles like an ordinary broadcast receiver on medium waves—except that there are more stations to choose from and there is less overlapping. Each station can be tuned in to the mid-point of its bandwidth as easily as the local station, and if the ear does not give this point clearly, it can be found quite accurately by observing the cathode-ray tuning indicator with its two-stage sensitivity.

The set is remarkably free from self-generated whistles on all wavebands and the sensitivity and selectivity enable any station above background noise to be well received. On the bandspread

ranges the scales are accurately calibrated in both metres and megacycles and a check at several points showed that the gradua-

the back of the set and a large proportion of the top area of the chassis is occupied by them. The main tuning condenser is rubber-

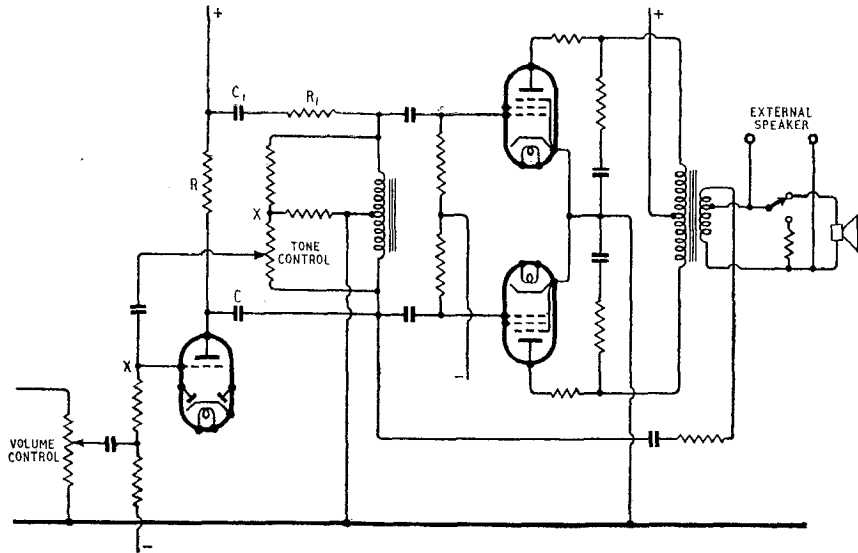


Fig. 3. Output stage and its associated circuits.

tions could be relied upon to find a wanted station.

Frequency stability was also very good and no warming-up drift could be detected. Station settings can be logged with accuracy by means of an auxiliary 180-degree scale.

The 8-inch loudspeaker gives good quality, and volume much above the average for a table model.

Mechanical Features.— The rather complicated wave-range switching is accomplished on three spindles, ganged together by a rack and pinion mechanism. It is positive in action and not unduly heavy to operate.

All trimmers are accessible from

mounted, but we did not find any evidence of microphony even when the condenser body was clamped for transit.

From every point of view the Type 681A can be classed as a high-quality receiver and it is particularly well fitted for serious short-wave listening.

The makers are Philips Electrical, Century House, Shaftesbury Avenue, London, W.C.2.

PUBLICATION DATE

In future *Wireless World* will be published on the last Thursday of the month preceding the date of publication instead of on the 26th as in the past.

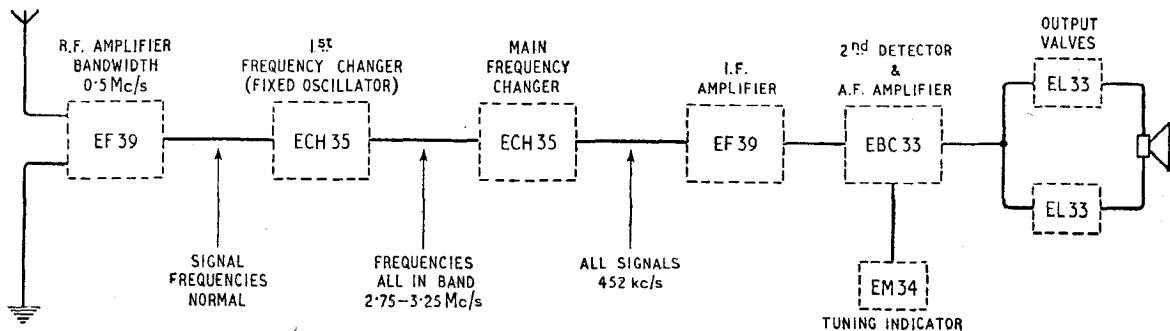


Fig. 2. Block diagram showing progress of signal on bandspread ranges

1R5

1SA

3SA

1TA

1S5

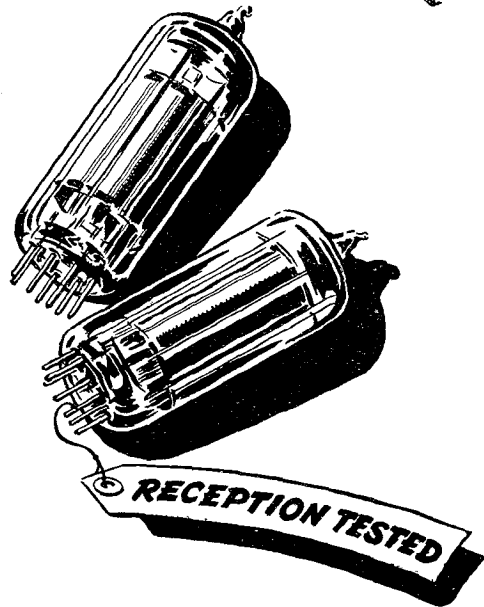
1L4

3VA

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Miniatures suitable for all Battery
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Reception Tested, for reliability,
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CRYSTAL PICK-UP PREJUDICES

—*their Rhyme and Reason . . .*

PREJUDICES are frequently unreasonable, often enough they are formed not from experience but from hearsay. The reputation of Crystal pick-ups has suffered in this way, yet every day and any day there are many thousands of Crystal pick-ups giving delight to gramophone enthusiasts, particularly those who are "sound purists." Then why this prejudice in other quarters? Let us be frank. *Under certain circumstances* Crystal pick-ups have in the past possessed some failings, but, let us hasten to add, failings small enough to be discounted by the user who sought the finest yet obtainable in sound reproduction.

Now, when Radiolympia is about to show us the great strides that ACOS research has made in utilising the amazing characteristics of the piezo-electric principle, it is opportune to review the reasons for the prejudices which persist from the pre-ACOS era.

The fallacy of their fragility

First, there is the belief that the Crystal pick-ups must necessarily be fragile and easily damaged. True, certain early types were easily fractured because assembly methods were as yet unperfected. But the Cosmocord laboratories produced an unbreakable crystal assembly which ensures that NO crystal in an ACOS pick-up can be broken, even by so drastic a measure as tapping the needle with a hammer—an extreme of violence which would never be approached in ordinary usage.

Humidity deterioration effects defeated

A second persistent prejudice against Crystal pick-ups is that the crystal element—Rochelle-Salt—is susceptible to deterioration when subjected to the higher degrees of humidity. Since this failing is an inherent characteristic of Rochelle-Salt, counter measures had necessarily to be those of *protection*. ACOS research was indeed set a formidable problem, the solution of which was particularly elusive, for in

this country the humidity count is much higher than, say, in the United States, where Crystal pick-ups are in almost universal use. Nevertheless the problem was solved by long and intensive research in the Cosmocord laboratories. Now an assembly has been designed which positively counteracts any danger of deterioration from humidity. In this assembly the crystal is mounted in a gel-like substance which provides a complete water-vapour barrier, rendering the cartridge absolutely non-hygroscopic.

Equaliser Circuits now past history

Another criticism is that the Crystal pick-up requires the fitting of an equaliser before satisfactory reproduction can be obtained from the ordinary commercial "constant velocity" records. In passing it should be mentioned that this condition is not confined to Crystal pick-ups only. The criticism is then that in order to attain the best from a crystal pick-up it is necessary to spend time and money on fitting additional components. The connoisseur of sound reproduction has con-

sidered this effort well justified by the results, knowing that a crystal pick-up alone is capable of giving him the high quality he demands.

Now, however, even the critical requirements of the connoisseur can be met without recourse to an equaliser circuit for again ACOS research has solved the problem in providing a crystal pick-up which, without additional components, can be connected direct to any domestic radio set or amplifier.

An invitation to the critics

Thus all past criticisms have been met, and any lingering prejudices shown to be without reason. And in confirmation there is to be inspected *and heard* at the Cosmocord Stand No. 7 and Demonstration Room No. D.10 the latest product from the Cosmocord Research laboratories—a Crystal pick-up of revolutionary design which, apart from providing a new and higher standard of performance, is also a thing of beauty. This pick-up will be available through the Trade after Radiolympia.

See and hear the new

ACOS G.P.20 MICRO-CELL PICK-UP at RADIOLYMPIA

STAND NO. 7. DEMONSTRATION ROOM D. 10.

- Has output 5 to 20 times greater than that of any comparable magnetic type.
- No equaliser components required. Can be connected direct to any domestic radio or amplifier.
- Has unbreakable Crystal element.
- Is unaffected by conditions of extreme humidity.
- No needle talk.
- Record wear virtually eliminated.
- Has provision for interchangeable clip-on head for long playing records. One instrument for ALL records.



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