Practical Wireless
and PRACTICAL TELEVISION
11th YEAR OF ISSUE
Vol. XX. EVERY MONTH No. 450. DEC., 1943.
Editor F. J. CAMM

COMMENTS OF THE MONTH BY THE EDITOR

Selling and Servicing

OUR comments last month on the Board of Trade system of issuing licences have evoked a large number of letters from radio dealers and service engineers all over the country. It cannot be denied that there is widespread dissatisfaction, and we are forced to the conclusion that the small business man is being victimised by the larger firms. The system seems to be that a dealer, wishing to sell wireless components and complete receivers, must first apply to the Local Price Regulation Committee, and this takes the advice of other wireless retailers in the district. Obviously, human nature being what it is, it cannot be expected that any dealer would be in favour of splitting the trade, and therefore, almost without exception, he raises opposition to the granting of fresh licences. In almost every case he succeeds.

Numbers of our readers have disclosed a somewhat disquieting state of affairs in connection with those firms who already possess selling licences. A few examples will suffice to convince the Board of Trade that some drastic alteration is necessary. One firm was approached by a customer to have his set repaired. By a lugubrious statement concerning the condition of the set and the repairs necessary, and the time it would take to obtain the necessary spares, the customer was persuaded to buy another receiver at 15 guineas, with an allowance of 30s. for the old set. Now, this customer, two months later, was astonished when he visited a friend's house to find his old receiver in full working order. His friend had purchased it from the dealer for 15 guineas! Another example is even more intriguing. A set was purchased but proved unsatisfactory. In fact, it ceased to function after two days. The dealer was sent for, and, at first, refused to take it back, but after some harangue he promised to "do what he could." When the receiver was returned it still was unsatisfactory, and so, finally, the dealer agreed to allow him 10 guineas credit on the purchase of another receiver costing 15 guineas. The customer had originally paid 15 guineas, and so was a further 5 guineas out of pocket. The second receiver functioned well, and the purchaser was curious to ascertain its make, which he did not recognise from the cabinet. Upon removing the back, he observed that it was the chassis of the first receiver installed in a different cabinet! Now, this sort of chicanery and cantrip in our view amounts to forgery, and we think that the Board of Trade should conduct a full investigation into the methods of buying and selling second-hand receivers. At the present time it amounts to a ramp, and the public has no protection. Because wireless components and receivers are in short supply, the public needs to be protected against the wiles of these sharks, who batten themselves on like barnacles to every industry. It is possible that, through the medium of parliamentary debate, this matter can be remedied, and we invite our readers in possession of well-authenticated details of cases similar to those we have quoted to communicate with us, stating the facts. They will be treated in the strictest confidence. We should, of course, require names and addresses of the traders concerned.

Similarly, we hope all dealers whose licences have been refused on grounds which they consider insufficient will forward the details to us, as we are already in communication with the Board of Trade on the matter. If this matter is not pursued, the wireless and other industries will remain in the hands of small groups, and this cannot be to the benefit of the public. The present system of granting licences really amounts to the granting of monopolies. No doubt the idea behind the present licensing system was good. It was designed to prevent the opportunist from jumping into an industry and cashing in on the abnormal demand for a diminishing supply. The very thing, however, which it was designed to prevent it is encouraging among those that the system was intended to protect.

Outworking

A BOOKLET issued conjointly by the Ministry of Production and the Ministry of Labour and the Supply Department describes several types of outworking schemes and gives instructions on how to organise them. There are certain details in receiver construction which lend themselves to outworking. The book is obtainable from the Ministry of Production Regional Controllers, from whom fuller details can be obtained.

Indexes to Vols. 11 to 18

WE discontinued the supply of indexes as from Volume 10. In the passage of the years, however, readers who have preserved their copies are finding it increasingly difficult to wade through piles of issues in order to locate particular articles. In view of the great demand for indexes to Volumes 11 to 18, we have printed a limited number of copies of each, which are available for 9d. each, or 10d. by post from the publisher, George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. These indexes are fully cross-referenced, and include not only the titles of articles, but of paragraphs and replies to readers' queries.

"Screw Thread Tables"

WE have just published from the offices of this journal a new vest-pocket book, containing over 200 pages, entitled "Screw Thread Tables." It costs 5s. or by post, 5s. 3d.

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The Editor will be pleased to consider articles of a practical nature suitable for publication in PRACTICAL WIRELESS. *Such articles should be written on one side of the paper only, and should contain the name and address of the sender. Whilst the Editor does not hold himself responsible for manuscripts, every effort will be made to return them if a stamped and addressed envelope is enclosed. All correspondence intended for the Editor should be addressed: The Editor,* PRACTICAL WIRELESS, *George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2.*

Owing to the rapid progress in the design of wireless apparatus and to our efforts to keep our readers in touch with the latest developments, we give no warranty that apparatus described in our columns is not the subject of letters patent.

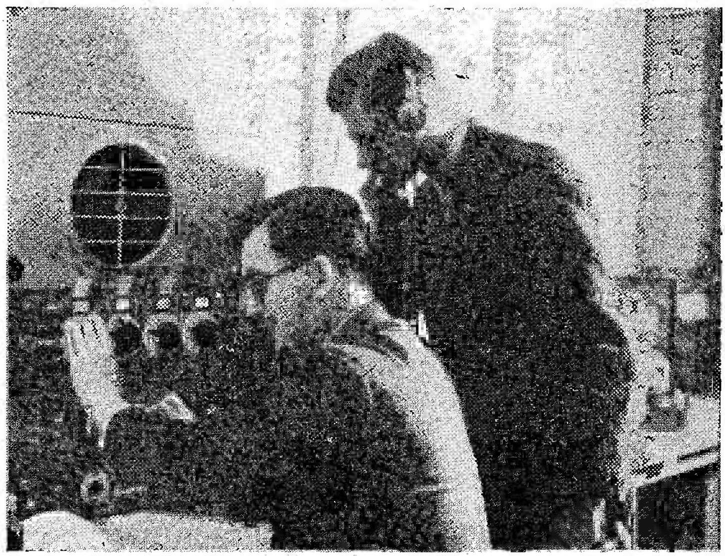
ROUND THE WORLD OF WIRELESS

Workers' Playtime

THE B.B.C. Variety Department has always tried its utmost to pursue a policy of helping in the war effort. The best way it can do this is by entertaining all those troops and munition workers situated in lonely spots, and unable to get entertainment. Soon after the beginning of the war they took over a huge theatre, from which many variety shows, such as "Music Hall" and "Happidrome," were performed. Blocks of tickets for these productions were then issued to the troops and munition workers. This policy was so successful that now two big theatres are in commission for these performances. But this idea, although good, was not comprehensive enough; it did not embrace those munition workers right out in the heart of the country. For these the problem of transport was too great for a visit to the theatre-studio, so John Watt and his assistant, Mr. Imlay Watts, conceived a new idea. As the workers could not get to the shows the shows must go to them.

Radio Show in a Factory

TWO engineers set off in a van filled with outside broadcasting gear. By dint of innumerable official permits they eventually found themselves in one of England's busiest factories, right in the heart of the country. They were taken to a shed that had not yet been fitted up for work and asked "will this do?" Two workmen were busily erecting an improvised stage at one end of the room. The engineers went outside and found a little hut which they could use as a listening room, and spent the afternoon erecting their gear. Early next morning a shooting brake, which is now used as a transport vehicle for artists and staff, turned up. In it were producers Michael North, and Glyn Jones, their secretaries and four world-famous artistes. Two pianos which had arrived earlier in the morning were set on the stage, all was ready for a balance test. Twenty minutes before the show was due to start the hall was empty, but the minute the doors were opened the workers poured in. Their seats were allotted by ballot, the programme being relayed to their colleagues still at work in their shops. It was a tremendous success.



In the miniature cubicle fitted up in an outhouse of a factory for controlling the Workers' Playtime programme. The programme engineer, Peter Duncan, and the outside broadcasts engineer, D. G. Jones, who travelled to the factory the day before to rig up the equipment, are seen listening to the run through.

Change of Address

AS from November 1st the new address of Messrs. Multicore Solders, Ltd., will be Commonwealth House, New Oxford Street, London, W.1. Telephone: Chancery 5171/2.

B.I.R.E. Paper

AT a members' meeting of the London Section of the British Institution of Radio Engineers, held at the Institution of Structural Engineers, London, S.W., on Thursday, October 28th, a paper on "Colour and Stereoscopic Television" was read by John Logie Baird.

I.E.E. Meeting

THE wireless section of the Institution of Electrical Engineers held a meeting in the Lecture Theatre of the Institution on November 3rd, when a paper on "Wave Guides in Electrical Communication" was read by Mr. J. Kemp.

"Science at Your Service"

"THE Science of Materials" is the title of the first five talks in the new series on applied physical science, which began on October 1st. These weekly talks are on science and the house, the science of building, plastics, clothing and fabrics, and explosives.

Modern man requires more amenities in his home than mere protection from the weather. There are certain standard needs, and these were discussed in the first talk of the series. The second will show how the standards established by research can be utilised by designers, architects and builders. Science ensures that buildings shall be made strong, durable, damp-, rot- and vermin-proof, and home-makers of the future should see that these aims are achieved. The newer science of plastics will play an increasingly important part in the future. The talk on these materials told of the long and patient research which has gone to the perfecting of each of them. Clothing and fabrics were fourth. Equally important researches into the use of waste materials have been made as the need for saving all kinds of textiles has steadily increased during the war. Listeners heard something of what utility clothing and modern battledress owe to chemists in their laboratories. The last talk, on explosives, which we are apt to think of as wholly warlike, explained how they have important uses in peacetime in mining, quarrying and road building.

The second section of the series "Science of the Earth" began in November.

Radio Work at Borstal Institution

FORTY girls in a Borstal Institution have been assembling radio power units for tanks for a Ministry of Supply contractor. A shop in the institution has been fitted up, and work is supplied by a local factory. The girls are between 16 and 23 years of age, and the factory management says that their work is as good as that done in their own factory. (See illustration on this page.)

Listening Schools

THE new school broadcasting year started recently with a record registration for the beginning of term, 10,829 schools. Registration, however, does not stop once the term has begun; it goes on throughout the year and there is every indication that last year's figure of 12,112 schools listening to the broadcasts specially given for them will be substantially increased before the autumn of 1944.

In studying registration figures for the years 1937-1943, one significant fact stands out. In spite of dislocation due to evacuation and other disturbed conditions, registration has more than doubled between 1940 and 1943. Comparative figures are:

1940-41	beginning	5,206,	end 7,022	(Registration in-
1941-42	,,	9,960	,, 11,299	complete owing
1942-43	,,	10,429	,, 12,112	to disturbed
1943-44	,,	10,829		conditions.)

As registrations are flowing in steadily it is not unreasonable to anticipate that the total number of listening schools will reach 13,000 by the end of the current school year.

An interesting point is the number of schools who have listened consistently throughout the years, many since very early days. Thousands of young listeners have gained their first ideas of musical appreciation, literature and world history from Broadcasts to Schools.

Mice and Organ Men

A SPEAKER in the B.B.C. series "From all Over Britain: Stratford-on-Avon," said recently, "Our work is not without its humour. Organists—*and* organ-blowers—have their funny moments. Recently, I attended an organ which had been damaged by mice. I knew that, because when I arrived I found on the keyboard a little piece of paper on which the organist had drawn four little mice. I repaired the damage to the bellows, and before I left I made a little drawing for the organist. I sketched a mousetrap, a ferocious cat and a farmer's wife with a carving knife—just in case the organist didn't know how to deal with the mice!"

"Shipmates Ashore"

DORIS HARE, hostess of the Merchant Navy's programme "Shipmates Ashore," was formally elected an honorary member of the National Union of Seamen at the 52nd annual general meeting held recently. She is the first woman to be so distinguished.

Doris Hare is tremendously popular with officers and men of the Merchant Navy, both for her contribution to their favourite programme and the work she has done on their behalf. She has given many concerts for their benefit, and this money, and any additional sums sent to her, has been used to endow the Doris Hare Ward in the Henry Radcliffe Convalescent Home for seamen at Limpsfield. Cottages for aged seamen are also being built in the grounds of this convalescent home, and Doris is already planning to provide one of these, to be named "Susan's Cottage," in honour of her small daughter.

B.B.C. Arabic Poetry Competition

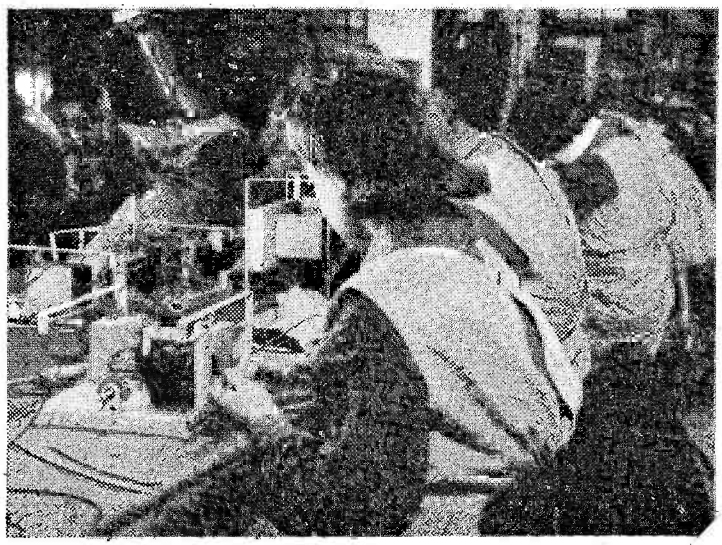
THE interest aroused by the B.B.C.'s Arabic Service and its popularity among listeners both of Arab and non-Arab stock is proved by the success of the third Arabic poetry competition arranged by the B.B.C. There were over 250 entries, and the first prize went to a Syrian for his poem on "The Youth Movement," the second to a Meccan whose theme was "The Underground Front in Europe," and the third to a Muslim Syrian living in West Africa for his poem on "Salah Al-Din al-Ayubi."

The poems were submitted to local stations in the Middle East, local prizes were awarded and the prize-winning poems sent to London for final judgment. This year an extra preliminary competition for Arab listeners outside the Middle East was held and the poems judged in London. North African poets competed for the first time and an interesting feature of the competition was that poems were sent in by Haussa religious leaders for West Africa. Judges for the finals of the competition were His Excellency the Egyptian Ambassador, His Excellency the Saudi Arabian Minister, the Iraqi Chargé d'Affaires and Professor Gibb, and the prize-winning poems were later broadcast in the B.B.C.'s Arabic Service.

"Germany's Dead Acres"

BROADCASTING in Radio News Reel, a B.B.C overseas programme, a Liverpool sailor gave striking proof of the terrific damage done to Germany by the R.A.F. The sailor was in a party of British prisoners of war who returned recently to this country.

Although the train windows were covered while the party went through Germany the sailor managed to note a great deal through a slit in the blind. They passed through Duisburg, Dusseldorf, Essen and Cologne, which they recognised because the names were on the stations. The railway goes through the busiest industrial part of those towns, and in the sailor's words, "There was no life—the place was dead right through the centre." City after city was the same. Most of it was flat, but it was obvious that the biggest damage had come from fires. No attempts had been made to clear it up. Bomb craters still gaped in the streets."



Borstal girls completing work on built-up chassis of radio power units.

A Battery-operated "Communication" 3-valver

An interesting Superhet Reflex Circuit Possessing Novel Features.

By D. B. HALL, B.A.

THE writer lives in Northern Rhodesia, and his next door neighbours are 25 miles away. The nearest town, electric light mains, cinema and doctor are 77 miles away by a road which is not always passable. Wireless is therefore supremely important, but there are several problems in the design of a receiver suitable for these conditions. It must be very sensitive in order to provide reliable reception from Daventry under all conditions, and it must also be very economical owing to the high cost of batteries in these parts. They are not only expensive, but very difficult to secure.

The result of four or five years' experimenting is described in this article. Although only three valves are used, the results are similar to those obtained with a superhet with two signal frequency amplifiers, frequency changer, separate oscillator, single I.F. stage, diode detector, triode L.F. amplifier and pentode output.

Frequency Changer

This is the critical part of the circuit, and the values shown should be adhered to. The valve used is a IA7G 1.4 volt type. A 2-volt heptode has been used successfully in this circuit with some modification to the coils, particularly the tapping point of the oscillator coil; this depends on the particular valve used and is best found by experiment.

An essential point is that the inductance capacity ratio of both tuned circuits must be kept high, otherwise it is impossible to get satisfactory oscillation in the oscillator section *and* satisfactory aerial reaction at the same time, and the exceptionally high gain of this stage depends on smooth reaction being available when required. With 50 mmfd. tuning condensers it is possible to cover 13 to 52 metres with three separate pairs of coils, with convenient overlapping. If the coils are wound as shown the two condensers can be ganged, provided there is some external means of trimming the aerial circuit. This is necessary when reaction is being used. The best method is to gang the condensers in such a way that the fixed plates of the aerial tuner can be rocked through a few degrees by means of a separate control. This method of trimming avoids throwing any extra capacity across the circuit. If it cannot be arranged it is probably better to have the two controls quite separate.

The tapping point on the oscillator coil is really critical, especially in the case of the smallest coil. The position of the tap not only determines the oscillator voltage, but at the same time it has a big effect on aerial reaction. If the tapping is too near the grid end of the coil the oscillator voltage will be too high, and as a result of this the screen current will drop to such a low figure that reaction on the aerial circuit will not be possible. But if the tapping is too low there will be insufficient oscillator voltage for satisfactory conversion, aerial reaction will be fierce, and there will be interlocking of the two tuned circuits. It should be noted that the screen of the valve is the oscillator's anode in this circuit. The real anode is joined to the screen and does little work. The circuit will function quite well with this electrode disconnected.

H.F.C.1. should be a small choke. It should be just large enough to prevent unwanted reaction effects via the H.T. battery, but not so large as to damp the I.F. transformer. H.F.C.2 is a filament choke with low

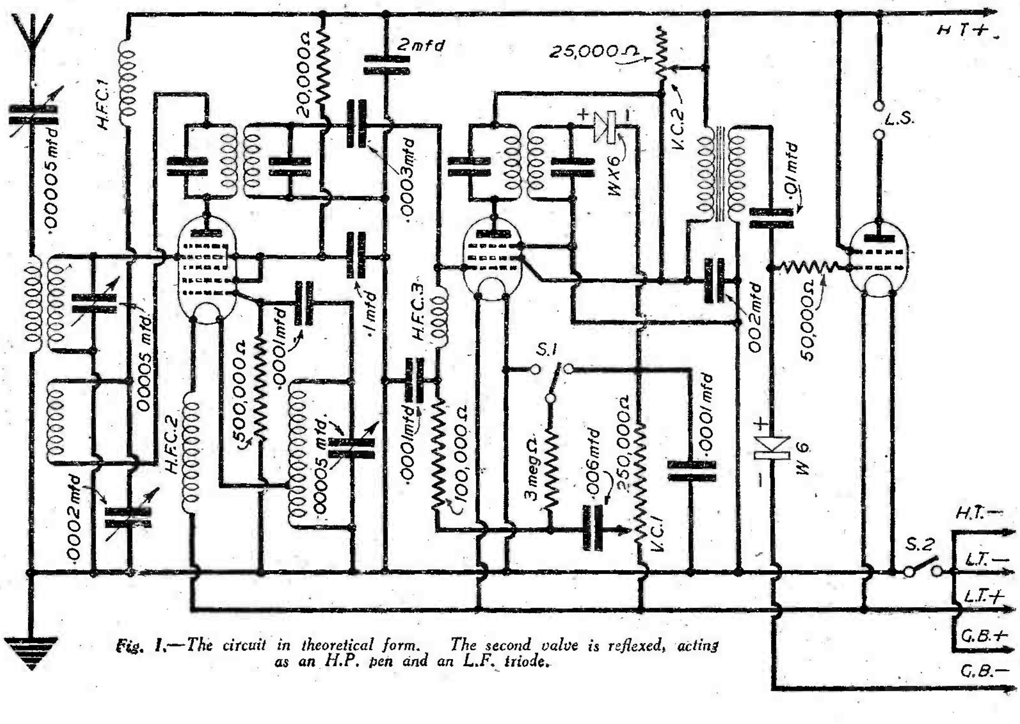


Fig. 1.—The circuit in theoretical form. The second valve is reflexed, acting as an H.P. pen and an L.F. triode.

resistance, and functions exactly as does a similar component in a straight circuit with electron coupled reaction.

The I.F. transformers can be any good quality components tuning to 465 kc/s or thereabouts, but the capacity of the primary trimmer of the first transformer must be not less than 50 mmfds. when adjusted, otherwise too great an impedance will be offered to signal frequencies for satisfactory reaction to be obtained. Air-spaced trimmers are an advantage from the stability point of view. The writer uses the Varley "Air Tune" transformers with great success.

Reflex Valve

The second valve is reflexed. If the circuit is studied it will be seen that as an I.F. amplifier the valve functions as an ordinary pentode, but that when amplifying at L.F. it behaves as a triode, the screen and anode being connected by the primary of the I.F. transformer which has negligible impedance at speech frequencies. This results in a much better performance than is given by normal reflex methods, especially as regards quality. The filtering is ample for its purpose, but not enough adversely to affect quality. It will be seen that for low frequency purposes the total capacity across the grid circuit is .0005 mfd., and across the anode circuit .002 mfd. This provides a modicum of tone control which saves such a circuit being needed across the output valve.

H.F.C.3 should be a really good choke of the screened all-wave variety. It should have a high impedance and a low self capacity, otherwise it will affect the I.F. amplification.

Second Detection and A.V.C.

Second detection and the provision of A.V.C. are carried out by a WX6 type Westector. The A.V.C. can be switched in or out as required. The Westector is biased by means of the filament circuit so as to be sensitive to very weak signals. The A.V.C. works surprisingly well. Although it is applied only to one valve it is effective on two stages owing to the reflex action.

The L.F. transformer should be a good one. The impedance of the valve as an L.F. amplifier is normally fairly low, being essentially a triode at this frequency, but the impedance rises to a high value when the valve is being heavily biased by the A.V.C. If a poor transformer is used the quality will become thin as the strength of the carrier increases.

Two manual volume controls are provided. V.C.1 is the important one, as it prevents overloading of the reflex valve, but if used alone it is found that a powerful signal cannot be fully controlled owing to a certain amount of L.F. break-through via the 3 meg. A.V.C. feed resistance. It is convenient to gang V.C.2 with V.C.1.

A IN5G valve is used in the circuit described. If it is desired to make up the set with 2 volt valves an H.F. pentode should be chosen with characteristics that allow the full voltage to be applied to the screening grid. A Mazda VP210 is suitable among others. The circuit should also be modified to allow s nding bias to be applied to the control grid of the 2-volt valve in order to avoid excessive anode current when receiving weak carriers or when the A.V.C. is switched off. The bottom of V.C.1 should be connected to earth instead of to L.T.+, and the bottom of the secondary of the I.F. transformer and the point of the A.V.C. switch connected to earth should both be taken instead to a low tapping on the grid bias battery. This will ensure a reasonable anode current and will also give correct bias to the Westector for rectification of weak signals.

Output Valve

This part of the circuit is standard except for a simplified economy arrangement employing a W6 type Westector. About twice the normal grid bias voltage is required. With the IQ5G valve 9 volts is correct. About 15 volts would be wanted for the IC5G.

Construction

Although the overall amplification is very high, this amplification is carried out at several widely separated frequencies so that the circuit is inherently stable provided normal precautions are taken. The aerial and oscillator circuits should be screened from each other and the usual methods should be adopted with regard to the I.F. circuits. In the writer's receiver the first I.F. transformer screens the two coils from each other, H.F.C.3 is a screened component, and low capacity screening is used round the grid lead to the reflex valve. That is all and it appears ample. For convenience in experimenting the set has been assembled on a metaplex baseboard with all components and wiring visible.

The coils are critical, as mentioned above, and should be carefully made. They are made on standard 1½in. formers with standard ribs and threading. Single spacing is used for all coils *except the smallest oscillator coil, which alone is double spaced.* Twenty-two gauge wire is used for all windings except the aerial coupling coils, for which 30 gauge wire is used. These aerial windings are interspaced with the lower part of the grid winding, and the bottom of the aerial winding is connected to the series aerial condenser. Windings for use with a IA7G valve are as follow:

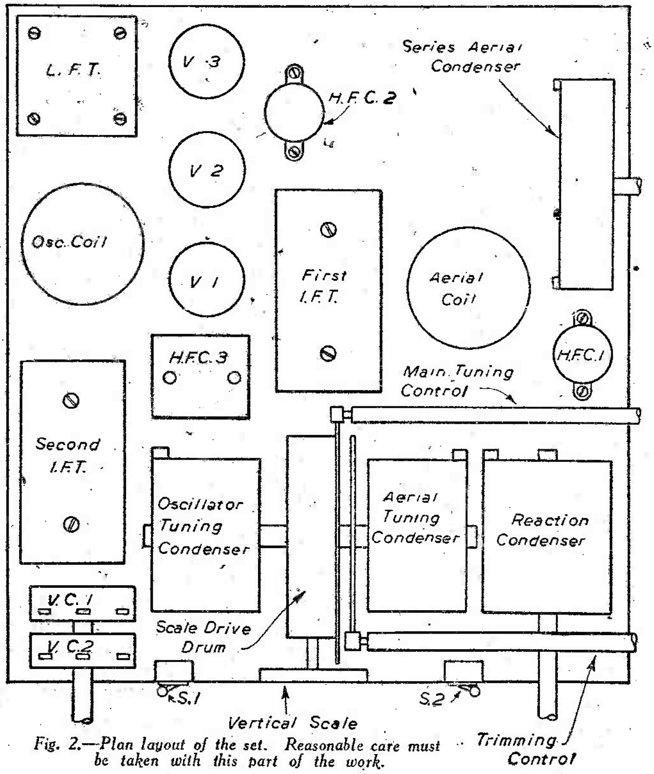


Fig. 2.—Plan layout of the set. Reasonable care must be taken with this part of the work.

Aerial Coil			Oscillator Coil	
Grid	Reaction	Aerial	Coil	Tapping from bottom (doublespaced)
5	3	$1\frac{3}{4}$	$6\frac{1}{2}$	$1\frac{7}{8}$
$8\frac{3}{8}$	4	$2\frac{3}{4}$	$9\frac{3}{8}$	$1\frac{1}{2}$
16	9	5	$10\frac{1}{4}$	$2\frac{3}{8}$

The ranges covered by these coils are approximately 13 to $21\frac{1}{2}$ metres, 19 to $31\frac{1}{2}$ metres, and $30\frac{1}{2}$ to 52 metres.

Operation

It will be noticed from the coil details that the oscillator circuit is tuned to a lower frequency than the signal. This is contrary to usual practice, but is essential with this circuit as reaction will not work properly if the higher frequency point is used for the oscillator. If the tuning condensers are ganged the difficulty is not likely to arise, but if separate condensers are used the matter should be remembered.

The I.F. transformers must be trimmed in the usual manner. When this has been done the reaction control should be set to zero and a strong signal will soon be found by rotating the main tuning control. The aerial tuner should be adjusted for maximum response and the feel of the reaction control should then be grown accustomed to. Except on frequencies above about 16 megacycles, where there is a slight interaction of the controls, it will be found that reaction can be increased to oscillation point without the oscillator tuning being affected. The aerial tuner, or trimmer, will require slight readjustment with alterations of the reaction control, as in a straight circuit. This independence of the oscillator tuning is one of the good points of the circuit and is doubtless due to the Hartley type of circuit used.

If the controls are ganged, the coils carefully made and the series aerial condenser adjusted so that only a small amount of damping is present, it will be found that reaction can be adjusted to the critical point and then the whole of a band searched without touching the aerial trimmer or reaction control. Under these conditions the receiver will be in an extremely sensitive state and the L.F. volume control will have to be turned back to a point where it is only about one-fifth on, except for the weakest of signals.

It will be found that as reaction approaches the critical point of degree of I.F. regeneration will be introduced in addition to the signal frequency reaction with which the control is primarily concerned. This still further increases the overall sensitivity and also provides a marked increase in selectivity. With critical reaction there is not only a remarkable degree of second channel suppression, but a razor edged adjacent channel selectivity into the bargain. Under these conditions it may be necessary to slacken off the aerial series condenser in order to avoid overloading the frequency changer. This would entail a readjustment of the aerial trimmer and reaction control.

C.W. can be received by advancing the reaction control to just beyond the critical point.

It is an advantage to switch off the A.V.C. when searching for a weak station, the circuit being switched in again when the signal has been accurately tuned. A very good degree of control is provided. Here again, the reaction control is most useful as a means of regulating the A.V.C. effect. As the L.F. signal is controlled in addition to the intermediate frequency, it is possible for the volume to be overcontrolled. That is to say it is possible for the "troughs" to receive so much more amplification than the "peaks" that fading is still apparent only in reversed phase. Adjustment of reaction in conjunction with the L.F. volume control, and possibly the series aerial condenser, enables the operator to control most types of fading at will.

Using 1.4 volt valves and 90 volts H.T. the standing anode current should be about $6\frac{1}{2}$ milliamps. With A.V.C. switched on this will drop to about 5 milliamps or a little over, on receipt of a strong carrier. At full volume there will be momentary peaks of 15 milliamps, but the average consumption at normal volume levels is only about 8 milliamps. With 2 volt valves 120 volts H.T. is required, but the current consumption remains about the same with average valves.

The set works well from a vibrator unit provided the output is well smoothed. The smoothing choke should have a low resistance to direct current if the economy circuit is in use.

For a variety of reasons this circuit is not suitable without considerable modification, on frequencies below about 3 megacycles.

Intensified training of the Fleet Air Arm has been taking place in this country. Fleet carriers, apart from the smaller escort carriers, carrying bombers and fighters, into the sea war, are being used particularly to smash the menace of the U-boats. Big or small, they are manned by the highly trained men of the naval air service. The illustration shows the instructor with his "bats" which he uses to convey to the pilot who is practising to land on the correctness or otherwise of the attempts.

Two-valve All-dry Portable

Constructional Details of a Small and Efficient Receiver

THIS receiver was based upon that described by A. Melvill Elliott in the February, 1942, issue of PRACTICAL WIRELESS. (Fig. 1.)

The only midget component used was the L.F transformer, but this was by no means essential as there was ample space left around it.

The complete receiver measures 7½in. long, 7¾in. high, and 6in. deep, while the weight is little over 8lbs.

The Case

This was constructed from ½in. thick wood, and was made as small as would conveniently house the components and batteries. The back, consisting of a piece of stiff card, was tacked in place after the set had been tried out. (Fig. 2.)

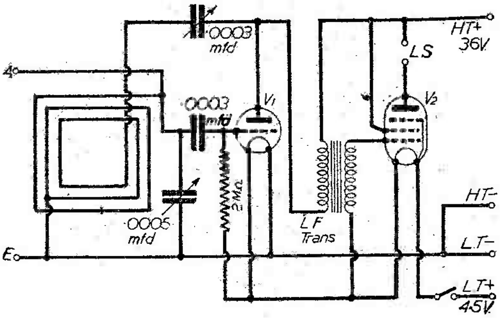
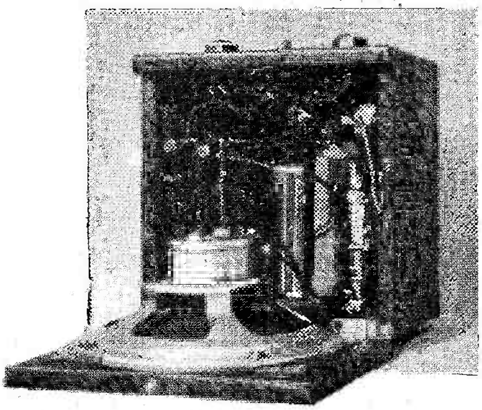


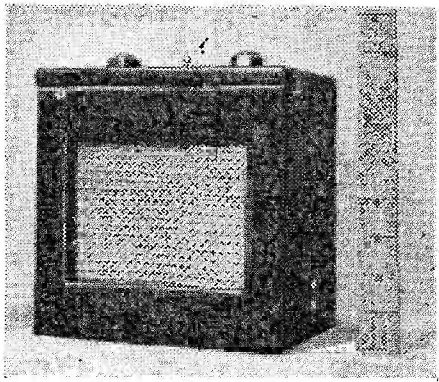
Fig. 1.—The theoretical circuit of the handy all-dry battery set.

A small ball catch was found to hold the hinged front in position quite securely, while the speaker opening was covered by suitable fabric.

After the set had been tried out and found to work satisfactorily, the case was covered with rexine. This was easily obtained from a furnishing store.



The complete receiver with speaker panel lowered.



The set is neat and compact, as this illustration shows.

The Frame Aerial

The frame aerial was constructed, as before, using 18 turns for the reaction winding, followed by another 18 turns for the grid winding. The actual wire used was 28 S.W.G. D.S.C., and it was found that the cardboard former could be cut down to 6½in. square to fit the case. (Fig. 2.)

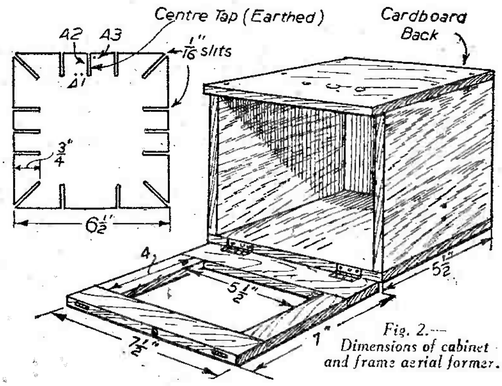


Fig. 2.—Dimensions of cabinet and frame aerial former.

Assembly

The right-hand side and top of the case were screwed together, and all the components mounted, except the pentode valve holder, which was screwed to the base. The wiring was then completed as far as possible before completely assembling the case.

The speaker, which is by no means the smallest on the market, was mounted with its transformer downwards, and in this way cleared the components and batteries when the front was closed.

Valves

Various combinations of valves were tried, but the best results were obtained by using a Cossor 210 HF as detector and a Mazda pentode output. These valves have small bulbs, but there was ample space for larger ones.

Batteries

The 36 volts H.T. was obtained from four 9-volt grid-bias batteries connected in series by short lengths of flex and wander plugs. Using a milliammeter which read on the high side, the total H.T. current was between 1 and 2 m.A.'s.

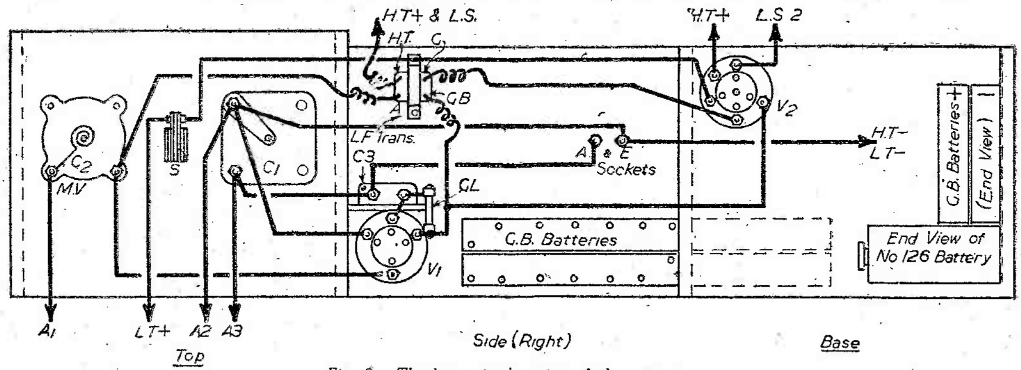


Fig. 3.—The layout and wiring of the receiver.

The L.T. was provided by an Ever-Ready No. 126 battery ($4\frac{1}{2}$ volts). A small series resistor (resistance depending on the valves used) was used in the connections to cut the voltage down to 4 volts. Two-volt valves were used, filaments connected in series. The position of the batteries is indicated in Fig. 3.

Range

The Home, Forces, and European News programmes were received quite clearly without aerial or earth, but with a short throwout aerial and earth the volume from all these programmes was quite sufficient for an average size of room. If an excessively long aerial was used some difficulty was experienced in separating the stations, but normally the selectivity was excellent.

LIST OF COMPONENTS

- One tuning condenser .0005 mfd. (Telsen bakelite dielectric reaction condenser), C1.
- One reaction condenser .0003 mfd. (Ready Radio), C2.
- One grid condenser .0003 mfd. (Telsen), C3.
- One on-off switch (Bulgin No. S.80), S.
- One L.F. transformer (Bulgin L.F.33).
- One 2Ω grid-leak (Dubilier). G.L.
- Two 5-pin valve holders (Telsen).
- Eight wander plugs ; two sockets.
- Two spade terminals.
- One detector valve, V1 (Cossor HF 210).
- One output pentode, V2 (Mazda).
- Four 9-volt grid bias batteries.
- One 4.5 volt battery (Ever-Ready No. 126).
- One $6\frac{1}{2}$in. Rola moving coil speaker.

Secondary Batteries—4

Initial Charge : Changing the Electrolyte : Charging "Low" Cells

By G. A. T. BURDETT, A.M.I.I.A.

Initial Charge

THIS charge is the most important charge of a battery and it is as a result of the treatment received during this charge that the ultimate length of useful life of the battery will depend. The same applies to batteries which have been replated and they are treated in the same manner in the initial charge.

New batteries are usually sold with Cellophane caps placed over the vent plugs. This is to keep them airtight, to prevent hydration and also to prevent the wooden separators from drying out. Seals should not be removed until just prior to the cells being filled with electrolyte for the initial charge.

Filling with Electrolyte. Lead Acid

Each cell, prior to the initial charge, must be filled with electrolyte to within $\frac{1}{4}$in. of the top of the plates. The S.G. of the electrolyte should be as stated on the maker's label. The cells are then stood for a period of 12 hours to allow the electrolyte to saturate the plates and separators. Although in some instances this period is exceeded, batteries must be put on charge within 24 hours of their being filled. The electrolyte should then be "topped up" with sulphuric acid of the same S.G. Do not exceed the maximum height of $\frac{1}{4}$in. above the top of the plates or the electrolyte will spray out of the vent during the gassing period. The battery is then placed on charge for a period of 36 to 60 hours at the correct rate of charge, according to the maker's instructions. This rate will be lower than the normal charging rate. At the end of this period there should have been no further rises in voltage of the cell, nor in the S.G. of the electrolyte for three hours.

Changing the Electrolyte

Batteries with wooden separators cause a reduction in the initial S.G. of the electrolyte owing to the water or moisture in the wood which further dilutes the electrolyte. For this reason electrolyte of higher S.G. is initially placed in the batteries than is required for their normal operation. For instance, with some batteries the S.G. of the initial electrolyte is 1.350, while that during normal operations is 1.270. At the end of the initial charge the original acid is poured out and the battery filled with electrolyte of the correct S.G. Most makers advise this change of electrolyte after the completion of the initial charge. Where sulphuric acid is difficult to procure such a procedure is not always possible except with batteries required for special duties, and this practice in other than exceptional circumstances is discontinued for the duration of war. Where the S.G. of the electrolyte is not reduced, e.g., the case of batteries with ebonite, glass or other non-absorbent material, a change of electrolyte is not necessary provided the makers are first consulted as to the desirability of such a procedure. In any event, makers' instructions should always be rigidly adhered to and any proposed deviation from them should be made only upon their advice. When the electrolyte has been changed the battery should be given a short refresher charge of about six hours at normal rates, during three hours of which there should be no further rise of S.G. and voltage in respect of each cell. It is a good plan to mark each battery undergoing initial charge to that effect, giving the time and the date when it is first placed on charge. Batteries on initial charge should, if possible, be charged separately from routine charges to prevent interference of current during their charging period. The series method only should be adopted. Before the seals are broken and the electrolyte is placed in new and replated batteries, first ascertain that the D.C. is available and that the charging plant is able to cope with such batteries immediately upon the expiry of the standing period.

With regard to alkaline batteries, the manufacturers prefer to carry out their own initial charging and batteries are usually delivered charged and filled with electrolyte with the vent holes plugged with wooden stoppers to prevent spilling. It is then necessary only to remove the wooden stoppers and give the alkaline batteries a refresher charge.

Routine Charging

Batteries received for charging will have various maximum charging rates according to their size and type. These will range from ½ amp. to 10 amps. or more. Few charging plants are flexible enough to allow each type to be charged at its normal rate. In practice the charging is arranged so that the batteries of the most

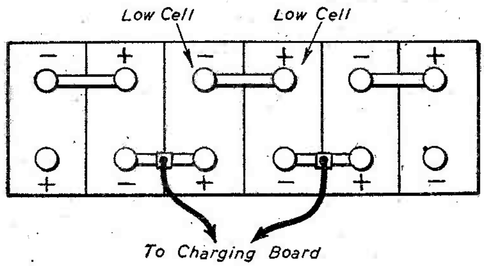


Fig. 2.—Connections for boosting two adjacent cells.

common types are charged at the normal rate, while odd batteries are charged simultaneously at the "popular" rate next lowest to the size. For instance, where a number of batteries are received for charging, the

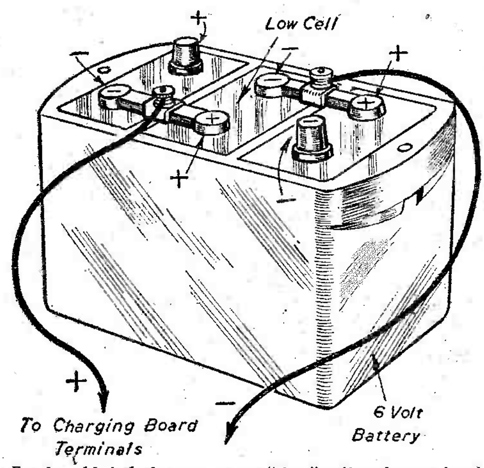


Fig. 1.—Method of connecting one "low" cell to charging board to prevent other cells being overcharged.

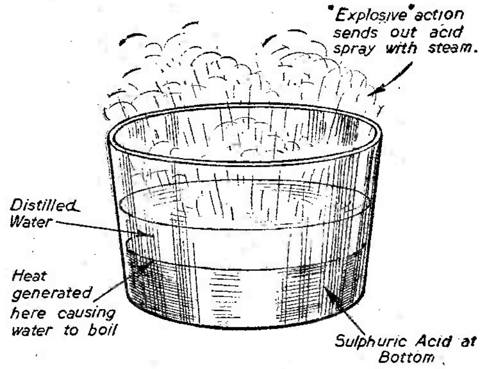


Fig. 4.—Wrong way of mixing electrolyte. Water must be poured in first.

capacity of the majority of which is 10 amp./hours and 20 amp./hours, the charging rate of each is 1 amp. and 2 amps. respectively. Two odd batteries are also included, the normal charging rates of which are 1.5 and 3 amps. The former will be put on charge at the 1 amp. rate and the latter at the 2 amp. rate.

The charging rate should not exceed that stated by the manufacturers, or the plates will be damaged and the temperature of the electrolyte will rise above the

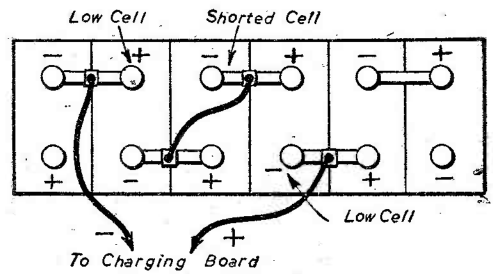


Fig. 3.—Showing how one cell is shorted by connecting two cells in series when they are not adjacent.

limit, e.g., 100 deg. F. The state of discharge of all batteries received will also vary, and, as a result, the circuit will frequently be interrupted for removal of batteries upon their becoming fully charged. In view of this, systematic testing of all the batteries on charge is therefore essential. The testing should be so arranged that each battery is tested at regular intervals, and as soon as the S.G. and the voltage have ceased to rise a record should be made to avoid overcharging or undercharging a battery where it is in circuit with batteries in a low state of charge.

Charging "Low" Cells

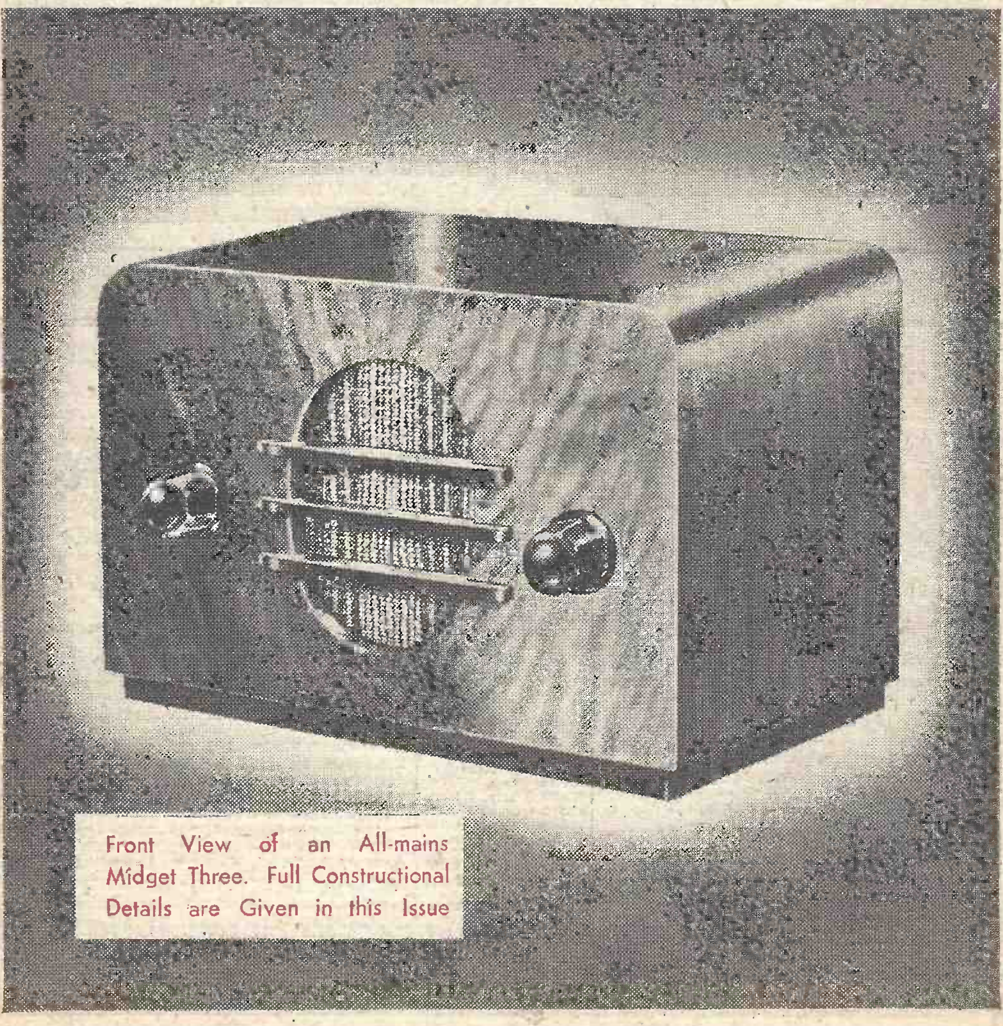
Frequently batteries are found to have one or more faulty cells indicated by low voltage, S.G. and the presence of gassing when other cells are fully charged. The simple remedy may be an extra period of charging, but unless the faulty cells are isolated this cannot be carried out without overcharging the remaining cells. Some batteries do not allow of such isolation as their connecting bars are not exposed. Such batteries should be taken off charge for further inspection and testing, and, if necessary, the sealing compound must be removed in order that the cell may be isolated for a special charging. Where the connecting bars are exposed it is a simple matter to fix a special clip (Fig. 6 illustrates a suitable type of clip which may be made, and how it is fixed on the connecting bar of a M.T. type of battery) on the bars to give the cells an independent

A COMMUNICATIONS THREE-VALVER

Practical Wireless 9D EVERY MONTH

Editor F. J. CAMM

Vol. 20. No. 450 NEW SERIES. DECEMBER, 1943



Front View of an All-mains Midget Three. Full Constructional Details are Given in this Issue

extra charge. Figs. 1 and 2 illustrate the method of boosting one low cell and two adjacent low cells respectively. When connecting care must be taken to ensure that the positive lead from the charging board is placed on the positive terminal of the cell in question, since the connecting strap of two cells is "positive" one end and "negative" the other. The polarity of the connecting strap is ascertained, therefore, in relation to the cell in question, as will be seen by Fig. 3. Where more than one cell in a battery is low and the cells in question are not adjacent one cell only may be given a boosting charge at a time. Were the two cells connected as in Fig. 3 the centre cell would be shorted, or if the cell was ignored it would receive an overcharge, since the current flowing through the two low cells will also flow through the healthy cell. Where the S.G. and voltage of cells are consistently low, obviously some internal fault must exist and must be located and rectified as further charging will only aggravate the trouble.

Renewal of Electrolyte

Sometimes the electrolyte in a battery has a low S.G. due to either spilling of the electrolyte or loss of electrolyte due to excessive gassing, and it is therefore advisable to renew it. It is pointed out, however, that electrolyte does not become diluted through ordinary evaporation, since water only is evaporated, leaving the more dense electrolyte in the cell. For this reason batteries are not "topped up" in normal circumstances with acid. Do not undertake the renewal of electrolyte unless it is definitely ascertained that the low S.G. is not due to a short-circuit of the plate or a low state of charge. Where all the cells of a battery are in such a condition the trouble is probably due to dilution. Before removing electrolyte fully charge and then test. If the electrolyte is still low drain it off and replace with that of the correct S.G. Do not fill a discharged battery with "charged" electrolyte, e.g., 1.270 S.G., or a charged battery with discharged electrolyte, 1.150 S.G. No mistake can occur where the battery is first fully charged and electrolyte of normal S.G. put in. Acid may be added to the existing electrolyte of a battery to correct it, but this is a difficult procedure since the S.G. of the resultant mixture must be correct, and it is difficult to judge when mixing acid of different densities in this manner. A more suitable method is to pour out the "low" electrolyte from the battery into a suitable container and add new acid until the correct S.G. is obtained.

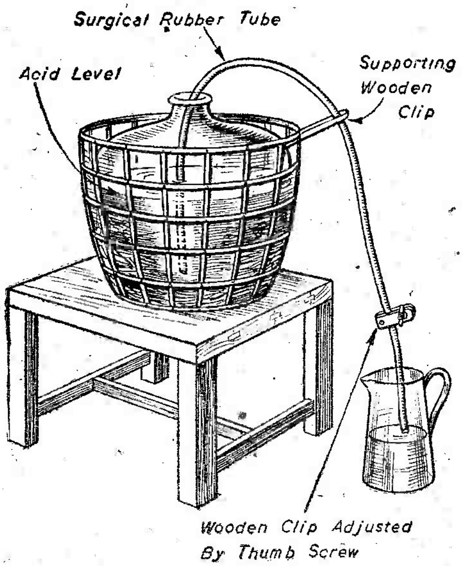


Fig. 5.—Simple method of siphoning sulphuric acid from a carboy.

Mixing Acid

Acid received in concentrated form, e.g., 1.840 S.G. or lower, but still above that required for batteries, has to be broken down to the required density. This procedure requires careful handling. The acid is usually delivered in 10-gallon glass carboys. Suitable mixing vessels of glass, wood, lead-lined wood or glazed earthenware must be used. When mixing, the distilled water must be placed in the vessel first *and the acid added to the water—never vice versa.* Were the water poured on to the acid the water, being the lighter, would not mix with the acid, but would float on top of it. At the level where the water joined the acid (see Fig. 4) heating action would be set up, causing the water to boil. The steam created would give rise to explosions and spray the acid over the operator. When mixing, acid should be added slowly and the liquid slowly stirred with a glass or wooden rod. Mixing slowly prevents undue rises in temperature, which should not exceed 100 deg. F.

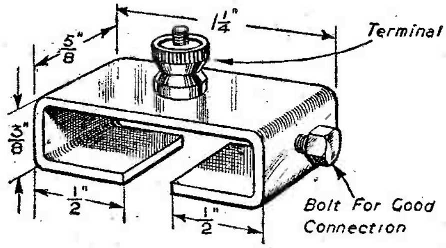


Fig. 6.—Dimensions of connecting clamp as shown in use in Fig. 1.

Extracting Acid from Carboys

The practice of tipping a carboy and pouring acid in a jug is to be deprecated, even where protective clothing and goggles are provided. In the absence of suitable acid pumps, stand carboys on a strong box or bench. Fill a length of ordinary surgical rubber tubing with distilled water, place one end in the acid and allow the water to run out of the tube. Then place a suitable clip over the tube and release as necessary, when the desired quantity of acid may be siphoned out. Fig. 5 illustrates this method.

Mixing Alkaline Electrolyte

Alkaline accumulators, as referred to previously, are usually charged initially by the makers and delivered in a wet condition. For the periodical renewals of electrolyte, viz., every 12 months, the electrolyte may be received in liquid form, when it should be treated, extracted from the carboys and poured into the cells in a similar manner to the lead acid. Often, however, alkaline electrolyte is delivered in crystal form, packed in sealed 4lb. tins, and special treatment is required. Obtain an earthenware or galvanised iron vessel for mixing. Allow one tin of 4lb. of crystals to one gallon of water, or similar quantities *pro rata*, pouring in the distilled water *and gradually add the crystals to the water* and stir slowly until all the crystals have dissolved. When the temperature of the solution has dropped to about 60 deg. F. test the S.G., which should be 1.190. The solution may then be stored in glazed earthenware containers used expressly for alkaline. Do not, on any account, use vessels which have previously contained sulphuric acid.

YOUR SERVICE WORKSHOP—9

A Shadow Output-meter

Testing and Operating. By STANLEY BRASIER

(Continued from page 508, November issue)

Construction

THE plate on which the coil, magnet and movement are mounted must be made of non-magnetic metal, otherwise the instrument will not function. Aluminium of stoutish gauge will do, and should be cut, drilled and bent to measurements given in Fig. 8. The small end plate in which the light aperture is cut is at right angles to the base at its narrow end, and is included in one piece with the cover (see Fig. 10). The coil, magnet and movement are mounted on the base plate in a similar way to that of the original shadow tuner, except that, owing to the different position of rest required of the needle, the coil bobbin—with the magnet in place—is swivelled round so that the outer part of the coil bracket engages the segment shaped slot (see Fig. 9), and which enables the coil to be turned to and fro slightly. By this means a suitable zero position for the pointer may be found after which the screw holding the whole assembly may be tightened. If the pointer is now slowly moved with some fine instrument towards its maximum position, a point will be found where the magnetic resistance is overcome, and the pointer moves quickly to the rear. At this point a small stop is stuck —with a spot of wax—to the base, and may consist of a short stub of bristle just long enough to stop the pointer going past. (Fig. 9.)

At this stage the movement may be tested by connecting the various voltages of, say, a grid bias battery across the coil. If the needle tends to swing the wrong way the polarity of the battery should be reversed. The action should be consistent and "easy," and the bristle pointer should, at all points of its travel, be dead vertical as any slight cant either way will be greatly magnified on the screen.

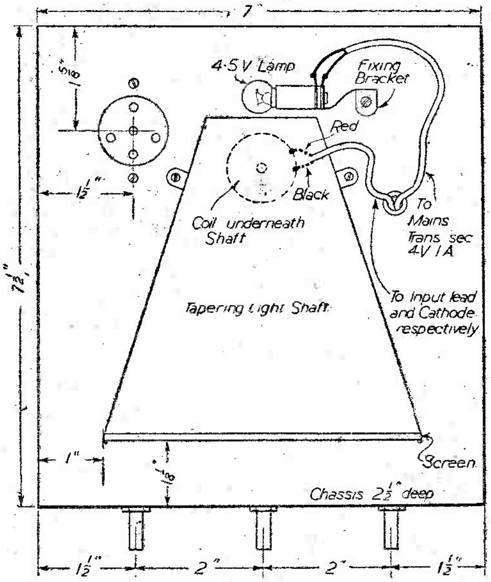


Fig. 5.—Top of chassis, showing position of light shaft, and wiring details.

The cover for the base plate may be made from any thin metal—an old tin of suitable size would do—and cut out to shape as in Fig. 10. It is then bent up to form the tapering box affair, a good idea of which may be gained from the illustrations. The two nuts and bolts which secure the cover to the base (at the front) pass through

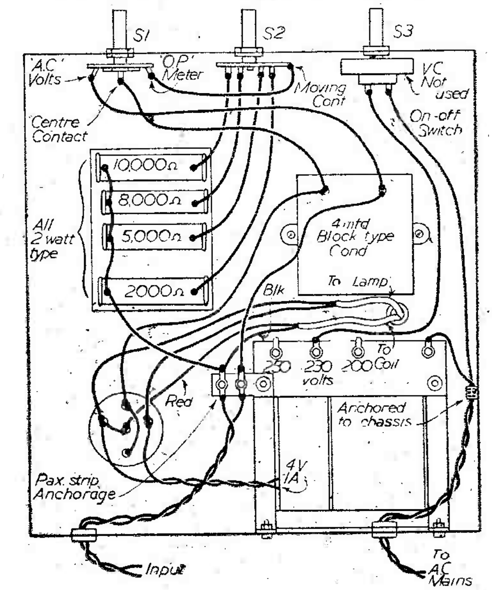


Fig. 6—Underchassis layout, and wiring diagram.

the chassis also, and are fixed with another nut. Two angle brackets are soldered to the sides of the cover, towards the other end, to act as supports, and so that the movement becomes level and parallel to the chassis. The box need not be absolutely "light tight"—it will not be, owing to the bend in the base plate—but it is advisable to paint the inside dull black, or it can be "smoked" with a wax taper in order to obviate any reflected secondary rays. The position and size of the aperture in the small end plate is important, as also is the position of the lamp, and for this reason it is mounted on a simple adjustable bracket so that the bulb is placed right up to the aperture and is capable of slight up and down adjustment. The best sort of paper to use for the screen is typewriting copy paper, and this is placed behind a piece of thin clear glass cut to the size of the large opening and secured by bending over the clips provided on the front of the cover.

The construction of the rest of the instrument is quite straightforward. It is built on a chassis measuring 7in. × 7½in. × 2½in. bent up from one piece of tinned iron and the corners soldered. The remaining parts, except the valve, are all mounted underneath the chassis. The transformer has a standard 4-volt secondary which feeds the diode heater and the 4.5-volt lamp, although, in the original, a few more turns of thinner wire (28 S.W.G.) were put on so that an extra tapping of 5 volts provided good illumination for the lamp. The load resistors are of nominal value calculated to suit the requirements of varying types of output valves. Each resistor is made up of two 1 watt in parallel, thus giving a rating of 2 watts to each value, but this may, of course, be increased if required. They are all mounted on a paxolin group board, and the switch S.2; which selects either of these resistors, is a S.P. four-way rotary of the Yaxley pattern, while S1 is a rotary S.P.D.T. switch, and any type making sound, positive contact may be used. The switch from a disused volume control makes a convenient rotary on/off switch, which method was adopted in the original. The 4mfd. condenser must be of the block type—not electrolytic—with a working voltage of 250 or over. Wiring of the instrument (Figs. 5 and 6) is extremely simple, as may be judged from the under-chassis illustration.

It will be noted from Fig. 5 that the screen is set back from the front of the chassis. This is to allow for the deeply recessed escutcheon fitted to the cabinet which is necessary in order to shade the scale from any bright outside light (otherwise the shadow of the pointer would not be seen). The escutcheon is made from pieces of tin soldered together, and measures $4\frac{3}{4}$in. × 2in. × $1\frac{1}{2}$in. deep, but this depth will depend upon the thickness of the front of the cabinet. The escutcheon allows only the upper half, approximately, of the screen to be seen; on the lower half there appears a shadow of the lower part of the movement, which is not wanted.

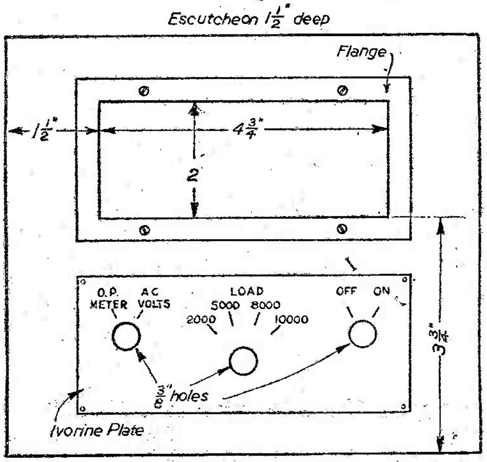


Fig. 7.—Showing size of escutcheon and layout of cabinet front.

Testing and Operation

After connecting the completed output meter to the mains, it may be switched on, and while waiting for the diode valve to warm up, the position of the lamp can be adjusted behind the small aperture until an even diffusion of light appears over all the visible portions of the screen. The zero and maximum positions of the pointer may now be noted, and the scale marked out in a manner similar to that shown in Fig. 11. No attempt has been made to calibrate the output scale, except in degrees, which is suitable for indication or comparisons.

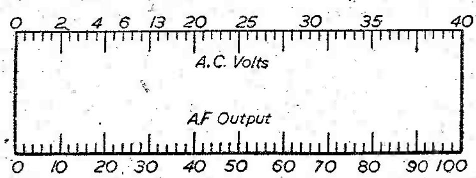


Fig. 11.—The scale fitted to the original instrument. The calibration of the A.C. volts scale must be carried out individually for each meter.

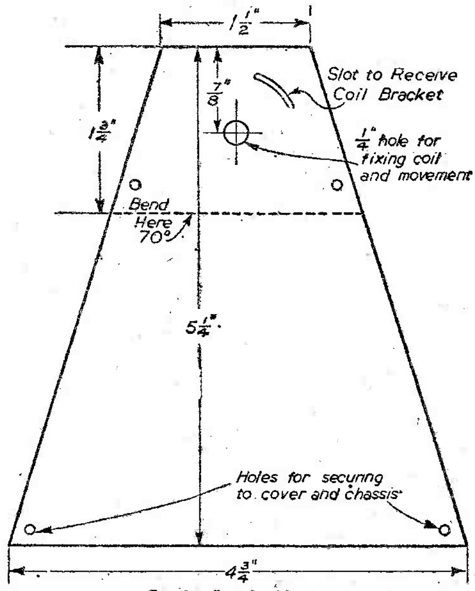


Fig. 8.—Details of baseplate.

In use the switch S1 is set to "output meter" and the input leads connected to the O.P. transformer *primary* of the receiver under test and into which a signal from a test oscillator or similar device has been injected. S2 is then adjusted to connect the load resistor most suited to the load of the output valve in use and, for the purpose of quietness, the speech coil of the loud-speaker may be disconnected. The instrument is quite sensitive and will respond to small changes of input as a tiny variation of the pointer will produce an easily visible change of the shadow on the screen or scale. The output meter will not work satisfactorily if joined across the O.P. transformer secondary—at least, not unless a very powerful signal is available which, in any case, is not practical.

Using on A.C.

The meter may also be used for A.C. measurements of a given frequency, and the scale can be calibrated for, say, 50 cycles. The switch S1 is turned to "A.C. volts" and the input leads applied to the voltage source; the meter will measure about 40 volts full scale. Two volts will give an indication on the scale of about $\frac{3}{8}$in., which is reasonably good, remembering that the movement is of the moving iron type and that not too much must be expected of it. Higher A.C. voltages—such as those of the mains—may be measured by joining a suitable

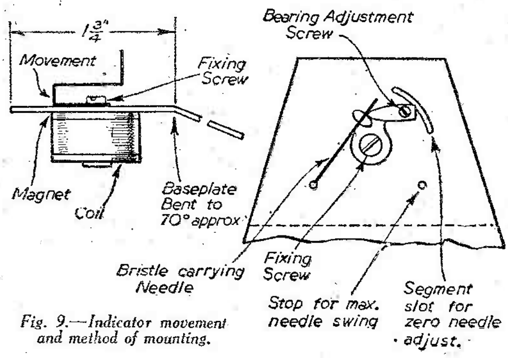


Fig. 9.—Indicator movement and method of mounting.

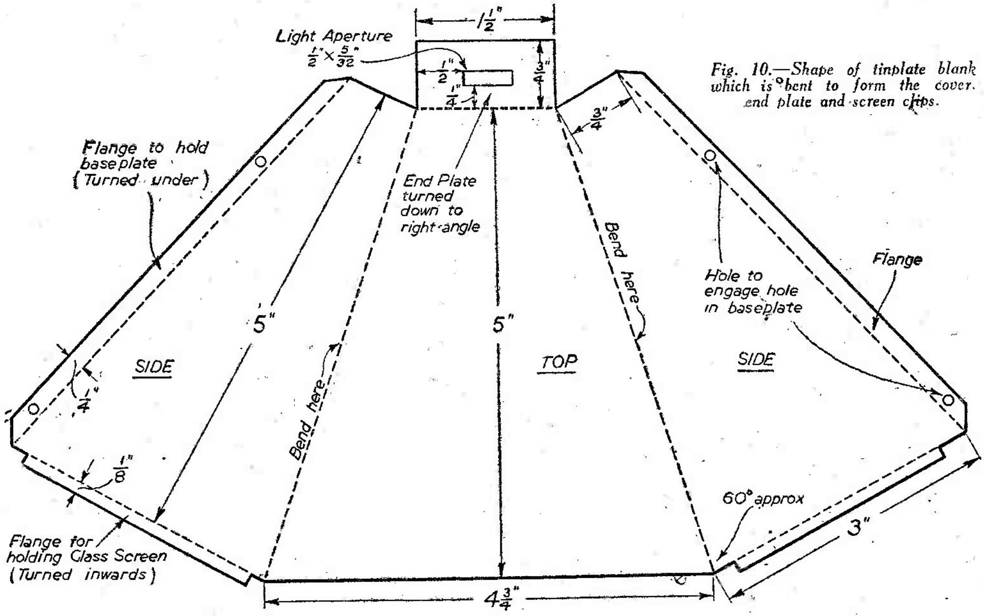
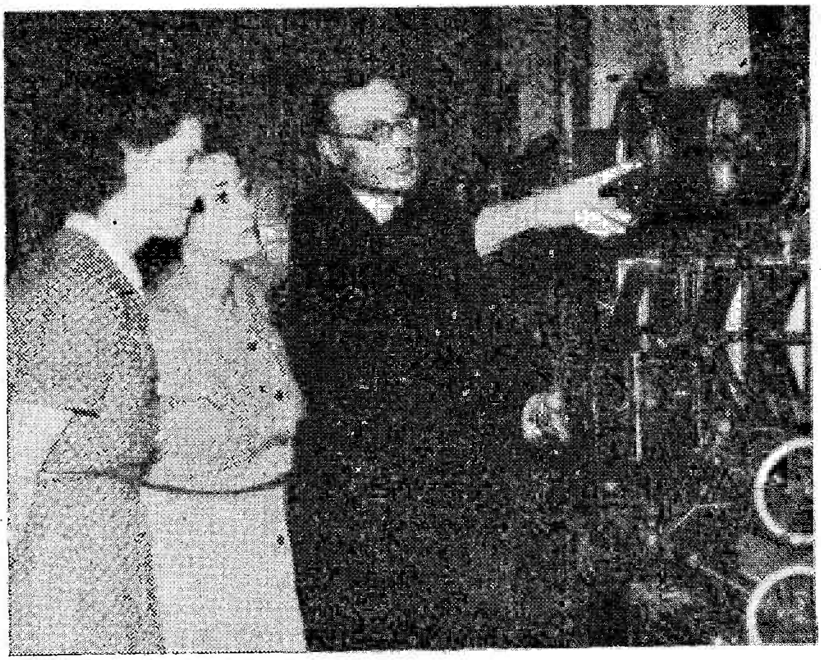


Fig. 10.—Shape of tinplate blank which is bent to form the cover, end plate and screen clips.

resistor in series with one of the input leads, and in this connection one of about 30,000 ohms provides a full scale reading of 250 volts approximately, the exact value of resistor being best found by experiment. Calibration, on the lower voltage range, is best carried out from the mains via a multi-tapped transformer and the one incorporated in the valve tester is eminently suitable since its range is from 2 to 40 volts A.C.



Faraday House, the mecca of training in the electrical world, has decided to open its doors to women. The Government offered bursaries to women and some are already in training. In the illustration Dr. Coode Adams, the principal of Faraday House, is seen explaining the motor generator switchboard to the first women students.

Low Frequency Amplifier Design—3

The Use of Pentode, Beam-tetrode and High-mu Triode Valves

(Continued from page 492, November issue.)

PENTODES have come into such widespread use during more recent years that it has become customary to expect to find this type of valve in the output stage of almost any type of receiver. What advantages do pentodes confer, and what disadvantages?

The principal advantage is in connection with the stage gain, especially when high-tension voltage is limited. It is possible, with a pentode, to obtain two or three times as much gain as with a normal small output triode used in the same general circuit arrangement. In the case of battery-operated sets, a single pentode will provide up to about half a watt of audio output; and this for the consumption of under 10 mA at 120 volts. To obtain a similar output with any triode valve would necessitate the use of a valve taking double the current, and operating at a much higher plate potential. This is true whether the valve is used as a class A amplifier or a pair of valves is used in a push-pull stage. Conditions are more favourable if class B is employed, but in that case the extra cost of components must be borne in mind.

Third-harmonic Distortion

Push-pull and class B amplifiers will be dealt with later, so nothing more will be written on that side of the question here. Most good things in this world have to be paid for, so one might well ask what disadvantages attach to the use of pentodes. The first is that the pentode gives rise to distortion of uneven harmonics—particularly the third. A triode also tends to produce a certain degree of harmonic distortion, but this occurs at even harmonics, and applies principally to the second harmonic.

The essential difference is that even harmonics are far less offensive to the ear than are odd harmonics. Hence the widely-held belief that the pentode does not give quality of reproduction equal to that of the triode. There is another important point in this connection: both types of valve give increased harmonic distortion as they approach the limit of their power-handling capacity. But whereas the rise in distortion with a triode is roughly proportional to the rise in output (within the working limits of any particular valve) the distortion increases more rapidly with a pentode as the output is varied from about one-fifth to the maximum.

Tone Compensation

In general, a pentode tends to emphasise the upper audio register. Because of that it is normally found desirable to apply some form of tone control or tone compensation. This can be done without much difficulty, but the result is to reduce to a certain extent the gain provided by the valve. On the other hand, there are cases in which a little extra amplification of the higher audio frequencies is desirable; it may then prove satisfactory to employ a pentode without any appreciable degree of tone compensation. This applies in the main to "straight" circuits where the utmost degree of selectivity has been provided, with the result that there is a noticeable attenuation of the upper register.

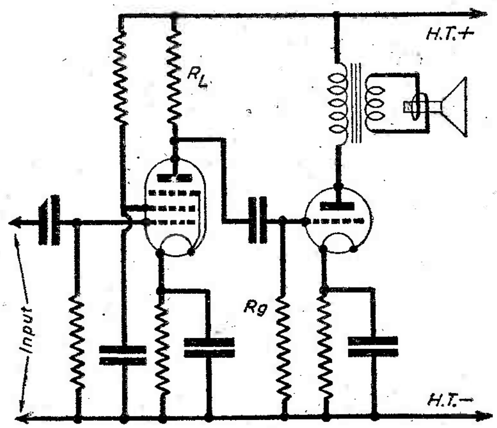


Fig. 2.—A two-stage amplifier with a pentode used as intermediate voltage amplifier and feeding into an output triode.

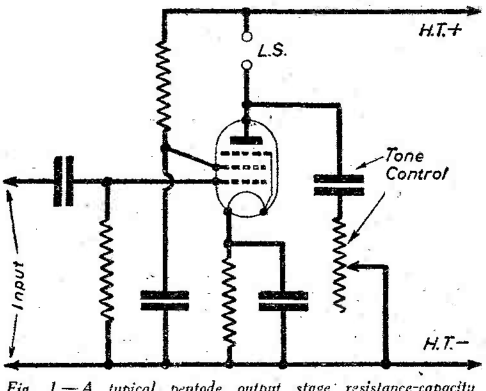


Fig. 1.—A typical pentode output stage resistance-capacity coupled to an intermediate L.F. amplifier.

Another tendency of the pentode—due largely to its higher amplification factor and higher impedances involved—is toward self-oscillation at audio frequency. This can be overcome by the application of negative feedback, which will call for due consideration later in this series.

Beam Tetrodes

So far reference has been made only to triode and pentode valves. What of the beam tetrode? This resembles a pentode in many respects, and gives a similar degree of gain. The connections to it are the same as to a pentode, the only "mechanical" difference being the omission of the cathode-connected suppressor grid. This type of valve, however, has one marked advantage over the pentode in that it introduces less third-harmonic distortion. It does, on the other hand, produce appreciable second-harmonic distortion. In general, the beam tetrode is to be preferred to the pentode, and for many purposes it may eventually be the cause of the pentode becoming obsolescent.

Pentode Circuits

Now let us turn to some of the more practical aspects of pentode-circuit design. Fig. 1 shows the circuit of a pentode output stage, resistance-capacity coupled to a preceding L.F. or detector stage. It works quite well in such a circuit, and has the advantage of very low "Miller Effect" grid-cathode capacity. This is due in the main to the screening effect between grid and anode of the suppressor and auxiliary grids. The values of the grid condenser and leak can be determined as previously explained in the case of triodes. The bias resistor and condenser can also be found by the application of

Ohm's Law; there are no known simplified methods of estimation.

The values of the auxiliary-grid decoupling resistor and condenser are not usually very critical, but the effect of changes should be considered. It should first be borne in mind that changes of auxiliary-grid voltage have more effect on anode current, and hence on gain and maximum output, than have changes in anode voltage. In fact, the anode current will be found to remain constant over a fair range of anode voltages, provided that the auxiliary-grid voltage remains unchanged. The reason is simply that the auxiliary grid is closer to the cathode than is the anode, and therefore has more controlling effect.

Component Values

A value of 2,000 ohms for the resistor is generally as good as any for all-round results, but values between 1,000 and 5,000 ohms can be used. Clearly, the value of this resistor affects the voltage applied to this grid, and therefore a higher value will result in lower gain and lower maximum output. It is because of this that in many simple and inexpensive battery sets the auxiliary grid is often connected directly to the H.T. supply line. That method of connection is not desirable from other points of view, and often emphasises the distortion. The inclusion of the resistor has a stabilising effect on the valve and tends to "iron out" the effect of differences in characteristics of different samples of valves of the same type.

The by-pass condenser is necessary in conjunction with the resistor to avoid the building up of audio-frequency voltages across the resistor; these would cause variations in voltage applied to the auxiliary grid and add to the distortion, whilst causing a loss in output. A capacity of 2 mfd. is often recommended for the by-pass condenser, but a much lower value is normally just as satisfactory, and obviously more economical. It also reduces the likelihood of hum. If a few tests are made it will nearly always be found that a capacity of .5 mfd. is fully satisfactory with resistances up to 2,000 ohms; and it is seldom desirable to go above this resistance unless it is desired to limit the gain and the valve is by no means fully loaded.

A simple form of tone filter or tone control is shown in Fig. 1. This takes the form of a fixed condenser in series with a resistor between the anode of the valve and earth. Values of .1 mfd. and 25,000 ohms are suitable when a variable control is required. If a fixed compensating filter is sufficient—as is generally the case—.05 mfd. and 10,000 ohms will suit most pentodes. Reducing the capacity of the condenser or increasing the value of the resistor will bring about a rise in the average pitch of reproduction.

Speaker Feed

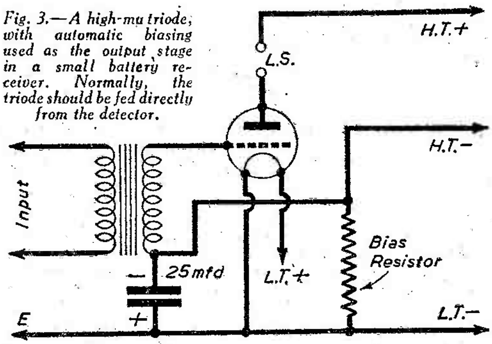
We now come to the final link in the chain: the speaker, or speaker transformer. This is very important, and introduces what is probably the greatest difficulty. If we are to have any pretence of matching, the impedance of the transformer primary must be high. But unfortunately, as explained earlier in this series, the impedance increases with frequency. Thus, although it may be well chosen for average audio frequencies, it may then be near resonance at the third harmonic of lower frequencies. In consequence, the third harmonic would be brought into increased prominence, and reproduction may be distinctly unpleasant. With normal methods of coupling that is a difficulty which must be tolerated. At the same time, the network which we have described as a tone compensator will virtually smooth out the variations in speaker-transformer impedance and thereby provide some relief from the trouble mentioned.

Pentode as Voltage Amplifier

It is not customary to feed the output from a pentode into a triode, but this may be done. Alternatively, it may be fed into a push-pull stage. This arrangement would normally be used only when it was required to obtain a fairly large output and when it was wished to avoid the use of two intermediate voltage-amplifier stages. Nevertheless, the pentode can be used to good purpose, and it does give a high degree of voltage amplification for a very economical consumption of H.T. and L.T. current.

Fig. 2 shows a circuit of a two-stage amplifier in which a pentode is resistance-capacity coupled with a triode power-output valve. The choice of auxiliary-grid resistor and condenser is governed by the factors already dealt with, so we have to consider only the values of anode resistor and grid condenser and leak. Matching, as considered for triodes earlier, is out of the question because of the high internal resistance of a pentode. The higher the value of R_L the greater the stage gain (provided that the available H.T. voltage is sufficient) and the greater the attenuation of the higher audio frequencies. Suitable values normally lie between about 100,000 ohms and 500,000 ohms, and a resistor of 250,000 ohms will be found suitable with almost any pentode. If the bias resistor is of the normal value, determined as for a triode, it is possible to use a comparatively low H.T. voltage without the anode potential falling too seriously. This is because of the low resulting anode current. And since the valve is used purely and simply as a voltage amplifier, and if the applied grid voltage is low, a very satisfactory signal voltage can be fed to the triode by using the normal H.T. voltage of 120 or 250, for battery and mains valves respectively.

Fig. 3.—A high-mu triode, with automatic biasing used as the output stage in a small battery receiver. Normally, the triode should be fed directly from the detector.



The grid leak, marked Rg, should have a resistance equal to about twice that of the anode load resistor, whilst the value of the grid condenser may be about .05 mfd. Due to the constant impedance of the anode load, frequency distortion will not be a serious factor. Because of the high shunt impedance, the "Miller Effect" capacity of the triode will come into prominence. This may be more of an advantage than a disadvantage, since it will tend to give a "cut" of the higher frequencies.

The Output Tetrode

So far little reference has been made to the output tetrode, although it has been stated that this valve has most of the advantages of the pentode, without the most important disadvantages of producing third-harmonic distortion. The method of using it is practically identical with that applying to a pentode; in fact, it would be possible to substitute a tetrode for a pentode in almost any circuit, without doing any more than adjust the grid-bias voltage to suit the new valve. It is not, therefore, necessary to deal here with any particular tetrode circuits.

High-mu Triodes

So-called high-mu triodes have been in use for a number of years in the output stage. In general, it is the battery-set high-mu triode which is most widely employed. It has a high value of mutual conductance (the figure may approach 4 mA./volt for a two-volt valve) and a comparatively high internal resistance—

in the region of 5,000 ohms for a battery valve. This type of valve is more sensitive than the normal small power valve; that is, the output provided for any given small input is greater than is the case with other types of triode. In this respect it can be said to fall between the normal triode and the pentode. The chief disadvantage is that it is capable of handling only a small input, whilst the available output is normally limited to around 200 milliwatts.

Correctly employed, it is very convenient when in search of good reproduction with a small battery set designed for economy in prime cost and battery-current consumption. The setting of the bias voltage should be arranged with the utmost care, for which reason it is highly desirable that automatic bias should be employed, a circuit for this being shown in Fig. 3. The value of the bias resistance is determined by the normal application of Ohm's Law, but it should be remembered that the current passed through the resistor is the total cathode current taken by all the valves in the set. As the approximate bias voltage required is 4.5, and the average battery set takes about 10 mA, it will be seen that the bias resistor should have a value in the region of 500 ohms. It is well worth while to use a good variable resistor of 1,000 ohms and set this carefully for maximum output and optimum quality of reproduction.

Oscillators

Anode Load Inductive. Grid Circuit at Operating Frequency. Equivalent Circuits. Crystal Oscillators

(Concluded from page 495, November issue.)

CASE 3. Anode Load Inductive

THIS time the stage reduces to the circuit of Fig. 11, where again the vector representations are given.

This time, the angle θ is positive, and therefore both $\sin\theta$ and $\cos\theta$ are also positive.

$\therefore R_i = -1/m\ \omega.\ C_{ga} \sin\theta.$

i.e., a negative resistance.

Thus, under these conditions the damping of the input circuit may be offset by the energy fed back from the anode circuit and oscillations set up in the grid circuit may be maintained provided the anode circuit is sufficiently inductive.

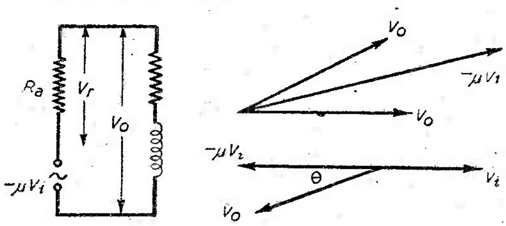


Fig. 11.—As for Fig. 10, but in this case with the anode load inductive.

Hence for TP/TG circuit to oscillate the anode circuit must be inductive, i.e., it must be tuned to a frequency *above* the operating frequency.

We shall now consider the grid circuit.

CASE 1. Grid Circuit at the Operating Frequency

Suppose that the natural frequency of oscillation is that of the grid circuit, i.e., let the grid circuit be tuned to resonance. As we know, for oscillations to be maintained, the anode voltage must have a component which is antiphase to v_i. In the above case, as the diagrams of Fig. 12 will point out, this condition is not obtained and consequently oscillations would not occur.

CASE 2. Grid Circuit Capacitive

This is self-explanatory from a study of Fig. 13. Again V_a has no component antiphase to v_i and therefore oscillations cannot be maintained.

CASE 3. Grid Circuit Inductive

Fig. 14 shows in this case that it is possible, when the grid circuit is inductive, for V_a to have a component antiphase to V_i. Oscillations can therefore be maintained.

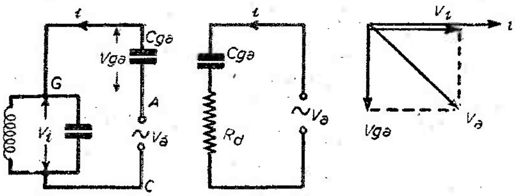


Fig. 12.—With the grid circuit tuned to the operating frequency oscillations cannot be maintained.

The important result, therefore, is this: the anode and grid coils must be tuned to a frequency *higher* than that of the required operating frequency.

Equivalent Circuits

In Fig. 15a is shown the equivalent circuits connected by the C_{ga} of the valve. So far as total reactance is concerned it can be replaced as shown in Fig. 15b, thus obtaining effectively a series circuit, the resonant frequency of which will be:

$$f_0 = 1/2\pi\sqrt{(L_a + L_g)\,C_{ga}},$$

and this is approximately the frequency at which the

(Continued on page 19.)

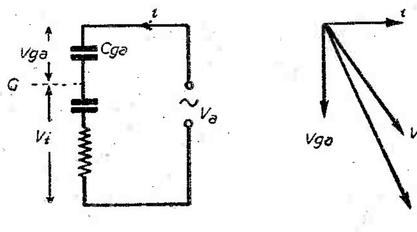
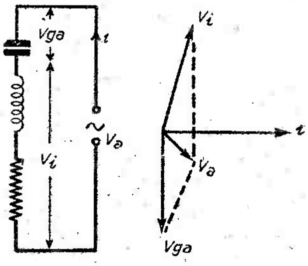


Fig. 13 (left).—Oscillations cannot occur when the grid circuit is capacitive.

Fig. 14 (right).—When the grid circuit is inductive it is possible for V_a to have a component antiphase to V_i.



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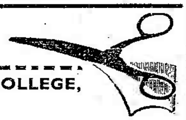

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TP/TG will oscillate. The amplitude of the oscillations depend in a rather complex manner on the ratio of L_a to L_g, hence, for a certain frequency and a maximum amplitude there is only one setting of the anode and grid tuned circuits.

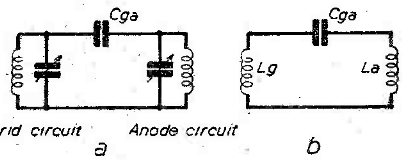

Fig. 15.—By reducing the simple equivalent in this way, the frequency of operation of the oscillator is given by $1/2\pi\sqrt{(la+lg)\,Cga}$.

The frequency control is usually greater in the circuit having the higher Q.

Crystal Oscillators

The crystal oscillator is a TP/TG oscillator in which the grid tuned circuit is replaced by a piezo-electric crystal (Fig. 16).

Rochelle salt, tourmaline and quartz crystals exhibit marked piezo-electric effects, that is, if a pressure is exerted between two opposite faces of a slice of such a crystal, a p.d. is set up between the faces. If the pressure is changed to a tension a p.d. of opposite polarity is the result. Consequently, if an alternating pressure and tension is applied, an alternating p.d. is produced between the faces. The converse effect can also be produced, i.e., if an alternating p.d. is applied a mechanical vibration tends to occur.

The amplitude of these vibrations is very marked at the natural frequency of vibration of the crystal, and so in this respect the arrangement resembles a tuned circuit. The change in amplitude of the oscillations for a small change in the frequency is very marked, that is, the crystal has, in effect, a very high Q, probably several thousand.

Consider the circuit of Fig. 16. The crystal is included in the grid circuit and a grid leak is provided to allow any D.C. grid current to flow to earth. The crystal has a very much higher Q than the anode circuit and so the frequency of operation will be very nearly that of the crystal.

The natural frequency of a crystal depends upon several things:

(a) The type of crystal—generally quartz—is employed for radio work.

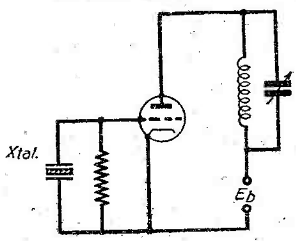

Fig. 16.—The TP/TG oscillator, where a crystal replaces the tuned grid circuit.

(b) The crystal cut—the inclination of the slice to the various axes.

(c) The dimensions of the slice—frequency increases as thickness decreases, the upper frequency limit generally being around 15-20 megacycles per second.

(d) Temperature—the natural frequency normally varies with the temperature, though special cuts can be chosen to give almost zero temperature coefficients.

Effect of Tapping a Tuned Circuit

Tapping points are sometimes taken across part of the anode tuned circuit of oscillators, and the effect this has on various circuit conditions will now be considered. In Fig. 17a is shown the normal untapped tuned circuit, while in Fig. 17b is the tapped version.

If we assume that there is no mutual coupling between the two sections of the coil, L_1 and L_2 of this latter figure, then the two circuits may be compared in the following way:

For Circuit A:

Resonant frequency $= 1/2\pi\sqrt{LC}$.

Dynamic resistance $= L/CR$.

For Circuit B:

At resonance the reactance of path 1 is equal to the reactance of path 2.

$$\therefore\ 1/\omega C - L_2 = L_1$$
$$1/\omega C = \omega(L_1+L_2)$$
$$\omega^2 = 1/C(L_1+L_2)$$
$$\text{and } \omega = 1/\sqrt{C(L_1+L_2)}$$
$$= 1/\sqrt{LC}.$$

The resonant frequency of the circuit remains, therefore, unaltered, though in practice the mutual coupling between L_1 and L_2 does have some slight effect.

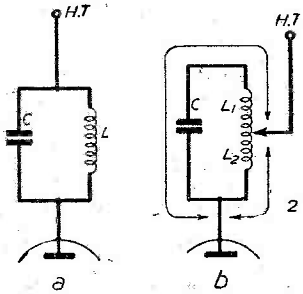

Fig. 17.—Effect on circuit conditions of a tapping point on the anode circuit.

As regards the dynamic resistance, the capacitance of path 1 is effectively increased, while the inductance of path 2 is effectively reduced. Thus the L/C ratio is effectively reduced; as is the R_D and the selectivity.

The tapping point, therefore, can be adjusted so that the tuned circuit presents the correct load impedance.

PRIZE PROBLEMS

Problem No. 450

NASH was building an A.C. receiver in which an H.F. pentode was used in the H.F. stage. Following the valve maker's instructions, he arranged for a potentiometer network to supply the H.T. voltage to the screening-grid. The potentiometer was made by connecting two resistors in series across the H.T. positive and negative, the junction of the two resistors forming the supply point for the screen. On test results were quite good, but the resistors became very hot, and Nash thought that the current flowing through the potentiometer was too great. On thinking the matter over, he decided that the voltage on the screen must be correct—as results were so good—therefore, to cut down the current he thought he would insert another resistor in series with the one on the earth side of the screen. This had the effect of preventing the potentiometer warming up, but results were nothing like the original. What was wrong and what should Nash have done?

Three books will be awarded for the first three correct solutions opened. Address your solutions to The Editor, PRACTICAL WIRELESS, George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Envelopes must be marked Problem No. 450 in the top left-hand corner, and must be posted to reach this office not later than the first post on Thursday, November 11th, 1943.

Solution to Problem No 449

Had Robinson possessed a reliable voltmeter, he would not have been puzzled as to the cause of the distortion. The fact that the removal of the G.B. plug helped to improve matters should have given him a clue to the trouble; a test of the applied H.T. voltage was obviously indicated, and if Robinson had used a meter he would have found that the H.T. voltage was well down. The G.B. battery was, apparently, still in fairly good condition, and was applying a bias voltage suitable for an H.T. voltage of 120 volts, thus over biasing the output valve which was now receiving a much lower H.T. voltage owing to the fact that the battery was down.

The three following readers successfully solved Problem No. 448, and books have accordingly been forwarded to them. H. C. Greenway, 6, Wilderness Mount, Sevenoaks; J. Robertson, Aukengill, Wick, Caithness, Scotland; Cpl. W. J. Williams, 23, Monfa Road, Orrell, Liverpool 20.

Practical Hints

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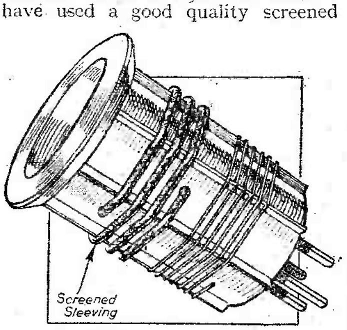
SPECIAL NOTICE

All hints must be accompanied by the coupon cut from page iii of cover.

Making S.W. Coils.

IN the making of short-wave coils, it is a well-known fact that the higher frequencies travel on the surface of the wires. So when making coils for the 10- to 19-metre bands I have used a good quality screened sleeving (plaited type) for the grid winding, as shown in the accompanying illustration, with a considerable increase in signal strength. It is necessary to make a good joint in soldering the braided sleeving to the coil pins.—R. B. DOUGLASS (Ashington).

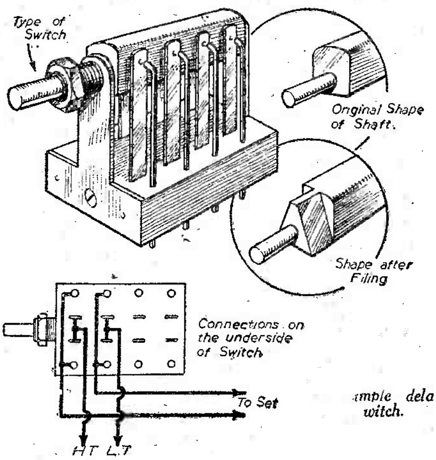


Using braided sleeving for a short-wave coil.

An Improvised Delay Switch

HAVING recently obtained an A.C. mains eliminator for use with my receiver, I realised that the switch incorporated in the receiver was inadequate as the L.T. should now be switched on before the H.T. and off after the H.T. This indicated a switch of the "delay" type.

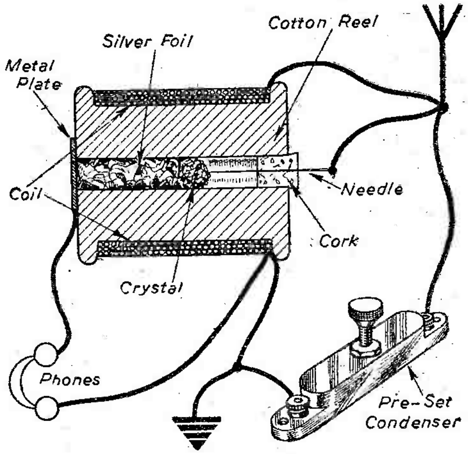
Not having such a switch, I looked among my "spares" to see if I could replace it. I found a switch of the type illustrated, which could easily be converted into a delay switch by the simple method of filing the ebonite centre shaft down, as shown in the sketches. The shaft being filed in this manner, the end contact closes a fraction of a second after the others, and opens a fraction before, making it ideal for my purpose. The wiring is shown on the diagram, spare contacts being wavechanging.—E. BOLLANS (Bellingham).



ample dela witch.

Midget Crystal Set

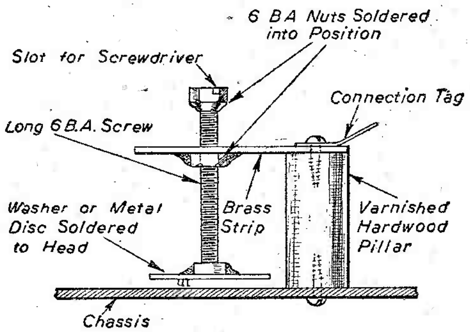
I HAVE recently used with success the following midget coil and crystal detector on a cotton reel. I wound three layers of 23 s.w.g., s.c.c. (25 turns to a layer). I also fastened a metal disc to the reel, as shown in the diagram. A needle pushed through a cork is used as a "cat's whisker." This coil and detector when used with a .0005 pre-set and bed frame aerial and water-tap earth, works efficiently, giving good signals. The 'phones have a resistance of 120 ohms.—B. HAYES (New Bradwell).



midget crystal set built round a cotton reel

Small S.W. Trimmers

HAVING difficulty in obtaining small air-spaced trimmer condensers I devised a simple method of making them. The parts necessary were found in the junk box. The sketch is self-explanatory, except that the 6 B.A. screw must be a tight running fit in the nut, which is soldered to the brass strip support. It is necessary, therefore, to squeeze this nut slightly before soldering it in position. The capacity will then remain constant after setting, which is carried out by rotating the slotted nut with a screwdriver.—K. E. WEEKS (Reading).



Method of making an S.W. trimmer.

ON YOUR WAVELENGTH

By THERMION

Gossip

I WONDER why it is that so many of our broadcasters are so name-proud? I am referring to the Lancelots, the Vernons, the Marmadukes, and others whose names signify that when young they were Mammies' darlings. No one can help their prænomens, but there is no earthly reason why they should be used except in family circles; surely the initial and the surname should be sufficient to establish identity?

I was enjoying my snack at the bar the other day when I overheard a conversation between a pale-faced young woman and a thin, thoughtful young man. I could not help overhearing, and the whole of the restaurant must have done so. The conversation was evidently intended to impress us. The young woman was about 25 years of age, grim countenanced, very evidently a Woman With a Purpose. She was discussing with her friend the text of a broadcast which she proposed to submit to the B.B.C. on foreign policy, what was wrong with international politics and how to put the world right in general. What can a young woman of 25 know of these things? Do not the B.B.C. take age into consideration? Some would be far better occupied, in my view, in the war effort instead of talking a lot of regurgitated flapjack from erudite books by equally lank-haired loons wearing corduroy trousers and yellow ties. It is my view that too many of these people are allowed to broadcast. They should be given the air in another sense!

Selling and Servicing

I WAS pleased to see that the Editor of this journal has taken up the matter of the Selling Licence. I have received a large number of letters on this subject myself. The position seems to be that application to sell wireless parts must be made to the Local Price Regulations Committee. From what I have learned it seems that the small trader is being victimised by larger firms who can lodge opposition to the granting of licences, and nearly always succeed in suppressing the small man. Now this is wrong, and it is unfair. It amounts to the granting of a monopoly to mutiple stores, and that is not in the best interests of the community. The sooner the Board of Trade abolishes this stupid system the better. In the meantime, if any of my readers know of dealers who have had this sort of raw deal I am asked to advise them to send names and addresses to the Editor, who has the matter in hand.

B.I.R.E. Exams.

HERE are further details of the syllabus referred to last month:

The Fundamental Principles of Radio.—Current/voltage relationships in A.C. and D.C. circuits; primary and secondary cells; theory of magnetism; magnetic screening; laws of induction; mutual and self-inductance; electrostatics; electrostatic screening; resonance; series and parallel resonant circuits; modulation; thermionic valves; rectifiers; rectification and detection; electro-magnetic waves; simple wave theory; aerials and transmission lines; amplifiers and oscillators; receiver circuit practice; reproducers and electrical pick-ups.

Wireless Club for Manchester

IT is proposed to form a wireless club in Manchester, and those interested should write to the headquarters at 13, Milton Grove, Whalley Range, Manchester, 16.

Present Position

FOUR years of war have seen a very great transformation in our industry. Its growth can be gauged by the fact that many hundreds of firms are now engaged wholly or in part on other forms of radio production (including the manufacture of valves and components) and the output of the industry which is now in turnover many times greater than before the war is still rising. Virtually the whole of this output consists of operational equipments for the Armed Forces—in fact production of broadcasting receivers for civilian use has been curtailed to such a degree that the manufacture of additional receivers for broadcast listening in British homes is now becoming an urgent matter. Moreover, many types of apparatus which are now produced for the Fighting Services are very different in character from pre-war productions. A higher degree of technical skill in production is necessary in a large number of cases (for example, in many radiolocation equipments the required percentage of skilled/unskilled labour was at one time of the order of 1 to 4, and is still of the order of 1 to 8).

Brains Trust Answers—We don't know

[Press Item.—A twelve-years-old schoolboy has baffled the B.B.C. Brains Trust. He asked the question of why the French divided their words into only masculine and feminine genders, and Brains Trust reply was: We really don't know!]

To query made by smart young lad,
Whose age is only tender,
The Brains Trust answered, We don't know
Why French have no third gender.
With them all words are "He" or "She"—
That much at least we know;
But when you ask us why this is,
We cannot tell you so.

A neuter gender English has,
Which fact perhaps explains
Why critics rude unkindly hint
At somewhat neutral brains;
And say the things we do not know
Would fill a great big book!
Listeners, excuse us now and then,
Whilst we for answers look!

Then when we've found the right replies,
With you we'll play quite fair.
Our words of wisdom you shall hear
Transmitted through the air.
Meantime our intellects we clean,
And free from rust and dust,
Until there's less of "We don't know"
From B.B.C. Brains Trust!

"TORCH."

Our Roll of Merit

Readers on Active Service—Thirty-sixth List.

N. Jefferiss (Petty Officer-Electrical Mechanic), R.N.V.R.
R. G. Major (Rfn., King's Royal Rifle Corps).
G. R. Powell (A/A, R.A.F.).
B. Walker (Dvr., R.E.M.E.).
R. Trull (L.A.C., R.A.F.).
S. O. Chapman (L.A.C., R.A.F.).
H. W. Goodman (L.A.C., R.A.F.).
A. W. McLennan (Sgn., Signals Section).
J. Edwards (A.C./1, R.A.F.).
H. Pryce (Cpl., Field Dressing Station).
G. F. Charlston (Cpl., R.A.F.).
A. V. Rodgers (Cfn., R.E.M.E.).
F. Crook (L.A.C., R.A.F.).
A. L. Hulse (Sgt., R.A.F.).
J. Edwards (A/C., R.A.F.)

An All-mains

An A.C./D.C. Receiver Capable of Giving Good

THIS all-mains midget straight three was designed and built for reception on the medium wave-band, and gives good quality reproduction with ample volume. Consistent results were obtained from three receivers built to the same specification.

The circuit of the midget three employs a triode pentode (12B8) as a radio-frequency and low frequency amplifier with the pentode and triode sections respectively; a pentode acting as an anode bend detector (6SK7 or 6K7) and a tetrode or pentode for the output (25L6 or 25A6). The rectifier is a full wave (double diode) type, having anodes connected together (25Z6). All valves are of the bantam type, i.e., small envelope or T type, e.g., 25Z6GT (G=octal base).

The wavelength range is from 200 to 550 metres, and is therefore suitable for the reception of all stations in the normal medium wave-band.

All components were obtainable from advertisers in PRACTICAL WIRELESS during the month of August, therefore the constructor should have little difficulty in securing the specified parts.

Push-button tuning can be incorporated with little extra work, and the tuning condenser fixing position is then used for a tone control.

The Circuit

The theoretical circuit diagram is shown in Fig. 1. C_1 ensures isolaton of the aerial terminal from the chassis, thus preventing shocks from the aerial and the possibility of chassis-earth short circuits via the aerial coupling coil. Also, the insertion of C_1 gives loose coupling, and hence an increase in selectivity. The earth terminal is connected to the chassis via C_4, which therefore isolates the " live " chassis from earth.

L_1 and L_2 are the aerial coupling and tuning coils respectively, L_2 being tuned by C_2, which is one section of a twin-gang condenser. C_2 is trimmed by means of C_3.

L_3 and L_4 are the anode coupling and tuning coils respectively, C_8 being the other half of the twin-gang tuning condenser for tuning L_4, and C_9 is the trimming condenser for C_8.

The bias voltage for the pentode section of the triode-pentode is provided by R_1, and R_3 is for the biasing of the triode section. Condensers C_5 and C_6 decouple R_1 and R_3 respectively. R_7 and C_{10} provide bias voltage and bias decoupling for the detector (pentode); whilst R_{10} and C_{13} serve the same purpose for the tetrode or pentode output.

It should be noted that R_7, in providing bias voltage for anode bend detection is rather critical in value, the best value being the lowest which can be fitted without causing instability through the entire tuning range. Too high a value for R_7 results in loss of gain, and too low a value causes instability. The general stability of the receiver depends largely upon layout of components and wiring; for the layout given a resistance of 7,000 Ω was found to be the lowest consistent with stability.

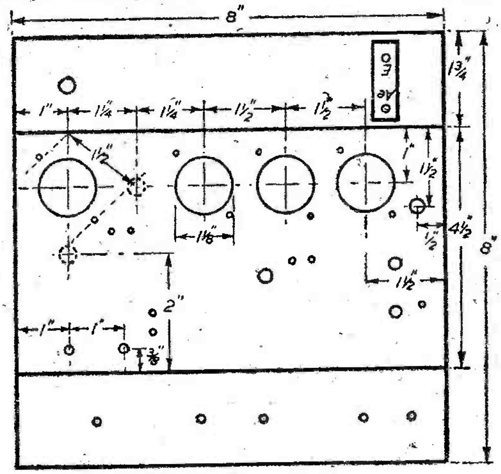


Fig. 2.—Chassis dimensions.

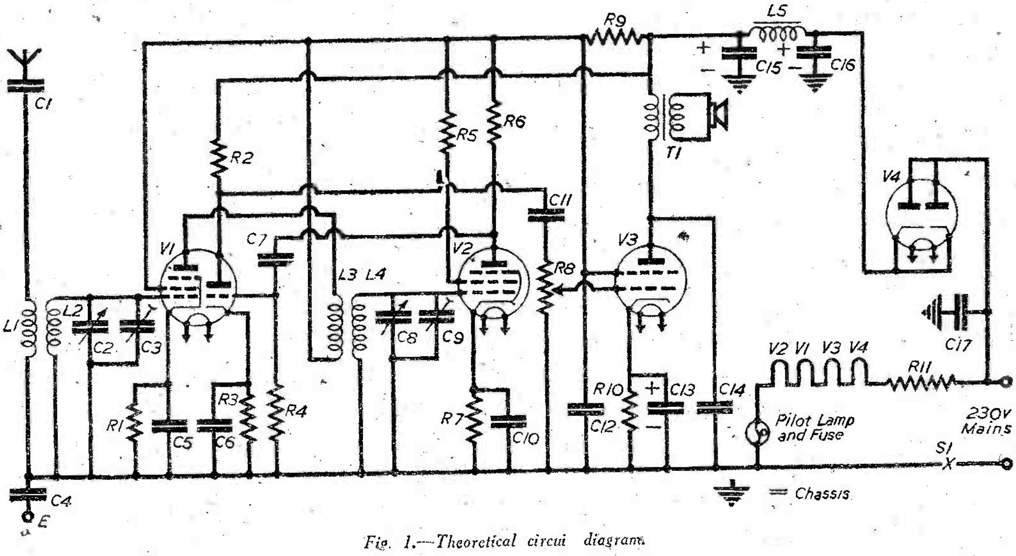


Fig. 1.—Theoretical circui diagram.

Midget Three

esults on Medium Waves. By JOHN JAY

The anode load of the pentode detector is R_6, and the output from this stage is fed via coupling condenser C_7 to the grid of the triode section of the triode-pentode: R_4 is the grid leak for that section.

The triode's anode load is R_2, its output being fed via C_{11} to the output valve's (pentode or tetrode) grid, volume control being achieved by varying the input to the output valve by means of potentiometer R_8. R_9 ensures decoupling between the low frequency and high frequency sections.

Smoothing choke L_5 operates in conjunction with smoothing condenser C_{15}, which should have a value over 16μF. The reservoir condenser C_{16} should not be greater than 8μF.

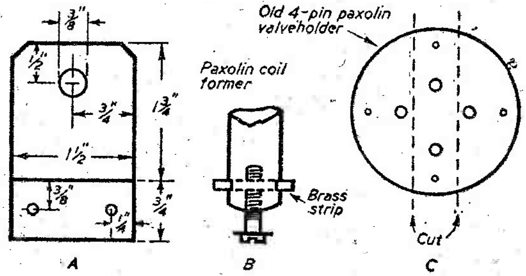


Fig. 3.—Mountings for volume control and coil.

The voltage dropping resistance R_{11} for the heaters and pilot lamp may be of the line cord, or chassis mounting type.

The on-off switch, S_1, is incorporated in the volume control, R_8.

The input to the set may be either A.C. or D.C. mains of 230v., and the pilot lamp acts both as an indicator that the set is switched on, and as a fuse.

Constructional Details

The chassis may be constructed of a sheet of steel or aluminium, 8in.×8in., which is first drilled as shown in Fig. 2, and then bent into the form of a trough, 8in.×4½in.×1¾in. A chassis constructed of three-ply wood may be made to the dimensions given, provided that its top is covered with tinfoil and all earth points (not the actual earth terminal) are connected together with heavy gauge tinned copper wire.

Volume control fitment is achieved by means of the bracket, whose dimensions are given in Fig 3(a).

COMPONENTS.

C1, 0.0002 μF; C2, C8, 0.0005 μF; C3, 50 PF; C4, 0.01 μF; C5, 0.1 μF; C6, 0.1 μF; C7, .01 μF; C9, 50 PF; C10, 0.1 μF; C11, 0.01 μF; C12, 0.1 μF; C13, 25 μF, 25 V.W.D.C.; C14, 0.025 μF; C15, 16 μF; C16, 8 μF; C17, 0.01 μF; C18, 0.002 μF.
R1, 400Ω*; R2, 0.25 MΩ; R3, 1,000 Ω; R4, 0.25 MΩ; R5, 2MΩ; R6, 1 MΩ; R7, 7,000 Ω; R8, 0.5 MΩ; R9, 10,000 Ω; R10, 150 Ω; R11, 550Ω†; R12, 50,000Ω.

* If a 25A6GT pentode output is used instead of the 25L6GT, this value must be 450 Ω.

† 1,000 Ω if low anode voltage-high heater voltage valves used as suggested under "alternatives."

V1, 12B8GT; V2, 6SK7GT or 6K7GT; V3, 25L6GT or 25A6GT; V4, 25Z6GT. Alternately: V1, 25B8GT; V2, 12SK7GT; V3, 50L6GT; V4, 35Z4GT.

The tuning condenser is mounted on its side by means of the holes drilled and threaded in its frame for this purpose.

Drilling valveholder holes need not present any difficulty as an inch wood bit may be used, although, if the constructor possesses an adjustable bit, he is advised to make the diameter of these holes just over an inch—see Fig. 2—to permit complete insertion of the valves in their holders. Hole positions are given where possible in Fig. 2, which shows the *top* of the chassis. Holes shown dotted, and the aerial and earth terminals mounted on a paxolin strip and bolted over a slot in the chassis must be positioned when the constructor obtains the smoothing condenser, C_{15}; in fact, the constructor would be well advised to obtain *all* components before drilling the chasses.

The chassis is fastened to the cabinet by means of angle brackets bolted to the chassis and through the bottom of the cabinet.

The Cabinet

The cabinet was made from good quality three- or five-ply wood, braced at all junctions with square wood strips as shown in Fig. 4. Its dimensions (inside) being 9in. × 7½in. × 5½in. Two holes for the volume and tuning condenser spindles must be drilled and positioned when the chassis has been constructed. The cabinet was fastened together with ½in. brass countersunk head wood screws, care being taken that all screw heads were below the surface of the wood, the depressions left were filled in with plain wood filler. Great care must be taken when cutting the oval speaker opening; the writer used a fret-saw and the edges of the hole were then rounded by the aid of a round file. The method of marking out the oval is as follows: Tap two tacks 1¼in from the top and bottom of the cabinet's front panel, tie a piece of string around them and move a pencil along the boundaries presented by the taut string.

The assembled cabinet was carefully smoothed with decreasing grades of sandpaper, until a very smooth surface was obtained. This tedious task must be carried out otherwise it is impossible to get a good finish. The cabinet was left unstained but a coat of clear copal varnish was applied. Oak or walnut, etc., finish m[illegible] e obtained by staining the wood before varnishing. [illegible]ery satisfactory effects have been obtained by using matt or glossy enamel of a suitable colour. Give the cabinet plenty of time to dry in a dust-free situation.

Dial plates were mounted over the spindle holes, and these may be made of ivorine ruled with the aid of a steel ruler and a sharp point, the grooves thus formed being filled in with indian ink. As an alternative plain white paper suitably marked and covered with celluloid would suffice. Knobs were of the "pointer" type.

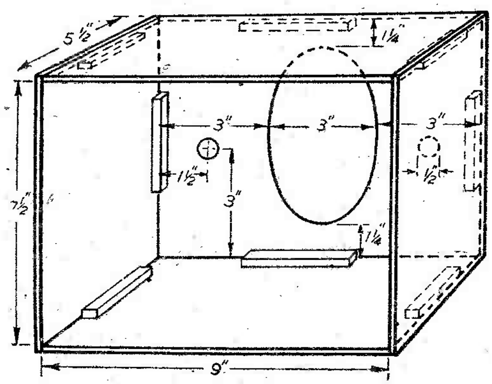


Fig. 4.—Rear view of cabinet, showing construction.

The loudspeaker, which was a 5in. permanent magnet moving coil type, is screwed to a three-ply wood baffle in order to obtain better tone, and the baffle screwed over the speaker opening in the cabinet. The speaker opening was previously covered by means of a suitable fabric glued to the back of the front panel. A hole is left in the speaker baffle and the pilot light fastened over it, this light shines through the fabric. See Fig. 5 for details of the speaker baffle and pilot light fitment.

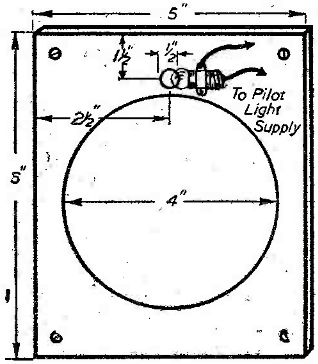


Fig. 5.—Baffle board and pilot lamp fitment.

✱ or Beam Electrode. T Top Cap grid in 6 K7

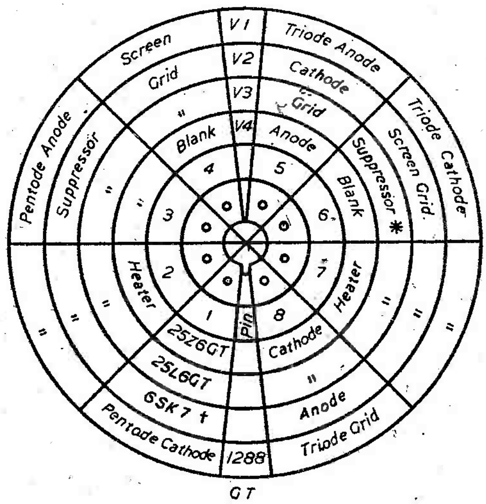


Fig. 6.—Indicator for valve-base connections (seen from the underside of valveholder).

Four rubber feet screwed to the bottom of the cabinet completes its construction.

Wiring Details

All connections with the exception of the heater, loudspeaker and mains connections, were made with No. 22 S.W.G. gauge tinned copper wire insulated with 2 m.m. systoflex; ordinary 5 ampere lighting flex being used for the other parts (Fig. 7).

The heaters, voltage dropping resistance, pilot lamp, on-off switch and mains lead circuit were wired first, and tested by connecting to the mains and noting that the heaters and pilot lamp lit to normal brilliancy. If the constructor has an ammeter he should check the current flowing in this circuit; about 0.3 amperes is all right. Then followed the rectifier and smoothing circuit, and each stage from output to the radio frequency amplifier; with the exception of the tuned circuits. Great care was taken in wiring up the tuned circuits, long leads, parallel runs and low frequency circuits being avoided; neglect with this wiring would have probably caused instability and poor performance.

(*To be concluded.*)

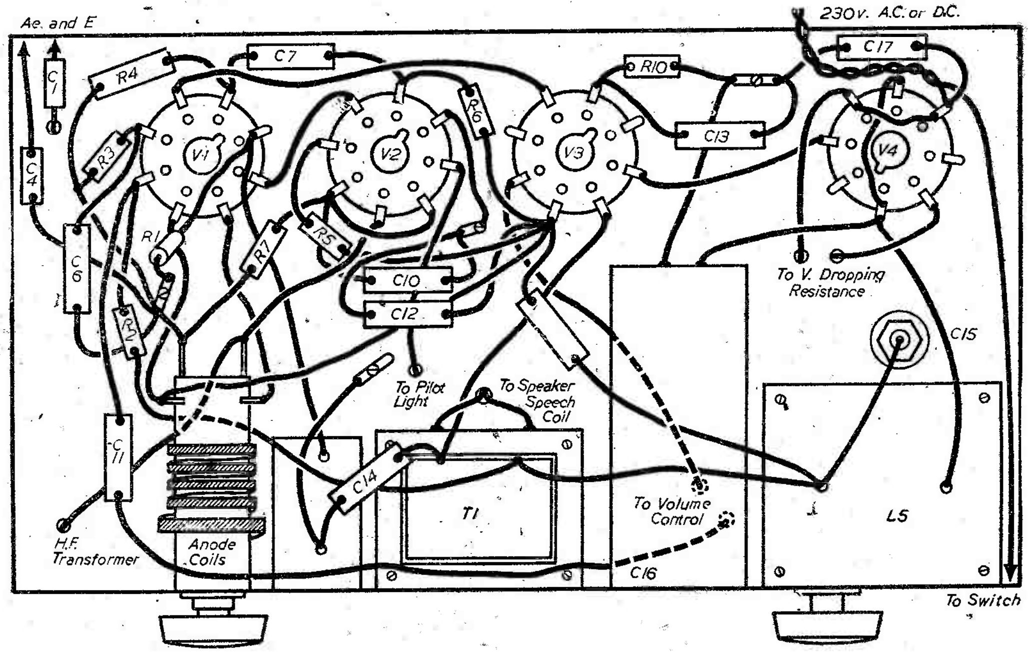


Fig. 7.—Wiring diagram of underside of chassis.

Elementary Electricity and Radio—11

Reading a Circuit Diagram. By J. J. WILLIAMSON

(Continued from page 503, November issue.)

WITH high power transmitters, relays are often used in conjunction with a hand key, and some method of keeping the voltage of the supply constant (stabilisation) during the keying process is necessary. Also, in order that a rapid cessation of signals occur when the key is raised, the grid circuit of the M.O. is often "keyed"; thus, when the grid is isolated, the grid condenser charges and hence biases the M.O. valve beyond "cut-off," thereby stopping oscillation. With high speeds the key or relay should be small to enable rapid movement to take place. The transmitter of Fig. 55 (Nov. issue) could be keyed by placing the key at F.

Wavemeters

A method of measuring wavelength or frequency is very necessary for the setting up or tuning of a transmitter. Fig. 59 shows a simple "absorption" type wavemeter, L_1 C_1 is a tuned-circuit, C_1 being variable and having a calibrated dial to enable wavelength or frequency to be read directly. When C_1 is adjusted for

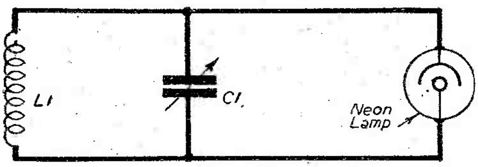


Fig. 59.—The circuit of a simple absorbtion type wavemeter.

resonance with the transmitter's frequency, the voltages built up across the tuned circuit will cause the lamp to glow.

Fig. 60 shows a valve wavemeter. L_1 and C_1 are as before, but are connected to grid and filament of the valve which is operated as an anode-bend detector, thus when a signal is "tuned-in" the meter in the valve's anode circuit will read the rectified signal currents, no circuit flowing—if the biasing is correctly adjusted—until a signal is applied to the valve.

General Examples

1. What meters are necessary for tuning an M.O.-P.A. transmitter?

2. Draw a circuit for an M.O.-P.A. transmitter having choke modulation, a Colpitt's oscillator, H.T. biasing and neutralising.

Answers for Article Nine

1. C_1—Tuning.
   C_2—Condenser for detection.
   C_3—R.F. by-pass.
   C_4—Coupling.
   C_5—Coupling.
   C_6—Decoupling (supply).
   C_7—Decoupling (bias).

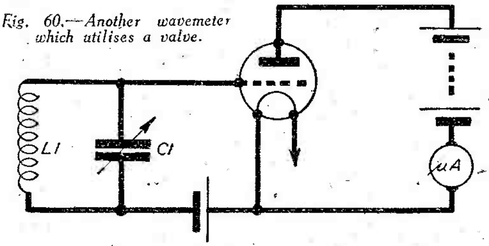
   L_1—Aerial coupling.
   L_2—Tuning.
   L_3—Reaction coil (movable).
   L_4—Load of output value.

   R_1—Grid leak.
   R_2—Detector anode load.
   R_3—Grid resistance.
   R_4—H.T. biasing.

Circuit Reading

It is of great importance to be able to recognise the various radio and electrical symbols in general use; also necessary is an understanding of the effect that a component (inductance capacity or resistance) may

Fig. 60.—Another wavemeter which utilises a valve.



have upon others in either a series or parallel circuit, with due regard to the frequencies being dealt with. As a direct result of the latter requirement, the manner in which voltages are distributed around a circuit and the magnitude and effects of currents that may flow, at various frequencies, must be considered.

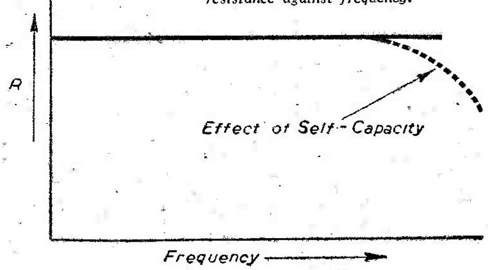
Next to the considerations already mentioned, other specific phenomena due to certain circuits and pieces of apparatus are of importance, such as series and parallel resonance, valve functions, crystal usage, radiation, heating, etc. A full review of the various factors mentioned is beyond the scope of this series, but an attempt will be made to describe the fundamental factors.

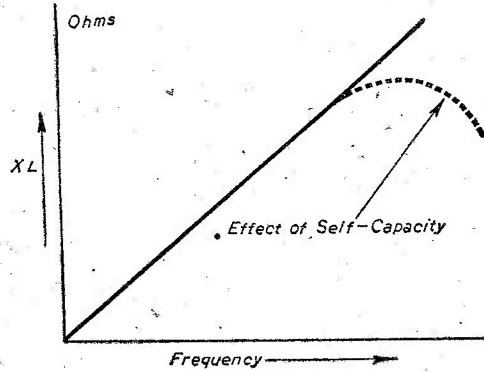
Practical Considerations

It is to be realised that R.F., L.F. and direct voltages and currents will be met with in a radio circuit, i.e., R.F. voltages in the tuned circuits; R.F. and L.F. and

Fig. 62 (Right).—Variation of inductive reactance with frequency.

Fig. 61 (Below).—Opposition of a pure resistance against frequency.





direct components make up the current through the detector, L.F. and direct components comprise the L.F. amplifier and output valves current, and so on. Now, these currents at their characteristic frequencies pass through suitable oppositions thereby creating

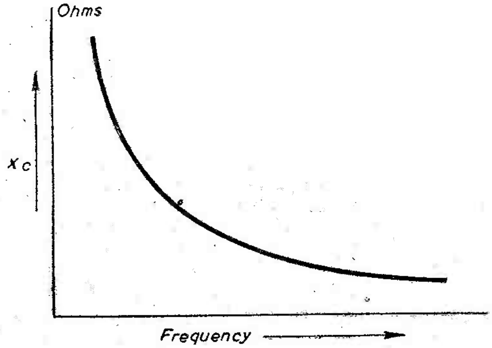


Fig. 63.—Showing how capacitive reactance varies with frequency.

L.F., R.F. or direct voltage drops (IX_L, IX_C, IZ, IR) which are fed to the grid and filament of the next valve, telephones, speaker, etc. It is obvious that circuits

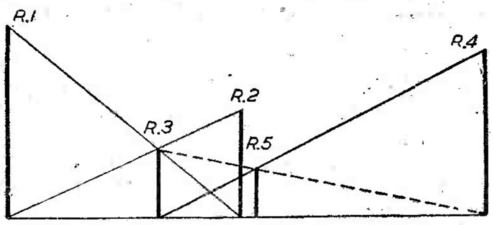


Fig. 64.—The graphical addition of parallel resistances.

capable of passing one band of frequencies (not well defined) to the exclusion of others or any combination of R.F., L.F. or ZF., will be required.

Opposition to R.F., L.F. or D.C.

There are three types of opposition that are encountered by electric currents, i.e., resistance, inductive reactance and capacitive reactance. By arranging these oppositions in suitable combinations, with due regard to the frequency/ohm characteristics (Figs. 61, 62 and 63), we can produce the desired L.F., R.F., or direct voltages or provide easy paths for L.F., R.F., or direct currents.

Consider the types of opposition encountered and the manner in which the magnitude of this opposition varies with the frequency and/or the size of the condenser, inductance or resistance.

Fig. 61 shows that the opposition presented to an alternating current by a *pure* resistance remains constant for different frequencies.

Fig. 62 shows how the opposition of an inductance (inductive reactance—X_L) *rises* with an *increase* of frequency; similarly the larger the inductance the higher is its opposition to alternating currents.

Fig. 63 gives the manner in which the opposition of a condenser (capacitive reactance—X_C) varies with frequency—notice that the higher the frequency the lower the opposition; also, the larger the condenser the smaller is its opposition to alternating currents.

These properties, as already mentioned, can be used to filter out or provide paths for currents—or oppositions for the production of voltages—of different frequencies.

In practice it is not possible to obtain a *pure* resistance, capacity or inductance. A resistance or inductance

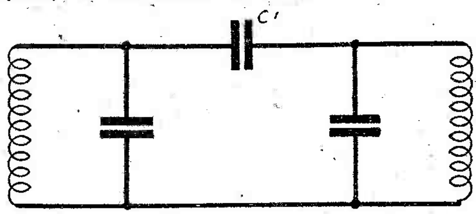


Fig. 65.—Theoretical representation of capacitive coupling.

usually possesses a certain amount of self-capacity which will by-pass or "shunt" the higher frequencies, as shown by the dotted lines in Figs. 61 and 62. If wire-

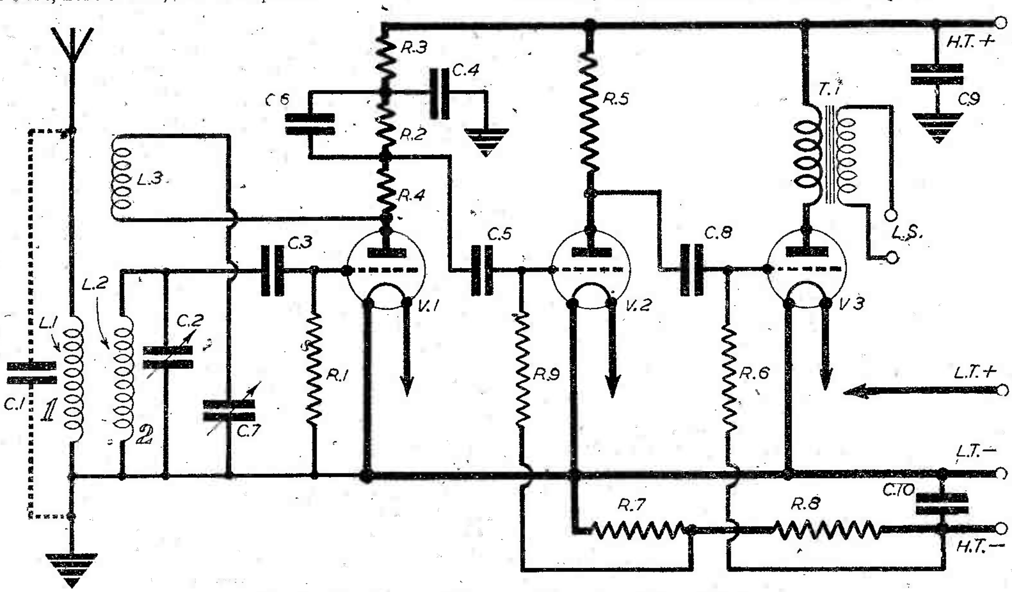


Fig. 66.—Analysis of a battery-operated receiver of the o-V-2 class.

wound without special precautions a resistance can possess an appreciable self-inductance.

A condenser will have a certain amount of resistance, and, in fact, any losses of energy in a condenser that give rise to heat can be expressed as a resistance.

As an inductance possesses a small amount of resistance and self-capacity the voltage produced across the inductance increases to a maximum and then falls off as the frequency is increased and the self-capacity becomes effective. If D.C. is passed through the coil a direct voltage will be produced across its resistance.

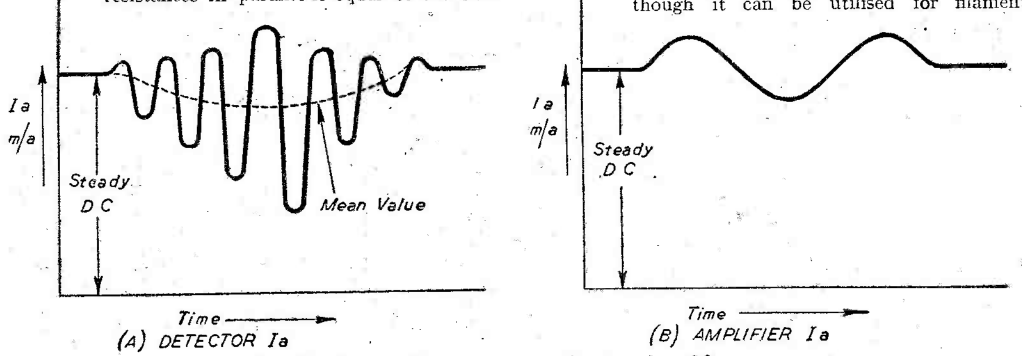
The self-inductance of a wire-wound resistance can be mainly overcome by doubling the wire back on itself so that the total magnetic field is greatly reduced by the opposing nature of the two fields of the turns, due to the current flowing down one turn and up the adjacent turn. Care in the design of terminal caps, etc., will reduce a resistance's self-capacity.

The self-capacity of a coil can be reduced by sectionalising the windings, i.e., winding in slots, etc.; this prevents turns having a high potential between them from coming together.

Series and Parallel Connection of R., C. and L

The total resistance of resistances in a series circuit is their simple sum, i.e., $Rr = R_1 + R_2$, etc.

The reciprocal of the total resistance of resistances in parallel is equal to the sum



Figs. 67.—Variation of anode current in a detector and amplifier.

of the reciprocals of the individual resistances, i.e.,

$$\frac{1}{Rr} = \frac{1}{R_1} + \frac{1}{R_2} \text{ etc.}$$

Notice that the total resistance in the parallel case is smaller than the smallest resistance in the combination.

Also,

$$\text{if } \frac{1}{Rr} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\text{then } Rr = \frac{R_1 R_2}{R_1 + R_2} \quad \text{(for two resistances only).}$$

Graphically, let the heights of two lines be R_1, and R_2 respectively (Fig. 64). Join the top of R_1 to the bottom of R_2, and the top of R_2 to the bottom of R_1. The height from the base to the point where the two lines cross is the value of the total resistance. Any number of resistances can be dealt with in this manner, as shown by R_3 and the dotted lines in Fig. 64. The distance between the lines is of no consequence, except for an increase of accuracy with distance, although, of course, their heights must be to the same scale.

Condensers in Series or Parallel

Condensers in series are totalled up in the same manner as resistances in parallel; the rules for the addition of series resistances are the same for parallel condensers.

Inductances in Series or Parallel

The addition of series and parallel inductances is the same as for resistances, provided that the magnetic field of one inductance does not cut the conductors of any other, when we have to consider a factor known as "Mutual Inductance."

By working out a few examples it wil be found that a high resistance in parallel with a low one, has little effect on the total resistance of a circuit; also, that a low resistance in series with a high one has little effect.

Similarly, a large condenser placed in *series* with a small one causes little change of the total capacity, neither will a small condenser in parallel with a small one. The former fact enables us to limit the capacitive effects of one circuit upon another—as in the case of the Franklin Oscillator. Fig. 65 shows how a circuit may be coupled to another by a small condenser in such a manner that the effect of circuit one on circuit two or vice versa can be no greater than the value of C_1.

A Circuit Analysis of a Simple Receiver (Fig. 66)

Examine the simple receiver circuit shown; remember that there must be a complete path for every current that flows or voltage that acts and is to be utilised.

Direct current is flowing from the supply via the H.T. biasing resistances through the valves and back to the supply, and any potentials no matter whether direct, L.F. or R.F., applied to the grid and filament of any valve will affect this current. The current heating the valves' filaments flows from the L.T. supply to and from the valves as shown. This current merely serves to heat the filaments, although it can be utilised for filament biasing purposes. D.C. is shown by heavy lines.

Commencing with the aerial circuit (1), electromagnetic waves striking the aerial system will induce R.F. voltages in it. These voltages will cause a minute R.F. current to flow around the circuit L_1, and the capacity of aerial and earth (dotted lines and C_1.)

The R.F. currents through L_1 will cause an alternating magnetic field to be produced, the lines of magnetic force of which will cut the conductors of L_2.

L_2 C_2 comprise a tuned-circuit (2), and because of its properties (discussed in a previous article) will produce large R.F. potentials, which are applied to the grid and filament of the first valve—the detector—via C_3 and direct connection. The detector is a cumulative grid detector and thus the values of C_3 and R_1 are governed by its action, which causes L.F. and R.F. components to appear across the grid and filament of the first valve. The anode current will thus be fluctuating at R.F. and L.F. rates as shown by Fig. 67 (A). L.F. voltages must be produced to feed to the next valve (L.F. amplifier) and R.F. potentials are required to drive R.F. currents through the reaction circuit.

The L.F. potentials are produced across the combination of R_2 and C_6; the condenser gives the combination a low opposition to R.F. currents but has a high opposition for the L.F., thus L.F. voltages are mainly produced whilst R.F. voltages would be very small. The L.F. voltages are allowed to act via C_5 to the grid and via C_9 to the filament of the L.F. amplifier.

(To be continued)

Radio Examination Papers—24

The Questions and Answers by THE EXPERIMENTERS this Month Deal with Such Subjects as Side-bands, Meters, "Blue Glow," Space Charge and Amplifier Calculations

1. Side-bands

IT is general knowledge that when telephony is transmitted audio-frequency voltages are used to modulate the radio-frequency carrier. As a result, the transmission occupies a band of frequencies, instead of the single frequency represented by the carrier. The width of the band transmitted depends entirely upon the frequency of the modulation. Thus, if the modulation consisted of a single 3,000-cycle note, the band occupied would be 6,000 cycles or 6 kilocycles per second wide.

Assuming a carrier frequency of 2 megacycles, the transmission would "spread" from 1,997 kc/s to 2,003 kc/s, and if good reproduction were to be obtained the receiver tuning circuits would have to be capable not only of tuning to 2 megacycles, but also of accepting a band-width of 6 kc/s.

The two halves of the band-width situated on each side of the carrier frequency are known as side-bands, for fairly obvious reasons.

In the case of normal telephony transmission the modulation consists of constantly-varying audio frequencies, with the result that the extent of the side-bands is a fluctuating quantity. Good reproduction is limited by the ability of the receiver tuning circuits to accept a band equivalent to the highest audio frequency represented by the modulation.

The side-band theory (it is actually more than a theory, since proof is possible) states that when a modulated frequency is transmitted there are, in fact, three different radiated frequencies. One of these is the carrier frequency, a second is the carrier frequency *plus* the modulation frequency, and the third is the carrier frequency *minus* the modulation frequency. By means of suitable equipment it is possible to detect all three frequencies; it is also possible to suppress one of the side-bands at the transmitter and provide restoration at the receiver. This is done in certain forms of "secrecy" transmitting systems.

QUESTIONS

1. *What are side-bands? Briefly outline the side-band theory.*
2. *Explain the dominant differences in characteristics between meters of the moving-coil, moving-iron, hot-wire, thermo-junction and electrostatic types.*
3. *Name the causes of "blue glow" in a valve or rectifier.*
4. *Describe a simple form of radio-frequency filter, and compare it with an audio-frequency filter such as may be used for tone control.*
5. *What do you understand by the term "space charge," as applied to a radio valve?*
6. *A certain R.C. coupled L.F. valve of 10,000 ohms internal resistance and amplification factor of 12, passes an anode current of 10 mA when its anode load consists of a 25,000-ohm resistor. Find the voltage amplification of the stage when operating in these conditions, and determine the correct value of bias resistor to give a bias of 5 volts.*

2. Electrical Meters

The moving-coil meter, the type most widely employed, is suitable for measuring direct current only. It can be made to give very accurate readings, and has the advantage that the movement of the needle is proportional to the current passed through the moving coil. In other words, the meter scale is equally divided from zero to maximum.

Moving-iron meters are not, in general, quite as accurate as moving-coil meters, and have "square-law" characteristics. This means that the needle movement is proportional to the *square* of the current passed through the meter. As a result, the scale calibration is more crowded toward the lower end, and opens out toward the upper limit. An advantage of this type of meter is that it can be used for both direct and alternating currents.

The hot-wire meter is normally suitable only for use as an ammeter, where the available current is upwards of about .1 amp. It is very simple in construction, and can be used for D.C., A.C. or high-frequency current measurement. In this respect, it shows an advantage over both other types previously mentioned. A disadvantage is that needle movement is somewhat sluggish. Another disadvantage is that fairly frequent "zero" adjustment is required.

Thermo-junction meters are, to all intents and purposes, moving-coil meters with the addition of a thermo-junction. The heating element of the latter is connected in the circuit under test, while the moving coil is connected to the two elements of the thermo-junction.

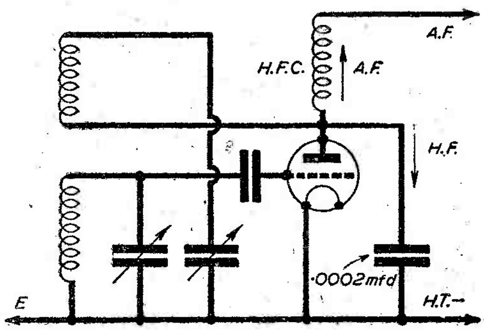


Fig. 1.—A simple R.F. filter. The choke offers a high impedance to radio frequencies, while the condensers offer a low reactance to such frequencies.

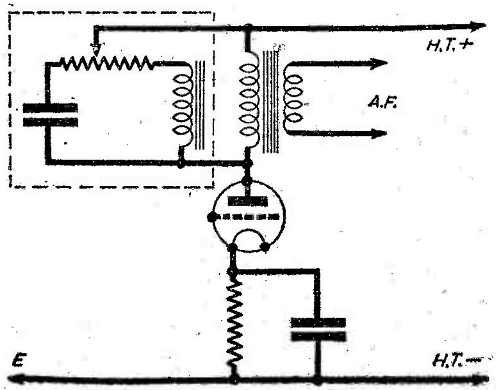


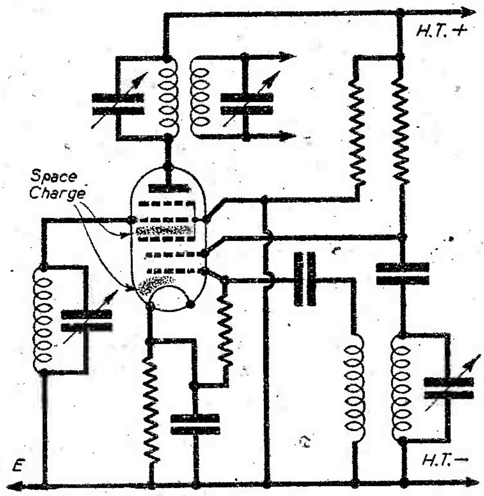
Fig. 2.—An A. F. filter used as a tone control. The control is enclosed in a broken-line "box" for clarity.

This type of meter combines the advantages of the moving-coil and hot-wire types, while being free from the disadvantages of both.

Electrostatic meters are suitable only for voltage measurement, and are desirable when large voltages have to be measured and when, at the same time, there must be no current drain from the circuit under test. They read most accurately toward the top end of the scale; the spacing is crowded toward the lower end. Electrostatic voltmeters can be used for measuring D.C., A.C. or H.F.

3. "Blue Glow"

The normal kind of "blue glow" in a valve or rectifier is due to ionisation of the residual gases, which are left in the bulb during evacuation. In the case of most types of valve, the glow discharge normally indicates either that the valve is becoming "soft" (due to release of gases by the electrodes) or that too high an anode voltage is being employed. The two factors may combine to give the glow.



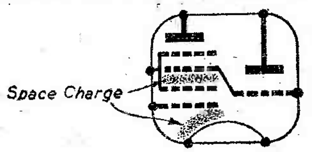


Fig. 3 (above). — A heptode frequency-changer circuit, showing where space charges occur. (Left) A triode-hexode valve, in which the locations of the space charger are indicated.

In other types of valve, however, the glow may merely indicate that the valve or rectifier is operating. This is because the glass envelope contains, by design, a certain amount of gas at low pressure; examples are so-called gas-filled and mercury-vapour rectifiers and argon-filled triode relay valves, of the kind often used in time-bases.

4. R.F. and A.F. Filters

Probably the best-known example of a radio-frequency filter is the H.F. choke used in the anode circuit of a triode or pentode detector. Its purpose is to prevent the passage of high, or radio-frequency currents into the low-frequency amplifier. It does this because it has a high impedance or reactance to high frequencies, while offering little opposition to the free flow of low or audio frequencies.

A circuit including an H.F. choke is shown in Fig. 1, where it will be seen that the choke is used in conjunction with a small by-pass condenser of about .0002 mfd. capacity. The condenser allows the unwanted high frequencies to leak away to earth; it thus simplifies the job of the choke.

Other forms of radio-frequency filters are band-pass circuits, which comprise two tuning circuits so coupled that the overall selectivity is increased. They thus accept only a certain band of frequencies, and "filter" out all others.

Fig. 2 shows a simple tone-control arrangement wired in parallel with the primary of a low-frequency transformer. The filter comprises a condenser and iron-cored choke, with a potentiometer to vary the effect on the transformer primary of the two components. When the condenser "holds sway" the higher audio frequencies are by-passed; when the choke takes control it by-passes the lower frequencies.

5. Space Charge

In any electronic valve there is a discharge of electrons from the cathode to the anode. The electrodes are liberated from the cathode as a stream. Being negatively charged, they are attracted to the anode, which is at a positive potential in respect of the cathode. Even when the anode is not charged positively, electrons are still emitted by the heated cathode; in that case, the electrons form a negatively-charged "cloud" around the cathode. This "cloud" tends to repel other electrons emitted by the cathode, due to the fact that "like charges repel."

It can be stated that the electron "cloud" is a collective negative charge, and is in the space between the cathode and anode. This explains the meaning of the term "space charge."

It is of interest that use is made of this electronic cloud in heptode and triode-hexode frequency-changers. In the case of the heptode, for instance, the main electron flow from the cathode is divided, so that one portion passes through the grid and anode of the oscillator triode section, while the other passes to the main anode through the screening and control grids. The space charge or electron cloud which forms between the inner screening grid and the control grid is modulated at oscillator frequency. And since the instantaneous charge governs the electron flow through the pentode section of the valve, the space charge acts, in effect, as a cathode; it is described as a "virtual cathode." See Fig. 3.

In the case of the triode-hexode, use is made of the space charge between the inner screening grid and the coupling grid (which is internally connected to the oscillator grid).

6. Amplification, and Bias Resistance

The voltage amplification—not to be confused with stage gain, which takes into consideration additional factors—of a valve amplifier stage is equal to the amplification factor of the valve multiplied by the ohmic resistance of the anode load and divided by the sum of the anode load resistance and the internal resistance of the valve.

This is more simply expressed in mathematical form thus: $\text{V.A.} = \frac{\mu R}{R + R_a}$, where μ is the amplification factor of the valve, R is the anode load resistance, and R_a is the internal resistance of the valve. The result is given as a factor or ratio (to unity) of the voltage developed across the anode load by comparison with the voltage applied between the grid and cathode.

If we substitute in the above formula the figures given in the question, we find that the voltage amplification ratio is $\frac{12 \times 25{,}000}{25{,}000 + 10{,}000}$ which is equal to $\frac{60}{7}$, or 8.5.

Assuming that the valve is of the indirectly-heated-cathode type, we can readily determine the correct value for the cathode bias resistor by applying Ohm's Law in its simplest form. Resistance in ohms is equal to the required bias voltage divided by the anode current in amps. Thus, we have: $R = \frac{5}{.01}$, which gives as the answer 500 ohms exactly. It will be seen that the anode current of 10 mA is converted into a decimal fraction of an ampere.

Alternating Current

Critical Coupling. Nature of Coupled Impedance. The Transformer

(Concluded from page 514, November issue.)

Very Tight Coupling

THE coupling factor here is very nearly unity and the primary current is much affected by the reflected impedance. As resonance is approached Z_1 decreases, but ω^2M^2/Z_2 increases. There will be a point where ω^2M^2/Z_2 is increasing at the same rate as Z_1 is decreasing so that, in consequence, the i_1 curve becomes substantially horizontal.

Nearer resonance the reflected impedance increases more rapidly still and the i_1 curve has a minimum value at the resonance of the primary alone. (Fig. 29a.)

Since $e_2 = \omega M i_1$ the e_2 curve will have the same shape.

In the case of the i_2 curve, consider again that:

$$i_2 = e_2/Z_2$$

and study the curve in Fig. 29b.

From the point A to the point B e_2 is increasing and Z_2 is decreasing; therefore i_2 is increasing rapidly.

From B to C e_2 is substantially constant while Z_2 is still decreasing; therefore i_2 is still increasing though not so rapidly.

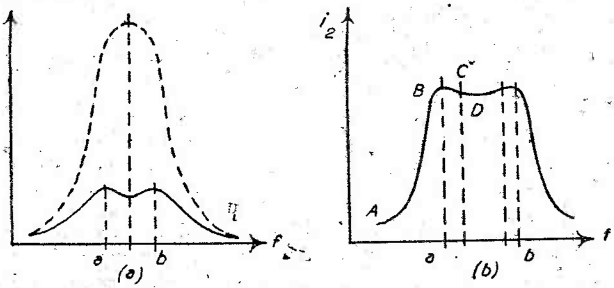


Fig. 29.—The i_1, and i_2 curves of Fig. 27 with tight coupling between the coils.

From point C to D—if the coupling is tight enough—e_2 will decrease at a more rapid rate than Z_2 so that the i_2 commences to fall again.

Consequently, the i_2 curve has steeper sides, the peaks are closer, and the trough is not so marked compared with the i_1 curve.

Critical Coupling

This value of k is so chosen that the i_1 and e_2 curves have peaks which are closer together and a trough which is not so marked as in the case of tight coupling. This gives an i_1 curve which is level near resonance. Any increase in the coupling must cause i_2 to double-hump. (Figs. 30a and 30b.)

Practical Curves

The curves given in Figs. 31a and 31b were taken with a circuit using the following component values:

$$L_1 = 150\mu H;\ L_2 = 150\mu H;\ R_1 = 9.5r$$
$$C_1 = 169\mu\mu F;\ C_2 = 169\mu\mu F;\ R_2 = 9.5r$$

e being 1 volt.

The value of k for critical coupling is .01

For bandpass working rather a wide band is required and k is usually about 2 times critical k.

The Q of a bandpass is usually about $\frac{1}{2}Q$ of one circuit.

Nature of the Coupled Impedance

The additional impedance in the primary of the coupled circuits is, as we have seen:

$$\omega^2M^2/Z_2$$

This can be given:

$$\frac{\omega^2M^2}{\sqrt{R_2^2+(\omega L_2 - 1/\omega C_2)^2}}$$

$$= \frac{\omega^2M^2}{R_2+j(\omega L_2 - 1/\omega C_2)} = \frac{\omega^2M^2}{R_2+jX_2}$$

$$= \frac{\omega^2M^2(R_2-jX_2)}{(R_2+jX_2)(R_2-jX_2)} = \frac{\omega^2M^2(R_2-jX_2)}{R_2^2+X_2^2}$$

$$= \frac{\omega^2M^2R_2 - j\omega^2M^2X_2}{Z_2^2} = \frac{\omega^2M^2R_2}{Z_2^2} - \frac{j\omega^2M^2X_2}{Z_2^2}$$

Thus the impedance added to the primary consists of:

1. A resistive component $\omega^2M^2R_2/Z_2^2$
2. A reactive term $j\omega^2M^2R_2/Z_2^2$ which is opposite in nature to the reactance of the secondary circuit; *i.e.*, if x_2 is capacitive, the reactance "thrown back" into the primary is inductive.

Relation between Q and k for Critical Coupling

It can be shown that:

$$k = 1/\sqrt{Q_1 Q_2}$$

where Q_1, Q_2 are the Q's of the primary and secondary circuits respectively, or for identical circuits:

$$k \text{ critical} = 1/Q.$$

For optimum (bandpass) coupling

$$k = 1.5/Q.$$

The Transformer

Essentially the transformer consists of a closed iron core on which are two windings, a primary and a secondary. (Fig. 32.) The ratio of the primary turns Tp to the secondary turns Ts is called the transformation ratio of the transformer and is denoted by ρ.

Approximate current and voltage relations for a transformer can be obtained from the formulæ:

$$Es = (Ts/Tp)\ Ep = Ep/\rho$$
$$Is = (Tp/Ts)\ Ip\ \rho Ip$$

A transformer is known as a "step up" type when the secondary has a greater number of turns than the primary and the output voltage is greater than the input; similarly a transformer in which the primary has a greater number of turns and the output voltage is less than the input, is known as a "step down" transformer.

Effect of a Transformer on Circuit Impedance

Consider Fig. 33, where the primary winding is

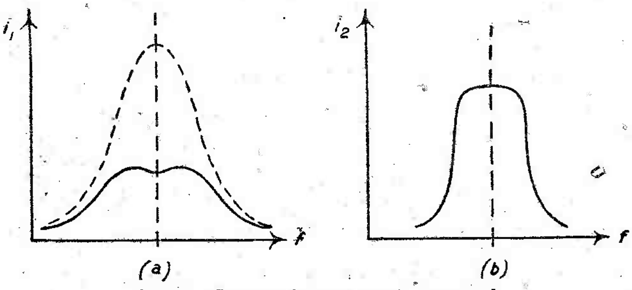


Fig. 30.—Curves with critica coupling employed.

connected to an alternator developing E volts, and an external load, of impedance Z, is connected across the secondary winding.

The secondary e.m.f. is E/ρ volts, where ρ is, of course, the transformation ratio, and the secondary current is consequently $E/\rho Z$ amps. The balancing current (see later) which flows in the primary winding s $1/\rho\ (E/\rho Z) = E/\rho^2 Z$ amps, and if the transformer can be considered a very efficient one with few losses, we may write:

Primary current $= E/\rho^2 Z$ amps.

This is the current that would flow if the alternator were directly connected to a circuit whose impedance was $\rho^2 Z$ therefore we may say: in a transformer circuit the impedance of the circuit is increased by $\rho^2 Z$ ohms.

This is, of course, not strictly accurate, as losses have been ignored.

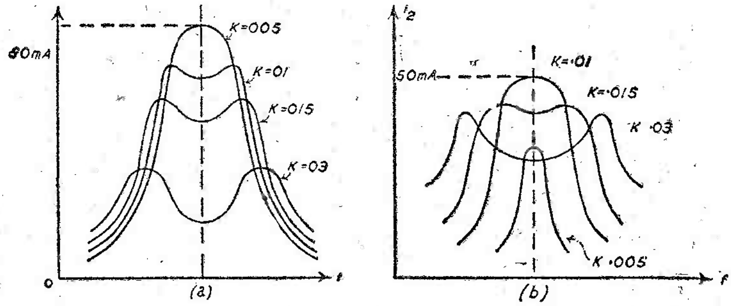


Fig. 31.—Practical curves obtained by experiment where the value of k for critical coupling was .01.

Balancing Current

Suppose that in the previous figure, the secondary load Z was not a purely resistive one, but contained reactive elements, say inductive. The induced secondary e.m.f. would cause a current to flow round the secondary circuit, and this current lagging by some angle ϕ on the e.m.f. would attempt to create a magnetic flux in the iron core. Since, however, the magnitude of the transformer flux is determined solely by the magnitude of the applied p.d. and is unaffected by any currents caused to flow in either circuit, a current is forced to flow in the primary winding of such value and phase that the secondary effect is cancelled. This current is known as the balancing current.

Phase of the Balancing Current

Since the transformer flux is unalterable by current changes, the magneto-motive force (M.M.F.) due to the balancing current must be equal and opposite to the M.M.F. due to the secondary current. Therefore the former must be 180 deg. out of phase with the latter.

The primary balancing current lags behind the primary p.d. by the same angle ϕ by which the secondary current lags its e.m.f. Similarly, if the secondary load is capacitive, then the secondary current leads the e.m.f. by some angle χ, and the primary balancing current leads the applied p.d. by the same angle χ.

In the case of a purely resistive load, both primary and secondary currents will be in phase with their respective voltages, though this is impossible in practice.

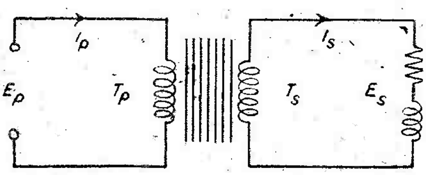


Fig. 32.—The transformer, where E_s is given by $(T_s/T_p)\ E_p$

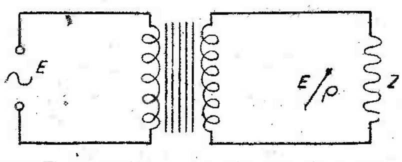


Fig. 33.—The circuit for examining the effect of a transformer on the circuit impedance.

Regulation

The regulation of a transformer is given by—

$$\frac{(\text{No load p.d.} - \text{full load p.d.}) \times 100 \text{ per cent.}}{\text{full load p.d.}}$$

B.B.C. Symphony Season

BETWEEN now and the end of the year listeners to the fortnightly public concerts by the B.B.C. Symphony Orchestra will hear unusually attractive and big-scale programmes, under the conductorship of Sir Adrian Boult, Sir Henry Wood, Basil Cameron, Clarence Raybould and Freitas Branco, the Portuguese conductor who has been described as "the Adrian Boult of Lisbon."

Branco conducted the orchestra on October 20th in a programme that included Portuguese, Spanish, French, Russian and English music. Branco, born in Lisbon on October 31st, 1896, is the brother of a famous Portuguese composer. He began his symphonic concerts in Lisbon in 1928, and since 1934 has been conductor of the State Symphonic Orchestra. His wife is a well-known French pianist.

At Sir Henry Wood's concert on November 3rd Prokofiev's Scythian Suite, "Ala and Lolly," was heard. Stravinsky's Symphony in C will have its first performance in England at Sir Adrian Boult's concert on November 17th. Roy Harris's Third Symphony—an American work that has already made a big impression here—is the high-light of Raybould's concert on December 1st, and on December 29th Basil Cameron will conduct Sibelius's masterly Fourth Symphony.

The schemes of the seven concerts do not neglect the classics. Schubert's Symphony No. 9 ("Of heavenly length"); Beethoven's Grosse Fuge and Piano Concerto No. 1, Schumann's Third Symphony, Elgar's 'Cello Concerto and Brahms' Violin Concerto will all be heard.

British composers were represented by Walton's "Portsmouth Point" overture on October 20th; Bax's "In the Faery Hills" on November 3rd. John Ireland's Piano Concerto will be heard on November 17th; Alan Rawsthorne's Piano Concerto on December 15th; and Eugene Goossens' Two Nature Poems on December 29th.

Valve Data Sheets

MULLARD

41

"E" SERIES (SIDE CONTACT)—*Continued.*

Type.	Description.	Base.	Bulb Finish.	Working Conditions. If.	Va.	Vg2.	—Vg	Ia.	Characteristics at Working Conditions. Ri.	G.	S. or Sc.	Optimum Load.
EB4	Double-diode (separate Cathodes)	P (41)	Met.	0.2	200	—	—	0.8	—	—	—	—
EAB1	Triple-diode	P (42)	Met.	0.2	200	—	—	0.8	—	—	—	—
EBC3	Double-diode Triode	P (40)	Met.	0.2	275	—	6.25	5.0	15,000	30	2.0	—
EFM1	L.F. Amplifier and Tuning Indicator	P (43)	Met.	0.2	250	—	—	—	—	—	—	—
EBF2	Double-diode H.F. Pentode	P (46)	Met.	0.2	250	100‡	2.0	5.0	1,300,000	—	1.8	—
EL2	Output Pentode	P (47)	Clear	0.2	250	250	18.0	32.0	70,000	—	2.8	8,000
EL3	Output Pentode	P (44)	Clear	0.9	250	250	6.0	36.0	50,000	—	9.0	7,000
EL6	Output Pentode	P (44)	Clear	1.3	250	250	7.0	72.0	17,000	—	15.0	3,500
EBL1	Double-diode Output Pentode	P (46)	Clear	1.5	250	250	6.0	36.0	50,000	—	9.5	7,000

Type.	Description.	Base.	Bulb Finish	Vf.	If.	Anode Voltage (R.M.S.).	Rectified Output (mA).
AZ1	Directly-heated F.W. Rectifier	P (48)	Clear	4.0	1.1	300—0—300	100
AZ2	Directly-heated F.W. Rectifier	P (48)	Clear	4.0	2.0	300—0—300	160
AZ3	Indirectly-heated F.W. Rectifier	P (49)	Clear	4.0	2.0	350—0—350	120
EZ2	Indirectly-heated F.W. Rectifier	P (49)	Clear	6.3	0.4	350—0—350	60

‡ Rg2=95,000 Ω

42

INDIRECTLY HEATED A.C. MAINS VALVES

Vf=4.0 V.

Type.	Description.	Base.	Bulb Finish.	Working Conditions. If.	Va	Vg2	—Vg.	Ia.	Characteristics at Working Conditions. Ri.	G.	S. or Sc.	Optimum Load.
TV4	Tuning Indicator ..	P (33)	Clear	0.3	250	—	0–5	—	—	—	—	—
TV4A	Tuning Indicator ..	P (33)	Clear	0.3	250	—	0–21	—	—	—	—	—
TH4	Triode Hexode Frequency Changer	7-pin (25)	Met.	1.0	250	70	1.5	4.0	1,500,000	—	1.0	—
TH4B	Triode Heptode Frequency Changer (replaces TH4A)	7-pin (25))	Met.	1.45	250	100	2.5	3.25	1,500,000	—	0.75	—
FC4	Octode Frequency Changer	7-pin (23)	Met.	0.65	250	90*	1.5	1.6	—	—	0.6	—
VP4	Vari-mu H.F. Pentode	5-pin (14)or 7-pin (19)	Met.	1.0	200	100	2–50	4.5	1,000,000	2,000	2.3	—
VP4A	Vari-mu H.F. Pentode	5-pin (14)or 7-pin (19)	Met.	1.2	200	100	2.0	4.25	1,400,000	3,500	2.5	—
VP4B	Vari-mu H.F. Pentode	7-pin (20)	Met.	0.65	250	250	3.0	11.5	—	—	2.0	—
SP4	H.F. Pentode ..	5-pin (14)or 7-pin (19)	Met. or Clear	1.0	200	100	2.0	3.0	2,200,000	5,000	2.3	—
SP4B	H.F. Pentode ..	7-pin (20)	Met.	0.65	250	250	2.4	4.0	2,000,000	6,300	3.4	—
MM4V	Vari-mu Screened Tetrode	5-pin (14)	Met	1.0	{200 200	110 110	1.5 40.0	6.0 0.15	—	—	2.5 0.01 }	—
S4VA	Screened Tetrode ..	5-pin (14)	Met. or Clear	1.0	200	110	1.5	2.75	500,000	1,000	2.0	—

* Vg3+5=70V.

43

INDIRECTLY HEATED A.C. MAINS VALVES—(*Continued*)

Vf=4.0 V.

Type.	Description.	Base.	Bulb Finish.	Working Conditions. If.	Va.	Vg2.	—Vg.	Ia.	Characteristics at Working Conditions. Ri.	G.	S. or Sc.	Optimum Load.
S4VB	Screened Tetrode ..	5-pin (14)	Met. or Clear	1.0	200	110	1.5	4.6	300,000	750	2.5	—
2D4A	Double-diode ..	5-pin (9)	Met.	0.65	200	—	—	0.8	—	—	—	—
2D4B	Double-diode with separate Cathodes	7-pin (27)	Met.	0.35	200	—	—	0.8	—	—	—	—
TDD4	Double-diode Triode	7-pin (26)	Met.	0.65	250	—	7.0	4.0	13,500	27	2.0	—
354V	Medium Impedance Triode	5-pin (10)	Met. or Clear	0.65	250	—	4.5	6.5	11,500	40	3.5	—
244V	Medium Impedance Triode	5-pin (10)	Met.	0.65	200	—	5.5	5.5	9,000	25	2.8	—
TT4	Low Impedance Triode (replaces 104V)	5-pin (10)	Clear	1.0	250	—	16.0	20.0	3,300	10.5	3.2	10,000
TT4A	Low Impedance Triode	5-pin (10)	Clear	1.0	250	—	9.0	20.0	4,400	18.0	4.1	5,000
Pen 4VA	Output Pentode ..	5-pin (12)or 7-pin (17)	Clear	1.35	250	250	22.0	36.0	40,000	—	2.8	6,000
Pen A4	Output Pentode (replaces Pen 4VB)	7-pin (17)	Clear	1.95	250	250	5.8	36.0	50,000	—	9.5	8,000
Pen B4	Output Pentode ..	7-pin (17)	Clear	2.1	250	275	14.0	72.0	22,000	—	8.5	3,500
Pen 4DD	Double-diode Output Pentode	7-pin (29)	Clear	2.25	250	250	6.0	36.0	50,000	—	9.5	7,000
Pen 428	Output Pentode ..	7-pin (17)	Clear	2.1	375	275	20.5	62.0	—	—	8.0	6,500†

† Data for 2 x Pen 428 in Class AB push-pull.

44

DIRECTLY HEATED A.C. OUTPUT VALVES

Vf=4.0 V. unless otherwise stated.

Type.	Description.	Base.	Bulb Finish.	Working Conditions. If.	Va.	Vg2.	—Vg.	Ia.	Characteristics at Working Conditions. Ri	G.	S.	Optimum Load.
AC044	Triode	4-pin (1)	Clear	1.0	300	—	38.0	50	1,200	6.0	5.0	2,300
AC042	Triode	4-pin (1)	Clear	2.0V 2.0A	300	—	38.0	50	1,200	6.0	5.0	2,300
PM24	Pentode	4-pin (4) or 5-pin (8)	Clear	0.15	150	150	11.0	20	—	—	1.75	8,000
PM24A	Pentode	5-pin (8)	Clear	0.275	300	200	22.5	20	—	—	2.0	10,000
PM24M	Pentode	5-pin (8)	Clear	1.1	250	250	17.0	30	43,000	130.0	3.0	7,000
PM24B	Pentode	5-pin (8)	Clear	1.0	400	300	40.0	30	—	—	2.1	8,000
PM24E	Pentode	5-pin (8)	Clear	2.0	500	200	35.0	50	—	—	4.0	7,000
D024	Triode	4-pin (1)	Clear	1.85	400	—	40.0	63	1,070	8.0	7.5	3,200
D025	Triode	4-pin (1)	Clear	6.0V 1.1A	400	—	112.0	63	800	3.0	3.75	4,000
D026	Triode	4-pin (1)	Clear	2.0	400	—	92.0	63	950	3.6	3.8	3,000
D030	Triode	4-pin (1)	Clear	1.85	500	—	140.0	60	890	3.1	3.5	—

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Valve Data Sheets

MULLARD

45

D.C./A.C. VALVES

Pin Bases: P Base (8 contact) and V Base (5 contact)

Type	Description	Base	Bulb Finish.	Working Conditions. Vf	If	Va	Vg2	—Vg	Ia	Characteristics at Working Conditions Ri	G	S.or Sc.	Optimum Load
EM1	Tuning Indicator (replaces TV6)	P (33)	Clear	6.3	0.2	250	—	0—5	—	—	—	—	—
TH21C	Triode Hexode Frequency Changer	7-pin (25)	Met.	21.0	0.2	250	70	1.5	4.0	1,500,000	—	1.0	—
TH30C	Triode Heptode Frequency Changer (replaces TH22C)	7-pin (25)	Met.	29.0	0.2	250	100	2.5	3.25	1,500,000	—	0.75	—
FC13	Octode Frequency Changer	P (36)	Met.	13.0	0.2	200	90*	1.5	1.6	—	—	0.6	—
FC13C	Octode Frequency Changer	7-pin (23)	Met.	13.0	0.2	200	90*	1.5	1.6	—	—	0.6	—
VP13A	Vari-mu H.F. Pentode	P (37)	Met.	13.0	0.2	200	100	2.0	4.0	—	2,200	2.2	—
VP13C	Vari-mu H.F. Pentode	7-pin (20)	Met.	13.0	0.2	200	200	2.0	9.0	—	—	2.2	—
SP13	H.F. Pentode ..	P (37)	Met.	13.0	0.2	200	100	2.0	3.3	1,300,000	3,000	2.2	—
SP13C	H.F. Pentode ..	7-pin (20)	Met.	13.0	0.2	200	200	2.2	2.5	2,500,000	7,000	2.8	—
2D13	Double-diode Detector	V	Met.	13.0	0.2	200	—	—	0.8	—	—	—	—
2D13A	Double-diode Detector	V (32)	Met.	13.0	0.2	200	—	—	0.8	—	—	—	—

* Vg 3+5=70 V.

46

D.C./A.C. VALVES—*(Continued)*

Pin Bases; P Base (8 contact) and V Base (5 contact)

Type	Description	Base.	Bulb Finish.	Working Conditions Vf	If	Va	Vg2	—Vg	Ia	Characteristics at Working Conditions Ri.	G	S. or Sc	Optimum Load
2D13C	Double-diode Detector	5-pin (9)	Met.	13.0	0.2	200	—	—	0.8	—	—	—	—
HL13	Medium Impedance Triode	P (39)	Met.	13.0	0.2	200	—	3.7	5.0	12,000	40	3.3	—
HL13C	Medium Impedance Triode	7-pin (28)	Met.	13.0	0.2	200	—	3.7	5.0	12,000	40	3.3	—
TDD13C	Double-diode Triode	7-pin (26)	Met.	13.0	0.2	200	—	5.0	4.0	13,500	27	2.0	—
Pen26	Output Pentode ..	P (47)	Clear	24.0	0.2	200	100	19.0	40.0	—	—	3.1	5,000
Pen36C	Output Pentode ..	7-pin (17)	Clear	35.0	0.2	200	200	9.0	40.0	—	—	8.0	4,000
Pen40DD	Double-diode Output Pentode	7-pin (29)	Clear	44.0	0.2	200	200	8.5	45.0	—	—	8.0	4,500
CBL1	Double-diode Output Pentode	P (46)	Clear	44.0	0.2	200	200	8.5	45.0	35,000	—	8.0	4,500
CL4	Output Pentode ..	P (47)	Clear	33.0	0.2	200	200	8.5	45.0	35,000	—	8.0	4,500
CL6	Output Pentode ..	P (47)	Clear	35.0	0.2	200	100	9.5	45.0	19,000	—	8.0	4,500

47

A.C. RECTIFIERS

Type	Description	Base	Vf	If	Max. Va (R.M.S.)	Max. Rectified Output (mA)
DW2	Directly-heated F.W. Rectifier ..	4-pin (2)	4.0	1.0	250—0—250	60
DW4/350	Directly-heated F.W. Rectifier (replaces DW3)	4-pin (2)	4.0	2.0	350—0—350	120
DW4/500	Directly-heated F.W. Rectifier (replaces DW4)	4-pin (2)	4.0	2.0	500—0—500	120
IW2	Indirectly-heated F.W. Rectifier ..	4-pin (3)	4.0	1.2	250—0—250	60
IW3	Indirectly-heated F.W. Rectifier ..	4-pin (3)	4.0	2.4	350—0—350	120
IW4/350	Indirectly-heated F.W. Rectifier ..	4-pin (3)	4.0	2.0	350—0—350	120
IW4/500	Indirectly-heated F.W. Rectifier (replaces IW4)	4-pin (3)	4.0	2.4	500—0—500	120
FW4/500	Directly-heated F.W. Rectifier ..	4-pin (2)	4.0	3.0	500—0—500	250

D.C./A.C. RECTIFIERS

Type	Description	Base	Bulb Finish	Vf	If	Max. Anode Volts (R.M.S.)	Max. Rectified Output (mA)
CY1	Half Wave Rectifier (replaces UR1)	P (50)	Clear	20	0.2	250	75
UR1C	Half Wave Rectifier ..	5-pin (11)	Clear	20	0.2	250	75
CY2	Multiple Rectifier (replaces UR3)	P (51)	Clear	30	0.2	250—0—250	120
UR3C	Multiple Rectifier ..	7-pin (30)	Clear	30	0.2	250—0—250	120

48

OCTAL BASE

Type	Description	Base	Bulb Finish	Working Conditions. Vf=6.3V, except 25A6G If	Va	Vg2	—Vg	Ia	Characteristics at Working Conditions Ri	G	S	Optimum Load
6U5/6G5	Tuning Indicator	6-pin U.X.	Clear	0.3	250	—	0—22	—	—	—	—	—
6A8G	Hep. Freq. Ch'ger	8-pin Octal (68)	Clear	0.3	250	100	3.0	3.5	360,000	—	—	—
6L7G	Hexode Mixer ..	7-pin Octal (65)	Clear	0.3	250	150	6.0	3.3	> 1,000,000	—	—	—
6K7G	Vari-mu H.F. Pen.	7-pin Octal (66)	Clear	0.3	250	125	3.0	10.5	600,000	990	1.65	—
6J7G	H.F. Pentode ..	7-pin Octal (66)	Clear	0.3	250	100	3.0	2.0	> 1,500,000	≥1,500	1.225	—
6Q7G	Dble.-diode Triode	7-pin Octal (67)	Clear	0.3	250	—	3.0	1.1	58,000	70	1.2	—
6R7G	Dble.-diode Triode	7-pin Octal (67)	Clear	0.3	250	—	9.0	9.5	8,500	16	1.9	—
6H6G	Double-diode (separate Cathodes)	7-pin Octal (65)	Clear	0.3	100	—	—	4.0	—	—	—	—
6C5G	Medium Impedance Triode	6-pin Octal (61)	Clear	0.3	250	—	8.0	8.0	—	20	2.0	—
6F6G	Output Pentode	7-pin Octal (64)	Clear	0.7	250	250	16.5	34.0	80,000	200	2.5	7,000
6V6G	Beam Power Output Pentode	7-pin Octal (64)	Clear	0.45	250	250	12.5	45.0	52,000	218	4.1	5,000
6L6G	Beam Power Output Pentode	7-pin Octal (64)	Clear	0.9	250	250	14.0	72.0	22,500	135	6.0	2,500
25A6G	Output Pentode	7-pin Octal (64)	Clear	Vf=25 0.3	135	135	20.0	37.0	35,000	85	2.45	4,000

Type	Description	Base	Bulb Finish	Heater Rating Vf	If	Anode Voltage (R.M.S.)	Rectified Output (mA)
5Y3G	Directly-heated F.W. Rectifier	5-pin Octal (60)	Clear	5.0	2.0	400—0—400	125
5U4G	Directly-heated F.W. Rectifier	5-pin Octal (60)	Clear	5.0	3.0	500—0—500	250
5Z4G	Indirectly-heated F.W. Rect.	5-pin Octal (62)	Clear	5.0	2.0	400—0—400	125
25Z6G	Indirectly-heated Multiple Rec.	7-pin Octal (63)	Clear	25	0.3	125	85
5V4G	Indirectly-heated F.W. Rect.	5-pin Octal (60)	Clear	5.0	2.0	400—0—400	200

The Manufacture and Testing of Valves—5

Test Boards : How Valves are Tested : Gas-filled Valves : Inspection

By LAURENCE ARTHUR

(Concluded from page 498, November issue)

THE leakage capacity must be kept as low as possible because it serves as a coupling between grid and anode circuits, causing feed back and instability. In screened grid valves the electrostatic screen is purposely introduced to lower this leakage capacity to the minimum.

Inter-electrode capacities, which are described in terms of micro-microfarads (sometimes called picofarads), are measured on a capacity bridge. Fig. 29 (November issue) shows the circuit diagram of the Sullivan bridge which uses an accurately calibrated standard variable condenser, on the dial of which may be read directly the capacity being measured. A valve holder, shielded from the bridge, is connected with stiff wiring to the three terminals shown. If the grid-anode capacity is to be measured the leads from those electrodes are connected to the terminals marked HP and LP, whilst the filament or cathode is connected to E. (In multi-electrode valves it is frequently necessary to measure capacities between one electrode and two or three others, the remainder being connected to earth.)

The bridge has to be set up without the valve in the holder. With the standard condenser at zero, the initial balancing condenser is adjusted until the note from the signal generator cannot be heard in the headphones. Then the valve is inserted in the holder and the standard condenser rotated until the note again cannot be heard when the capacity being measured is shown on the dial. The balance sharpening condensers are used to sharpen up the "null" point and thus make the reading more accurate.

Other means of measuring small valve capacities consist of apparatus using a "magic eye" valve, a neon lamp or a cathode ray tube. The general principle of these is that the introduction of additional capacity (e.g., grid-anode) into an oscillatory circuit alters the resonance. The amount of capacity, in the form of a calibrated variable condenser, needed to return to the resonance point is the value of the capacity being measured.

Each type of valve has its "rating," or its list of operating voltages and currents, worked out theoretically on the basis of the valve being perfect in every way. Owing to the many possible variations in manufacture, it is impossible to produce the perfect valve in large quantities, so the specifications to which valves are tested allow tolerances in permissible values. For example, the filament current of a two volt battery valve may be rated at 0.1 amperes, but the test specification might tolerate a reading from 0.09 to 0.11 amperes. Similarly, the mutual conductance of an indirectly heated H.F. pentode may be rated at 3.5 milliamperes per volt, but the test specification might allow a variation from 2.5 to 4.5 milliamperes per volt. As a general rule the rating is midway between the two values given in the specification.

Test Boards

There are at least three general types of test boards:

1. Those capable of testing all types of directly and indirectly heated receiving and small transmitting valves, having suitable voltage supplies and meters, and interchangeable valve holder panels.

2. Those designed for the testing of one type of valve and therefore only having the voltage supplies, meters and valve holder required for that type.

3. Semi-automatic boards designed for rapid operation by unskilled workers on one type of valve only. This kind of board has pre-set voltages and current indications are taken either from relay-operated coloured lamps or "blind" meters having a white or green "permissible" sector, with red "reject" sectors on each side. Fig. 30 shows a type of blind meter requiring negligible skill to read it.

The universal type of test board is probably of most interest, and it is proposed to show in detail the testing of a directly heated battery valve and an indirectly heated

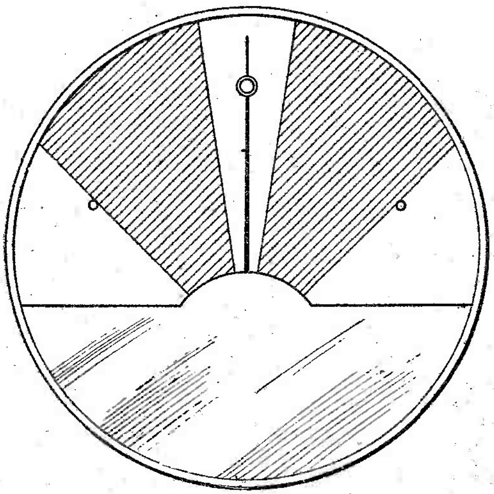

Fig. 30.—"Blind" meter, with central white permissible sector, the rest of the dial coloured red for rejects.

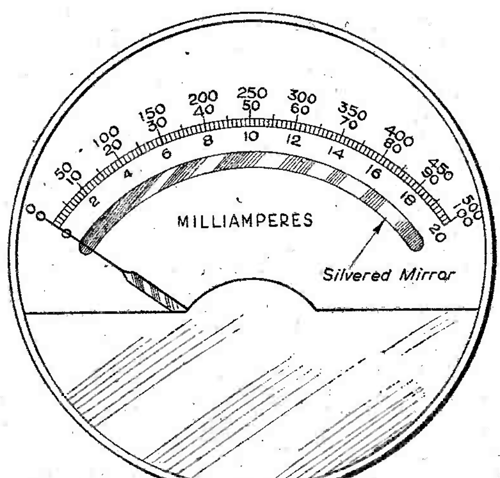

Fig. 31.—Dial of a triple-range milliammeter.

mains valve. For the first example, a small battery output triode or power valve, the rating would probably read: Filament volts, 2.0; filament amperes, 0.2; maximum anode volts, 150; mutual conductance, 2.0 milliamperes per volt; impedance, 4,000 ohms; amplification factor, 8; anode current, 10 milliamperes; grid bias, 7.5 volts. The individual controls on the test board are set at zero before the valve is inserted in the holder. The filament control is turned up until the filament voltmeter reads 2.0. The filament ammeter must now read between 0.18 and 0.22. The grid

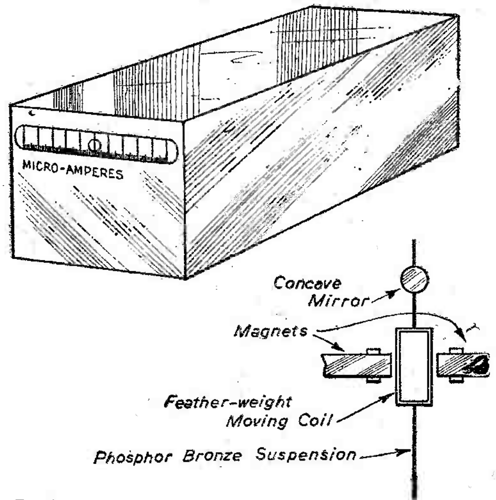

Fig. 32.—External view and movement of a mirror galvanometer used as a micro-ammeter.

voltage control is now turned up until the grid voltmeter reads 7.5. Anode volts are applied until the anode voltmeter reads 150. The anode milliameter should read between 8.5 and 11.5. A typical milliammeter with a triple range is shown in Fig. 31. Note the arc of silvered mirror; accuracy in reading is ensured by seeing that the knife-edged pointer is directly over its reflection in the mirror.

The grid volts are reduced by one: the resulting increase of anode current is a direct reading of the slope or mutual conductance in milliamperes per volt, and should be between 1.5 and 2.5. The impedance is measured by reducing the grid bias voltage to zero, and reading the anode current change when the anode volts are reduced from 150 to 100. The difference with the valve now being tested would be 12.5 milliamperes. This figure divided into the anode voltage difference (50) and multiplied by 1,000 gives the impedance.

Relationship Between g, Ra and μ

The amplification factor is readily obtained by multiplying the mutual conductance by the impedance and dividing by 1,000. It can also be obtained by measuring the ratio of change in anode volts to the change in grid volts in order to make the same change of anode current. There is a simple relationship between mutual conductance (g), impedance (Ra) and amplification factor (μ) which can be expressed:—

$$g = \frac{\mu}{Ra} \times 1{,}000.$$

$$\mu = \frac{g \times Ra}{1{,}000}.$$

$$Ra = \frac{\mu}{g} \times 1{,}000$$

where impedance is in ohms and mutual conductance in milliamperes per volt.

A final test before the valve is removed from the holder is a measure of the goodness of the vacuum. It consists of reading on a sensitive galvanometer the reverse current flowing from the grid to the filament and in the majority of valves must not exceed 3.0 micro-amperes. Fig. 32 shows a mirror galvanometer with a schematic drawing of the movement.

Measurements of impedance and amplification factor are not made in normal testing. They are so bound up with the physical characteristics of the valve that, providing no change of design is made, it is not necessary to take the readings.

Testing an H.F. Pen.

For the second example it is proposed to take an indirectly heated H.F. pentode. The rating would probably read: heater volts, 4.0; heater current, 1.0 amperes; anode volts, 200; screen volts, 100; mutual conductance, 2.8 milliamperes per volt; grid bias, 1.5 volts; anode current, 5.0 milliamperes. Because of the time taken for an indirectly heated valve to warm up and stabilise, it is usual to have alongside the test board at least six additional valve holders wired to a heater supply, so that the valves are pre-heated before test. Placing the valve in the test holder the heater volts are run up to 4.0. The current shown on the heater ammeter must be between 0.9 and 1.15 amperes. The grid bias is adjusted to 1.5 volts; 200 volts are applied to the anode and 100 volts to the screen. The anode current should now read from 4.0 to 6.0 milli-amperes. It is usual to take the screen current and in this case it should be a maximum of 3.0 milliamperes. No minimum is specified because the screen current must be kept as low as possible. The grid volts are reduced by one; the resulting increase of anode current is a direct reading of the slope or mutual conductance and should be between 2.2 and 3.4 milliamperes per volt.

With indirectly heated valves it is necessary to measure the heater-cathode leakage. With the heater run at normal voltage and current, 100 volts are applied between cathode and heater (the positive side of the supply being to cathode), and the current flowing, measured on a sensitive galvanometer, shall not exceed 36 micro-amperes. Before removing the valve reverse grid, current flowing from the grid to the cathode is measured and must not be more than 3.0 micro-amperes.

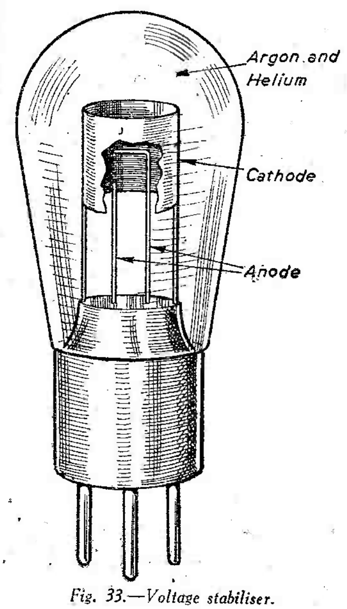

Fig. 33.—Voltage stabiliser.

More complicated types of valves, such as double diode pentodes and triode hexodes, require means for measuring many additional currents, so that the universal type of test board may have from fourteen to twenty different meters, five or six ranges of voltage supply and a row of Dewar type key switches or Yaxley type rotary switches to make the connections from the valve holder to the meters and to change over meter ranges.

(*To be concluded.*)

Impressions on the Wax

Review of the Latest Gramophone Records

Columbia

ONE of the finest pianists of the nineteenth century, and the most outstanding pupil of Clementi, John Field earned a meagre living as a showroom assistant, and, later, as a demonstrator of Clementi's pianos. In the latter capacity he travelled extensively, until he finally parted from his employer and master in Russia and settled down in that country. Strange as it may seem, when we bear in mind his numerous compositions, John Field was not a born musician, in fact, it is said that music was beaten into him by his father and grandfather. In spite of that treatment, Field became an important figure in the history of piano music because of his undoubted qualities as a fine musician and composer. It was when he settled in Russia that he concentrated on composing, and it is a great pity that the majority of his works are now sadly neglected. He was fond of reflective piano pieces, which he called nocturnes, and it is his "Nocturne in G Major" and "Nocturne in A Major" which Louis Kentner plays for us—so magnificently as pianoforte solos—on *Columbia DX*1129. These two outstanding recordings give all lovers of piano music the opportunity of enjoying compositions, which, in their day, were admired by such masters as Chopin and Liszt.

Isobel Baillie—soprano—has selected two of Thomas Augustine Arne's beautiful compositions for her recordings this month. They are "O Ravishing Delight" and "Where the Bee Sucks," and she is accompanied by Gerald Moore at the piano. Isobel Baillie's singing and interpretation are beautiful, and I do not think I can add anything to that other than remind you that the record is *Columbia DB*2121.

David Lloyd—the noted Welsh tenor—has made an exceptionally fine recording of "When Night Descends" (Rachmaninoff Op. 4, No. 3) and "To the Children" (Rachmaninoff Op. 26, No. 7—words, Komiakov). The first of these is a tender and impassioned love song, and the second, made famous by John McCormack, is based on the rather pathetic cry of parents through the ages: the children are children no more. David Lloyd's singing is superb, and he shows a thorough understanding of both compositions and their true beauty.

Records of the performances by the Albert Sandler Trio have, for me—as I am sure they must have for many thousands more—a very strong appeal. They possess that very rare quality of originality; they are not swamped by an annoying characteristic in the orchestration or rendering of the pieces, thus it is possible for one to listen to several of their records without being irritated by a pronounced sameness.

The two latest recordings are on *Columbia DB*2122, and these consist of "Demande Et Reponse"—a charming piece by Coleridge-Taylor—and that delightful composition by Mendelssohn, "On Wings of Song." A very fine record.

My last record in the *DB* series is *Columbia DB*2123, on which the ever popular Bing Crosby has recorded "You're Beautiful To-night, My Dear" and "You're Still In My Heart," both very good numbers. Bing sings with all his romantic appeal, and I advise all his followers to make a note of the record number.

Victor Silvester has done the hat trick this month. I have before me three of his records, and all of them are recommended for dancing enthusiasts. The first two are by Victor and his Ballroom Orchestra, and they are "In the Blue of the Evening"—slow fox-trot—and "With All My Heart"—quick step—on *Columbia FB*2962. On *Columbia FB*2961 they play "The 'Request' Waltz" founded on Waltz "Pomone," and with this is linked "Take It From There"—a good quick step.

The third record is by Victor Silvester's Strings For Dancing, and, in this instance, the two numbers are "La Cumparsita"—a tango—and "Valse Des Fleurs"—a very nice waltz. These are on *Columbia FB*2959.

For those who like brass band performances I recommend *Columbia FB*2956. This will enable them to hear Foden's Motor Works Band—conducted by Fred Mortimer—playing "Military Polonaise" and "Lohengrin—Prelude (Act 3)." The band is too well known to need any comment from me, but I can say that they have made two fine recordings.

Felix Mendelssohn and his Hawaiian Serenaders offer that evergreen favourite, "Roses of Picardy," and, on the other side of the disc—*Columbia FB*2957—"Chez Moi." The vocals are taken by Helen Clare.

H.M.V.

AT a recent concert of French music, Maggie Teyte sang that very delightful song by Chausson, "Chanson Perpetuelle." Its revival, and, of course, the superb performance given by this great artiste, resulted in many requests that she should record it.

On *H.M.V. DB*6159 we have, so to speak, the answer, as Maggie Teyte, accompanied by the Blech String Quartet and Gerald Moore at the piano, has made a beautiful recording of it, and thus added yet another gem to the dozen or so records she has made of nineteenth century French songs. The full title of the record is "Chanson Perpetuelle, Op. 37," Part 1 and Conclusion. I recommend this record to all who enjoy listening to a great artiste possessing a soprano voice of the finest quality, and the works of Chausson.

One of the greatest works, in any form, of Beethoven is his Trio No. 7 in B Flat, Op. 97, which is also known as "The Archduke." It seems rather strange to link a nickname—for such it is—with a composition of this high order, but it is not alone in the world of music in that respect, in fact, many works are more widely known by their nicknames than by the titles given them by their composers. Trio No. 7 in B Flat was dedicated to His Royal Serene Highness, Prince Rudolf, Archduke of Austria, one of the first and most loyal aristocratic friends of Beethoven in Vienna. It was written in 1810-1811, and it forms the supreme pianoforte trio in the literature of music.

"His Master's Voice" have made an important contribution to the musical life of the country, by bringing together three great players, namely, Solomon—pianoforte, Henry Holst—violin, and Anthony Pini—'cello, to produce a wonderful recording of Beethoven's masterpiece. The records are *H.M.V. C*3362-3366, ten parts on five records, and they form a highlight in performance and recording.

If the Indian Love Lyrics are included in your list of favourites, then I would most certainly recommend *H.M.V. B*9342, as this is the number of the latest recording by Webster Booth, during which he sings "Temple Bells" and "Less Than the Dust" with great expression and understanding.

This month, "Hutch" (Leslie A. Hutchinson) has selected "Alone With My Dreams" and "All Or Nothing At All" for his contribution. *H.M.V. BD*1055.

Eric Winstone makes his debut on H.M.V. this month and his first record includes "All Or Nothing At All" and "In the Blue of the Evening"—foxtrot and slow foxtrot respectively. The fact that this is his first recording in the H.M.V. studios does not mean that it was a new experience for Eric; he is already widely known through his broadcasting, the variety stage and his recordings with Columbia and Regal. It is his ambition to build up a band that would eventually be the finest in the country, and it is already very obvious that no effort is spared to select the finest musicians and arrangers for his recording performances. His many compositions are now famous, the latest addition being

(Continued on page 41)

Open to Discussion

The Editor does not necessarily agree with the opinions expressed by his correspondents. All letters must be accompanied by the name and address of the sender (not necessarily for publication).

Midget One-valver

SIR,—Regarding the Midget One-valver in the October issue of PRACTICAL WIRELESS. Two small points have arisen from the model made up by a friend. Firstly, the results obtained from a receiver of this type depend very largely upon the efficiency of the reaction circuit. There is no H.F.C. in the set, the 'phones being connected between the anode of the valve and H.T. plus. Some sets of 'phones will not provide sufficient choking effect to enable the reaction circuit to function—possibly because they have a large internal capacity—so that the set will not oscillate. The inclusion of an H.F.C. will remove this trouble. In the original receiver there is just room for a small choke wound in the form of a flat coil. Secondly, if the L.T. minus is connected to earth, instead of as shown, it will be found difficult to get the valve to oscillate.—F. G. RAYER (Longdon).

S.W. Broadcasts

SIR,—I was very interested in F. G. Rayer's letter, in the October issue, and I have a few more stations to add which will probably interest readers.

Free Jugoslavia 25.3 m. (approx.), News 08.05 and 14.30, not regular. FZI test transmission 19 band 11.10-11.25. WWV 15 megacycles, National Bureau of Standards, Washington D.C. It is modulated by a standard musical note of 440 cycles per second corresponding to A over middle C. Also there is a pulse every second heard as a faint tick. Announces every half-hour; heard in evening. WLWK has replaced WLWO on the 19 m. band. WKRX, which used to share wavelengths with WNBI and WRCA, now has one of its own, 19.75 m. WQV, New York, 14.8 megacycles, point-to-point transmissions with other stations, mainly Allied Force Headquarters; sometimes works with WKD, frequency unknown, and WCG 10.38 megacycles. A.F.H.Q. afternoon 18 band. Radio Congo-Belge News in English 12.45 Sundays, 14.97 m. and 16.88 m. (not the new Nationale-Belge transmitter but slightly higher wavelength). United Nations Radio, same wavelength as Radio France 24.77, and 33.46 m. News on the hour in evening. Jap stations heard: Tokyo 19.8 and 16.87 m., News 10.40 and 21.05 hours. Radio Saigon, "Voice of France in the Far East," 25 m. band, News 15.30. All times B.S.T. I have left out the stations recently mentioned in PRACTICAL WIRELESS. My set is a Standard Three with an extra untuned H.F. stage. The reaction is extremely smooth. I suppose all DX listeners noticed how bad conditions were at the beginning of September.—S. HUDSON (Cambridge).

SIR,—I recently received a letter from Guatemala City, which might interest some readers. The following are the transmitters:

TGW, medium wave, 10 kilowatts, broadcasts on 491 metres. TGWA, 10 kilowatts, broadcasts in daytime on 19.78 metres; night time on 30.98 metres. Other frequencies, 11.760 and 17.800 megacycles. TGWB, 1 kilowatt, on 6.480 metres. TGWC, 1 kilowatt, on 1.520 metres. Programmes in which announcements are made in English are as follow:

To the United States, from 04.00-05.45 hours, every Monday, Tuesday, Thursday and Saturday, TGWA on 30.98 metres. To Europe, from 21.30-23.15 hours every Sunday, TGWA on 19.78 metres. Every day from 18.45-19.45 hours, and on Sundays only, from 04.00-0600 hours.

So much for Guatemala. Here are other items of interest:

HCJB, Quito, Ecuador, on 24.08 and 30.00 metres gives a special programme in English every Sunday at 22.00 hours.

PRE9, Fortaleza, Brazil, on 19.78 metres, gives a programme in Spanish every night, which is fairly loud.

U.S. transmitters give a list of the bands used for their English news bulletins, on the hour; during the 15.00-15.15 hours bulletin.

PMA, Batavia (has been renamed Jakarta), operates on 16.6 metres every day in English.

Radio Tokyo, at the low frequency end of the 19 metre band, gives an English programme at 21.00 hours.

All times B.S.T. Receiver, 0-v-1 triode-pentode. Aerial, north-south, 66 feet.—R. M. PREVETT (Nottingham).

A Set's Peculiar Behaviour—In Verse

SIR,—A friend of mine asked me to overhaul his set, as it was behaving in a very peculiar way. In fact I should say that its behaviour was unique—because upon switching on the set I found that—

There were oscillations in the wire.
And static in the set.
The H.F. choke was set on fire.
The valves became all wet.

And superheterodyne began,
To whistle in the 'phones
Like autodyne the screening can
Gave rattles of its bones.

The A.C. undamped waveform was
A sinusoidal curve.
The angle didn't care a cos
For asymptote or swerve.

The high-μ valve was getting thin
Its screen grid lost some weight.
The anode-cap threw off its tin,
The A.V.C. was late.

The pentodes then began a dance
Some farads gave a yell.
An ohm or two began to prance,
The henries made for Hell.

One glance was good enough for me,
I staggered back in fright:
And when I'd had a cup of tea
I fled into the night.

—H. C. PARTEN (Loughborough).

Distorted B.B.C. Transmissions

SIR,—On page 485 of the November issue of PRACTICAL WIRELESS, under the heading "Selling and Servicing," you state that "Radio is an important part of our national life, and it is essential that every wireless set should be kept in working condition."

The first part of this quotation prompts me to ask if you are aware of the conditions governing reception in this and other districts after dark, due to the miserable transmission, which is distorted to such an extent that one is forced either to switch off or tune to foreign stations.

The B.B.C. have now had over four years' experience of this type of transmission, and it appears that their engineering department is not capable of effecting an improvement.

I have taken up this matter with them every winter since 1939, but have received no satisfaction, but merely the statement that it is to avoid guiding enemy aircraft, with a leaflet on suggested measures to obtain a possible improvement, which were all futile.

All the medium-wave stations are affected, and to make matters worse the S.W. 48.54 m. station is more often than not off the air, while the S.W. transmission of the Forces programme has been stopped altogether.

I think that if the technical press were to take up the matter some improvement would be forthcoming, as very little notice is taken of mere listeners by the highbrows at Broadcasting House, and I respectfully ask that you will do your best for those who are placed in such an unfortunate position.—C. FIELD, Manager, Gas Works, St. Asaph.

Selling and Servicing

SIR,—On page 485 of your November issue you set forth the unfair conditions operating against a great number of those in the radio business by the licences issued by the Board of Trade.

It is quite obvious that the small practical radio trader is being victimised to the benefit of a minority of large dealers, and it is time that some united action was taken in the matter.

As I am greatly interested in the welfare of the smal business man, I shall be pleased to hear from any of your readers who are suffering from the anomalies of B.O.T. licences as outlined in your article.—K. A. BEADNALL, A.F.C.S., The Business Men's Defence Association, Albion House, 59, New Oxford Street, London, W.C.1.

SIR,—With reference to the Comments of the Month, on Selling and Servicing, in the November issue of PRACTICAL WIRELESS.

I have a shop here at Clacton, and am doing radio repairs. I have applied for a Board of Trade licence for selling radio components, valves, etc., but without success. It seems that any other firm in the district who holds a licence such as above can oppose the applicant's request, and have it suspended.

This is what happened in my particular case. I am the only radio service engineer in my own and surrounding villages, except a firm who are mainly electrical engineers, who happen to hold a licence for radio as they used to sell radio sets in pre-war days. This firm is the one that opposed my request for a licence. They still do a few repairs, although they have hardly any stocks of radio valves, parts, etc., and will not sell any radio goods to any customer who calls at their shop.

The few repairs they get are either refused or the ones taken in are looked at and mostly returned to the customer as unrepairable. These sets find their way to me to be repaired.

I also find it extremely difficult to explain to a customer who comes to me for some small article such as aerial wire, plugs, or valves, that I cannot supply, although I have them in stock.

I am not fit for military service, having been passed Grade 4 by the Medical Board, but am a member of the H.G., and am a signaller in that service. I think it is very unfair the way licences are distributed, not only for myself but for the countless numbers of others who must be in a similar position.

I have had a large amount of experience in radio repairs, having worked for a large firm at Colchester as their engineer for a period of 14 months, after which I started on my own account at Clacton, and have been doing so for nearly two years.

I also used to do repairs in my spare time since I was 15. I am now nearly 20.

I am a keen radio amateur, and have every issue of PRACTICAL WIRELESS, which I find very useful. I have made the signal tracer in the September issue, and find it very good; it also saves a lot of time when doing repairs. I have fitted my tracer with P.U. terminals for testing radiogram pick-ups, and have also made up the power pack separately and use it for supplying a signal oscillator, and valve-voltmeter, which are also partly of your design.

I also agree with your comment on the racket going on in repairs. The other firm mentioned wanted £3 5s. for repairing a radio set that should never have reached the £2 mark, even in wartime. There is also another firm adjacent who started a shop about February, who charge as much as £2 for fitting a valve. This firm also has no licence, and is well known by the local council for overcharging on repairs.—L. E. HEALEY (Clacton-on-Sea).

Impressions on the Wax

(*Continued from page* 38.)

" Pony Express." It is certain that we shall hear much more in the future about Eric Winstone and his Band. Make a note of the number—*H.M.V. BD*5818.

Joe Loss and his Orchestra have made a good recording of that very popular number from " The Lisbon Story," " Never Say Goodbye "—foxtrot, and " You Rhyme With Everything That's Beautiful "—a slow foxtrot. *H.M.V. BD*5816.

Parlophone

ALTHOUGH I have already included several vocals in my selection for this month, I cannot resist recommending *Parlophone RO*20524, on which Richard Tauber has recorded two fine performances. He sings, in a delightful manner, " At Dawning " and " Just For a While," with orchestra accompaniment.

The other Parlophone records I wish to mention are chiefly for the dance enthusiasts, the first one being by Joe Daniels and his Hot Shots in " Drumnasticks." The record is *Parlophone F*1994, and the two numbers they play are " Canzonetta " slow foxtrot, and " Snug as a Bug."

On *Parlophone R*2886 and *R*2885, we have Nos. 107, 108, 109 and 110 of the 1943 Super Rhythm-Style Series. The first of these two—*R*2885—is by Harry Parry and his Radio Sextet, playing " Running Wild " and " Basin Street Blues." On the other record, namely *R*2886, we have " Dinah Lou " linked with " Rosetta," played for us by Henry Allen and Orchestra.

" Strictly Instrumental " and " When You're a Long, Long Way from Home "—both foxtrots—are the two numbers selected by Harry James and his Orchestra for their contribution on *Parlophone R*2888.

No. 57 of Tin Pan Alley Medley, Parts 1 and 2, is on *Parlophone F*1991, and Ivor Moreton and Dave Kaye introduce " Johnny Zero," " You'd Be So Nice to Come Home To," " A Fool with a Dream," " Silver Wings in the Moonlight," " You'll Never Know " and " I've Heard That Song Before."

Regal

GEORGE FORMBY—with, of course, his ukulele, plus orchestra accompaniment, tells us that " Bunty's a Big Girl Now " and all about the activities " On the H.M.S. Cowheel." Both numbers give George a chance to shine brilliantly, which he does to the full. The number is *Regal MR*3710.

Finally, I finish my selection this month with *Regal MR*3712, on one side of which Mitchell Ayres and his Orchestra play " Walkin' by the River," and on the other side Freddy Martin and his Orchestra give us their rendering of " The Louisiana Lullaby," both numbers being foxtrots.

A REMINDER

The need for materials for making new records is most urgent. Ask your dealer for details about the allowance given on certain makes of records, even if they are chipped, scratched or cracked.

Replies to Queries

The "A.C. Three"

"I am building the 'A.C.3,' a 'Practical Wireless' circuit, but cannot obtain the A.C. pen output pentode. I have on hand a Cossor PT 41 5-pin pentode, but this is a directly heated valve, and of course the A.C. pen is indirectly heated. Could you send details of the necessary alterations in wiring to enable me to use the PT 41.

"I should also like to know the field resistance of the speaker specified for this particular circuit."—J. T. D. (Nr. Birmingham).

It is a pity you are unable to obtain an indirectly heated output valve suitable for the receiver, as the use of a directly heated type will necessitate a fair amount of alteration to the circuit. For example: For best results the heater of the output valve should have a separate L.T. winding on the mains transformer. This is really desirable to enable it to obtain its grid bias by means of a suitable resistor inserted between the centre tap of the L.T. winding and the common negative earth-line. If, however, this is not possible, then an alternative arrangement is to insert a resistor between the H.T. negative line and the earth or chassis line, the value of the resistance depending on the amount of bias required and the total H.T. current consumption of the receiver. The field resistance is 1,500 ohms.

Testing Electrolytics

"I am unable to obtain a 2,000 ohm potentiometer used in the valve voltmeter described in July issue 1943 of 'Practical Wireless,' Could I use a 5,000 ohm wire or carbon?

"I have some resistors from a G.E.C. set. They are of one colour, no dot or tip. How should these be read?

"How can I test electrolytic condensers with a D.C. Avominor?

"In building a universal meter, such as the one described in 'Practical Wireless Service Manual' is it possible to put in fuse to safeguard meter? Where should they be placed, and what should be its rating?"—A. G. B. (Swansea).

If you are unable to obtain the specified potentiometer, you could make use of one having a resistance of 5,000 ohms, but we suggest that you try to secure one having the specified value at the earliest opportunity.

The resistors do not follow the Standard Colour Code, therefore we are unable to determine the values.

To test electrolytic condensers with a low-reading milliammeter you should apply a D.C. voltage to the condenser and connect the meter in series. If an excessive current flows in the circuit it will tend to indicate a breakdown in the condenser. A good component will pass approximately .05 to .1 milliamps per microfarad.

A fuse can be inserted in the universal meter and it should be connected between one of the meter terminals and the shunt and/or series resistors. The value of the fuse should be approximately the same as that of the maximum reading of the meter.

Two-valve Portable

"I recently built a two-valve portable as described by Sgt. Andrews in the October, 1942 issue, and perhaps you could help me on a point which has arisen. I built the frame aerial as stated, and I find that reaction is applied only when condenser is 'open' (min. cap.); although I have reversed the wires results are the same. In case this is not clear, reaction is applied only when condenser is about two-thirds open."—A. J. T. (Liverpool).

It is highly probable that the receiver is oscillating when the reaction condenser is moved in the correct direction, but that the oscillations are above audible frequency and only become audible when you reduce the capacity. In such circumstances, it would be advisable to try the effect of removing one or two turns from the reaction winding.

Inverted "L" Aerials

"In your issue for September G. Reeve, of Norton-on-Tees, speaks of using a 25ft. inverted 'L' aerial; could you please give me particulars of an aerial of this type, including what type of wire used and thickness of same, and if this aerial would be suitable for use on the flat roof of a block of flats? My flat is on the top floor, and I doubt if I would be allowed to erect any type of pole.

"If the above type is of no use, can you help me out by a suggestion, as I am absolutely ignorant of types of aerials, lengths, etc.? I have a three-wave set—M.W., S.W.1-13-30, S.W.2-30-90, and am also about to build the P.W.88, so would like an aerial to operate on both sets."—V. F. (W.12).

An inverted "L" aerial is formed by arranging a horizontal length of aerial wire and continuing it so that its down lead is brought away from one end at approximately right-angles to the horizontal portion. When one speaks of an inverted "L" aerial having a length of 25ft. this includes the length of the horizontal and vertical portions. In most districts an aerial of this type is quite satisfactory for the reception of long-, medium- and short-wave stations, provided it is erected clear of surrounding earth objects. In your case, if it is erected above a flat roof, its effective height will not be height above street level but its height above the roof, therefore, it is very desirable to secure the maximum possible height for the supporting points. A suitable gauge of wire is 7/22 SWG, bare or enamelled copper wire. An average length is 50ft.

A.C. Meter Calculations

"*Re* your article on 'Multi-range Test Meter' in your copy of March issue, 1942. Will you please give me complete details as to how one arrives at the series resistances for different measurements of A.C. volts? I quite understand D.C. calculations. Regarding the calculation for A.C. volts, how does one account for the voltage drop across the rectifier, and how to work the value? Also, does the voltage drop across the meter have to be taken into account? I understand that the current flow is 1.11 times the D.C. current flow. Your series resistance stated, say, for 25 volt range is 22.400 ohms, so if 1.11 ma. is flowing almost the 25 volts are dropped across this resistor. I would be grateful for precise details of calculating resistors for different ranges. As I see it, the same current flows through the dropping resistor, rectifier (the leakage of rectifier being negligible) and the meter. Even the meter on D.C. range has a volts drop of 100 volts; then there must be another drop across the rectifier."—L. J. T. (W. Drayton).

There are several difficulties about metal rectifiers and moving coil meters which have to be considered when one is concerned with reading rectified voltages. The metal rectifier presents a resistance to the external circuit which varies with the amount of current passed through it. It is not, however, usually necessary to measure this variation, as manufacturers generally publish curves showing the variation likely to be experienced with meters of various internal resistance and various types of rectifiers, and such curves can be relied on to an accuracy greater than that normally required by the amateur.

A moving coil meter, instead of reading R.M.S. values of A.C. voltage (which is what is required), is sufficiently sensitive to read average values which are lower than R.M.S. values by 1.11 times; therefore, this necessitates series resistances of a value of 1.11 times lower than were used for ordinary D.C. work. With a rectifier of the Westinghouse MBS1 type, and used in conjunction with a 0.1 milliammeter having an internal resistance of 100 ohms, a 100,000 ohm resistor in parallel with a .5 megohm resistor is satisfactory for the 100-volt scale. For the 500-volt reading a 500,000 ohm resistor should be parallel with a 4 megohm resistor. The common lead should have in series with it a .006 mfd. condenser in parallel with a .1 mfd. and a .25 mfd. condenser.

Might we suggest that you consider constructing the multi-range and multi-purpose meter, which is fully described in "Practical Wireless Service Manual," price 8s. 6d., or 9s. post paid?

Classified Advertisements

LITERATURE, MAPS, etc.

RADIO SOCIETY OF GREAT BRITAIN invites all keen experimenters to apply for membership. Current issue " R.S.G.B. Bulletin " and details, 1/-, below : **AMATEUR RADIO HANDBOOK** (300 pages), paper cover, 4/- ; cloth, 6/6. Radio Handbook Supplement (140 pages), paper cover, 2/9 ; cloth, 5/-.—R.S.G.B., 28-30, Little Russell Street, London, W.C.1.

WEBB'S Radio Map of the World. Locates any station heard. Size 40in. by 30in., 4/6, post 6d. On linen, 10/6, post 6d.—Webb's Radio, 14, Soho Street, London W.1. GER ard 2089.

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FULL range of Transmitting Keys, practice sets and other equipment for Morse training —Webb's Radio, 14, Soho Street, London, W.1. 'Phone : GERrard 2089.

" **H.A.C.**" Short-wave Receivers. Famous for over ten years. Improved one-valve model now available. Complete kit of components, accessories, with full instructions—only 16s., postage 6d. Easily assembled in one hour. S.A.E. for free catalogue.—A. L. Bacchus 109, Hartington Road, London, S.W.8.

RECEIVERS & COMPONENTS

BRITISH and American Valves, many types in stock. Mains Dropping Resistances for all sets, Speakers, Condensers, Volume Controls, etc. Everything for the serviceman and experimenter. Stamped envelope with all enquiries, please.—O. Greenlick, 34, Bancroft Road, Cambridge Heath Road, E.1. Stepney Green 1334.

WANTED.—Trophy Battery 3.—W. Spearman, Stansfield, Sudbury, Suffolk.

GENERATE free electricity from the wind, build your own Wind Charger. Complete drawings, instructions for building, Mast, Head, Vane, Propeller, 2/6, post 2½d.—Pearse, P.W., Middle Taphouse, Liskeard.

SOUTHERN RADIO'S WIRELESS BARGAINS

SCREWS and Nuts, assorted gross of each (2 gross in all), 10/-.
SOLDERING Tags, including Spade Ends, 6/- gross.
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CIRCULAR Magnets, very powerful, 1⅛in. diameter by ⅜in. thick, 1/6 each, 15/- per doz.
ERIE Resistances. Brand new, wire ends. All low value from .8 ohms upwards. A few higher value are included in each parcel, ¼, ½, 1 and 2 Watt. 100 resistances for 30/-.
MULTICON Master Mica Condensers, 28 capacities in one from .0001, etc., etc., 4/- each.

SPECIAL ASSORTED PARCEL FOR SERVICE MEN

100 ERIE resistances (description above), 24 assorted Tubular Condensers ; 6 Reaction Condensers, .0001 ; 12 lengths Insulated Sleeving ; 75ft. Push-back Connecting wire ; Soldering Tags, Screws, Wire, etc., 65/-. All brand new.
CRYSTALS (Dr. Cecil), 6d. ; with catswhisker, 9d. ; complete crystal detectors, 2/6 ; 75ft. wire for aerials, etc., 2/6 ; 25 yds. Push-back wire, 5/- ; Telsen Reaction Condensers, .0001, 1/9 each ; Telsen large disc drives, complete with knob, etc. (boxed), type W 184, 2/6 each ; Insulated sleeving, assorted yard lengths, 3/6 doz. ; single screened wire, doz. yards, 10/-.
LOUD Speaker Units, unshrouded, Midget type, 4/- ; Metal case condensers, .1 + .1 + .1, 2/6.
POWER Rheostats, Cutler-Harmer, 30 ohms, 4/6 each ; Pointer Knobs, instrument type, ¼in. spindle hole (Black or Brown), 1/- each ; Push-button Switches, 3-way, 4/- ; 8-way, 6/- (complete with knobs) ; Bakelite Escutcheon Plates for 8-way P.-B. Switches, 1/6 ; Hundreds of other Bargains.
SOUTHERN RADIO SUPPLY CO., 46, Lisle St., London, W.C. Gerrard 6653.

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A27D, ACHL, ACME, ACO44, ACP, AC Pen, ACTH1, ACTP, ACVP1, ACVP2, AC2 Pen, AC5 Pen, AZ1, AZ31, B63, CL4, CL33, D41, D63, DD13, DD14, DDT, DD Pen, DD2A, DL63, DW2, EBC3, EBC33, EBL1, EBL31, ECH2, ECH3, ECH35, EF5, EF6, EF8, EF9, EF39, EK2, EL2, EL3, EL5, EL35, EM4, FC2A, FC4, FC13, FC13A, FW4/500, H63, HD24, HL4, H13, HL13C, HL21DD, HL22, HL23, HL41DD, HL133DD, HL1320, HP210, IW4/350, KT2, KT24, KT32, KT33C, KT41, KT61, KT63, KT66, KTW61, KTW63, L63, KTZ63, LD210, LP220, MH41, MH41, MHD4, MHL4, MKT4, MS Pen, MVS Pen, MS Pen B, MVS Pen B, MX40, OM4, OM6, OM9, P2, Pen 4DD, Pen 4VA, Pen A4, Pen 25, Pen 45, Pen 45DD, Pen 46, Pen 428, Pen B4, PM2A, PM12M, PM22A, PM24A, PM25, PP5/400, PX4, PX25, RF30, FF120, SP4, SP4B, SP13, SP13C, SP1320, TH4, TH4B, TP1340, TDD2, TDD4, TDD13C, TX4, TX41, U5, U10, U12, U14, U17, U31, U50, U52, UU5, UU7, URIC, UY31, VMP4G, VO4S, VP2, VP2B, VP4, VP4A, VP4B, VP13A, VP13C, VP20, VP23, VP41, VP133, VP210, VP1320, W21, W42, X21, X24, X41, X61, X64, X65, Y61, Z14, Z21.

OZ4, 1A4, 1A5, 1A7, 1B4, 1C5, 1C7, 1H5, 1H6, 1F4, 1G5, 1LH4, 1N5, 1Q5, 1J6, 2A6, 2A7, 2B7, 2D4B, 2P, 2XP, 4D1, 4THA, 5U4, 5Y3, 5Y4, 5V4, 5Z4, 6A3, 6A6, 6AG6, 6A8, 6B4, 6B6, 6B7, 6B8, 6C6, 6C8, 6D5, 6D6, 6F6, 6F7, 6F8, 6H6, 6J7, 6K6, 6K7, 6K8, 6L6, 6L7, 6P5, 6R7, 6Q7, 6SQ7, 6TH8, 6V6, 6X5, 7B7, 7B6, 7D5, 8D2, 9A1, 6Z5, 9D2, 10, 10A, 10D1, 11D3, 12F5, 12J5, 12J7, 12Q7, 12SA7, 12SQ7, 12SF5, 15, 15A1, 15D2, 19, 20A1, 20D1, 24, 25A6, 25B6, 25Z4, 25Z5, 26, 27, 29, 30, 32, 33, 31, 34, 35, 35Z4, 36, 37, 38, 39, 41MHL, 41MP, 41MPG, 41STH, 42, 42MP Pen, 43IU, 46, 48, 49, 50, 52, 53, 57, 58, 59, 56, 71A, 75, 77, 78, 79, 80, 81, 82, 84, 85, 89, 117Z6, 150B, 210DDT, 210PG, 210LF, 210SPT, 210VPA, 210VPT, 215SG, 220B, 220TH, 290L4, 994V, 1821.

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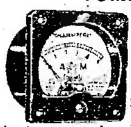

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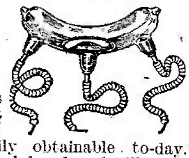

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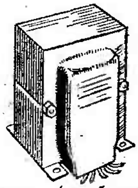

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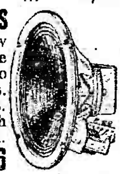

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AMATEUR WIRELESS AND WIRELESS MAGAZINE

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Blueprints, 6d. each.

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Mains Operated.

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SPECIAL NOTICE

THESE blueprints are drawn full size. The issues containing descriptions of these sets are now out of print, but an asterisk beside the blueprint number denotes that constructional details are available, free with the blueprint.

The index letters which precede the Blueprint Number indicates the periodical in which the description appears: Thus P.W. refers to PRACTICAL WIRELESS, A.W. to *Amateur Wireless*, W.M. to *Wireless Magazine*.

Send (preferably) a postal order to cover the cost of the Blueprint (stamps over 6d. unacceptable) to PRACTICAL WIRELESS Blueprint Dept., George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2.

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