Radio Constructor

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Editorial

The Beginner

WHAT is the most popular feature in the "Constructor"? That would be difficult to ascertain, since opinion differs from one extremity to the other, but the correspondence we receive and the informal chinwags we have with visitors point to the fact that if not **the** most popular feature at least well in the running was the series "Making a Start." The series was prompted by the plight of a reader in dire need of assistance as readers remember from the first article. It appears that we were correct in our assumption that large numbers of beginners also required guidance. Our inspiration, the inimitable George, has proved to be the ideal person to use as a "guinea pig." He not only asks us about things we take for granted as generally known but does things that even in our early days we would have thought twice about doing! Therefore, we have more or less adopted our keen but impetuous friend as a permanent institution to guide us in our beginners articles. Those who personally know George will, we know, shudder slightly at the agonies we will have to endure but we ourselves consider this decision well worth it in the interests of our younger readers and feel we can truly class ourselves as martyrs!

Apart from the beginner we know several genuine "old timers" who read those articles with more than superficial interest. The reason? Even the old hand can learn a few new pointers.

Ingenuity

Reader F. H. McGee was one of the older hands who built the 0-v-2. He had most of the necessary components in the junk box and writes to say that the total cost of the receiver to him was one shilling! He says "many thanks for your foolproof 0-v-2," and sends along a fine list of DX heard. Mr. McGee is obviously one of the many who likes to use what one has to the best advantage. In the thousands of constructors "dens" throughout the country there must be very many examples of personal ingenuity, of little ideas that effect an economy, of constructional dexterity, and so forth. Why not drop us a line with that idea of yours? We would be very pleased to select the best examples for publication and so grant a service to fellow constructors. The ideas may be either theoretical, mechanical or in any other shape or form. If you feel you have something that may be of interest and use to the fraternity please let us hear from you.

Views and Wants

In our December issue, Mr. W. Mackintosh put four points to readers which dealt with subjects on which information was sought. Readers who are also interested in the subjects mentioned will be pleased to hear that the response has been such that we will soon be publishing articles on the questions raised.

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.

DX One-Valver

Describing a simple and efficient DX set

By E. Munnery

THE tendency nowadays is towards multi-valve communications receivers and for those whose pockets and/or technical knowledge are suitable such receivers are no doubt "just the job." But for the young SWL, or those who prefer to place a greater reliance on skilfull operating, the small receiver has much to commend it. In any case, those whose means are limited (and there must be very many in this category) have no alternative but to use a simple receiver for their short wave listening.

The beginner usually contents himself with a rather indifferent reacting triode circuit, possibly with one or two audio stages and occasionally with an RF stage preceding the detector. The writer has always been interested in getting the most out of little and with this object in view spent many months experimenting with various types of detector stages with 2 volt valves. One of the conclusions reached was that though the triode is a very useful valve—one in fact that has almost universal applications—there is no doubt whatsoever that the RF pentode is far more suitable as a detector than any triode. The main advantage of a pentode over that of a triode is of course the smoothness of reaction that can be readily obtained by virtue of screen voltage variation with a potentiometer of suitable value.

● The Circuit

The outcome of the experiments previously mentioned was the circuit shown in Fig. 1. The values of the various components have been most carefully selected and prospective constructors are advised to keep strictly to these values—within, of course, the usual tolerable limits. No specific manufacturers are stated, but providing that components bearing a reputable name are used no trouble should arise.

As will be seen from the circuit diagram the receiver is of comparative simplicity. The first feature that will attract the attention is the tapped aerial coil, and perhaps a few words on this item would be appreciated. The set of coils used are home made and wound on standard four-pin coil formers, winding data for various ranges being given in the accompanying table.

COIL DATA

Approx. tuning range				Coil formers 1½in. dia.
Metres	Mega-cycles	No. Turns	SWG	Spacing
9-14	33-21.5	3	18	One diameter
12-26	25-11.5	5	18	One diameter
24-55	12.5-5.5	12	22	One diameter
50-90	6-3	25	24	Close wound
75-180	4-1.6	35	30	Close wound

Some experimenting may be necessary to determine the best position for the aerial tapping position. As will be appreciated, the nearer the aerial tap to the grid end of the winding the greater will be the amount of aerial "damping." Therefore the correct procedure is to tap the aerial down the coil until the damping decreases to the stage whereby oscillation is obtainable over the whole range. In practice it will be found that the best position is around one-third the way up from the earthy end of the main winding. A little time spent in getting this tap in the right position will be well rewarded when the time comes to get down to serious listening and it is suggested that an experimental coil of bare wire is used for each range so that, with a crocodile clip on the aerial lead, adjustments may readily be made. When the best position has been found, a permanent coil may then be wound, with the tapping point taken to

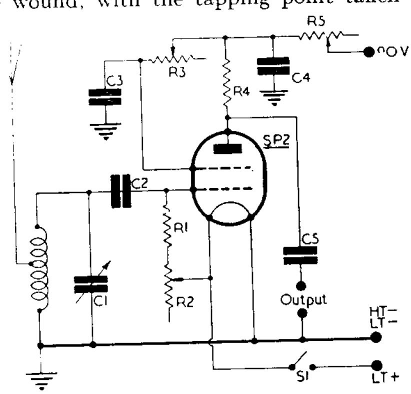


Fig. 1. Circuit of the one-valver

C1	100 μμF	R1	1 MΩ
C2	300 μμF	R2	2 MΩ
C3	0.1 μF	R3	15000Ω
C4	1.0 μF	R4	10000Ω
C5	2 μF	R5	15000Ω

a pin on the former. It is not possible to give any definite figures for the tapping points on the different ranges, since different aerials will cause varying degrees of damping. It is advisable, however, to use a low-loss base for the coil former.

The remainder of the grid circuit consists of C1 as tuner (bandspread could be added), C2 as grid capacitor and R1/R2 as variable grid-leak. The latter item is not permanently variable but is pre-set. Once it has been set in the most suitable position it is not necessary to adjust it further and so it can be placed underneath the chassis and not brought out to the panel (panel controls have a fascination and it's best to put temptation out of harms way!) Another advantage of placing this component under the chassis is the important one that short leads may be obtained to the valveholder. If a knob be deemed out of place on the chassis, the potentiometer spindle could be cut to accommodate a screwdriver and thus could be adjusted by that worthy tool.

The HT supply to the anode and screen is adjusted by means of R5 and R3 respectively and the modus operandi will be discussed later, as will be the setting of the potentiometer R2. Choke output is employed with this receiver using C5 and an LFC. Little more need be added on the subject of the circuit so we will pass on to a few notes on wiring up.

● Wiring

Wiring should be carried out with stout gauge tinned copper wire (around 18-20 swg) and should be well soldered. Care should be taken to maintain a clean hot iron and in the writer's opinion cored solder used throughout, as this is far superior to using stick solder and flux. Make certain that each component and lead is well tinned before attempting to make a joint and do not use more solder than is necessary. Go easy on the solder, for a mountain of solder on a joint does not make the connection better—probably worse!* Take a pride in your soldering and produce connections that you can show others with pride. Appearance is not everything, but it does help to give a finish to an electrically sound piece of gear.

Low loss components should be used, particularly the coil and valve holders. The variable capacitors should also be of the type provided with a low loss insulation. These little points all add up. The drawings will show the layout of components and little need be said on that aspect providing that care is taken to make the shortest leads possible, to mount the components rigidly and to follow accepted constructional practices.

● Operation

First of all set the anode potentiometer R5 at about half-way in, then adjust the screen potentiometer R3 until the receiver is just below oscillation point. After this, the grid potentiometer R2 should be set for optimum value. When this has been carried out, the HT to the valve may be adjusted to such a value as to allow the screen

*For notes on soldering, see pp. 102-103, November, 1947 issue.

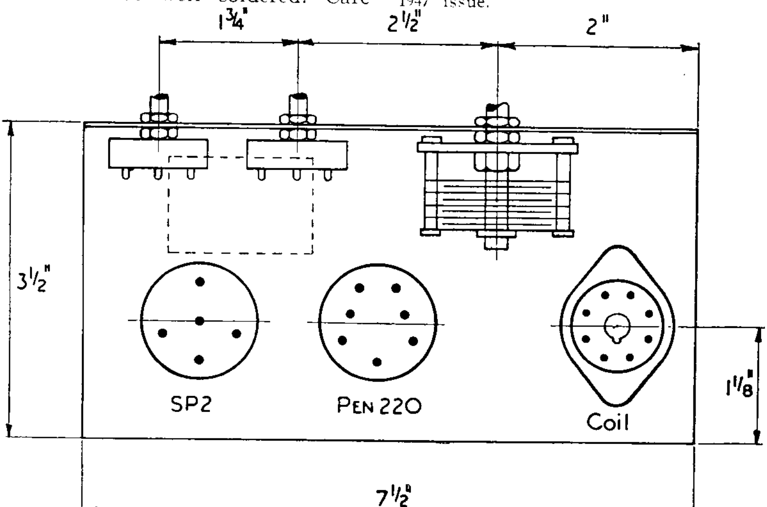


Fig. 2. Top of chassis lay-out of the receiver when used as an O-v-1. Layout for receiver as a one-valver is the same except for the deletion of V2 holder
N.B.—In the case of an SP2 with a 7-pin base, the suppressor grid is brought out to a pin and should be taken to earth.

potentiometer to have its maximum effect for regeneration. This procedure may sound, on first reading, a little involved but in actual practice it is quite straightforward. Once these settings have been made, the **only** control that will be used in operating the set is R3 (apart from tuning). It cannot be overstressed that time should be no object when making these preliminary adjustments, for their setting will determine the performance of the receiver. It is only by virtue of the variations possible that the receiver can be made to be so very effective, despite its electrical simplicity. By the way, when carrying out these preliminary tests it should be remembered that the aerial tapping has some bearing on the degree of regeneration. If reaction is difficult on parts of the band, try tapping down the aerial another turn or two.

When one comes to tune around for stations, the importance of smooth and slow control will become very apparent. Therefore, equip yourself with as good a slow motion drive for the variable C1 as you can afford. Ease of tuning is one of the most important items in short wave listening—without it even the most majestic of receivers will fail.

Amplification

The receiver as described will be found to fully warrant the trouble in building. Reaction on the original model is as smooth as silk and the set oscillates quite happily down to, and below, 10 metres. In fact, the author is at present using it for 5 metre reception in conjunction with a small amplifier. Which brings us to the subject of adding a further stage of amplification should this be wished. Obviously, with but one solitary valve, loudspeaker reception is hardly practical except for the very strong signals, but a much greater degree of satisfaction can be obtained for the adding of an LF stage.

Various couplings and output valves were tried on the detector unit and finally it was found that transformer coupling to a pentode of the high slope type provided the most satisfactory combination. A parallel-fed transformer will give rather better results than a series-coupled arrangement and the circuit adopted is shown in Fig. 3. With this stage added to the detector unit sufficient "kick" was obtained to drive a small moving coil speaker.

In conclusion it is as well to note that a good aerial and earth system may make the world of difference to any receiver used on the short wave bands. As with most aspects of short wave work, care, time and patience should never be spared in preparatory activities. Providing that these three factors are observed ,the whole world can be logged consistently on the little set described.

Chassis and Panel

The original set, with LF stage, has been accommodated comfortably on a chassis measuring 7in. x 3½in. x 2in. This is of copper, though aluminium may be preferred as it is easier to work and is more readily obtainable. The panel measures 8in. x 5in. Both the panel and chassis should be sufficiently rigid to avoid flexing—which would upset tuning, etc. In this respect probably the best material to use is steel (of about 15 swg), which, though tough to work, has the great advantage of being eminently rigid.

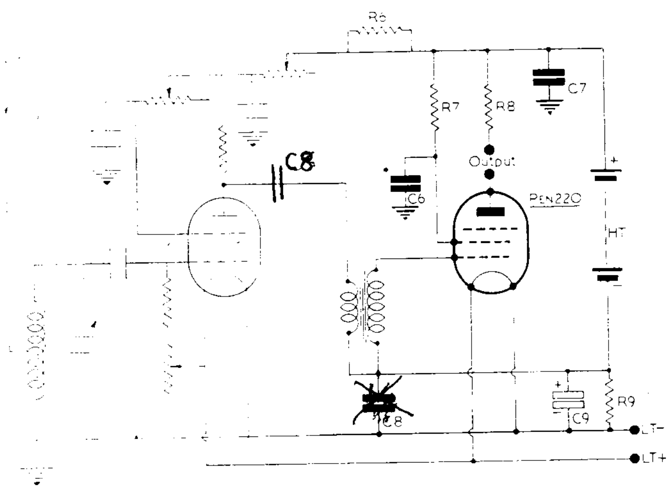


Fig. 3. Circuit of the receiver as a two-valver. Extra components are shown in bold outline

C6 0.5 μF
C7 2.0 μF
C8 0.2 μF
C9 50 μF 25v. wkg.
R7 15000Ω
R8 10000Ω
R9 450Ω

R6 should be inserted if HT is 120 V and the value is 10000Ω

LF transformer is the normal type of around 3.1 ratio.

Looking Back

Delving into Antiquity

By Centre Tap

MAYBE it was the interest aroused in my mention of the good old days in Miscellany, or perhaps the recent celebrations of the B.B.C's 25th birthday that has in recent weeks caused me to look back over the history of broadcast radio. Obviously to-day amongst our readers there are many who cannot remember the pre-broadcasting era, but perhaps what is more striking is that many of them seem to find it difficult to believe there was such a time! I hope these reflections on those years will help the younger generation to get a better perspective of the development of radio in the home, and I am confident that they will revive pleasant memories for those whose experiences have run parallel to my own.

As so few readers will know of the identity behind the nom-de-plume, it would be as well if I first gave some idea of the circumstances under which my interest was first aroused. The end of the first World War found me as a schoolboy whose most treasured possession was a very ancient plate camera, and when shortly after the Armistice of 1918 ex-W.D. gear was being jobbed off I set out in search of accumulators for the dark-room lamp. Electric mains were a rarity in those days and I was bent on having a light source free of smell and smoke from an oil lamp which failed just as the picture began to resolve. My more familiar readers are most likely to consider that the main inference to be drawn from this early visit to the junk shop is ascribable to a predilection for that sort of thing becoming apparent at an early age!

Bargains

Thus it was in the Marine Store that my imagination was fired and the latent enthusiasm kindled, for among the masses of field telephones, barbed wire and tin cans, were some alleged "wireless parts." It must be difficult for modern youth to imagine the magic surrounding the word "wireless" and its effect upon my youthful mind, and it was inevitable that it resulted in the exchange of my scanty pocket-money for some of the more promising looking pieces. I think that describes it best; my selection of bargains was guided entirely by appearance.

I tried every likely source for knowledge on how to get going but finally had to fall back on a couple of frighteningly learned books which I couldn't understand and in any case seemed to deal only with magnetism, profound theories and, in a vague sort of way, a little equipment as used in expeirmental work. Finally after discarding the books in disgust I set to, building a receiver having a truly massive coil and a variable capacitor of at least .001 μF, a crystal and steel needle, with a few odds and ends thrown in for luck, and listened hopefully on a single telephone earpiece. For eighteen months I tried to make it work but never a signal.

I did not expect telephony, of course, although even at that time "wireless telephony" was spoken of as an achieved fact. There were, however, known to be various Morse signals on the air, chiefly spark, and I felt I should at least hear something if only I kept at it long enough. Actually time signals by radio were started about 1911 (or even earlier) and were transmitted daily at intervals from a number of stations, some of the better known being Rugby, Paris, Washington, Nauen, etc., although it was not until February 1924 that the B.B.C. started the familiar pips. Strangely enough, these pips are still a mystery to many listeners. Actually they are the output of an oscillator which is short-circuited by relay, impulses from the the Royal Observatory by telephone line cutting the "short" to provide the note. It is, of course, the final of the six pips which denotes the hour, the first coming at five seconds to with the others following at one second intervals.

The Mark 1

To continue the story from the period of about 1920. With the passing months my enthusiasm had gradually waned and instead of the daily performance tuning or altering it, it became a desultory sort of business to try occasionally "just in case." This continued until a school friend suddenly acquired a complete portable receiver alleged to be of Naval origin and called the Mark 1. It was a most impressive looking piece of gear with many knobs, switches, coils, chokes, two tuning capacitors in magnificently spun cans and a whole range of crystals and needles. For the life of me I cannot even to this day conceive how so many parts could possibly be included in a single crystal set. Despite the regular adjustment and patient tuning by two very enthusiastic operators there was still no signal.

Our pooled knowledge totalled next to nil but we greedily devoured every scrap we came across—the chief thing we learned was how much easier it was for two to learn, than one. What we each read we discussed and argued and slowly the theories began to take on some form and meaning until we decided it was essential that we should buy one of these wonderful valves we had heard about and build a set around it. After much careful planning and improvisation we were at last ready and within a fortnight we actually heard a morse signal; to be followed within a week or two with the tail end of a telephony programme from the Writtle station. We could not have been more thrilled if we had invented the whole thing ourselves.

There had for a number of years been a scheme whereby one might listen to theatre programmes by subscription over the telephone, although the number of private telephones was comparatively small in those days, and even this was considered to be a wonderful achievement so it can well be imagined how awe-stricken the listeners to our receiver were. They came from far and wide and if we had had a little more enterprise we might easily have founded a fortune by forming a char-a-banc service to run trips for the sightseers. The period would be late 1921 at which time occasional broadcasts lasting about half-an-hour were put out—and that "programme" was made up chiefly of silent intervals which rumour maintained were needed to cool the transmitter, but in actuality was required by law to avoid possible jamming of SOS messages or important transmissions. Then came the programmes from Marconi House and stories of the remarkable progress of broadcasting in America, and in November 1922 daily programmes started from 2LO the station of the British Broadcasting Company which had been floated by a number of radio manufacturers. It remained as such for three years when it became the now familiar Corporation.

"Experimental Licences"

Within a few weeks crystal sets and headphones began to appear at what, for those days, seemed luxury prices and during the next few months half the male population began copying and building them while the more ambitious started talking of simple valve receivers.

In those early days it was decided there were to be two forms of licence, "Listener" and "Experimental." Those who applied for the latter (which were held up while the status of the experimenter was settled) proved very lucky. They didn't pay the Listeners licence as their applications for the "Experimental" were pending so they went licence free for a year or two until it was decided that a Listeners licence covered the home construction of receivers.

My friend and I were carried on the crest of the boom and found ourselves with established reputations as "experts" while some of the more imaginative of our neighbours pointed us out as future Marconis, the one name the lay mind connected with this new marvel of science. We supplied advice bounteously, and later, on a small scale a few home-made components, one speciality being our grid leak. Having tried many forms ourselves we felt fully qualified to serve the "best." They consisted of a strip of ebonite scored along the length with a pencilled graphite path and a protective cover (to prevent the leaky path being worn or rubbed off) held on with bolts which also served as terminal connections. They were moderately priced, "set-tested" and guaranteed. Capacitors of copper foil and mica, mounted in a similar form, followed and these too were also tested and guaranteed under "actual working conditions." We didn't make much profit as other people soon learned to make them for themselves so we returned to our purely amateur status determined to each own the best sets in the district. The "wireless" boom was simply terrific, components were on sale in every street, cycle stores, music shops, garages, and I can well remember chemists and even a pawnbroker having the "wireless parts" counters. Our old style components were outmoded and even variable grid leaks came along—ebonite tubes in which carbon granules were compressed by a threaded rod to vary their resistance.

Progress

Over the interval of years one can look back at the gradual changes. 4-volt valves at an amp. apiece were heavy on batteries and home charging was unknown so bigger sets than two valves were for broadcast reception extremely rare until the development of the "dull emitter" valve. When several valves became a practical proposition the loud speaker (instead of the family circle sitting round the receiver with a headset apiece) became the vogue. These early speakers, known as table-talkers, were simple earpieces fitted with straight metal trumpets while the more expensive types had horns shaped like the human throat for "natural" reproduction. One firm supplied a horn partly made up of small wooden panels.

Generally speaking reproduction was intelligible if one listened attentively and it was tolerated partly because it was the best we knew and partly because the standard of comparison was the gramophone of which the "hornless' type was by now in fashion. Electric recording and magnetic pick-ups had yet to come and the atmosphere can only be recreated today with the oldest record you can find listened to on an earpiece with a metal horn attached. From the musical angle the reproduction was positively cruel—musicians raged and condemned "canned" music as being poison. Sir Thomas Beecham said "Rather than wireless or a gramophone, take prussic acid at once"—and he wasn't exaggerating!

The advent of the balanced armature speaker was accelerated by the sore need of something more tolerable and with its introduction the habit of having the radio on as a background instead of being something to which one's attention was to be given, was formed. The cynical might well mark it as the beginning of the Era of Noise.

Home constructors busied themselves with pleated paper cones driven by Brown's "A" telephone earpieces and later used stretched linen diaphragms, suitably doped, driven by balanced armature units. More and more volume was demanded and the moving coil speaker was born and with it came the talkies and the doom of the silent film. Who, having not known the latter in its hey-day, can imagine the emotional appeal when no woman took less than a half-dozen hankies to the "pictures" to enjoy a good weep? And what guffaws of belly-laughter the comedies provoked!

Decline—And Revival

There is but little to comment upon in period 1932/1939. Progress had become too fast for the man in the street. With the introduction of multi-electrode valves and factory assembly, home construction dwindled to an ever-decreasing number of enthusiasts and genuine experimenters. Broadcast radio had outgrown the handyman and had become an exclusive hobby of the technician and too few had the background of technical knowledge to understand or apply the new developments while even on the question of costs the factory made set was far the cheaper. The handyman had been content to copy point to point wiring and was lost in the complication of the small superhet made possible by the new valves. The standard receiver became the inevitable 4 plus 1, and despite the great strides made in other branches there has been but little important development of commercial broadcast receiver design since. For many years prior to the War they remained essentially unchanged other than new style cabinets, brilliant dials and press-buttons, plus a "novelty" short-wave range. A marked contrast to those hectic early years.

To-day's popular priced sets offer no advance over those of 1939. At present day costs the price leap would be too great for an uninformed public to pay the extra cost entailed by an R.F. stage, bandspreading, high fidelity reproduction and the other features which should be found on every worth-while modern set. However much the home-built receiver lagged behind its factory-made counterpart in those lean years, to-day we stand at the reversal of the cycle. The former holds all the advantages, for the knowledgeable enthusiast can well make a receiver incorporating all these features at little over half the cost of anything within that quality class likely to be available for some time yet. Even disregarding the vastly increased interest in amateur short-wave radio the hobby has a far more hopeful outlook for the future than it appeared to have ten or twelve years ago, especially if the supply of text-books and magazines maintain the standard and scope of recent years.

Notes on Instability

Motor-Boating—is the name given to a form of instability which sounds like an engine ticking over, and is a form of low frequency oscillation. It can be divided into three distinct types: (a) AF feedback, (b) Modulation by AF feedback, and (c) RF instability.

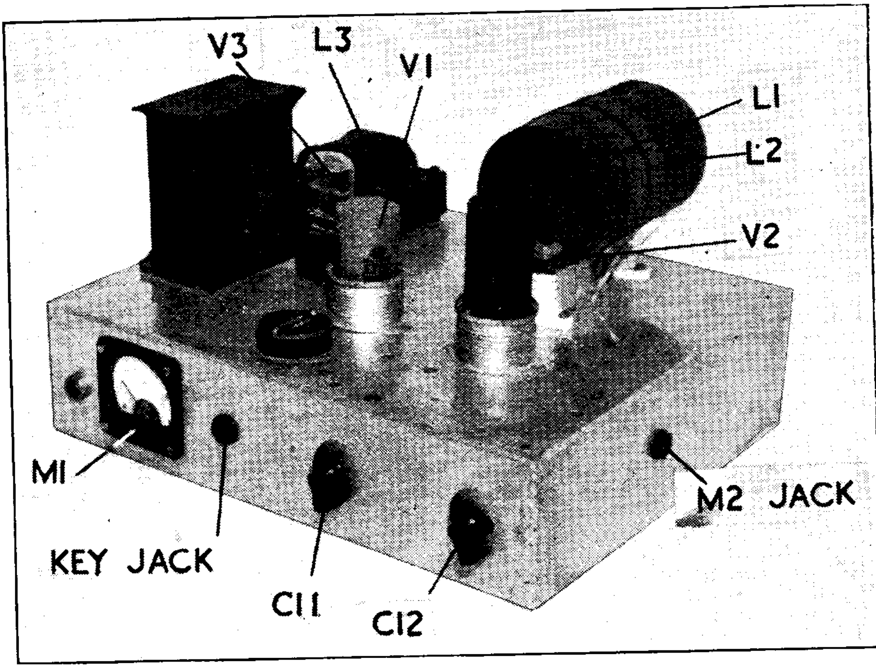
AF Feedback—This is the most common type and is due to a common impedance coupling, the impedance usually being the HT supply, though it can be the grid bias supply. The fault will be found in the decoupling circuits, being either a shorted resistor or open-circuited capacitor.

Modulation by AF Feedback—Usually appears only when a strong signal is tuned in, and is due to AF fed back to the anode or screen circuit of an RF stage. The cure is to thoroughly decouple these circuits and/or to reduce the bass response of the AF section.

RF Instability—Occurs in receivers fitted with AVC and appears except when tuned to a strong signal. RF instability is due to either impedance or capacitance coupling, or to electro-magnetic or electro-static coupling. Look for bad connections, dry joints, ineffective screening, long anode or grid wiring, open-circuited decoupling and bypass capacitors.

In Our Next Issue . . .

A complete 25-watt transmitter, A converter for television sound reception, A Multi Range test meter, Two valve receiver for the short waves, A Square Wave Generator, an RF stage for the receiver described in this issue, etc.



Top-Band Station

Part 1. The Transmitter

By C. L. Wright, B.Sc., G3CCA

Introduction

This series of constructional notes will give the reader all the information that is necessary to build a very cheap but efficient Top-band station. The transmitter, receiver and all the associate gear have been designed and constructed in a very short time, and was made specially for "Radio Constructor" readers. I know that most of you will be saying "Why the Top-band?" but I think that question can be fully answered by stating that the same circuit and valves, with slightly different L-C values can be used on the higher frequency ranges as a QRP rig if another band is preferred. Future articles in this series will give details for building a receiver, a modulator, and a very special frequency meter and cw/phone monitor combined.

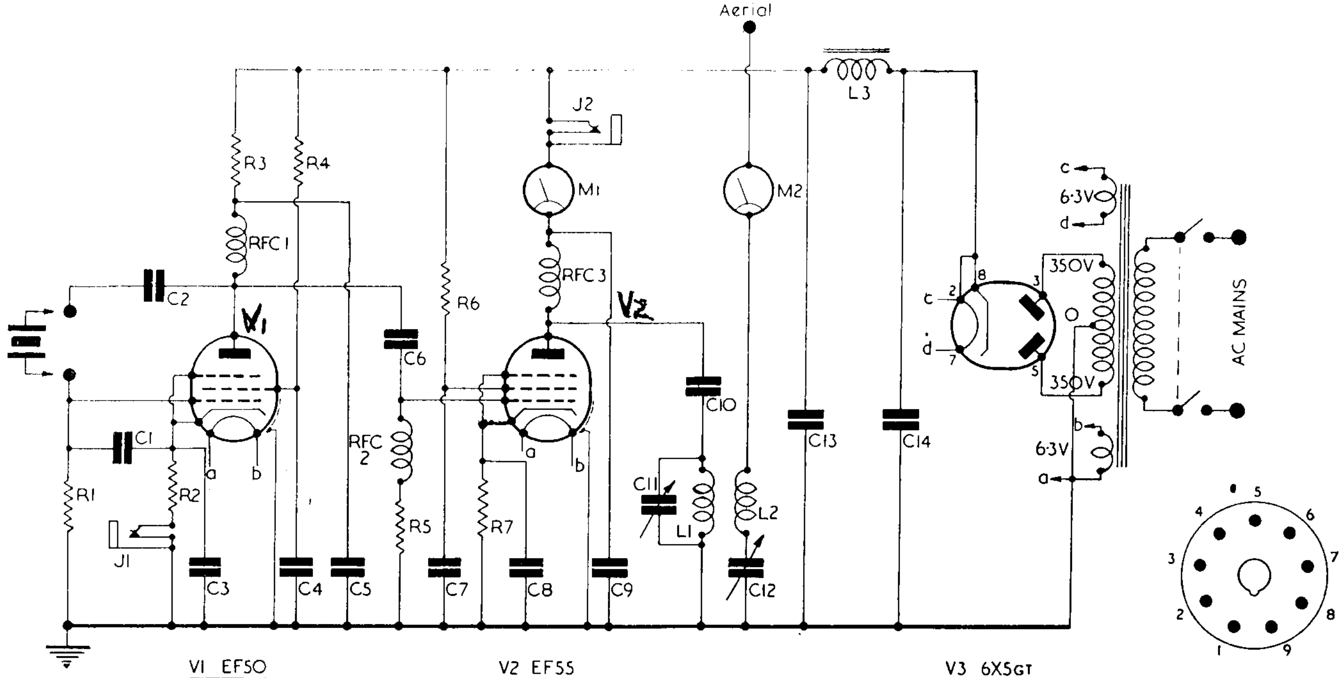
Before giving details of this new "Radio Constructor" Station I would like to say to all those stations who have worked G3CCA on the top-band during the past months, that this is the rig which was used for these QSO's.—AUTHOR.

The Circuit

IN designing the TX it was decided to make it as simple as possible, and of course as cheap as possible, so by using "demobbed" service valves this latter object was achieved. I think that the Pierce Crystal Oscillator assists greatly in making this TX very simple to build and to operate, and it also means that no variable tuned circuit is necessary. I know that some of you do not favour this type of oscillator and have "visions" of a shattered crystal but if the circuit constants are correct and the HT voltage low these "visions" can fade away.

To conform to the standards required by a good Pierce Oscillator circuit I chose the EF50 (VR91) as this valve with its low anode current makes it most suitable in this stage.

Now for the P.A. stage. Remembering that only 10 watts are allowed on the "Top band" I turned my mind to either a 6V6 or 6L6 slightly under-run, but I also thought about a valve which has not been



Capacitors
C1: 200 $\mu\mu$F (350 volt mica)
2: .002 μF (2 kv. working mica)
3: .002 μF (350 volt working)
4: .001 μF (500 volt working)
5: .001 μF (500 volt working)
6: 100 $\mu\mu$F (350 volt mica)
7: .001 μF (500 volt working)
8: .002 μF (350 volt working)
9: .002 μF (500 volt working)
10: .002 μF (500 volt working)
11: 350 $\mu\mu$F Variable—Receiving type
12: 500 $\mu\mu$F Variable—Receiving type
13: 8 μF Electrolytic 500 volt working
14: 8 μF Electrolytic 500 volt working

Chokes
RFC1, RFC2, RFC3: S.W. HF Chokes Standard type.
L3: 20 H, 70 mA. (Any standard make)

Meters (Optional)
M1 0-50 mA. Moving-coil
2 0-500 mA. R.F. meter

Jacks
J1 & J2
Closed circuit type

Resistors
R1: 47000Ω ½ watt
2: 400Ω 1 watt
3: 5000Ω 1 watt
4: 39000Ω 1 watt
5: 47000Ω ½ watt
6: 15000Ω 1 watt
7: 150Ω 3 watt

Pin connections for EF50 and EF55
1 Heater
2 Grid 2
3 Anode
4 Grid 3
5 Shell (to earth)
6 Cathode
7 Grid 1
8 Shell (to earth)
9 Heater

(Note—Cathode connection of V2 should be taken to earth) given much publicity but which most ex-service Radar Engineers must have used from time-to-time. This valve, an EF55, was used as a Video Amplifier in many Radar circuits under its "Services" name of CV173. The use of this valve as a P.A. would make the TX very efficient, and its maximum anode dissipation is 10 watts. A small transformer was re-wound from stampings taken from an old ex-service one to give a maximum of 350-0-350 volts at 75 mA.

As a rectifier, a 6X5 is very suitable and will supply all the voltage and current required.

Two spare meters were available, one a 0-50 mA., and the other a 0-500 mA. Thermocouple R.F. meter and I added these to the finished model, but whilst it would be advisable to have at least the meter in the P.A. it is left entirely to the constructor to arrange for these "refinements" to suit his pocket.

Construction

Several ideas were tried before the finished TX resulted, and I would like to point out here that all the construction was done with the aid of the following tools:—

One Soldering Iron, Cutters, Pliers. One Hand Drill and several drills and two "Q Max" chassis cutters.

The tuning capacitors are both at "Earth" potential, and so were mounted under the chassis, and being of the general receiving type with four feet this was found to be the best position. The keying jack (J1) was placed between the meter and the PA tuning capacitor, and a pilot light was added. This light is not shown on circuit diagram because it was for the writer's personal use only as his transmitters are situated 10 yards away from the receiving point and his "junior ops" have been trained not to touch anything showing a light.

The mains switch is at the side of the chassis next to the mains input plug and on the other side is the modulation jack (J2), this being again the most convenient position in the case of the writer's layout. The rest of the components on the top of the chassis can be seen from the photograph, but a word about the crystal. This is mounted in an American 5 pin (807) valveholder and can be plugged in and out easily, also as the crystal uses only pins No. 2 and 4 it was decided to earth pin No. 3 so that a V.F.O. could be inserted in place of the crystal as required, thus cutting out the use of a switch for this purpose.

The only chassis which could be obtained here was 14in. x 12in. and I would advise anyone building this TX in the same way as in the photos to give thought to purchasing a chassis with a "Black Crackle" finish as I realised only too late that these can be obtained for an extra shilling and they certainly do improve the looks of the equipment. (See Part 3—Modulator—to follow).

I have always found that in building equipment most of the work is done in drilling out the chassis, but by using the standard chassis cutters this was accomplished without any trouble. These were used to cut out the transformer slot by cutting several rings together and filing out the surplus material.

The coil is mounted on Eddystone stand-off insulators and the HT below the chassis is run to convenient anchoring points. A third "stand-off" is used to anchor the lead from the PA tuning capacitor to the aerial coil.

Wiring

All wires are as short as possible, and the PA grid capacitor (C6) with RFC2 are mounted direct on to the grid of the valve base (Pin No. 7). The Pierce Oscillator "feed-back" capacitor (C1) is mounted between pins No. 6 and 7 on the EF50 valveholder. These are small points but they go to make the TX more efficient, and the most important items regarding these valves is to see that the internal screens on the valves are placed at the same potential as the cathode and NOT

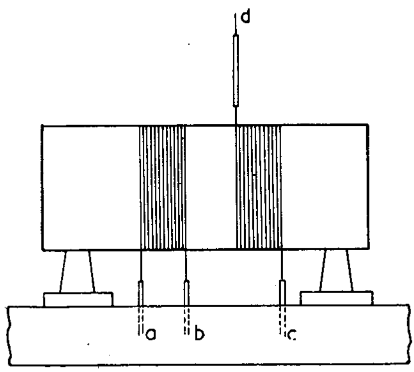
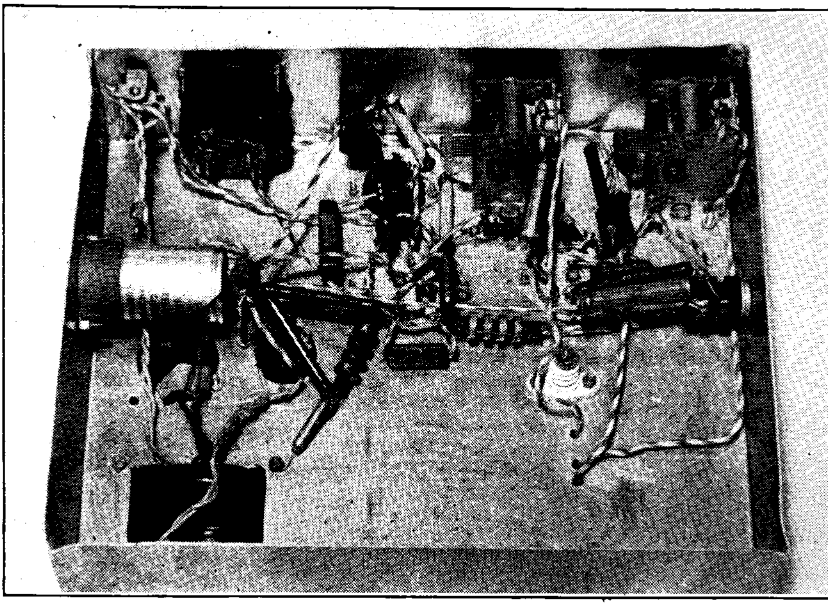


Fig. 2. TX coil mounting and assembly details: "a" to C11 fixed vanes; "b" to C11 moving vanes; "c" to C12; "d" to meter M2—or aerial

earth, this is achieved by joining pins Nos. 5, 6 and 8 together, and to earth the centre spigot. If these items are not carefully attended to, you may find that the performance of the transmitter is very erratic. In order to obtain full screening of the valve the valveholder clamping rings should be used thus clamping both valves very tightly in their holders and forming a very good earth on the metal screening cans.



The Coil

I have drawn out the mounting of coil on the chassis and also the position of the windings. The former is 3in. in diameter and the PA tuning coil is 20 turns of swg 22 double cotton covered. I did not have any d.c.c. wire so I wound this coil in single cotton covered and painted the winding with shellac, using the XYL's cooker to bake same!

The aerial tuning coil consists of 18 turns of the same **wire** and is wound ¼in. away from the PA coil, both these coils are close wound. The capacitors which I had available for the tuning of these coils were 350 μμF for the PA stage and 500 μμF for the aerial, and it was found that these tuned the top band with the capacitor vanes half out.

Operational Tests

Before giving the full details of the tests carried out with the author's transmitter it should be noted that the figures given may vary with different valves.

When the crystal had been placed in the holder and the TX switched on it was found that the current in the anode of the EF55 (PA valve) was 30 mA. On tuning the PA tuning capacitor (C.11) there was a spot where the current decreased to 20 mA, this of course meant the PA was in tune with the Pierce Oscillator and being driven correctly. The only aerial which would give any reasonable radiation at my QRA was a long wire (100 feet) and this was coupled to the aerial coil through a RF (0.5 Amps) meter. On tuning the aerial coupling capacitor (C12) the PA meter current rose to 30 mA. and a slight adjustment to the PA capacitor (C.11) increased the current to 35 mA.

By further adjustment of these capacitors to bring both circuits into the correct alignment 40 mA. was shown on the PA meter and on full load the PA anode volts were 250 volts, thus giving an input of 10 watts to the EF55 PA valve.

The current in the aerial RF meter was 0.4 amps (400 mA.) the time of the day was 12.52 GMT and the first CQ was sent out on CW. On tuning the receiver we heard G3AWJ calling us. A very fb contact was had with this station who gave us a very fine report on our transmission, the first on the "Radio Constructor" transmitter. We were very pleased to learn that the QRA of this station was Huntingdon and rapid calculations showed that the distance covered was 45 miles in **daylight** with a report of RST559. Another contact was made with G8RB of Derby who gave us RST579 thus proving that the TX was working really well. Since then we have worked "cross-band," G3CCA on 1.7 Mcs. with London on 7 Mcs. during daylight. It was after these tests that it was agreed that the TX was very efficient and credit is due to the EF55 valve. G3CCA will be very pleased to work anyone on Top-band with this TX any evening on sked (via "Radio Constructor") on a frequency of 1790 kcs., and it is hoped to use this transmitter to transmit "Frequency Predictions." SWL's reports would be welcomed.

Query Corner

A "Radio Constructor" service for readers

"S" Meter for an R1155

"Is it possible to connect an 'S' Meter to an Ex-R.A.F. receiver type R1155? If it is, could you please recommend the best method of connection."—K. Blower, Chelmsford.

An "S" or signal strength meter is a useful addition to any communication receiver. It may be used to indicate the relative strength of various signals and will also be found helpful when aligning the receiver. In its former role as a signal strength indicator it is a useful aid when giving reports.

It is normal to use a 0-1 mA. meter in the anode circuit of one of the A.V.C. controlled I.F. amplifiers. In order that the no-signal anode current of the valve will give zero deflection of the meter needle a form of bridge circuit is employed. One arm of this bridge network may conveniently be connected in the upper end of the screen potentiometer.

Fig. 3 shows an "S" meter connected in the anode circuit of the first I.F. amplifier of an R1155 receiver. The variable resistor R1 is for the purpose of adjusting the meter pointer to zero, this operation should be carried out with the R.F. gain control at maximum when no signal is being received. For this particular type of receiver the values shown for the resistors R2 and R3 should prove to be satisfactory. However, if desired, the sensitivity may be increased by increasing the values of these components. When connected up in the manner recommended the "S" meter will have no detrimental effect upon the operation of the receiver.

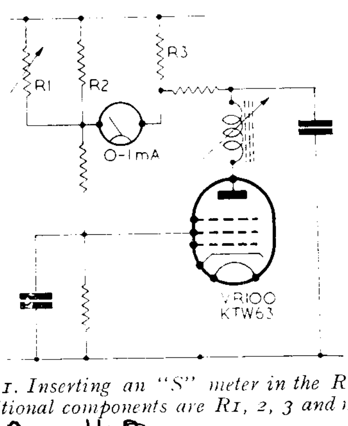


Fig. 1. Inserting an "S" meter in the R1155. Additional components are R1, 2, 3 and meter.

R1:- 1kΩ
R2:- 500Ω
R3:- 250Ω

Voltage Control

"I frequently undertake the repair of battery operated receivers and find that in order to test the receivers under ideal conditions, it is either necessary to renew the H.T. battery or to use a power supply. The latter method is preferable, but owing to the variety of H.T. voltages now in use, some means of voltage control is necessary. I have been using a potentiometer, but it is not satisfactory as it is wasteful of power and gives a poor voltage regulation. Can you suggest any better method of voltage control?"—C. W. Harris, Lyndhurst.

A power supply having a variable output voltage is a piece of equipment which every constructor should find extremely useful. Apart from the voltage control requirement, the voltage regulation must also be reasonably good as a supply whose voltage varies with small variations in load current is practically useless, and might lead to sever instability in a receiver with which it is used. Generally speaking the need for good regulation rules out the use of either series dropping resistors or potentiometers, both of which also result in an appreciable waste of power.

In order to overcome these difficulties circuits employing one or more control valves were developed. In the majority of these circuits a valve is connected in series with the load, and its grid voltage is made adjustable in order to control the output voltage. Fig. 2 shows a typical control circuit. Assuming the load draws 50 mA., then the cathode current of the valve must be 50 mA. and the grid bias must be such that the valve is permitted to pass this current. If the bias is increased negatively the cathode current will be reduced and the voltage drop across the load will be correspondingly reduced. Conversely, if the grid bias is increased positively the cathode current of the valve will be increased together with the voltage drop across the load. In this explanation the output voltage has been referred to as the voltage drop across the load, as the load may be considered to consist of a resistor in the cathode circuit.

The voltage regulation of a valve controlled power supply may be vastly improved by stabilising the grid potential of the control valve. Two neon stabilisers have been shown in series in the circuit diagram thus providing a maximum stabilised grid potential of 300v. It will be realised from the foregoing that the maximum output voltage will be approximately equal to the maximum grid potential, and the maximum permissable output current will be that which the valve will pass without exceeding its anode dissipation. The voltage supplied to the control circuit should be approximately 100v. in excess of the maximum required output voltage. The extra voltage will of course appear across the control valve. The potentiometer used to control the grid bias of the control valve dissipates negligible power and may therefore be a standard ½ watt component.

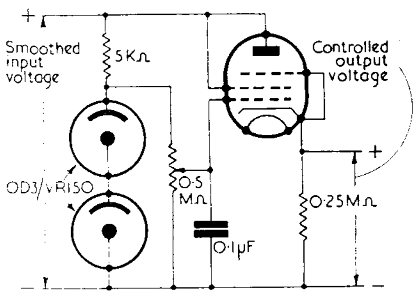


Fig. 2. Voltage control circuit. The valve should be a steep slope output pentode.

Danger from Headphones

"I have a battery operated T.R.F. receiver with which I wish to use a mains eliminator. However, I have read that it is dangerous to use headphones when an eliminator is also used, can you explain this and offer a solution to the problem?"—F. G. Bodiam, Kent.

It is a fact that if headphones are connected in the H.T.+ line to the output valve, as they so often are in battery receivers, it is inadvisable to use an eliminator without first making slight modifications to the receiver. This is chiefly because most eliminators provide a much higher output voltage on no load to that which is obtained on normal load. Therefore should the filament supply to the valves be interrupted the voltage appearing between the phones and earth will increase, perhaps by as much as 40%. Should the insulation in the phones not be able to withstand this increased voltage or should the external terminals (as seen on some phones) be touched the results will not be pleasant. Finally there is always the possibility, however remote it may seem, that a fault may occur on the mains transformer rendering the receiver live to the mains supply.

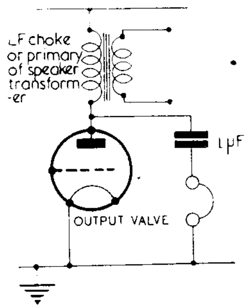


Fig. 3. Method of inserting headphones in a TRF receiver powered by a mains eliminator.

In order to make an eliminator-powered receiver safe when head phones are used the phones should be parallel fed. This means that they are isolated from the H.T. supply by means of a capacitor, and are therefore at earth potential. The method of connection will be clear from Fig. 1.

It is strongly advised that where D.C. eliminators are employed this method of connecting phones should be adopted.

"Query Corner" Rules

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

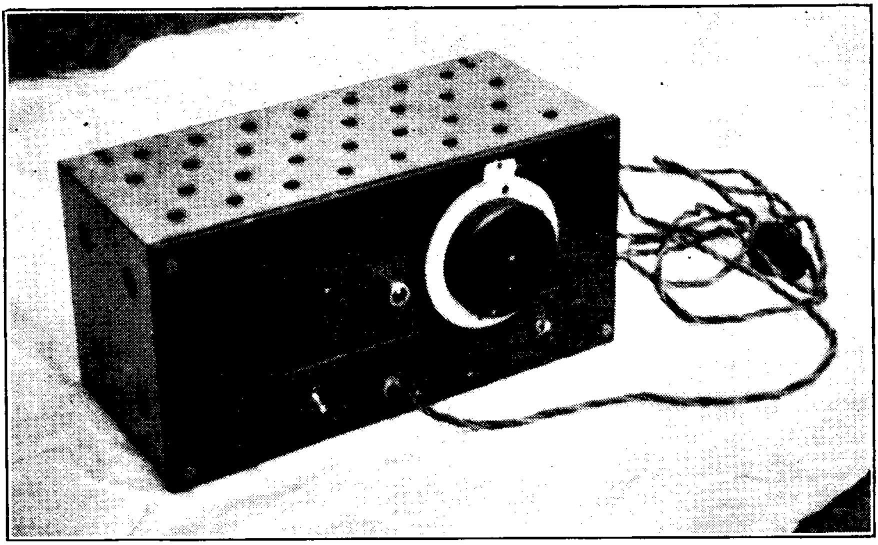
(2) Queries on any subject relating to technical radio or electrical matters will be accepted, though it will not be possible to provide complete circuit diagrams for the more complex receivers, transmitters and the like.

(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.



The Versatile Franklin

By L. F. Sinfield

THOUGH the author had often read a great deal about Franklin oscillators, the fact was duly noted that details from a practical experience point-of-view were usually lacking. Wanting to know much more than fundamental principles, work was commenced on a versatile unit which would incorporate all the points to secure good electrical stability and which could be constructed and used by the average amateur. Much tedious and patient work went into the design and construction of this unit and it is without a doubt the "apple of my eye." The model was carried to extremes with regard to small dimensions and it was felt that if high accuracy could be obtained with cramped space and normal mechanical construction, almost anyone should be able to repeat the same standard of accuracy.

There is always hot criticism regarding hypothetical construction which is merely suggested and not actually tried. However, the layout as suggested has been tested individually stage by stage and the results obtained show this layout to be ideal. The somewhat large size is to allow for easier construction, better ventilation and greater stability—important factors in a piece of apparatus of this nature. As very few amateur stations seem to have a really reliable and accurate source of frequency checking, despite Post Office regulations, this Franklin unit should fill the dire need in many stations!

The data to follow, on Franklin Oscillators, the construction of a small self-contained unit for frequency checking or drive purposes and suggested improvements should satisfy the needs of most amateurs, whether fully licenced or simply listeners. The unit described was built and tested in a laboratory over a period of several months by the author. During this time it was continuously in the process of modifications until it emerged as the circuit diagram Fig. 1 shows.

Requirements

(1) To obtain high stability using standard components without heavy mechanical construction.

(2) To be as stable, or more stable, than the average crystal oscillator on the amateur bands.

(3) To cover all amateur bands in harmonic relationship.

(4) To have instant crystal check with zero on VFO.

(5) To be self-contained and compact.

The factor (2) may cause a few eyebrows to be raised but nevertheless such stability can be, and was, obtained. The theory of the Franklin Oscillator has been so frequently described in the radio Press and text books that we will not dwell so much on this side of things but will concentrate mostly on small, but important, practical pointers which should materially assist in obtaining extra stability. The unit constructed was built into a steel box with the overall dimensions of 13in. x 6in. x 6½in.

The unit comprises a VFO, two buffers, a 100 kcs. crystal oscillator, beat detector and stabilised power supply. The heart of the equipment, and the portion which requires the most attention, is of course the tuned circuit. The coil L1 was wound on a bakelite tube ¾in. in diameter and 2in. in length, with 50 closewound turns of 26 swg DSC copper wire. The ends of the wire go through small holes, a pair of which are made at each end of the former, and about 2½in. of wire is left floating at each end. The whole coil is then given a good coating of lacquer as a preventative of turns moving, which would certainly have a dire effect on stability. The coil is then mounted vertically on top of the chassis by means of a tapped plate, fixed across the base of the coil and screwed from underneath. The free ends of the windings are covered with PVC sleeving and soldered to an anchor tag panel placed at a convenient point. It should be noted that the coil must be situated away from the sides of the screening box and is best placed near the centre. Expansion of the metal screening, through heat, would alter the self-capacitance of the coil to earth.

Capacitor C1 is a 250 μμF silvered mica type of close tolerance, zero temperature coefficient and high stability. Usually there is a slight positive coefficient and this can be compensated for by using a silvered mica and small silvered ceramic capacitor of slight negative coefficient in parallel. Exact relationship of capacitance is best found by experiment with frequency drift checks over a period of hours. However, the combined capacitance should be 250 μμF. In the author's case, only a silvered mica capacitor was necessary, but this was selected from very many tried.

If the frequency is found to increase gradually after the preliminary warming-up period, C1 should be adjusted so as to have a greater positive temperature coefficient. If, on the other hand, the frequency decreases, C1 should be adjusted to have a greater negative temperature coefficient.

C2 is a 100 μμF air-spaced variable capacitor of standard miniature type, having ceramic insulation. The rotor shaft should

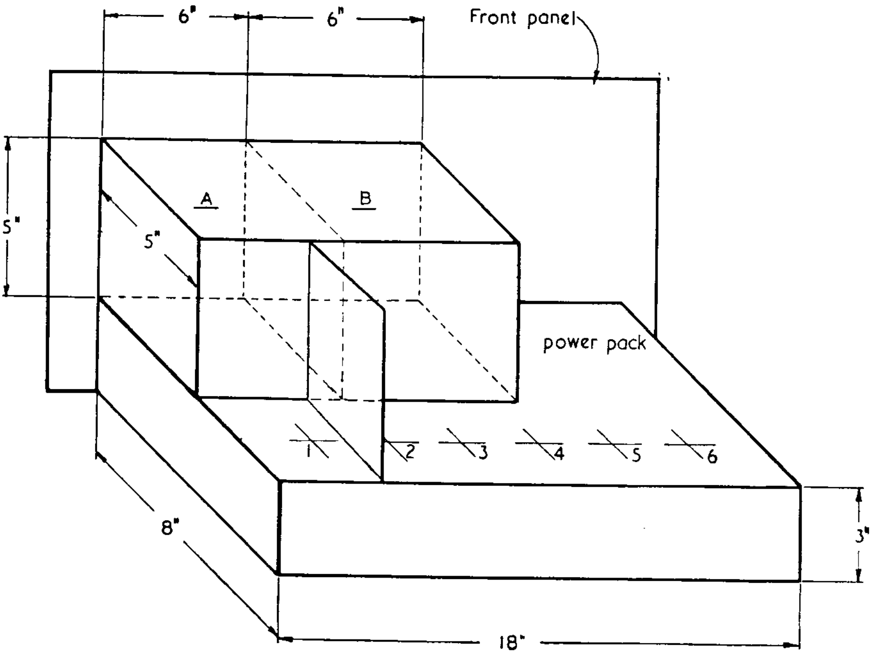


Fig. 1. Rear view of unit, showing position of screening boxes and layout. The numbers along the back indicate the positions of the valves, (i.e. "1" is the position of V1, etc.)

be supported at both ends to ensure mechanical rigidity. This capacitor is the bandset and zero frequency adjustment and is brought through the front panel for screwdriver adjustment. The capacitor C3 is of exactly similar structure as C2 except that it is of only 50 $\mu\mu$F capacitance. The shaft of C3 is carried through the front panel and fitted with a slow motion drive; this being the main frequency control. It is very important to note that the accuracy of the whole instrument revolves on this drive, for the accuracy with which the dial can be read in conjunction with its accompanying vernier determines the accuracy of the unit. Therefore it is of the utmost importance to use the best possible drive unit on capacitor C3.

The oscillator coverage of the capacitance of C3 (50 $\mu\mu$F) alone is about 150 kcs., so that with the oscillator constantly stable to within a few cycles it is important to be able to make use of its accuracy. The author's advice is to get the best drive and dial you can, easily read and with no backlash. If it is not possible to calibrate directly, then several graphs can be made, each one covering a small section of the scale.

Capacitors C4 and C5 are each 3 $\mu\mu$F and are of the silvered mica ceramic disc type. They are mounted on the anchor panel to which the coil is connected. All components in the "tank" circuit are mounted and wired so that there can be but negligible variation in proximity to the chassis or screen. The screening, by the way, should be of copper and amply spaced from the tank circuit components.

In the original model, the screen is well perforated in order to give adequate ventilation and painted a bright colour to reduce heat absorbtion and to protect the surface of the metal. The shield extends round the valve V1 but was left open at the top of V1, again in the interests of ventilation. This arrangement was also necessary owing to the cramped positioning. The ideal arrangement would be to have a copper box containing the tank circuit either away from any heat or at a thermostatically controlled temperature.

The Oscillator Valve

So much for the LC circuit. The oscillator valve is a 6SN7GT and is operated from a stabilised HT supply of 150 volts by means of a VR150-30 voltage regulator tube. The anode load resistors are kept high (47000 ohms) in order to reduce anode current and thereby keep the valve operating well within its rating. The absence of RF chokes helps to save space but even when they were inserted gave no noticeable advantage. The grid leak resistors are kept at a low value, also 47000 ohms, to reduce possible danger of parasitics and to keep the output more constant. If these resistors are increased in value self-oscillation tends to start. As a final note, the base of the valve is screened by a metal shield which encloses R1, R2, R3, R4 and C6.

The First Buffer

The first buffer stage consists of a metal type 6SJ7. The grid is connected directly to the second grid of the oscillator valve. The screen grid supply is taken from the stabilised 150 volt source, since the anode current of a pentode remains reasonably stable over changes in anode voltage provided that the screen voltage is constant. The first buffer is, therefore, not likely to change the loading conditions of the oscillator. The reason why the anode supply is not stabilised is that the VR150-30 will regulate better if the current of the regulated circuit is kept low. With the anode current of V1 being kept small and with only the screen of the 6SJ7 supplied, this condition is easily fulfilled. Also, the gain of the 6SJ7 is increased by the anode going to high voltage via its 2.5 mH choke load.

The dropping resistor R11 should be adjusted in such a way that when a meter is inserted at point "X" is indicated that

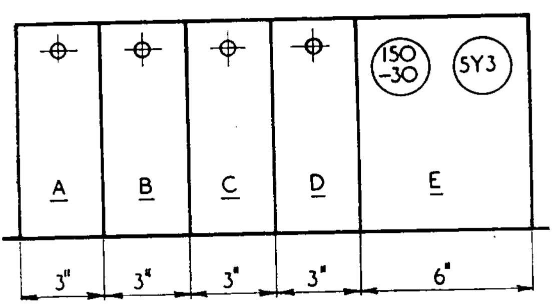
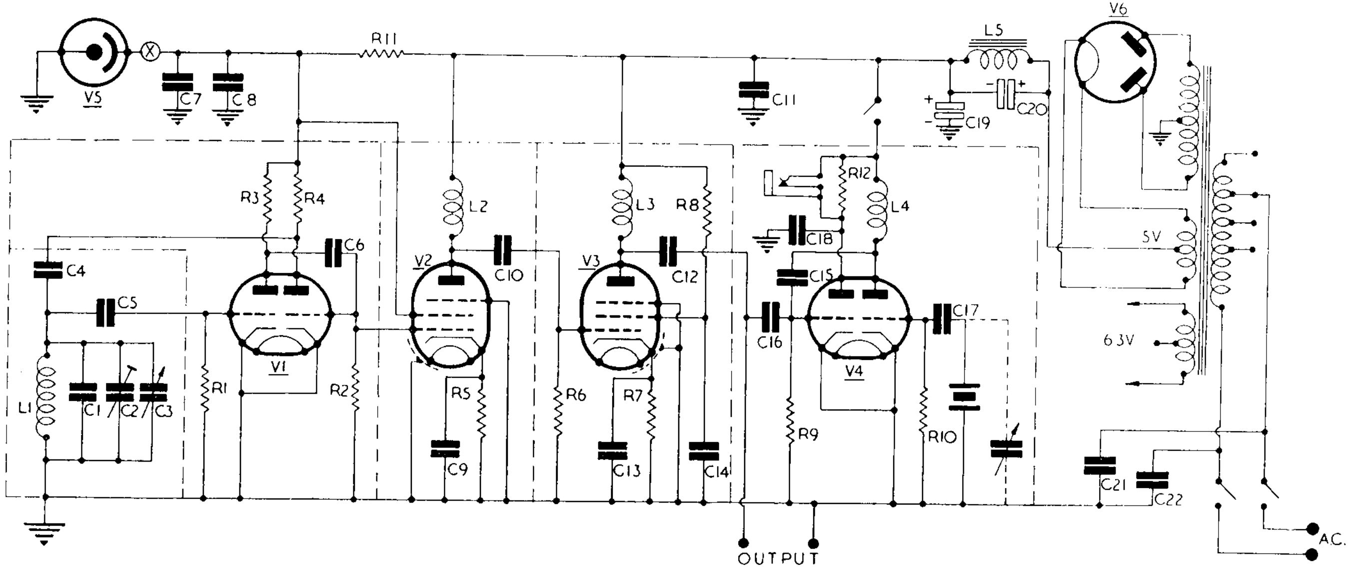


Fig. 2. Layout of underside of unit, showing positions of screening compartments.



Component List

R1, R2, R3, R4, R12	47000Ω	
R5	330Ω	
R6	220000Ω	
R7	470Ω	
R8	6800Ω	
R9, R10	1 MΩ	
R11	3300Ω	wirewound

C1 250 μμF (see text)
C2 100 μμF (see text)
C3 50μμ F (see text)
C4, C5, C15, C16 3 μμF (ceramic disc)
C6 500 μμF (silvered mica)
C7, C9, C11, C13, C14, C21, C22 0.01 μF mica
C8 4 μF paper
C10, C12, C17 100 μμF (silvered mica)
C18 0.002 μF
C19, C20 8 μF electrolytic

Valves: V1 6SN7GT; V2 6SJ7 (or 6AC7); V3 6AC7 (or 6L6); V4 6SN7GT; V5 VR150-30; V6 5Y3GT.

(Alternatives for V2 and V3 are those needed if unit is to be used as an exciter).

L1: 50 turns, 26 swg, ¾in. diameter. Close wound. Lacquered.
L2, L3, L4: 2.5 μH Choke.
L5: Smoothing Choke to suit power supply.

Transformer:
Secondaries: 210-0-210v. at 60 mA.
5v. at 2 A. 6.4v. at 4 A.

the VR150-30 is taking 15-20 mA. (about midway through its regulation range). Once adjusted, this resistor can be forgotten. In the original unit, the value was 3300 ohms, 6 watt. (Of the wirewound type). The base of the first buffer V2 is screened by a metal shield, enclosing R5, C9, C10 and L2.

The Second Buffer

The second buffer valve is a metal 6AC7 high slope pentode in a conventional untuned amplifier circuit. Again the base is screened, the shield enclosing R6, R7, R8, C12, C13, C14 and L3. The output lead goes to a socket on the front panel and via a small capacitor C16 (of 3 $\mu\mu$F) to the beat detector.

The Beat Oscillator

V4 is another twin-triode, a 6SN7GT, one half of which is used as a 100 kcs. crystal oscillator and the second half being a detector which mixes harmonics from the 100 kcs. oscillator with the VFO output to produce beat notes in the headphones. The phone jack is in the anode circuit of the detector and is situated on the front panel. Capacitor C18 is an RF by-pass which reduces 100 kcs. harmonic radiation from the phone leads. A switch in the common HT supply to this valve gives "Xtal Check On/Off" control.

The choke L4 was found to give better results on the 100 kcs. harmonics than a tuned circuit and it also has the advantage of keeping the amplitude of oscillations down at the fundamental frequencies. A small variable capacitor may be mounted across the crystal if the latter is a few cycles high and if greater accuracy is necessary. This was not found necessary in the original. The crystal frequency may readily be checked against the BBC long wave transmissions (200 kcs.)

Of the power supply little need be mentioned apart from the fact that RF by-pass capacitors are connected across the mains leads. Apart from that the supply is of perfectly conventional design.

Drift

The output from the completed unit as described is small but is ample enough for frequency checking purposes on the amateur bands. A short piece of wire should be run from the output socket to the vicinity of the receiver aerial.

After switching on, the unit should be allowed to warm up for a period of about half an hour. For the first minute or so the drift should be in the region of 100 cycles and for the next half-hour perhaps a further 100 cycles. There may also be a drift of 100 cycles or so during the following half-hour, but after this the unit should remain perfectly stable. Stability, of course, is dependant upon the tank circuit constants—most particularly C1.

As an Exciter Unit

For use as an exciter it is recommended that V2 be a high slope RF pentode, such as the 6AC7. A closed circuit key-jack should be inserted between R5 and chassis if cathode keying is to be employed. Alternatively, V3 could be used as the keyed valve in which case the jack is connected between R7 and chassis. V3 should be a metal 6L6 and the choke L3 replaced by a tuned circuit, tunable to double the frequency of the input and controllable from

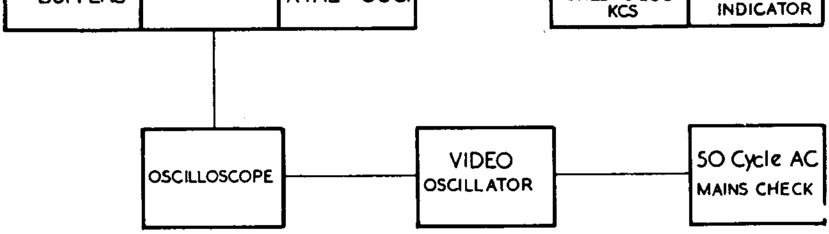
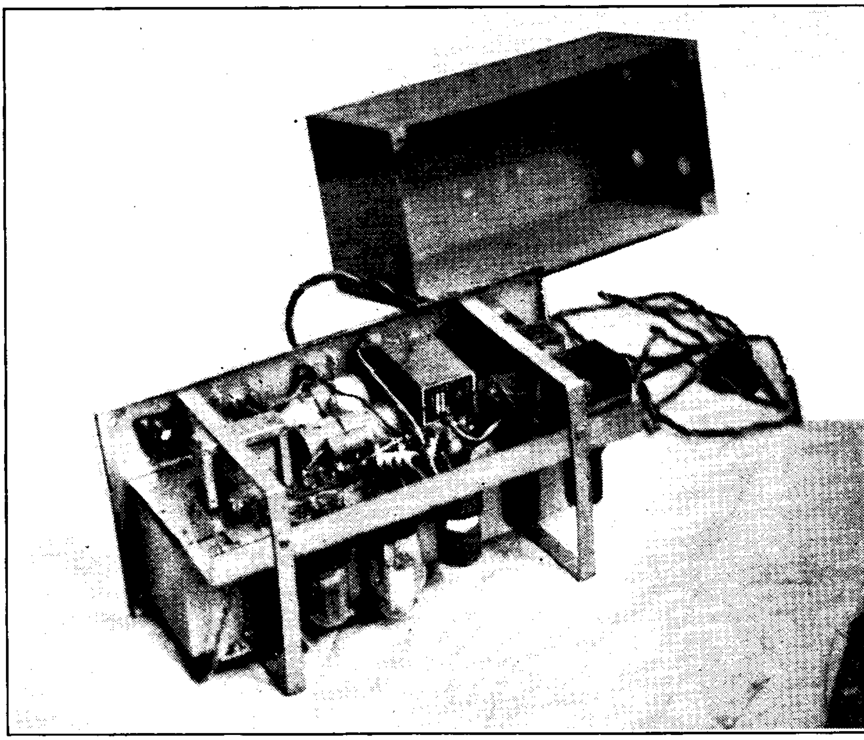


Fig. 4. Block diagram of equipment used for laboratory drift tests.



the front panel. The output could then be either link coupled or capacitance coupled direct from the 6L6 anode. If direct drive is used, care must be taken to reduce the capacitance to earth of the output lead otherwise it will seriously reduce output amplitude. The amplitude at the 6L6 anode (3.5 Mcs. sine wave) easily fills the screen of a normal oscilloscope and will be ample for most purposes. An arrangement of this nature would provide sufficient drive for a 807 PA. If desired, greater output can be obtained by utilising a power supply of increased rating. If this is provided, it will be necessary to use a higher value resistor at R11—the replacement having to be re-adjusted as previously described.

Frequency Tests

For frequency checks, the internal oscillator can be used satisfactorily with possibly an additional check against a standard broadcast transmission. As a matter of interest, the block diagram shown below is the layout as used for drift tests in the laboratory. The 100 kcs. oscillator was constantly checked against a broadcast signal. The output from the beat note jack on the unit was fed to the Y-plate of an oscilloscope and the video oscillator was adjusted for a one-to-one frequency pattern at the same time—itself being checked against 50 cycle mains. Reading obtained on the video oscillator scale denotes cycles drift away from the original zero beat setting of the Franklin. The layout diagram shown is not quite identical to the original but is an improved version and it should be easier for the average constructor to get working satisfactorily.

Frequency coverage of the unit constructed was slightly greater than 1.75 Mcs. to 1.875 Mcs., the harmonics of which cover almost all of the amateur bands. The coverage was kept "tight" in order to obtain a greater spread in preparation. A crystal check was provided at 1.8 Mcs. in the position shown in the circuit diagram. Naturally, the choice of fundamental coverage may be decided by the adjustment of C2, the zero adjusting capacitor. It should be observed that if the crystal check point is moved to give additional coverage, separate sets of calibration charts will be required.

Theory of the Triode-Hexode

(Without Tears)

By Len Miller

The author of this article being blessed (or cursed) with a practical, non-mathematical mind, always seeks a simple, physical explanation on all matters pertaining to radio, and herewith presents his version on how rectification occurs in a modern frequency-changer.

WHEN dealing with frequency changing, most text-books stress the fact that the mixer portion **must** rectify the incoming signal, and even go to the trouble of illustrating a set of sine waves "(the rectified incoming signal," "the local oscillator," "the resultant signal") to prove it. Usually, anode bend rectification is employed in the first detector circuit of the old two-valve frequency changer stage, accomplished either by means of a grid-bias battery or by a largish value of cathode resistor.

Many students are no doubt puzzled by the fact that the value of cathode bias resistor which provides the negative bias to the hexode portion of a pentagrid or triode-hexode single-valve frequency changer is no more than 150 ohms or so.

Assuming around 10 mA. to be the total current flowing through this bias resistor, the input (signal frequency grid) is only biassed about 2 volts negative (in many cases it is even less, and the all-dry 1.5 V. pentagrid works at zero bias), it would appear at first glance that one is entitled to come to the conclusion that the single valve frequency changer does not rectify the incoming signal, and throw away his text-book in disgust (or shoot the Instructor, if he is taking a wireless course in the Services!)

However, let him pause for a moment, and read on.

Rectification is a form of distortion—wave distortion, in fact. When an alternating voltage (or signal, same thing) goes positive during the first half-cycle, and goes negative by the same amount during the second half-cycle, the **average** anode current (as measured on a meter) remains constant (always provided the intensity of the signal is not so great that it overloads the valve, which is a subject we need not dwell on just now!)

In the R.F., I.F. and A.F. stages of a receiver, this is just what we want, and a simple and well-used method of checking up on valve overloading (or distortion) is to measure the anode current when a signal is being received, and observe that the meter needle remains steady.

This applies verbatim for A.F. stages (working under Class A), and with the proviso in R.F. and I.F. stages, if they are A.V.C. controlled, that the anode current will decrease when a strong station is tuned in, but will not jump about during heavy modulated passages.

As your text-book has already told you that the process of frequency-changing cannot be achieved without rectification of the incoming signal, and has proved this to be so, all that remains now is to find out exactly how this happens when the input grid is only biassed a volt or so negative, which is certainly not enough to cause anode-bend rectification.

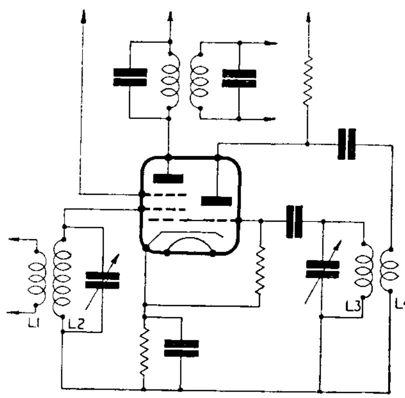


Fig. 1 Typical circuit of a triode-hexode frequency changer.

Just take a glance at the typical triode-hexode frequency-changer illustrated in Fig. 1. This shows one of the grids of the input (signal frequency section) to be joined to the grid of the triode (oscillator section). Now the grid of the triode section is alternatively going negative and positive, as a result of the oscillatory circuit, L3, L4 and the triode section of the valve. This means that the auxilliary grid of the input section which is joined to the triode grid is also going alternatively negative and positive, and as this auxilliary grid (usually called the "mixer" grid) is situated between the cathode and anode of the hexode portion, it naturally has the effect of increasing the flow of electrons (anode current, in other words) when it is positive, and decreasing anode current when it is negative. It can therefore be looked upon as an extra control-grid, as we all know (or should!) that the anode current of a valve can be increased by decreasing the standing negative grid-bias, and vice versa.

Continuing one step further, we should also know (and this is very important) that the mu or stage gain of a valve is lowered as the negative bias is increased, as is evidenced by the fact that most straight receivers use a variable bias potentiometer as a means of controlling "volume." (This should be called "Gain Control," not "Volume Control," but we can't do anything about that now!)

We need not worry any more about the triode section, as we are now only concerned with the "goings on" in the hexode, and can easily come to the conclusion that the electron flow from cathode to anode is being messed about "something terrible," having two control grids to contend with, each one going alternatively negative and positive at different rates (or at different frequencies). When both grids are positive at the same time, the mu of the valve will be high, and conversely, when both grids are negative at the same time the mu of the valve will be low. As the two grids are alternating at different frequencies, there will obviously be instances (many of them!) when one grid is positive and the other negative.

Although the input grid is receiving a signal of equal negative and positive magnitude, the mu of the valve is being continually varied at a rate depending upon the frequency of the oscillator section. During the half-cycle when the "mixer" grid is positive the mu is high, and as the "mixer" grid goes negative the mu of the valve decreases.

The wave of the input signal is therefore distorted, and as I mentioned at the beginning of this article "rectification is a form of distortion." This can now be enlarged upon, as it should (I hope) now be realised that the effect of the local oscillator is to alternatively increase and decrease the amplitude of the signal as it appears at the anode of the hexode. The text-book (or the Instructor, if still living!) has already explained how the frequency difference appears—I have only attempted to explain how rectification **does** occur, inside the valve itself.

One last word, please. I have repeatedly mentioned the grid(s) as going "positive." Actually I should have said "less negative" to be technically correct, but to keep saying "less negative" would have confused the text of this article, and in any case, if a potential goes less negative, it is in effect, going more positive, so let's leave it at that!

Apologies Dept.

Several errors inadvertently crept into our January issue and we wish to point them out herewith:

AC/DC Amplifier (pages 159-163): In the circuit diagram, the screened leads from V1, 2, 3 and 4 are shown taken to earth. Actually these should have been returned to the HT negative line. On page 160, the fifth line of paragraph 2, should read ". . . screen voltage is dropped through a 1 K-Ω . . ."

A Variable Frequency Oscillator. On page 154, a capacitor (CX) is shown in the layout diagram. This was not shown in the circuit diagram since it is an optional "extra" and if used should be connected between point "A" in the circuit diagram to HT negative. This information was omitted in error from the caption.

Some Notes on

Loudspeaker Repairs

Cone repairs ■ Centring ■ Pole piece alignment
Speech coil and field coil repairs ■ The Transformer

By C. N. Blatherwick, G3VU

THE current economy drive is at times inconvenient but at least it does throw us more and more to the development of our own resources and ingenuity. This is an asset anyone can be proud of; wastefulness, in any form, is a liability even to the rich! The exercise of economy and development of one's ingenuity can be extended to radio components, of which the loud speaker has been selected as the object of these notes. The act of throwing out as "junk" a damaged speaker is to be deprecated, for not only could it have been sent off to a firm specialising in speaker repair and re-winds but could possibly have been easily repairable at home in the shack. Apart from the obvious advantages of economy and increasing of ones knowledge there is, in these home repairs, a great satisfaction of a job well done. Here then are a few notes that may be useful to those with speakers now lying idle for want of a little attention.

Cone Replacement

One of the most common defects in a speaker that has been reclining in the junk box is a damaged cone. If the cone has been badly torn there is not much that can be done in the matter, short of fitting a new one or one taken from another speaker. This process is rather difficult, however, since the cone carries the speech-coil former and winding and must therefore be very accurately centred.

To remove the old cone, it is generally necessary to remove firstly the felt ring and metal retaining ring. Then, the stiffening ring must be taken off. With most modern speakers and especially the larger types. this process is simple inasmuch as it will only be necessary to take out the retaining screws or bolts, though with the small speakers the tendency is to rely on glue only. With the more antique speakers, however, it will be found that the ring is riveted to the cone. The rivet heads should

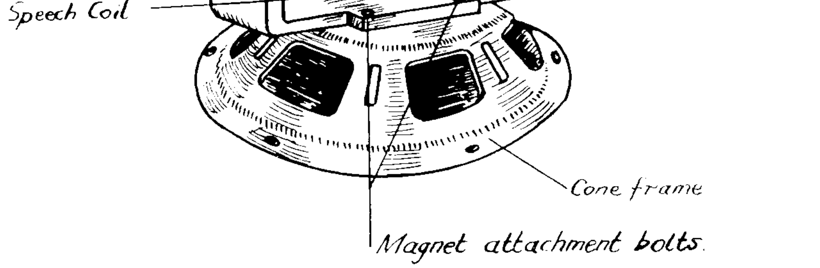


Fig. 1. Some details of a representative permanent magnet moving coil speaker, which are referred to in the text.

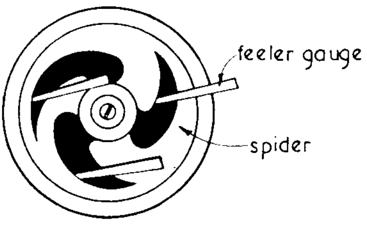


Fig. 2. The method of centring a speaker cone by the use of three feeler gauges of equal thickness. The screw in the centre of the spider is tightened only when the feelers have been inserted between the inside of the speech-coil and the pole-piece.

be filed off and driven out with a pin punch.

Since the sudden jarring of the magnet may result in loss of magnetism it is desirable that this component is removed before continuing with the main task. This is usually possible by the simple process of removing four bolts by means of which it is attached to the cone frame (see Fig. 1). Withdraw the magnet carefully and then gently slide a piece of soft iron over the face of the pole piece to act as a "keeper." When this has been carried out the magnet can be put aside out of harms way until required again.

Once the cone rivets or bolts have been removed it will generally be found that there is a front metal ring which can be drawn off, leaving the edge of the diaphragm exposed. Move the cone slightly forward and then unsolder the braided leads from the cone to the terminal plate; this is best done by unsoldering at the terminal end. If the new diaphragm is identical with the old one it can be laid in position and attached by means of new rivets or the existing bolts. Alternatively, if the speaker originally used rivets, ordinary bolts may be used as replacements but it should be noted that these must have a good clearance in the rings so that a certain amount of "play" is available for alignment purposes.

Reassembly

When the new cone has been fitted and the felt segment replaced (with glue) the speech-coil leads can be soldered to their appropriate tags. If the speaker is a small one, however, it may be more convenient to solder these leads before mounting the cone. After this, the magnet can be refitted after carefully sliding the "keeper" off. Care must be exercised here in order to avoid scratching the enamelled wire of the speech coil. The magnet bolts may then be fitted, making sure that the speech coil is reasonably centred in the magnet gap. Before replacing the centre bolt in the "spider," means must be adopted for ensuring really accurate centring.

Centring the Cone

One of the best methods of carrying this out is by the use of three small feeler gauges, made from celluloid, ivorine or similar material. These should be about 2 inches long by ¼ inch wide at the upper end and slightly tapering towards the other. At the thin end, the corners should be slightly rounded. These strips should be of such a thickness that when all are in position between the inside of the speech-coil former and the centre magnet pole the speech coil is held reasonably firmly. At the same time it must not be necessary to apply any force to insert these feelers since this would distort the former. It will be clear, then, that the feelers must be cut from material of just the correct thickness, which will vary with different types of speaker. Should celluloid not be available, strips of thick card would be admirably suitable. Alternatively, thin card treated with a coat of thin shellac varnish or a cellulose adhesive would serve the purpose. Spend a little time in getting the slips of the right thickness—it will be well repaid. Once the feelers are ready, insert them as shown in Fig. 2 and tighten the screw, by means of which the spider is attached to the end of the magnet pole, and the speaker should be accurately centred in the gap and ready for use again.

If, after this, you are not absolutely certain whether the coil has been correctly centred or if you already have a speaker suspected of being off-centre here is a tip that is well worth remembering. First of all it is necessary that the speaker is connected to the receiver. Then wrap a length of insulated wire around the mains input lead, taking one end of this wire and inserting it in the **live** pick-up connection (see Fig. 3). Switch on the receiver and await results! The effect of this operation is to induce a 50 cycle signal into the receiver and thereby it will be simple, by observing the speaker, to ascertain if any discrepancies in centring exist.

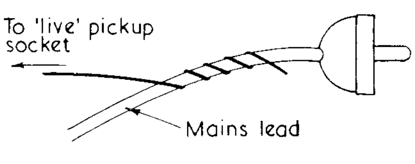


Fig. 3. Method for testing speaker suspected of being out of centre.

Cone Repairs

Where damage to a cone is not severe, it may be possible to effect a satisfactory remedy by applying a small amount of thin, liquid, glue to the edges of the tear and pressing them together. There are some cellulose adhesives, sold in small tubes and obtainable from multiple stores, which are ideal for this purpose. If the type used is labelled "Inflamable" the usual precautions should be taken if the tube has been lying around for a while and needs a little softening up! Unless the process is unavoidable, it is not a good plan to repair a cone by sticking a strip of adhesive material over the rent (such as cycle tyre puncture material). If a strip must be applied make it as small as possible and use very thin paper, applying a little adhesive to the edges before applying the patch. In some cases rubber solution makes a suitable repairing adhesive and this has the advantage of being flexible when dry. However, the choice of patching material will depend on the manufacture of the cone itself, some being comparatively thin and others being of thick oiled cartridge paper. In general, if the use of a patch can be avoided—so much the better; if not, then discretion and care must be exercised.

Pole-piece Alignment

If a speaker has been mishandled or dropped it may be found that the speech coil cannot be centred in the manner described. This would manifest itself by "scratchy" reproduction or by a mechanical scratch when pressing and releasing the centre of the cone. Before proceeding with remedies it should be ensured that the gap is clean. This can be accomplished in several ways, such as by blowing into the gap with a bicycle pump or vacuum cleaner. Care should be taken not to do any damage, due to the "thrust," and in this respect the conscription of an assistant to do the pumping whilst the pump is held would materially assist. Should the gap be clean, despite the symptons exhibited, the trouble may be due to the pole-piece having moved. This is usually independent of the main magnet and is secured by means of a long bolt passed into it from the back of the magnet (see Fig. 1). To effect a cure it will be necessary to remove the magnet from the cone frame, as described above, and then to slacken off the bolt with a large screwdriver. The pole-piece will still be held firmly due to the magnetic attraction and must be moved carefully until it is central with the hole in the front of the magnet. After centralising in this manner, tighten the bolt and reassemble the speaker—again centring the cone.

Speech Coil Removal

It is not unlikely that the speech-coil winding will have been badly scratched and/or damaged should the pole-piece be out of alignment and in this case rewinding is called for. Though this can be very tricky, it is not particularly difficult for those with deft fingers and the work can usually be accomplished without having to remove the cone from its frame.

It is essential to carefully count the number of turns on the coil and mentally note the method of anchoring the ends of the windings. Then obtain a few feet of enamelled wire, of similar gauge to the original, and rewind the coil with the same number of turns. In doing this, the wire should be kept just taut but should not be stretched otherwise the former may be buckled; this can be avoided, however, by fitting a wooden rod inside the former. To prevent movement and vibration, it is wise to coat the finished coil with very thin shellac varnish. Once the winding ends have been soldered, the speaker is again ready for action.

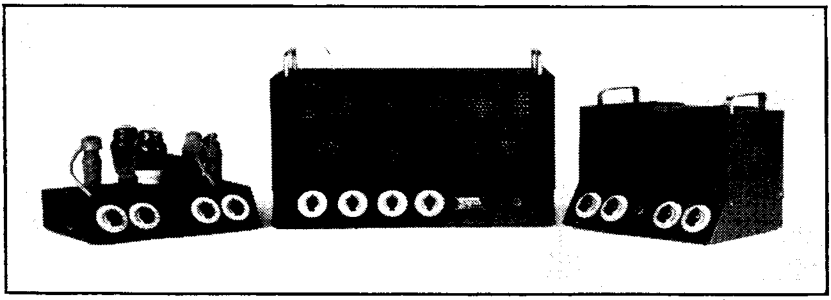
Rewinding the Field

In the event of the field coil in an energised speaker burning out, rewinding is not an easy task. Probably the winding will be partly melted so that its removal will be tricky. Additionally, the insulating tape normally bound round it will be "messy." However, providing that care is taken and if the gauge of wire used can be ascertained rewinding can be carried out simply by putting on wire of the same gauge until the bobbin is filled. If space permits, place a single layer of oiled silk or empire cloth after every few layers of the windings, providing that this was done in the original coil. Rewinding can be simplified if a lathe is available, though this machine should be run in back gear!

The Transformer

This is the point where most enthusiasts have to draw a line at home repairs on speakers. If no experience in this kind of work has been had, or if no coil winding machine is available, it will probably be prudent to pack off the transformer to a firm specialising in rewinds! However there may be a few who are intrepid enough to tackle the job themselves.

It will first be necessary to remove the clamps and core stampings in order to mount the spool for rewinding. Where the transformer cannot be rewound for any reason, and a replacement is not available, it is sometimes possible to make use of an old microphone transformer. In this case, the primary could be used as the secondary



Trade Notes

SOUND EQUIPMENT

The large photograph shows a group of AC/DC Amplifiers marketed by Messrs. United Electronics Ltd. The central position is occupied by the "HG15," incorporating Mu-Metal output transformer and high gain pre-amplifier unit. The two smaller models are the 15 watt Amplifiers designed for use with any microphone or gramophone pick-up and having twin input.

The single valve unit shown in the other photograph is a complete high gain pre-amplifier. A Mu Metal input transformer to match any microphone of 10-45 ohms impedance or the Lexington pick-up is wired directly into the SP41 high gain pentode. The input winding is centre tapped so that no hum develops in the pick-up or microphone leads. A 16 μF 500 volt decoupling capacitor is used. The unit is supplied for use with any amplifier or radio unit for 4v. or 6.3v. valves. Separate HT leads are wired into the unit and connecting up is only a matter of minutes.

The Amplifier type "HG15" is available with volume expansion and compression at a small extra charge.

NEW PRICE LIST

We have received a revised price list from Messr. Taylor Electrical Instruments Ltd. of their range of test gear. For the benefit of readers interested in purchasing any of these instruments here is the complete price list:

Model 20A, Circuit Aanalyser, £15/15/-; 30A, Oscillograph, £27/10/-; 45A/S, Valve Tester, £18/10/-; 45A/T, Portable Valve Tester, £21; 47A/S, Valve Tester and Universal Meter, £23/10/-; 47A/P, Portable Valve Tester and Universal Meter, £26; 65B, Signal Generator, £15/10/-; 70A Multirange Universal Meter (1000 o.p.v.), £10/10/-; 75A, Multirange Universal Meter (20000 o.p.v.), £14/14/-; 85A/P, Multirange Universal Meter, portable (20000 o.p.v.), £19/19/-; 90A, Multirange Universal Meter (1000 o.p.v.), £15/15/-; 110B, AC Measuring Bridge, £12/12/-; 120A, Junior Universal Meter, £7/10/-; 130A, Insulation Meter, £15/15- 140A, Output Meter (20000 ohms imp.), £15; 150A, Output Meter (2.5-20000 ohms imp., 5 watt max.), £30; 160A, Output Meter (as 150A but 2.5 watt max.), £27; 290A, Megohmeter, £29; 313C, Capacitance and Inductance Adaptor, £3/10/-; 330A, Dummy Aerial, 15/-; 520A, Test Set, £12/12/-.

Delivery on these models is (approx.): 7 days for 65B, 70A, 75A, 85A/P, 90A, 110B, 130A, 140A, 150A, 160A, 313C, 330A; 3weeks for 20A; 6 months for 30A; 2 months for 45A/S, 45A/T, 47A/S, 47A/P, 290A; 21 days for 120A; 3 months for 520A.

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and the secondary as primary. Although the primary is of fairly low resistance it will probably not be low enough for use as a speaker transformer. If used, it will usually be found that the output from the speaker is low due to the losses involved in the transformer "secondary"; but if this winding can be removed and then replaced by about one-third the number of turns of heavier gauge wire a fairly satisfactory component will result. Some experimenting by way of number of turns may be necessary.

It should be understood that the original secondary winding (now used as a primary) will most likely be of very fine wire and will not be suitable for connection in the anode circuit of a mains output valve. In that case, choke-capacitance output coupling is advisable.

In conclusion, the author would like to stress that, although extreme care has been advised throughout, the foregoing repairs should not prove to be beyond the capabilities of the average home constructor with a good eye (or rather two of them!) and steady fingers or beyond the capacity of the equipment found in the average workshop or shack.

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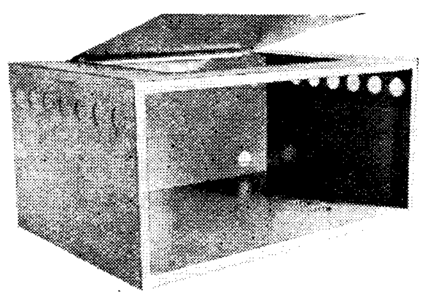

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