Radio Constructor

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Editorial

New Year's Thoughts

THE beginning of a new year is traditionally a time for reviewing the past and remodelling our plans for the future. This number of the "Radio Constructor" is the sixth, and we certainly feel that it is well and truly on its feet now. It's teething troubles have not been so bad as we anticipated and we feel that it has settled down very quickly to serve its readers. Producing new magazines is no easy task these days and whilst one instinctively hopes that the future may be easier, there are not many signs in the sky to cheer the heart of an editor! We would have liked to have offered promises of a bigger and better "Constructor" by the end of the year, but there are no indications of any improvement in the paper position. However, your editors will continue to produce a "Constructor" of as high a standard and quality as possible, and we hope that if our lusty youngster cannot increase in weight, he will at least improve in quality.

Co-operation

Our old friend Mr. Cyril Wright, recently phoned the writer right in the middle of some pencil chewing directed at preparing this editorial. On being informed of the paucity of ideas reigning at that time, he volunteered to send some suggestions! These proved so interesting that we'd like to quote some of his remarks herein. He writes:—"In the short space of twenty-five years the BBC has emerged from its embryo stage. In recalling the early days of wireless, it was not surprising to hear of people claiming that, 'that new fangled idea would not last for long.' It was doomed to failure from the start in their minds. This failure however did not come and it did not come because of the great team work of the engineers, announcers and all connected with broadcasting in those days. It was this team spirit which helped to make British broadcasting the finest in the world, and it is this self same 'team spirit' which should assist every amateur today to overcome his difficulties and be an example to him to give a helping hand to his fellow amateurs. It is, however, regrettable that in a world which is still showing the scars of war, some of the co-operative spirit has been lost; or perhaps a better word would be 'forgotten'."

There is no need for us to enlarge on this topic. All of us know instances of lack of co-operation between the more experienced and the beginner. Let's try and be a little more co-operative whether on the air or at the club with those newcomers to the game whom we may meet during the coming year.

Short Wave Listening

Those readers who take the "Short Wave News" will know that we are trying to encourage shortwave broadcasting listening. For reasons given in our November "S.W.N." editorial, we feel that much more interest could be taken by the man in the street in the entertainment value of shortwave broadcasts. Those who construct and operate short wave receivers, could help greatly by interesting their friends in their accomplishments. If they wish to further the interest of their friends, may we suggest that our latest publication, "These You Can Hear," (price 2/3 post-paid) will make a most useful introduction for them.

A.C.G.

NOTICES

THE EDITORS invite original contributions on construction of radio subjects. All material used will be paid for. Articles should be clearly written, preferably typewritten, and photographs should be clear and sharp. Diagrams need not be large or perfectly drawn, as our draughtsman will re-draw in most cases, but relevant information should be included. All MSS must be accompanied by a stamped addressed envelope for reply or return. Each item must bear the sender's name and address.

COMPONENT REVIEW. Manufacturers, publishers, etc., are invited to submit samples or information of new products for review in this section.

ALL CORRESPONDENCE should be addressed to "Radio Constructor," 57 Maida Vale, Paddington, London, W.9. Telephone CUN 6579.

Making a Start

No. 5 of a series of articles describing the progress of a newcomer to constructional work

By G3AKA

WE now come to the final instalment of this series of articles, dealing with the actual operation of the receiver. It must be a rather disturbing fact to some that however good a receiver is, it cannot hope to give of its best unless the operator approaches its handling with care, patience and common sense. We have been browsing through a pile of pre-war and post-war radio magazines and it became apparent that the star DX-ers were in most cases only using simple receivers. Many operators with elaborate communications receivers made only a very poor showing compared with their more modest colleagues. The amount of success achieved on the short wave bands relies to a great extent on the type of aerial available and on the actual geographical location of the receiving station, but it is a well defined fact that the greatest asset is to be able to handle a receiver with intelligence. A simple receiver in the hands of an experienced listener will do marvels!

With great trepidation, we handed over the 0-v-2 to George, who was having much difficulty in controlling his eagerness. With headphones donned, he started turning a few knobs and became more despondent every moment. In his excitement, he had even forgotten to switch on the receiver! Finally realising this, he switched on—only to be rewarded by a terrific screech which deafened him for some minutes. "What's wrong?" asked our innocent. That's where he learned his first lesson in handling a receiver. In his preliminary turning of all available controls he had set everything at "full on" so that not only was volume at its highest but the reaction control was so advanced that excessive feed-back had caused the set to go into violent self-oscillation. Therefore, when first switching on, volume and reaction controls should be set at minimum, and advanced slowly as required.

The strength of signals received, will depend upon several factors, amongst them the efficiency of the aerial system and the prevailing reception conditions. Therefore no given degree of rotation for the volume control can be advised, but it should be set in such a way as to allow reasonable strength for the average station receivable. It can be advanced, then, for weaker signals or decreased for the powerful "locals." The reaction control is of vast importance in such a receiver as our three-valver and should be mastered at the earliest opportunity. Having recovered from the blasting that his ears had received, George proceeded more cautiously with his tuning-in, leaving the volume set about half way in. The first major fault we found, and this is common, was that he was only using **one**-handed control. In other words, he turned the reaction control up and then started tuning round for a station. When he had located an interesting signal he returned to the reaction control for further adjustment.

This is incorrect for maximum control of the receiver. The correct procedure is to use one hand for the reaction and one for the tuning. In this way, one can be juggled against the other until the signal is at peak strength. Though this is not so important for powerful stations, it is essential if any success in tuning in the more elusive stations is to be attained—and after all the thrill of DX listening is concerned in getting the unusual rather than the everyday station. Whilst on the subject, a few words on the handling of the reaction control will not come amiss, since it is so important to grasp the art. The reaction should be advanced to the extent that the valve goes into oscillation, this effect being noticed by a "hiss" in the headphones. (Badly designed straight receivers are renowned for the "plop" or "screech" when the detector valve is forced into oscillation, but this should never happen in a well-built receiver). Just below the point where the hiss takes place (i.e., just before oscillation) is the most sensitive operating point, and this is the point where the control must be set when receiving the weaker stations. With the detector in oscillation, the rotation of the bandset capacitor will result in many whistles in the phones. These are heterodyne whistles caused by the incoming signals beating with the local oscillations (produced by "reaction"). In this way morse (CW) stations are easily received and the set should be kept in oscillation whilst listening to these signals. The reaction control should also be set just into oscillation whilst searching for telephony stations and then eased out of oscillation when the signal has been located. This is of immense usefulness when looking for very weak stations, since the very presence of a whistle will indicate that a station is there—the same signal could easily be missed if no beat note was used. The stronger 'phone stations will be heard intelligently even though the detector is in oscillation but will be subject to some distortion and background hiss.

Therefore, the golden rules to observe are to advance the reaction till the set is just in oscillation; to tune around in order to select a signal; to decrease the reaction until the set is just below oscillation point; to re-adjust both reaction and tuning controls simultaneously.

It may be asked, and indeed was by the bright George, why it is necessary to use both controls at the same time. The answer is that in a set of such a nature as our 0-v-2 it is inevitable that the amount of capacitance needed to push the detector into oscillation will vary from band to band. In other words, the setting of the reaction control for maximum results will be different for one part of the tuning range to another. The difference may not be great but without having controls advanced simultaneously some of the weaker stations may easily be missed.

When this principle has been absorbed, searching for stations may commence. With the bandspread capacitor set at zero, the bandset tuner should be rotated until a "band" is encountered. Despite initial impressions, it will soon be discovered that there is some sort of order in the allocation of channels used by stations. Broadcasters are allocated bands such as 13, 16, 19, 25, 31 metres, whilst amateurs are allocated bands as the 20, 40 and 80 metre ranges. Thus there will be several groups of stations on each coil between which only "commercial" morse and telephony stations will be heard. When a band has been discovered, by the rotation of the bandset capacitor, the bandspread should then be brought into use as this allows much finer tuning over the complete band. One word here that is important. If the bandset capacitor is so arranged that with maximum capacitance (vanes fully meshed) the dial reading is zero, then the bandspread capacitor should be likewise adjusted. If these two variables are not consistent in this respect, and having located a band on the main tuner, rotation of the bandspread will not bring in the stations required but will move away from the band instead of covering it! So make certain that the dial reading of zero on both capacitors is either minimum or maximum capacitance in each case.

Much to our surprise, George fairly quickly learnt these points and was soon tuning in stations with comparative ease. He had his troubles, but it was pointed out that it took plenty of experience to earn the promotion of DX-er from a mere knob-twiddler. Even with the very slow bandspreading he was still tuning much too fast and this was pointed out to him to be detrimental to a successful career of short wave listening. Then came the inevitable question of what bands to listen on for best results.

This subject is one that proves there is more in short wave listening than merely tuning stations in—a subject that could fill very many pages. However, the essentials to remember are that the higher frequencies (lower wavelengths) are best received during daylight whilst the lower frequencies (higher wavelengths) are better during darkness. Thus, we get the 13m. band at its best during the early afternoons, 16m. during late afternoons, 19m. late afternoons and early evenings, 25m. early evenings and late evenings, and so on. Seasonal changes of conditions affect this, and other factors too, but it may be relied on as a good general guide. Later, experience will allow for these variations to be taken into account.

Finally, a word or two on conditions. If, one day, hardly any signals can be heard and even the regular stations are almost inaudible, do not scrap the receiver! The factors affecting short wave propagation are unaccountable and there are often widespread "fade-outs," sometimes for days and sometimes for only hours. Also quite often the fade-out will affect some bands and not others. At its best short wave listening is erratic, but even so immense pleasure and hours of enjoyment are there for the asking.

Though this is the final instalment of "Making a Start," it is not the last you will be hearing about the now famous George. He is settling down nicely with his receiver but from what we can gather he has plans afoot to further disturb our peace of mind! So, don't be surprised if, in a couple of months time, he comes on the scene again with some further material for the newcomer to construction!

The Straight Receiver

Part 6

By H. A. Emm

Tone Control

EXTREME fidelity of reproduction is not one of the primary objects of the average short wave listener. Having received a signal, he is concerned only that it should be as readable as possible; with telephony, of course, distortion can mar or even ruin a signal, and to this extent, good quality is necessary. Readability, it will be found, can be greatly improved if the range of audio frequencies reproduced in the speaker or phones can be controlled. Background noise and other mush can be largely eliminated by attenuation of the upper frequencies, and control of the lower register does much to offset any tendency to microphony, while it often proves beneficial in reducing interference from stations in which the carrier is modulated at a low frequency, and in eliminating "key clicks."

The most popular form of tone control consists of a capacitor in series with a resistor, the latter generally variable. These are most often connected in the output stage of the receiver, either in the control grid or anode circuit, both types being shown in Fig. 9. At A the control is in the anode circuit, the amount of by-passing through the capacitance C1 being governed by the setting of the variable resistance VR. With output pentode or tetrode valves there is a tendency to high-pitched reproduction, due to the anode impedance of the valve increasing with frequency, and it is usual to off-set this by providing a fixed amount of tone correction, achieved generally by the connection of a small capacitance C2 across the anode load impedance. VR/C1 can also be wired in parallel with this impedance, instead of as shown, and in fact this method is to be preferred, as the voltage stresses across it are lowered and the risk of breakdown thereby lessened.

In Fig. 9B the tone control is shown connected in the control grid circuit of the output valve. In the anode circuit, the anode load impedance is relatively low, and the by-pass capacitance C1 must be of the order of .005 μF or larger in order that it should have a reactance sufficiently low to be effective. In the grid circuit, however, the transformer secondary or grid leak has a comparatively high impedance, and a

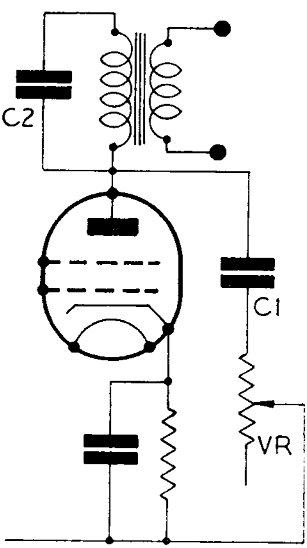


Fig. 9A

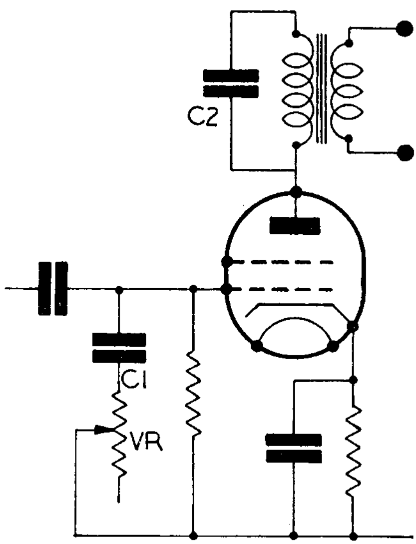


Fig. 9B

much smaller capacitance can be used. Indeed, in Fig. 9B the combination VR/C1 can be replaced by a .0005 μF variable capacitor; as a point of interest, this arrangement is used in some of the commercial receivers.

A variable capacitor can also be connected between the anode and the control grid, giving a form of negative feed-back. It is very important in this case, however, that the capacitor used should have adequate insulation between the two sets of plates, as a breakdown would mean the application of a high positive potential to the control grid, and consequent damage to the valve would follow.

A method of controlling the lower audio frequencies is shown in Fig. 10. Here, determined by the setting of the potentiometer, the grid leak is returned either to the negative line direct, or via an AF choke .The reactance of an inductance rises with frequency, so that when the choke is effectively in circuit, the result is a boost of the higher frequencies only. The arrangement of Fig. 9 can be combined by inserting a capacitance as shown in broken lines, thus giving a one-knob control enabling the choice of top cut, normal reproduction, or bass cut at will.

Where reception is confined to CW, using a reacting detector or a superheterodyne receiver employing a beat frequency oscillator so that the wanted signal appears as a note of definite frequency, then the resonant properties of a tuned circuit can be put to good effect. As shown in Fig. 11, the grid circuit consists of an AF choke tuned, by a parallel capacitance, to the frequency of the wanted signal. Unwanted signals at other frequencies will be attenuated. For good results, two such stages will be necessary owing to the difficulty of obtaining a high "Q" in an inductance at audio frequencies. A 250 mH choke tuned by a .1 μF parallel capacitor is suggested for a 1000cs. note, the choke preferably being wound on a powdered iron core.

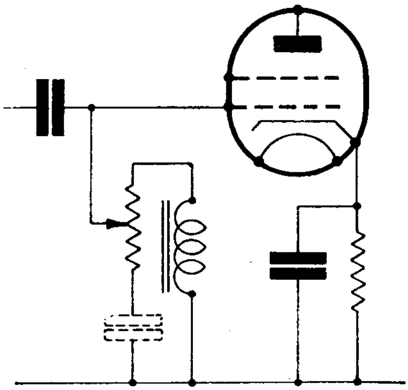


Fig. 10

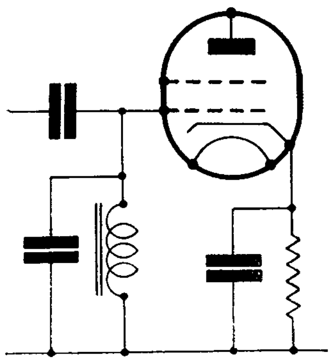
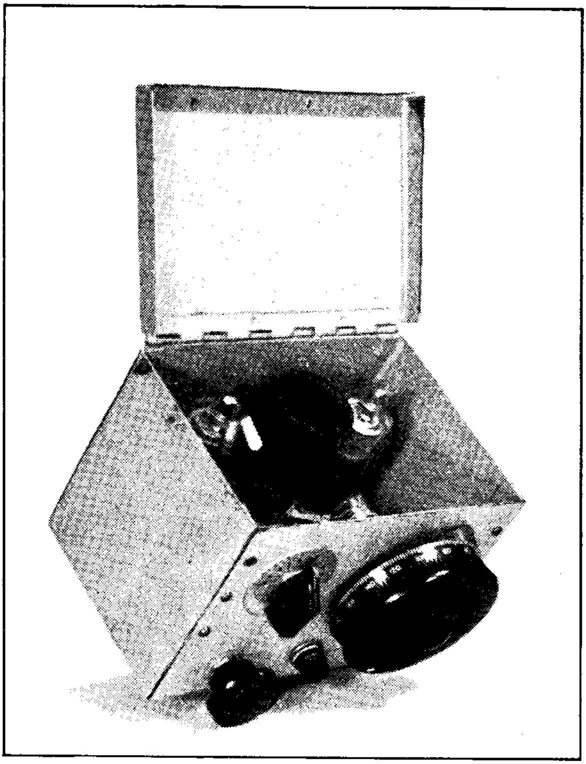


Fig. 11

THE EDITORS INVITE . .

- Constructional articles suitable for publication in this journal. Prospective writers, particularly new writers, are invited to apply for our "Guide to the writing of Constructional Articles" which will be sent on request. This guide will prove of material assistance to those who aspire to journalism and will make article writing a real pleasure!
- Constructive criticisms and suggestions on the magazine. Let us know what you like and what you don't like.
- Details and, if possible, photographs, of your workshop or "den."



A Short Wave Economy Two

An efficient "All Dry" Short Waver

By Jack Fisher

(Editorial Note: The circuit of this receiver, together with some brief notes, originally appeared in the "My Favourite Receiver" feature in Short Wave News. The author was so inundated with requests for fuller details that he found it necessary to have some mimeographed sheets made of the relevant points. Since the receiver aroused such interest, we invited Mr. Fisher to describe the set in full for this journal).

REFERENCE to the circuit diagram will show that the receiver is a straight of the 0-v-1 variety and that it uses "economy" or "all dry" valves. The use of this type of valve dispenses with the need for accumulators, a point well worth remembering if the receiver is to be used, as the original model was, for portable purposes. This fact, combined with the size of the receiver (6in. x 4½in. x 4½in. in cabinet) makes for a truly portable short waver, one that can be carried around with ease.

In the original receiver, American type 1N5 valves were used. Should readers find these valves unobtainable, the British equivalents must be used and, as these are taller than their American counterparts, it will necessitate increasing the height of the cabinet by about one inch.

The Circuit

The salient features of the circuit will be easily observed by reference to Fig. 1. The aerial is coupled to the primary winding of the 6-pin coil via the small variable capacitor C1. The object of C1 is to permit adjustments to be made to the degree of coupling so that reaction will be smooth over the various bands to be covered, and it is important that this capacitor should, therefore, be insulated from the metal chassis by insulating washers. The RF signals are induced from the primary to the grid winding of the coil and are tuned by the bandset capacitor C2 and the bandspread capacitor C3. The selected signal is then applied to the grid of the detector valve V1, which is operating under the leaky-grid detector conditions. The signal is then amplified and appears at the anode

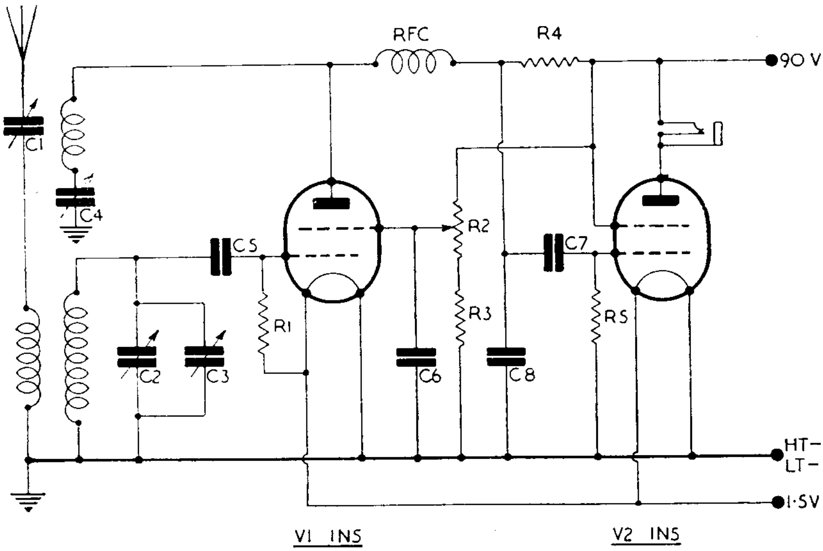


Fig. 1. Theoretical Circuit

section of the valve together with a proportion of unrectified RF. This RF is prevented from reaching the audio frequency stage by the RF Choke but is re-introduced back into the grid circuit via the reaction coil, which is magnetically coupled to the grid winding, in correct phase to amplify the original signal. The amount of this "feed back" is jointly controlled by the pre-set capacitor C4 and the potentiometer R2, the latter being used to vary the potential applied to the screen grid of the detector valve. The purpose of C6 is to prevent extraneous noises when R2 is being adjusted.

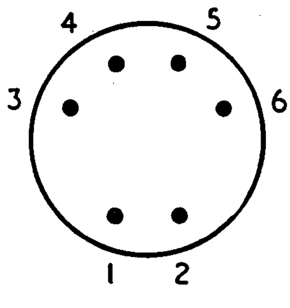
The audio frequency stage is resistance-capacitance coupled to the detector stage by R4/C7, and the capacitor C8 is to by-pass to earth any RF that might have escaped the RF Choke. The audio signal arriving at the grid of V2 is further amplified by this valve and appears across the anode load—the phones.

Construction

For constructors who wish to make their own chassis, a piece of metal is required and should be cut and drilled as shown in Fig. 2. The size of this metal sheet should be 8½in. x 7in., which, when bent into shape, will give a chassis measuring 5½in. x 4in., with a 1½in. sub-chassis space. A metal panel is also required and this should measure 6in. x 4½in. and should be drilled as shown in Fig. 3.

The panel is fixed to the chassis by means of the lugs and fixing nuts of the potentiometer R2, aerial trimmer C1 and the phone jack. The panel should overlap the chassis by ¼in. to enable fixture to the cabinet. It has been decided to omit details of the cabinet as individual constructors may have their own choice in the way of design.

The next task is to mount the variable capacitors, valve bases and so forth and then to commence wiring up. It is recommended that wiring should be carried out



Connections for Eddystone 6-pin coil holder: (1) Earth; (2) Stator of C2; (3) Earth; (4) C1; (6) Anode of V1; (6) C4.

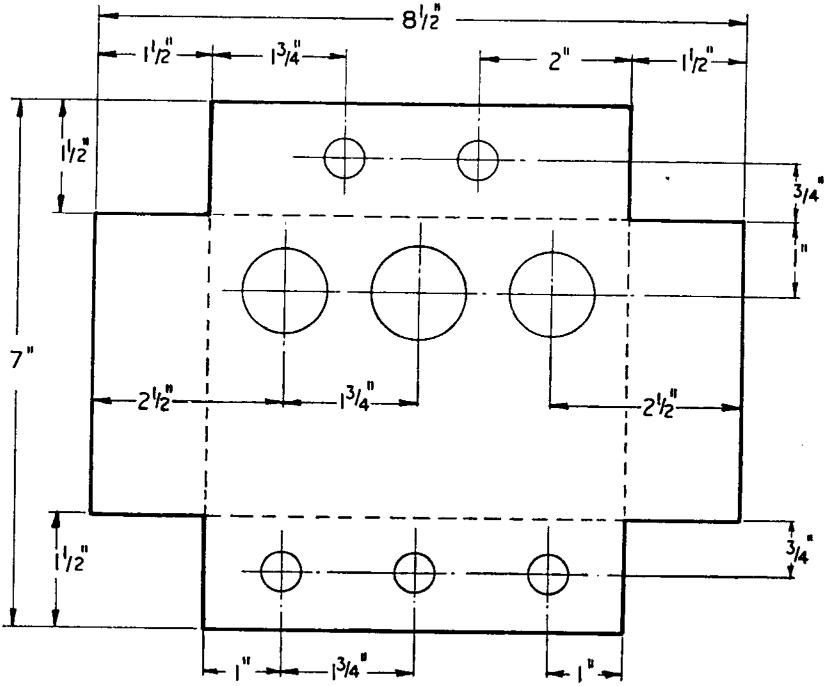


Fig. 2. Dimensions for Chassis.

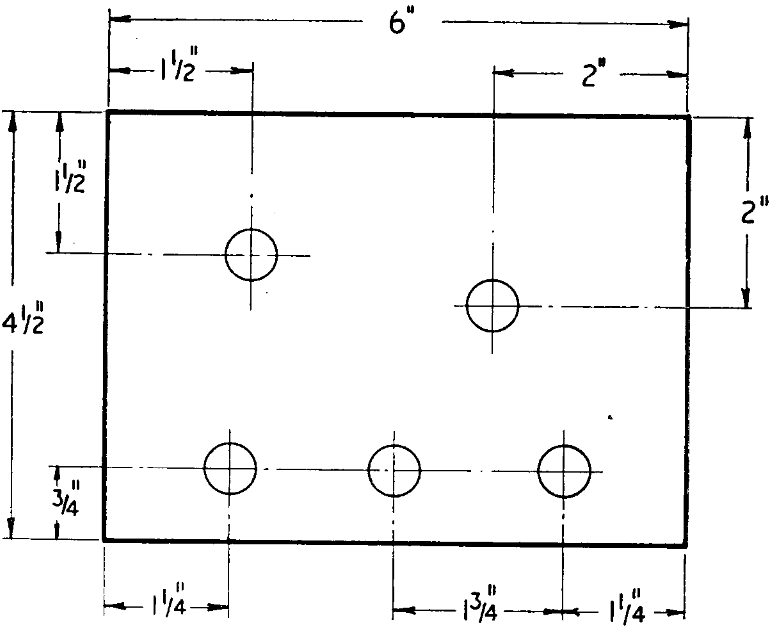


Fig. 3. Dimensions for Panel

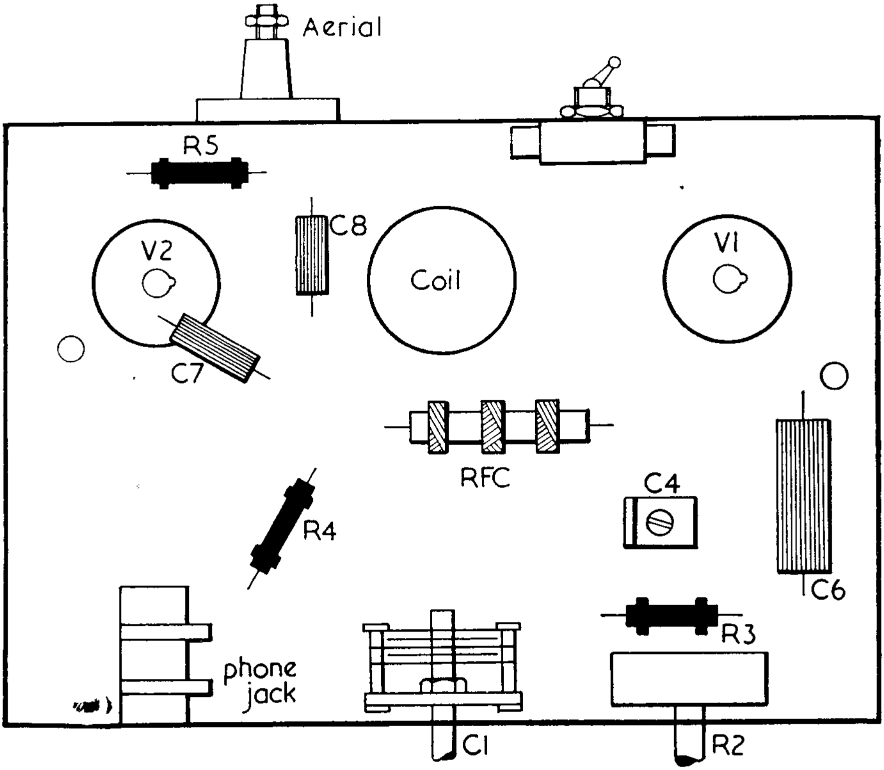


Fig. 4. Under Chassis Layout

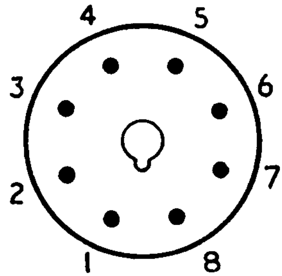
with 18 swg tinned copper wire, with systoflex sleeving, except for the battery leads which may be of any good quality multi-strand flex. No difficulty in wiring should be experienced if the layout as shown in Fig. 4 is carefully followed. The first step is to wire up the filament leads of the valves and then C5 and R1 can be fixed. The latter components should be soldered extremely close to the grid cap of the detector valve as may be seen from Fig. 5. Failure to adhere to this may easily result in instability and undesirable effects.

When the wiring has been completed, connect the batteries and, before inserting the valves, take a meter reading across pins 2 and 7 of both valves to ensure that not more than 1.5 Volts is being applied to the filaments. Many constructors will not possess a multi-range meter and in this case an ordinary flash lamp bulb can be used as an effective substitute. If the bulb "blows," the wiring should be carefully checked as it will be obvious that there is an HT short somewhere!

Operation

To operate the set, plug in coils, valves, and connect the aerial to the stand-off insulator at the rear of the receiver. Switch on the set and rotate the reaction control in a clockwise direction until a faint hiss is heard in the phones. Then turn the band-set control until a "chirping" is heard and slacken off the reaction until the receiver is just below the point of oscillation. Having selected the required band, the final tuning is carried out by means of the slow motion drive (the bandspread control). If re-action is not obtained, or if the reaction is too fierce, adjust the preset capacitor C7 until results are satisfactory. Once set, this capacitor need not be adjusted again.

Should reaction disappear over certain wavebands, adjustment of the aerial trimmer C1 will allow oscillation to be obtained. Very satisfactory results have been obtained on this little receiver using an ordinary "L" shaped aerial and no earth. The author did not experience any hand-capacitance effects but should readers ex-



Connections for 1N5 valves (as viewed from underside): (Pin 1) Blank; (Pin 2) Filament; (Pin 3) Anode; (Pin 4) Screen grid; (Pin 5) Blank; (Pin 6) Blank; (Pin 7) Filament; (Pin 8) Blank; (Top Cap) Control grid.

perience this fault then the addition of a good earth system should effect a cure. Remember, however, that earth connections must be short and direct.

LIST OF COMPONENTS

Capacitors

C1 3-30 μμF trimmer
C2 160 μμF
C3 15 μμF
C4 175 μμF (approx.)
C5 100 μμF (silvered mica)
C6 0.1 μF paper
C7 0.01 μF paper

Resistors

R1 5 MΩ ½ watt
R2 50000Ω potentiometer
R3 50000Ω ½ watt
R4 50000Ω ½ watt
R5 1 MΩ ½ watt

Miscellaneous

Stand Off Insulator (1)
Ceramic Octal valve base (2)
Six-pin ceramic coil base (1)
Short wave RF Choke (1)
Jack plug and socket (1)
Dry Battery, 90v. and 1.5v.
Slow Motion Drive (1)
Valves: 1N5 (2)
Double Pole Single Throw toggle switch (1)
Reel of 18 swg tinned copper wire (1)
Systoflex sleeving (3 lengths)
Set of plug-in coils (six-pin)

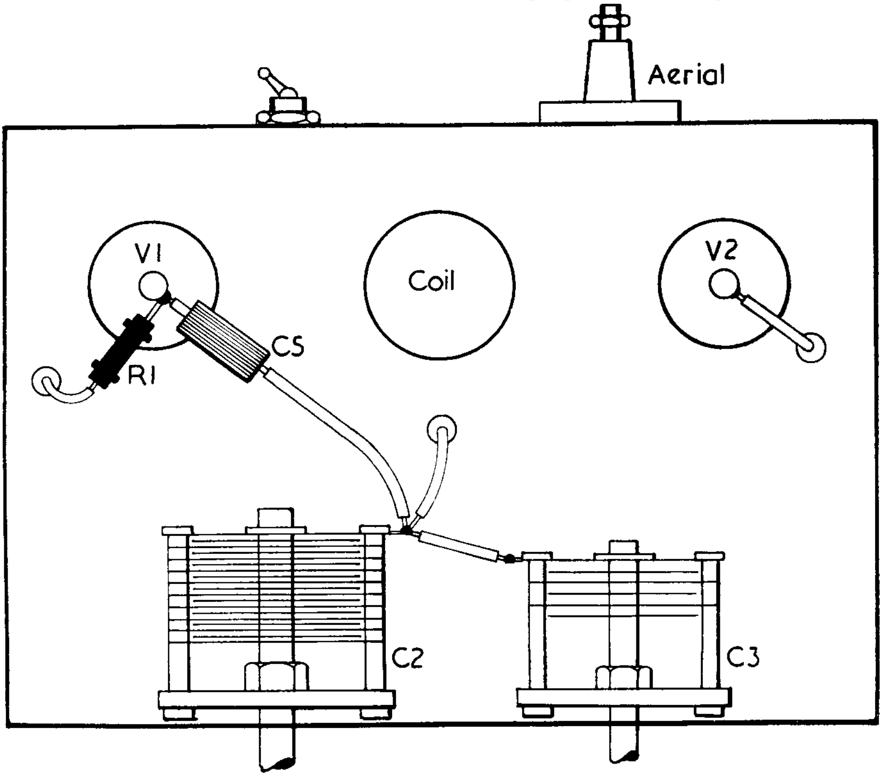
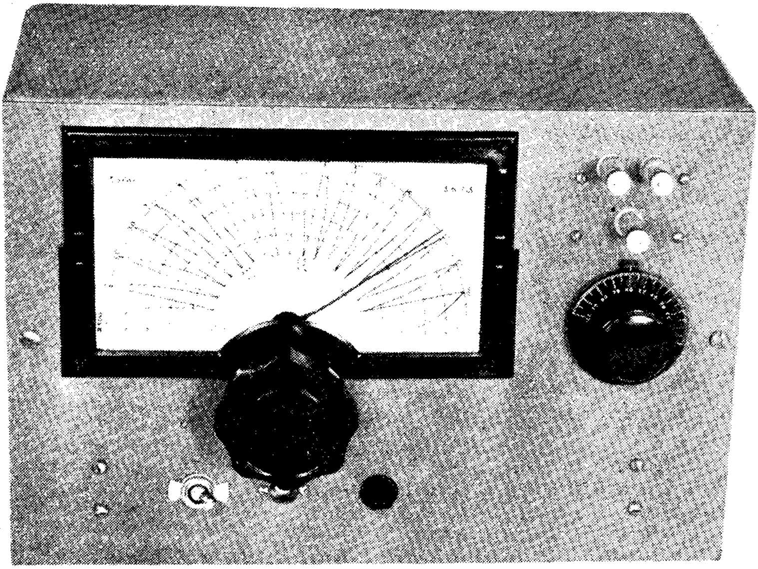


Fig. 5. Above Chassis Layout.



A Variable Frequency Oscillator

Describing a versatile ECO unit with combined crystal oscillator

By G2ATV

SINCE the resumption of amateur transmitting, the use of variable-frequency oscillators has become increasingly popular, and the position which existed pre-war of the majority of stations using crystal control, with a minority of VFO's, has now become completely reversed. There have been, and doubtless will continue to be, articles published in the Radio Press deploring this state of affairs—but the censure should really be addressed to certain so-called operators.

The crystal is admittedly the most stable form of oscillator frequency control at present in existence, yet it is quite possible for bad design and for faulty adjustment to lead to a chirpy note, a T7 signal, and frequency drift, even though crystal control is used. The variable frequency oscillator is certainly more responsive to misuse, but should not be condemned on this count alone. Given care in construction, and design, plus intelligent operation, the VFO can be as efficient as its crystal controlled counterpart, with the added advantage of frequency-at-will operation.

The exciter described in this article has now been in use for some considerable time—as is all "R.C." apparatus before being committed to print—and has produced reports equally as good as were forthcoming when its crystal controlled predecessor was on the air. It should here be noted that this exciter was designed to be used in conjunction with the voltage regulated power supply unit which was described in the July, 1947 issue of "Short Wave News." With this supply the note has invariably been reported as T9 or T9x, but the oscillator can, of course, be used with any other well-designed power unit. In any case it is essential in the interest of frequency stability that the power supply together with its accompanying heat be situated elsewhere than in the same cabinet.

Stability

A careful check has been kept on stability and drift. When first switched on, there is considerable drift—some 3 kcs.—for a few minutes until the valve heaters have reached almost normal working temperature. This is followed by a slow drift during the next half-hour which amounts to some 2 kcs. on the fundamental output frequency range (3.5 Mcs. band). From then on, the frequency has not been observed to drift through more than a further 1 kcs. throughout a whole evening on the air. In practice this has resulted in many solid QSO's of a half-hour and more with crystal filters in operation at the other end.

This is quite satisfactory, and has enabled us to make use of a directly calibrated dial. Here again we must make an observation—the Transmitting Licence clearly states that where the sending apparatus is not crystal controlled, the sending frequency shall be measured whenever necessary, and on all occasions where the sending frequency is changed, to an accuracy of not less than ±0.1 per cent. The calibrated dial is, therefore, not intended to record the operating frequency for log-keeping purposes. It will give the frequency sufficiently accurately for all purposes where the exciter is used as a wavemeter (a useful function) and it is also convenient for rough setting to any desired frequency (within 1 kcs. on the fundamental output band).

Stability is excellent, too. The exciter is being used regularly within a foot of the key, and has suffered its fair share of jars, knocks, etc., but has never yet jumped frequency.

The Circuit

Now for a glance at the circuit, as shown in Fig. 1. A 6F6 valve is used as an electron-coupled oscillator, with feed-back arranged in the usual manner via a section of the grid winding L1. The tuned circuit here has a high C/L ratio in the interests of stability, and includes no less than four separate capacitors. The bulk of the capacitance is provided by C3, which is fixed in value. C1 is a variable for band-spreading. C2 is for band-setting, and C4 is a very small value variable which is used for zero setting of the dial and which is adjustable from the front of the panel. Bias to the oscillator is provided solely by the grid-leak R1. The anode and screen HT supplies are broken by the switch S1, and are fed from a 150 volt source, preferably stabilised. The anode of V1 is untuned, which reduces the output somewhat, but has the advantage of rendering the frequency unaffected by adjustments to the tuning of the

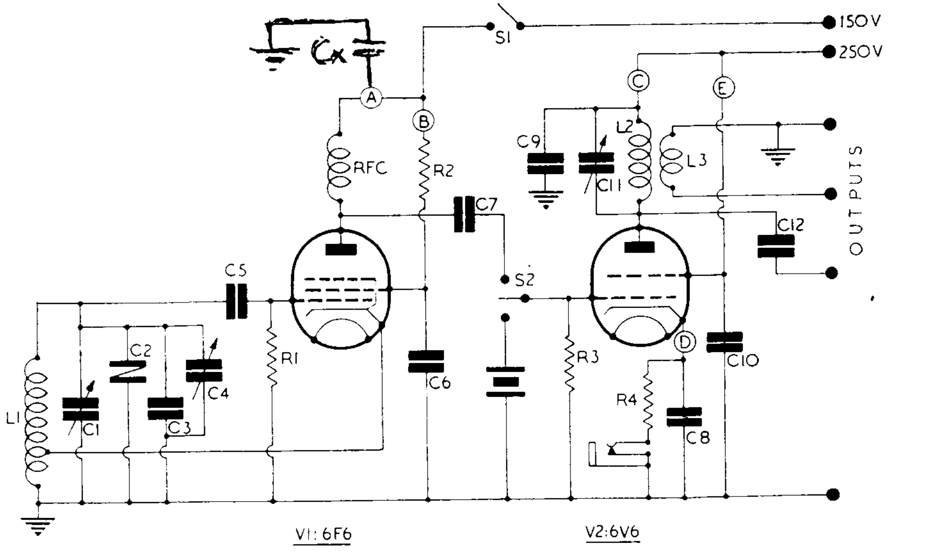


Fig. 1. Theoretical Circuit

C1, C2 25 $\mu\mu$F — C3 350 $\mu\mu$F (see text) — C4 5 $\mu\mu$F (see text)
C5, C7, C12 100 $\mu\mu$F — C6, C9, C10 0.01 μF — C8 0.1 μF
C11 160 $\mu\mu$F — R1, R2 50 K-Ω — R3 150 K-Ω
R4 250 K-Ω — For details of coils, choke, etc., see text

Cx Optional

following stage, and permits of the dial being directly calibrated.

The second stage fulfills two functions. The switch S2 in the grid circuit allows the valve to operate either as a doubler following the ECO, or as a self-contained crystal controlled oscillator. In the latter case S1 is left in the open position in order to avoid any confusion as to which is the correct carrier. The values of components used in this second stage were decided upon from the angle of efficient working as a doubler, but in practice do not unduly affect operation as a CO. The RF output is, in fact, greater when used as a CO than when working as a doubler.

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However, BK working can still be indulged in by keying the second stage when this is operating as a CO. When used as a doubler, keying V2 brings with it no problem of chirp, and also enables the operator to "swoop" on to any desired frequency without radiating to the discomfort of others! As a CO, too, this stage is very convenient as a means of providing check frequencies against the calibration of the ECO tuning dial, the zero point of which can be adjusted "spot-on" by means of C4.

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● Components

Before leaving the circuit, a few words may be opportune on the actual components, with regard to their construction or materials used in them. An exciter should be built as a precision instrument, and not as the "hook-up" which so often is the cause of prejudice against a VFO. In particular, the whole of the oscillator stage should be constructed with good quality components. L1, L2 and L3 are home-wound on ceramic formers, and will be described later. The variables C1, C2, C4 and C11 must be of the air-dielctric type, having end-plates of low loss material, and must be of solid construction. C3 and C5 are also important from the angle of stability and freedom from frequency drift, and should be of the silver-mica or silver-ceramic variety.

The coupling capacitors C7 and C12 may be of the moulded mica types, or better. The decoupling capacitors C6, C8, C9 and C10 are not so important, and here the non-inductive tubular capacitors are quite suitable, though moulded mica are better but more expensive. The RF choke in the anode of V1 calls for no comment, except that it should be efficient.

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There remains the drives and the cabinet and chassis. Several good quality drives are now available at reasonable cost; the most important considerations are rigidity and lack of backlash. Rigidity is also the point to look for in the chassis, panel and cabinet. It may involve harder work in construction, but any flimsiness will result in mechanical instability.

● Construction

The cabinet shown in the illustrations measures 12ins. long by 8ins. high by 6ins. deep. This particular shape is not essential, of course, but it does enable a very suitable layout to be adopted. All the components are mounted on the chassis and panel, so that the VFO can be withdrawn as a complete working unit if necessary. The panel measures 12ins. long by 8ins. high, and the chassis 10½ins. long by 5½ins. wide by 1¾ins. deep, and the latter is fixed to the panel with its lower edge ¾in. up from the bottom of the panel. This allows plenty of room underneath for those parts "below deck."

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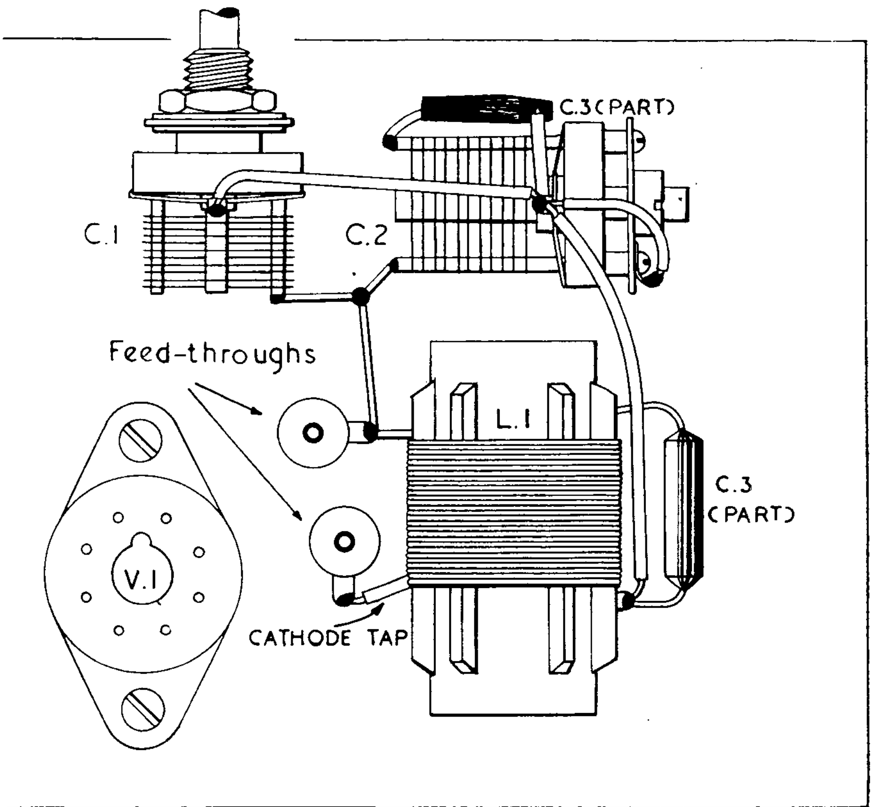

Fig. 2. Plan view showing layout of ECO section above chassis

The next step is to mark out and drill the holes for S1 (½ins. diam.), C4 (screw-driver clearance), and the key jack (7/16ins. diam.) The size of C4 will dictate the distance between the centres of these holes—we used one of the ex-WD preset types which are so plentiful at the moment, stripping it down until only one fixed and one moving vane remained. The panel can now be almost completed by drilling the holes for the other drive and the three output terminals. C11 has HT on both fixed and moving vanes, and must, therefore, be mounted on an insulated bracket, with an insulated coupler, flexible for preference, to the drive.

Two more feed-through insulators can now be "spotted," one near the fixed and one near the moving vanes, and then the 6V6 holder can be positioned and the hole drilled (1⅛ins. diam.) The coil L2/L3 is set on stand-offs fixed to the panel where shown, so that the axis is at right-angles to that of L1, in order to minimise any inductive coupling that might exist between them. The only remaining large holes are those for the dial lamp wiring (⅜in. diam. to take a rubber grommet), for the supply cable (size to suit), the switch S2 (usually ⅜in. diam.), and the crystal holder (also to suit).

We have shown S2 and the crystal holder mounted on the rear edge of the chassis, as in our case the crystal was required mainly to give a calibration check point. Where it is intended to use the 6V6 fairly frequently as a crystal oscillator to drive the transmitter, it would be more convenient to mount both the switch and the crystal holder on the panel, in line with the key jack. There is plenty of room available for this purpose, and the operation would not be affected in any way by so doing.

The only components above chassis not so far mentioned are the two coils. Both, in our case, were wound on ceramic formers 1⅛in. diam. The ECO coil L1 consists of a single winding of 42 turns, close-wound, of 26 swg enamelled copper wire, tapped at 7 turns from the earthy end for the cathode

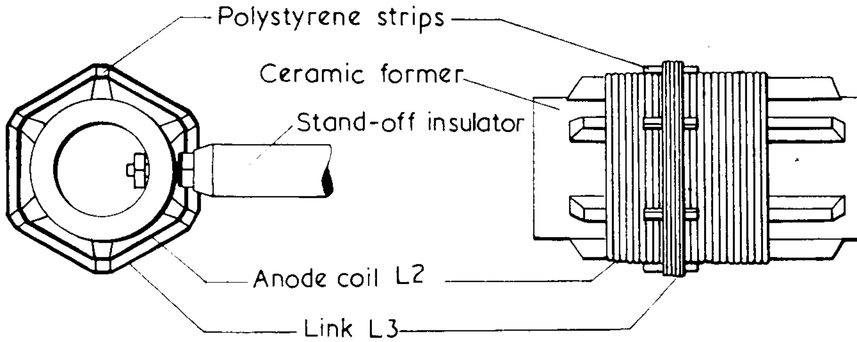

Fig. 3. Showing constructional details of PA coils (L2/L3)

connection. The 6V6 anode coil has two windings. L2 consists of 36 turns, also close-wound, of 24 swg enamelled copper. L3 is of the same gauge wire, close-wound, and has four turns; this winding is spaced at about 20 turns from the anode end—the distance is not critical—and is separated from L2 by thin slips of polystyrene cemented parallel with the ribs of the coil former. After winding, both coils were thoroughly impregnated with polystyrene cement.

The particular formers we used are provided with three rows of holes, making the provision of anchoring points a simple matter—just a question of enlarging those holes slightly (careful does it!) and using 6BA bolts and soldering tags. The number of turns given above for L1 and L2 may have to be modified slightly in individual cases, as stray capacitances will no doubt vary if a different layout is used. The coverage we obtained in our model was 3500-3673 kcs. Through further doublers, the 7 and 14 Mcs. bands can be covered by some 150 and 100 degrees of the dial respectively. If it be wished to cover the whole of the present 3.5 Mcs. band, C1 should be made 50 $\mu\mu$F and C3 built up of two paralleled capacitors having a total of 325 $\mu\mu$F.

Underneath the chassis, the key jack, S1, S2, C4, and the crystal holder have already been mentioned. The remaining components, such as the resistors, capacitors, and RF choke, are all mounted in the wiring and so do not require any large holes. Fig. 4 shows the layout of these as we arranged them. All earth (chassis) connections were taken to an earth line formed of 14 swg tinned copper wire, bent over at each end and soldered to two of the valveholder screws. The multi-way cable from the power unit is connected to tags on a mounting strip, to remove any strain on parts connected to the various leads. The whole job should be wired up with rigidity as one of the main considerations—nothing smaller than 16 swg wire should be used for wiring, except in the case of heater and dial lamp leads where 14/36 twisted flex is best.

There now remains only the cabinet which, as mentioned previously, should be a really sturdy affair. Another most important condition, from the point of view of freedom from frequency drift, is that it should provide ample ventilation. To take care of this, we made four 1⅛in. diam. holes along the top edge of the back, above the valves, and provided also a row of ⅜in. diam. holes along the ends and back of the cabinet bottom.

Tests

When completed, the unit should first be tested for shorts between the two positive HT leads and the chassis. Solder has a nasty habit of dropping into awkward places! There should be no reading in each case. Then plug in the valves, connect up to the power unit, switch on and monitor on a receiver. With signals being received, the next step is to ascertain that the VFO is operating within the amateur band. Superfluous? Just try occasionally outside the limits, and see how many hams can be logged! If coil formers have been used of a size different to that given in this article, check up on both stages with an absorption wavemeter to make sure that both are operating on the correct bands. Then check the frequency range with a crystal controlled wavemeter, and adjust C2 and C1 until the coverage is correct, leaving C4 set with the moving vane half-in. If no crystal controlled wavemeter is available, study the terms of the licence!

Table 1 gives a list of voltages and current readings as measured at various points in our model, as a guide to the constructor should the VFO fail for some reason to following stage, and permits of the dial being directly calibrated.

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TEST READINGS

Measurement	Reading	Where Measured
	6F6 ECO	
Anode volts	150v.	Between A and chassis
Screen volts	150v.	Between A and chassis
Anode current	8mA.	In series at A (oscillating)
	15mA.	In series at A (non-oscillating)
Screen current	1.6mA.	In series at B (oscillating)
	2.3mA.	In series at B (non-oscillating)
	6V6 AS DOUBLER (DRIVEN)	
Anode volts	240v.	Between C and chassis
Screen volts	240v.	Between E and chassis
Cathode volts	5.5v.	Between D and chassis
Anode current	15mA.	In series at C
	24mA.	In series at C (off-resonance)
Screen current	17mA.	In series at E
	1.7mA.	In series at E (off-resonance)
	6V6 AS CRYSTAL OSCILLATOR	
Anode volts	250v.	Between C and chassis
Screen volts	250v.	Between E and chassis
Cathode volts	5v.	Between D and chassis
Anode current	12mA.	In series at C
	36mA.	In series at C (non-oscillating)
Screen current	7mA.	In series at E
	3mA.	In series at E (non-oscillating)

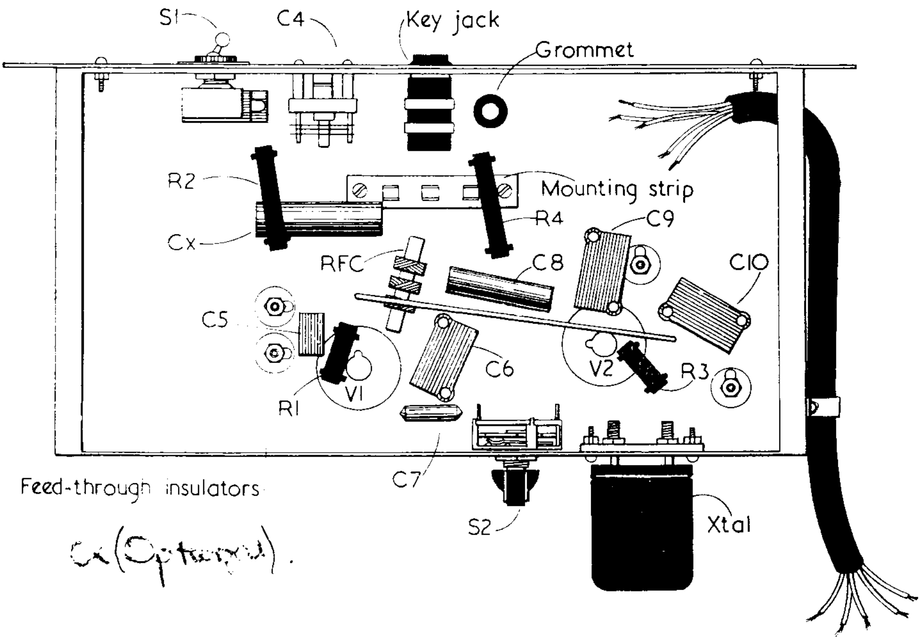


Fig 4. Under Chassis Layout

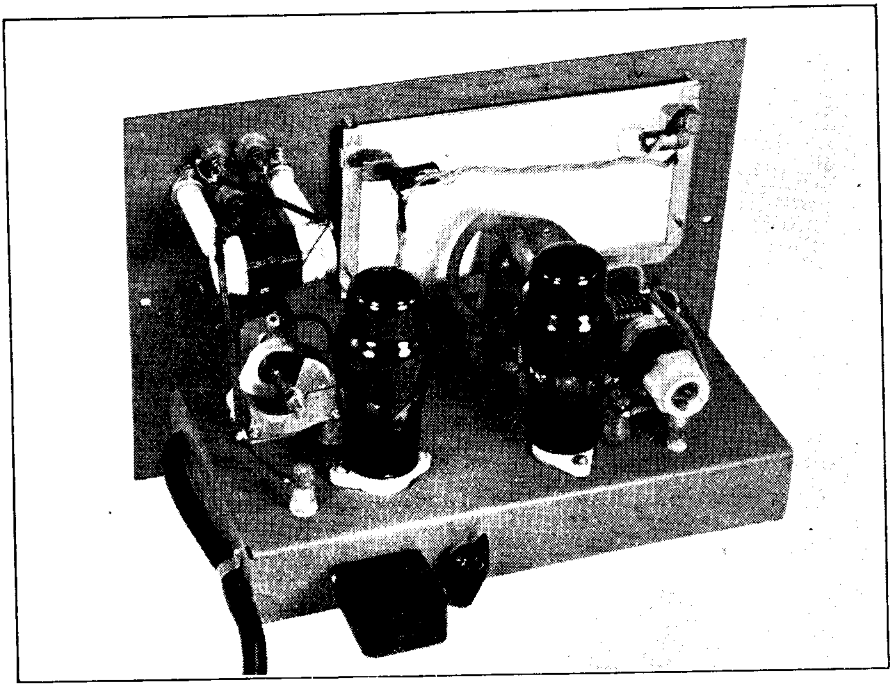
operate properly. The actual readings obtained will to some extent depend on the sensitivity of the measuring instrument, and due allowance should be made for this. All voltage readings were taken between the points named and the chassis; current readings were taken with the meter inserted in series at the points marked. V1 measurements were taken with the valve oscillating, and then with the control grid shorted to chassis—in each case V2 was switched to the crystal position with the holder empty. V2 measurements were taken both as a doubler and as a CO, and with the anode circuit tuned to resonance and then off-resonance. L3 remained unloaded throughout.

Calibration

Attention has already been drawn to the section in the transmitting licence which states that the sending frequency must be measured whenever necessary, and whenever the frequency is changed. The calibration of the VFO dial is thus to be regarded as a matter of convenience in enabling quick setting to any particular approximate frequency; at the same time, if undertaken carefully, it does allow the VFO to fulfill a most useful function as a heterodyne wavemeter.

Calibration is readily accomplished by monitoring on a receiver and beating the signal from the VFO with the harmonics from a 100 kcs. crystal sub-standard, that from the VFO being adjusted to zero beat. This will give marker points at frequency multiples of 100 kcs. when the receiver is set to the 3.5 Mcs. band. Further division giving 50, 25 and 12.5 kcs. points (on the fundamental 3.5 Mcs. scale) can be obtained by switching the receiver to the 28 Mcs. band, and beating VFO harmonics with those from the sub-standard. From these points a graph can easily be prepared which, with the coverage used in the prototype, can be read to within 1 kcs. on the 3.5 Mcs. output range. With a 180 degree dial, one degree will approximate 1 kcs. using a straight-line frequency capacitor for C1.

The direct-calibration dial shown in the illustrations is marked along the outer of the six concentric scales at intervals of 10 kcs. From these points, radial (parallel with pointer) lines are marked extending to the innermost scale. Each pair of these radial lines is then connected by a diagonal curve which indicates 2 kcs. points where it crosses the intervening scales. Such a dial can be comfortably set to an accuracy of ±2 kcs. on the 14 Mcs. band .



Rear view of unit with cabinet removed

Capacitors

By Centre Tap

FOLLOWING our recent informal chat on resistors it has been proposed that other components should be briefly reviewed in a similar manner, so this month capacitors of the various types are dealt with. Firstly, the variable or tuning capacitor. It will be noted that these have specially shaped vanes. They are designed thus to follow a given "law," or to put it more simply, to increase their capacity at a given ratio in proportion to an increased eumeshment of the vanes. Generally speaking, for amateur use, it is the mechanical side with which we are more concerned and the points to look for in good design.

These are, sturdy vanes, low loss insulation (and even that must be kept to a minimum) and a spindle bearing which gives good electrical contact at all points and during movement. Some of the older and cheaper patterns fall short in the last requirement particularly, which is responsible for their noisy operation.

Thin vanes, especially if of brass must be avoided. Their "springiness" under slight shock or even sound waves from the speaker striking them, may cause their capacity (and thus the tuning) to vary. A "pigtail" is essential to ensure perfect contact between the rotor, or moving, vanes and the connection, for silent operation.

Of fixed capacitors the mica types are well suited to RF circuits as they remain constant with varying frequency. They consist of metal foil electrodes separated by mica, tightly clamped together. A more modern development, the silvered mica type, is similar but instead of having foil electrodes, a silver film is deposited on the mica itself, thereby giving a higher degree of stability with no likelihood of the electrodes changing their relative positions and altering in capacity.

Ceramic capacitors are similar to the silvered mica type, but the dielectric is of a ceremic material instead of mica.

It would be as well at this point to consider the main uses for fixed capacitors, and their general classification is set out below.

Purpose	Types Used
RF coupling, grid and by-pass capacitors	Mica, silver mica and ceramic
Decoupling, and AF coupling	Non-inductive paper
Power smoothing	Large capacity paper and electrolytic

It will be seen that the mica, silver mica and ceramic, are all primarily used for similar purposes and their differences are merely a matter of degree. The latter are preferred where small and absolutely constant capacities are required.

Semi-Variables

The value of all capacitors is dependent upon the thickness and the nature of the dielectric between the plates of metallised surfaces and this also governs the voltage which they are expected to withstand. Pre-set, or semi-variable capacitors used for trimming, etc., depend on this, and as they are tightened down (or the vanes enmeshed) their capacity increases. The usual dielectrics are air or mica, their dielectric constants being 1 and 6 respectively. Proportionately waxed paper has a constant of 2.

Paper Dielectric Capacitors

These consist of metal foils, usually aluminium, interleaved with paper and tightly rolled. The greatest enemy of all capacitors is moisture and special precautions are taken in manufacture. Protection also has to be given against the possible admission of moisture during service so they are hermetically sealed and care should be taken to see that the sealing is not damaged. Some patterns have little more than wax sealing and this can be easily melted off with the careless use of a soldering iron. In what is popularly known as the non-inductive pattern each foil is extended over the opposite ends of the paper so that current can flow along the edge of the foil instead of following a circular path coil fashion.

Even so they cannot be absolutely non-inductive but their inductivity is so small that it is insignificant for the purposes for which they are used, chiefly for de-coupling, AF coupling or smoothing.

The larger sizes of paper capacitors are popularly known as "Mansbridge" type and in capacities of above several microfarads must of necessity become very bulky, particularly if thicker waxed paper, to ensure higher voltage working, has to be used.

Electrolytics

The great asset of the electrolytic type is the fact that a large capacity can be had in a compact space especially when the working voltage is low as in bias smoothing. For higher voltages as in HT reservoir and smoothing uses, they save considerable

(Continued on p.163)

Query Corner

A "Radio Constructor" service for readers

Tuned Circuits

"I am hoping to take the Radio Amateurs' Examination next May, and see from the syllabus that I have to know something about acceptor and rejector circuits. I cannot find anything about these in my books and wonder if you could give me some information."—L. Jarman, Edgware.

Acceptor and rejector circuits are tuned or resonant circuits; the acceptor circuit offers minimum impedance at the frequency to which it is tuned whilst the rejector offers maximum impedance at the frequency to which it is tuned. The acceptor circuit takes the form of an inductor and a capacitor in series with the signal source (Fig. 1) and at resonance, when the inductive reactance equals the capacitive reactance the effective impedance of the circuit is zero. This is because the capacitor causes the voltage which is developed across it to lag upon the current by 90 degrees, whilst the voltage developed across the inductor leads the current by 90 degrees. When these voltages are of equal magnitude they cancel out no matter how large the current is in the circuit. The impedance is therefore zero as Z=O=O by Ohms law.

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The rejector circuit takes the form of an inductor and capacitor in parallel, with the signal source in series with the combination (Fig. 2). At resonance the inductive reactance equals the capacitive reactance and the effective impedance of the circuit is at a maximum. It will be recognised that the rejector type of circuit is used for normal tuning purposes where it may be considered to short circuit all signals at frequencies other than the one to which it is tuned.

These types of tuned circuits are frequently employed in audio amplifiers for tone correcting purposes.

I.F. Instability

"Recently I constructed a five-valve superhet which defies all my attempts to align it. In spite of the fact that I built a signal generator for this purpose I can get nothing but whistles and rushing noises over the whole tuning range. Can you suggest the possible cause of this trouble."—A. Bellamy, Plumstead.

The trouble experienced with this receiver appears to be due to instability in the intermediate frequency amplifier. In severe cases this instability may lead to steady oscillation in the stage resulting in a hiss or rushing noise being heard from the speaker. When a signal is tuned in it will beat with the unwanted oscillation causing the familiar heterodyne whistle. Instability may be the result of poor connections, long connecting leads, insufficient screening or ineffective decoupling. The grid lead of the I.F. amplifier should be well screened and it is a useful tip, when using single ended valves, to mount the screen grid bypass capacitor directly across the bottom of the valve holder between the anode and grid connections. By so doing the capacitor acts as a screen across the valve base; the outer foil of the capacitor should be connected to earth.

In order to avoid instability care should be taken with the layout of components to ensure that anode and grid leads are spaced well apart and are of the shortest possible length. Similar trouble to that described may be caused by squegging in the local oscillator section of the frequency charger. This may be due to an oscillator anode voltage which is too high or the use of a grid leak of too large a resistance. If attention to these points does not affect a cure a resistor of 25 to 100 ohms should be connected in series with the oscillator feed back winding (untuned winding).

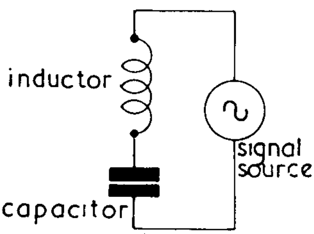


Fig. 1

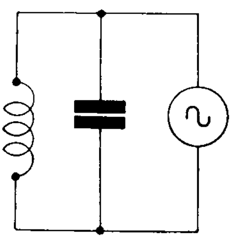


Fig. 2

Fig. 1 shows a series resonant or acceptor circuit. Fig. 2 shows a parallel resonant or rejector circuit.

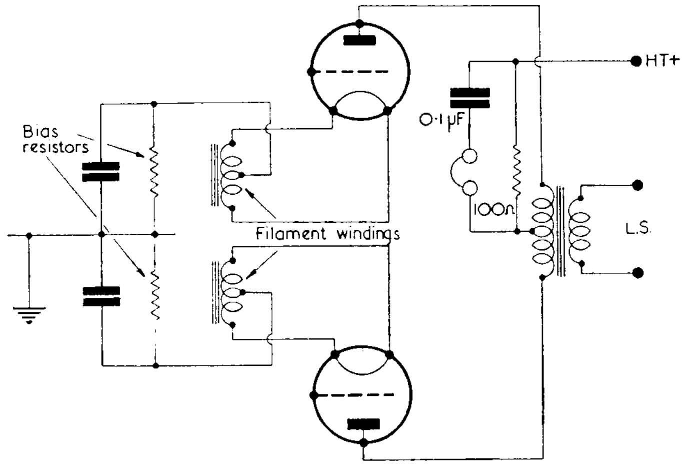


Fig. 3. Showing a method of detecting unbalance in a Class A or AB push-pull amplifier

Push Pull Balancing

"I have an amplifier using two separately biased triodes in the output stage. The individual bias resistors have been adjusted so that each valve passes the same anode current, but I understand that this does not necessarily provide perfect balance. As the best obtainable quality is required I should be glad to know if there is a better method of balancing a push pull stage."—B. Hemingway, Yeovil.

As it is possible that two similar valves will not have identical characteristics when passing the same anode current, the balance point may occur when the anode currents differ slightly. It will be realised from this that the equalising of these currents does not necessarily result in a balanced push-pull stage. Also by careful consideration of the circuit it will be apparent that any unbalanced current will flow in the HT lead to the centre tap of the output transformer primary. In order to check this a low resistance (say 100 ohms) if connected in this lead will cause a voltage to appear across it, which will vary with the unbalanced current. This voltage may be detected by means of a pair of headphones connected across the resistor as shown in Fig. 3. The capacitor in series with the headphones leads is included as a precaution to prevent DC from flowing through them.

Having connected up the headphones a signal should be fed into the amplifier and the individual bias resistors adjusted around the recommended value until the signal heard in the phones is at a minimum. The push-pull stage is then operating under the best possible balance conditions.

"Query Corner" Rules

(1) A nominal fee of 1/- will be made for each query.

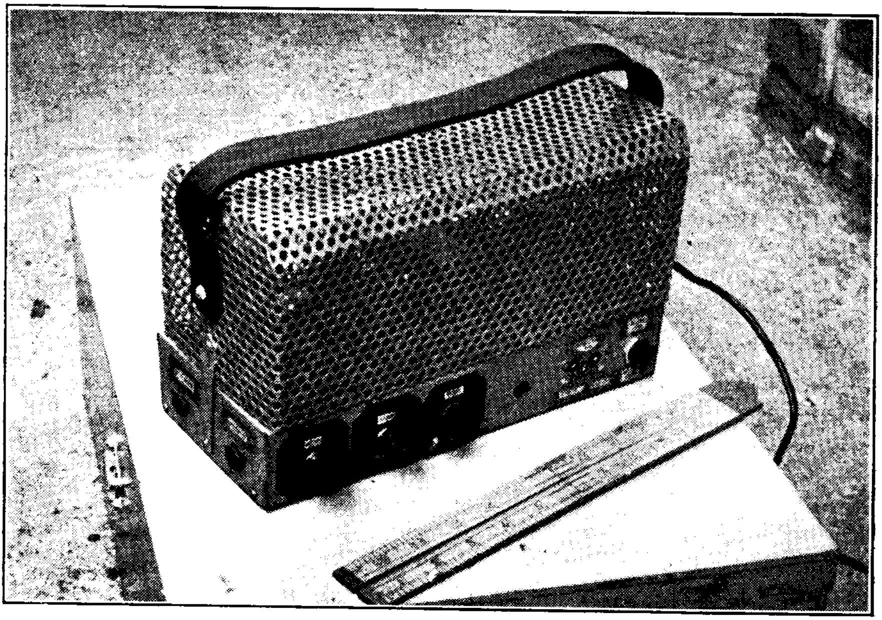
(2) Queries on any subject relating to technical radio or electrical matters will be accepted, though it will not be possible to provide complete circuit diagrams for the more complex receivers, transmitters and the like.

(3) Complete circuits of equipment may be submitted to us before construction is commenced. This will ensure that component values are correct and that the circuit is theoretically sound.

(4) All queries will receive critical scrutiny and replies will be as comprehensive as possible.

(5) Correspondence to be addressed to "Query Corner," Radio Constructor, 57 Maida Vale, Paddington, London, W.9.

(6) A selection of those queries with the more general interest will be reproduced in these pages each month.



An AC/DC Amplifier

A compact 8-watt unit

By L. F. Sinfield

IN spite of the comments concerning AC/DC apparatus meted out by those fortunate enough to be on AC supply, there still exists a large proportion of radio enthusiasts who have no source other than DC. The amplifier to be described will be of special interest to these latter enthusiasts and it was so constructed as to be as compact and portable as possible and at the same time to provide a performance electrically to satisfy the most stolid advocate of AC apparatus, by its operation and safety. The author feels that he has succeeded in both respects.

The complete amplifier assembly consists of a carrying case, which splits diagonally into two sections, with the speaker mounted towards the top of one half—allowing sufficient space below it to accommodate the amplifier itself. The other half is arranged to accommodate about 20 ten-inch gramophone records in the section that fits to the rear of the speaker. (If desirable, a second speaker could be fitted instead.) There is enough room left to enable a microphone to be clipped in and to accommodate the connecting cables. The arrangement will be clear from the accompanying photographs.

The amplifier itself is built on to a steel chassis of 11in. x 4¾in. with a 2in. flange all round. The main components are mounted with a view to provide adequate ventilation, freedom from hum pick-up in the wiring due to the high heater voltages involved, and this layout should be strictly adhered to if the components are to be accommodated in the space provided and if performance is to be trouble free. The photographs should make the general arrangement quite clear.

The Circuit

The first valve is a 6J7G microphone preamplifier and the circuit incorporates a built-in matching transformer to accommodate a microphone of the moving coil type. The output from the preamplifier is directly mixed with the input from the pick-up. This system of mixing has no attenuation on the input when the control is at full gain, unlike the series-resistance method. The second valve in the circuit may be new to some, a 6SL7. Unlike the 6L7, which is a pentagrid mixer, the 6SL7 is a twin-triode and it is used in this amplifier in a self balancing phase inverter circuit. The first triode in the envelope is used simply as a straight amplifier whilst the second triode section is the phase inverter which derives its grid input from a network between the two anodes of the 6SL7. The voltage at triode-2 anode is equal and opposite to that at the anode of triode-1 within fairly fine limits. In order to keep the variation as low as possible, to ensure efficient working, the gain is kept as high as possible.

The output stage consists of two EL32's in push-pull. As the heater current of these valves is normally 0.2 A. it is necessary to shunt both heaters with a resistor. The suitable for matching to most types of 3Ω resistor in order to keep the screen current reasonably low. The transformer used in the output stage is such that it gives output suitable for matching to most types of 3Ω speakers. It was not found necessary to by-pass the cathodes of the twin-triode or for that matter the output valve.

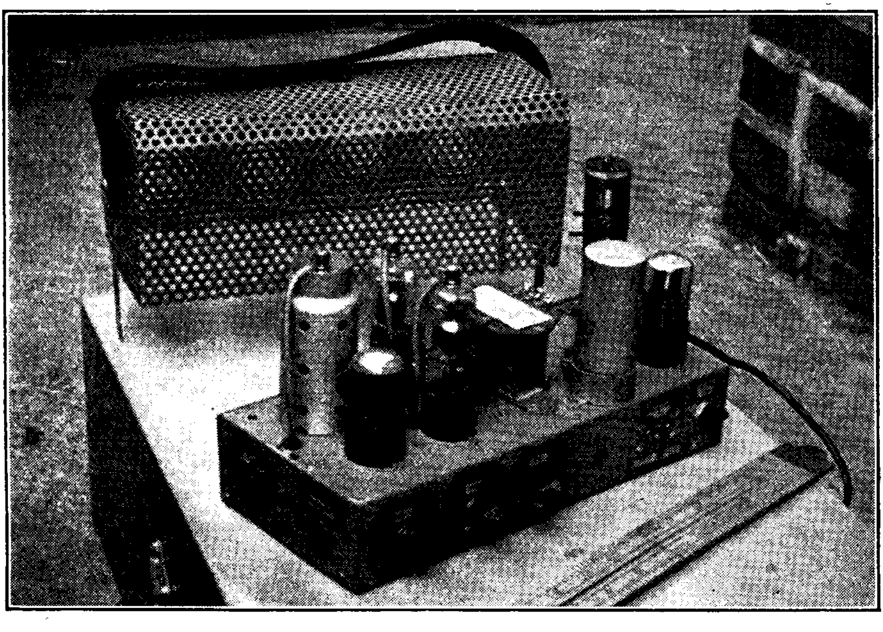
Construction

Now to some aspects concerning the constructional side. First of all mention must be made of the fact that the chassis is isolated from the HT negative line through a mica 0.01 μF capacitor, a precaution advisable in such AC/DC apparatus. All screened leads are covered with insulated sleeving and the metal braiding is bonded to HT negative and NOT to chassis. It can, of course, be bonded to an external earth but this is not by any means essential. Providing that the metalised braiding is taken to the HT negative line the chassis tself will be perfectly safe and will not be "live."

Even with the above precautions it may still be possible to get a slight shock from the earthy lead to the pick-up, when using AC mains. This will be due to the fact that the negative HT line is on the "live" side of the mains and that AC is flowing through the 0.5 μF isolating capacitor. By the simple process of reversing the AC mains input plug this effect will disappear—or alternatively the pick-up lead may be taken to an external earth.

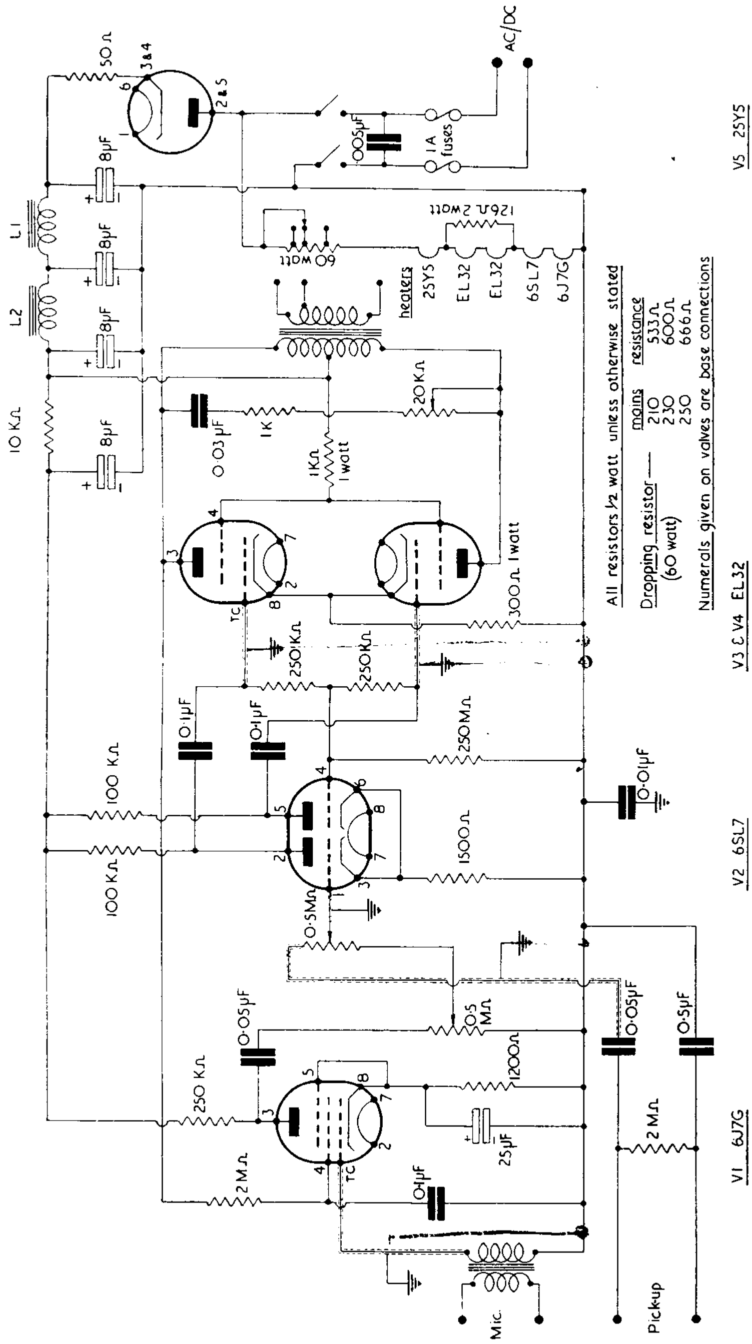
Experiments with an assortment of moving coil pick-ups showed that the lower frequencies were accentuated and this was cured by the incorporation of the screen supply circuit of the 6J7 as shown in the diagram. This is actually a low frequency negative feed-back arrangement and its inclusion was found to even things out and to give correct compensation.

The completed amplifier should be encased in metal which should be so provided with perforations as to give adequate ventilation which is necessary due to the heating of the valves and the dropping resistor. A leather carrying strap may be fastened to this metal case and, as will be seen from the photographs, makes for a "finish" to the job. The underside of the chassis should be covered by 1/16in. paxolin sheet and it is advisable to make this easily removable



The amplifier with cover removed

* the screen voltage is dropped through a 1kΩ resistor ....



Circuit of the 8-watt amplifier

See p 187.

should the occasion arise that it becomes necessary to replace the 1A. cartridge fuses.

Should any trouble arise with regard to instability in the output stage, resistors of about 50 ohm should be placed in series with each EL32 anode, as close to the anode pin as possible, and this will in most cases effect a cure.

Frequency Response

Tests for frequency response were highly satisfactory. Using a sine wave, fed into the pick-up sockets, from a stabilised audio frequency oscillator and taking measurements on an oscilloscope, across a 2½ ohm resistive load, a frequency response curve was drawn. The output was found to be reasonably flat over a range of 30-10000 cycles with a falling off noticeable at the high frequency end due to the tone control. The maximum audio output of the amplifier is, by the way, approximately 8 watts.

TEST VOLTAGE READINGS

Valve	Electrode	Voltage
6J7	Anode	45
	Screen	4
	Cathode	0.25
6SL7	Anode 1	98
	Cathode (common)	1.65
	Anode 2	98
EL32	Anodes	210
	Screens	208
	Cathodes	15

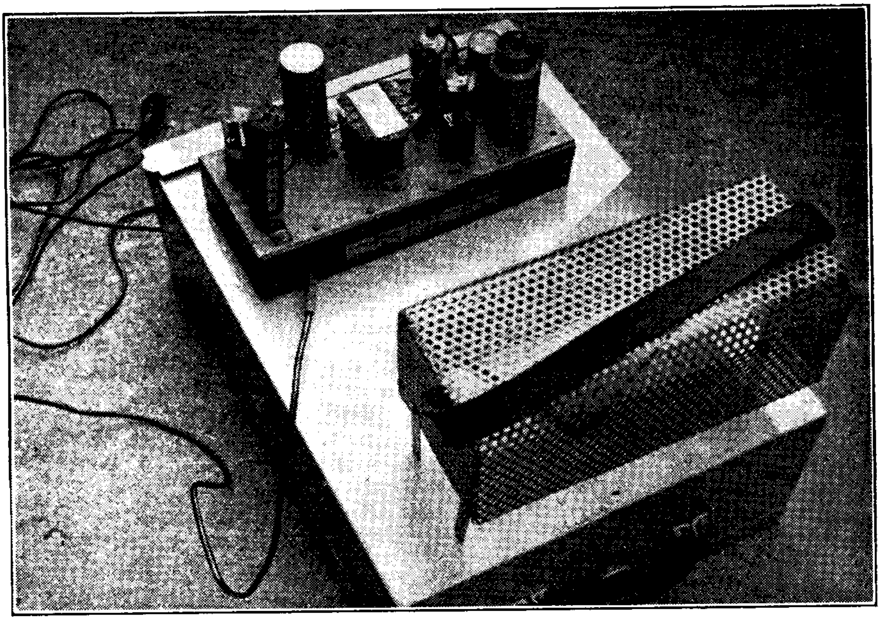
Notes:

Main HT (smoothed) supply was 220v. HT supply to the 6J7, after the 10000 resistor was 185v.

These test readings were obtained when using the amplifier on DC mains of 245 volts. On AC mains of 230 volts the main HT supply to the amplifier is 230 volts DC, therefore all above voltages wil increase proportionally.

OVERALL DIMENSIONS

Chassis: 11¼in. x 5in. x 2in.
Amplifier plus metal cover: 11¼in. x 5in. x 6¾in.
Material: 1/16in. enamelled steel.
Underside of chassis covered by 1/16in. paxolin sheet.
Chassis forms bottom of amplifier unit, with the perforated cover screwing directly onto it.



The amplifier, cover and carrying case

The complete amplifier, together with 20 ten-inch records and loud-speaker, is housed in the neat carrying case shown, making a fine self-contained unit.

(CAPACITORS—Cont. from p.156)

space as compared with the paper type. For practical purposes they can be divided into two types, the WET and the DRY, although the former are now less frequently used. The DRY can be mounted in any position but as both types are POLARISED care must be taken to see that the positive and negative ends are correctly connected. A later type electrolytic has been developed which can be used either way round.

Testing

A simple test for leakage in all types of capacitors is to charge them from a DC voltage source within the working rating, and then after a brief period, short them. If they are good they will hold the charge until shorted, when a spark will be seen varying in "fatness" with the value of the capacitor. Only a very small spark can be expected from capacitors of less than .1 microfarad or so, and these can be similarly tested by connecting in parallel with a known good capacitor of say 1 or 2 μF. If the small capacitor leaks the larger one will discharge itself through it and no spark will result from the shorting.

Electrolytics can be tested with a low resistance milliameter connected in series with it and a DC voltage applied. There will be a slight leakage even from a good electrolytic but this should not exceed .1 mA. per microfarad. There will of course, be a sudden surge of current as the capacitor charges up.

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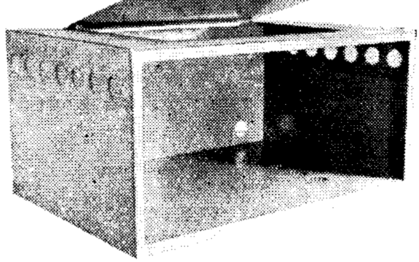

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