Ane B Dunn

A BEAT FREQUENCY OSCILLATOR

Practical Wireless

9D EVERY MONTH

Editor F. J. CAMM

Vol. 20 No 457 NEW SERIES JULY, 1944

These Wireless Operators in an R.A.F. Day Bomber Station Keep Constantly in Touch With Operators on Aircraft During Operational Flights

Practical Wireless

and PRACTICAL TELEVISION

12th YEAR OF ISSUE

Vol. XX. EVERY MONTH. No. 457. JULY, 1944.

Editor F. J. CAMM

Comments of the Month

By F. J. C.

Post-War Radio Problems

SIR EDWARD WILSHAW, K.C.M.G., in proposing the toast of the Wireless Section of the Institution of Electrical Engineers at the Jubilee Commemoration Dinner of the Institution, dealt not only with the past, but with the future of radio engineering. Wireless has played a most important part in war communications, and when the history of the war is published there will be revealed many stages of development at present secret for security reasons.

These developments are but the precursor of tremendous new developments which will take place as a result of wartime experiment. The Wireless Section of the Institution has, of course, done a great deal in assisting the science of radio along the right road. The work of such pioneers as Dr. Eccles, Prof. Howe, and many others is well known to our readers, and the Institution can quite fairly claim to be the forum of all wireless developments. Reference to the proceedings indicates the vast amount of work which has been done by members of the Institution in radio and its manifold branches.

Training of Personnel

THE main point made by the chairman in responding to the toast related to the education and training of young engineers, and we agree with him that if we do not find an adequate solution for this problem our research effort will suffer nationally, and we shall be overtaken by other nations. The wireless industry is a comparatively new one, and there have been tendencies for it to overgrow its strength, and for real development to be held up because of mushroom firms who jumped into the industry for the sole purpose of making money, and without contributing to its development.

Fortunately, that great refining influence in all industries, the purchaser who may be caught once, but not twice, has been responsible for seeing many of these quack firms fall by the wayside, to be suitably interred in a dishonourable commercial grave. Of course, the radio industry itself will have to accept responsibility in large measure for the training of its personnel. The recruiting ground is the experimental department. There will be no shortage of trained wireless engineers after the war. Many thousands have received excellent training at the country's expense in the Services, and this knowledge will stand the radio industry in good stead; unless conditions in the industry are made so onerous that the available labour drifts into more lucrative industries.

The wireless industry is not particularly well paid, and because of that it does not attract the men with degrees and higher scientific education. It has been largely peopled by those without scientific knowledge. There are vast fields for experiment before radio reaches finality of design, and in order that we may keep pace with developments in America and Germany it will be necessary to attract into the industry the best brains. That can only be done by means of adequate pay, and adequate opportunities for promotion within the industry itself.

We should like to see throughout our universities a Chair of Engineering, and more recruiting grounds in the form of evening classes in radio engineering.

There should be more radio scholarships, so that those with a natural bent may not be denied the attainment of their ambition because of lack of money.

Pooling of Knowledge

NOW it is here that the Radio Manufacturers' Association could perform a valuable service for the whole of the industry it represents. Its constituent firms should contribute to a central fund to be administered by the R.M.A., and devoted entirely to the training of radio engineers. There should be a scheme for the pooling of knowledge upon which pool the entire industry could draw. This would redound to the benefit of the whole industry as well as to individual firms. Surely we shall not return to the bad days of cut-throat competition, of the unnecessary production of new models, and the production of designs produced to a price.

We must not forget the work of the amateurs who have become the experts. It is true that during the war their activities have been stilted for several reasons; most of them are in the Services, or on war work. Additionally, there is a scarcity of components, and little time is available for those early-morning experiments which were part of the pleasure of radio experiment. The amateur transmitters, too, who have contributed so much to the sum total of our radio knowledge, had their apparatus confiscated in the early days of the war for security reasons. We do not know the Government plans in connection with post-war amateur transmission, nor how soon after the Armistice the transmitters will return, and their apparatus be handed back to them. It is, however, quite certain that the movement itself will be re-established, and it will attract a far larger number of devotees than it did before the war, for the Services have whetted the appetite of many thousands who, before the war, had no interest in radio.

It does not seem that that happy time is too far distant. In any case, amateur radio has much work to do.

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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.

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this paper should not be taken as an indication that they are necessarily available for export.

ROUND THE WORLD OF WIRELESS

Secret German Radio in U.S.

ACCORDING to a recent report from America, it was stated before a Congressional committee that the installation of a secret radio transmitter in the German Embassy in Washington did not do the Nazis much good. Even before it got going on the outbreak of war it had been located by the Government direction-finders. Apparently the Government's radio intelligence officials jammed the German Embassy's signals so effectively that the station never made contact with Germany.

Radio Relay Subscribers

UP to the end of September, 1943, radio relay statistics show an increase of 17,692 subscribers, despite the fact that the number of exchanges has been reduced by one to 275.

Resignation

MR. W. F. NEWELL, B.Sc., A.M.I.E.E., has resigned from Sangams Weston, Ltd., after more than 10 years' association with Weston Instruments, to take up the position of Technical Contracts Manager with the Automatic Coil Winder and Electrical Equipment Co., Ltd., the well-known makers of the "AvoMeter" and other "Avo" testing instruments, and "Douglas" and "Macadie" coil-winding machines.

"Radio Allotment"

WARTIME beginners, often intimidated by the superior knowledge of friends with green fingers, have appreciated "Radio Allotment." This year's series is slightly more advanced; more experiments are being tried. But it is still the practical side which matters; there is no script, and no rehearsal. Michael Standing walks about and takes the microphone to the gardeners; sometimes they carry on with the job as they talk. Cooking vegetables is the province of "Kitchen Front," but once "Radio Allotment" went into the kitchen, and found out how to salt beans down and bottle tomatoes.

Traditional ways of gardening in different parts of the country are described. Five different ways of planting potatoes were given the other day. Later, results will be compared.

Radio Corsica

A NEW transmitter, installed on the island since its liberation, can now be heard on the 29-metre band, and also on 355 metres. The new station relays programmes from Algiers at various times during the day, commencing at 0600 (G.M.T.).

B.B.C. Broadcasts to European Press

HERE are two stories from B.B.C. broadcasts to the clandestine press of Europe.

First: A Nazi propagandist was praising the New Order. "You have only to look round. No more strikes, order everywhere. Even the young are no longer rude to the police—what a change from the bad old days of democracy!"

"Maybe," said a voice at the back of the audience. "But in those days, when my doorbell rang at seven in the morning, I could at least be sure that it was only the milkman."

The second is a news item reported by the Norwegian clandestine paper *Fri Presse*:

"You remember the 3rd August, 1942, when people demonstrated in Oslo in honour of the King's Birthday? Well, this year our Norwegian Nazis managed to arrest a horse that celebrated the King's Birthday by standing in a public square with a flower behind its ear. The horse was taken to Office number nineteen, charged under paragraph 35,446, and sentenced for having stood in a public place in the service of an enemy power."

Ferry-service Radio

IT is reported that the U.S. Army have erected six long-wave wireless stations linking the United States, Newfoundland, Labrador, Greenland, Iceland and Great Britain, and the stations are greatly expediting the ferrying of aircraft across the North Atlantic. The new long-wave network ensures a 24-hour radio-telegraph service uninterrupted by atmospheric disturbances which so frequently interfere with short-wave communications across the North Atlantic.

When a damaged wireless set arrives at the R.E.M.E. wireless depot attached to the 8th Army it is repaired and tested for service again. The illustration shows a repaired set being inspected prior to its reinstallation in a Sherman tank.

"Radio Theatre"

"RADIO Theatre," under one name or another, has been running since the autumn of 1941. It began as an attempt to reflect, for listeners overseas, the British theatre and those who work in it. Twelve programmes, called "My Life in the Theatre," presented London stage personalities—John Gielgud, Fay Compton, Robert Donat and Yvonne Arnaud among them—their careers and their outstanding parts. Next came a series "Review of the British Theatre," in which the spotlight was on the British playwrights from Congreve to T. S. Eliot. This was tremendously popular. For one thing, almost every actor and actress of contemporary note took part in it.

Early in 1943 John Burrell, producer from the opening of "Radio Theatre," handed over to Mary Hope Allen, who is still in the chair. She plans to include a theatrical classic each month. Half an hour is a short time for a good play. A compromise is inevitable, and it is made by preparing a careful introduction which gives the plot; the play's best act follows in full.

"Romeo and Juliet"

ONE week a programme contained all the love scenes from "Romeo and Juliet." Uncut, they took 25 minutes. This was not because the actors gabbled! Those who know their "Romeo" will remember that the number of times during which the lovers are alone is very small.

Herbert Farjeon has edited a dozen programmes built around Shakespeare's secondary characters—Titania, Jacques, Mercutio, Caliban, Hotspur, Polonius and Shallow, for instance—with his own introductions to the selected scenes in which those characters appear.

On three occasions "Radio Theatre" has gone to a current London success for its half-hour: "Watch on the Rhine," "The Russians" and "Flarepath." Other outside broadcasts came from C.E.M.A.'s "Twelfth Night", at the Theatre Royal, Bristol, with Wendy Hiller as Viola, and from the Army's own "Journey's End," whose cast are serving soldiers.

"Radio Theatre," which has a big audience overseas, can now be heard by listeners at home who tune in to the General Forces Programme.

Broadcasts to Schools

THE new term of broadcasts to schools, which opened on May 1st, is the third of the year's cycle.

Listening schools, of which there are now over 12,300, will find all their old favourites are being continued.

Many questions that are being discussed in the world outside school take their place in such series as "Science and the Future," which this term includes discussions on house and town planning, the latest developments in aviation, such as jet propulsion. Sixth Form talks on "Leadership and Liberty" review such diverse characters as Pericles, Oliver Cromwell, Thomas Jefferson, Napoleon Bonaparte, Abraham Lincoln and William Gladstone. The talks on literature cover biographies of Joseph Conrad and Cervantes, with illustrations from their works. Senior history scholars will hear in "European Heritage" a collection of good stories on the building of modern nations, with three broadcasts about outstanding personalities of their time—Guiseppe Mazzine, Lenin and Nansen.

Radio Brazzaville

THE story of Radio Brazzaville since its inception in June, 1943, is one of sheer hard work on the part of its founders, the brothers Desjardins and their small band of helpers. There were endless difficulties to overcome, including the tropical climate, before the studios were equipped with effective sound-proof installations.

The geographical position of Brazzaville (French Equatorial Africa) was in itself a major disadvantage, and, indeed, there was no precedent for this attempt to establish an important wireless station so remote from the usual sources of information. By the time Allied newspapers arrived, they were at least two months old. Every manufactured article, down to the smallest nail, had to be imported into the Congo, and frequently machinery eagerly awaited from America was sunk or damaged on the way. To-day, thanks to the Radio Corporation of America, Brazzaville is equipped with everything that goes to make a modern wireless station. Forgotten are the mosquitoes, the toads and the crickets. Microphones are now encased in sound and airproof rooms.

Not only does it link all French possessions throughout the world, tell the real facts to the French people in the vast prison camp which the Germans have made of their homeland, and the Japanese of Indo-China, but it is also regarded as an accurate source of information throughout British Africa. Radio Brazzaville is the first powerful short-wave radio station which France has ever possessed.

Our Cover Subject

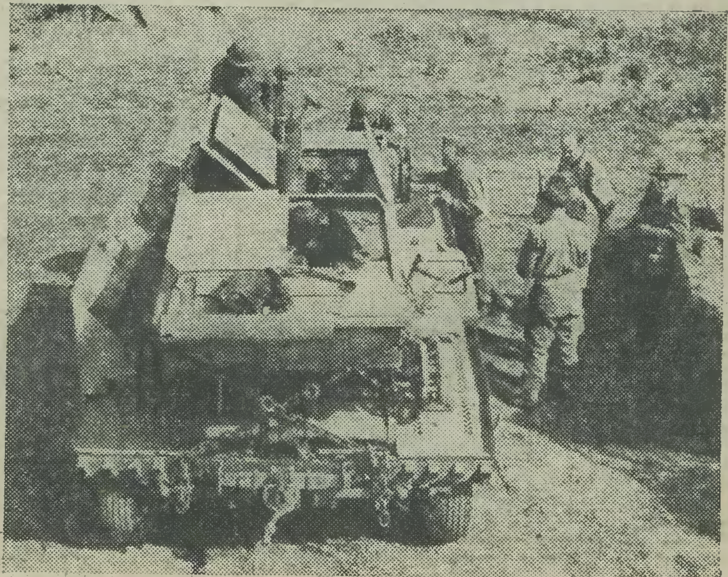
AT one of the R.A.F.'s day bomber stations the squadrons are equipped with the Douglas Boston III. It is a variant of the original Douglas D.B.7, and is probably the fastest twin-engined bomber the Americans have sent us. In fact, it is very nearly as fast as most of our fighters. Speed is an essential quality for daylight bombing and for working with fighter escorts. The Boston can also look after itself very well, with its four fixed forward-firing guns, and its two free guns in the rear gunner's cockpit amidships. All the crew, except the gunners, wear tin hats, because it has been found many A.A. bursts come above the machine, and when they are flying at more than 300 miles an hour the falling shrapnel smashes through the roof of the aircraft.

These day bombers are the only operational crews who actually see the results of their work the same day. Their automatic cameras are in action throughout the raid. Two hours after their return the prints are ready and the crews summoned to a room on the station, where the prints are projected on to a screen, when they see all their successes, or errors. An important part of the work at the bomber station is the radio watch, which maintains communication with the aircraft while on the outward and homeward journey.

B.B.C. in the Backyard: Aerial Allotments

BACKYARDS, in the war, have become small-scale farmyards, and the B.B.C. has helped in the transformation. Allotments, as in the last war, have been a powerful factor on the food front.

"Backs to the Land" is addressed to the "boys in the backyard" on Saturdays at 1.15. Each important subject has a specialist who broadcasts at regular intervals. Sometimes he brings as many as four experts with him to the microphone. Alan Thompson deals with poultry, Reginald Gamble with bees, Mrs. Arthur Abbey with goats, Major Osman with racing pigeons, and W. King Wilson with rabbits. Pig-keeping is dealt with by several broadcasters.

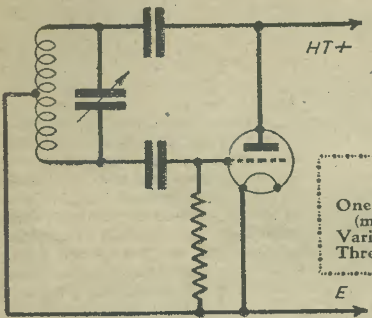


The first German radio-controlled tank captured at the Anzio Bridgehead. It is 12ft. long and 6ft. wide, and carries a high explosive charge of about 800lb.

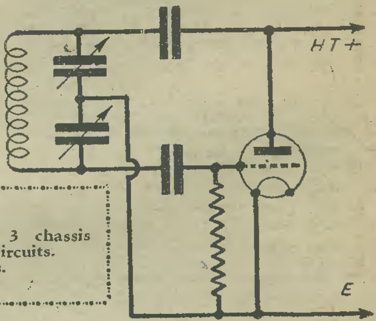
A Beat Frequency Oscillator

By J. R. GREER

NEXT to a multimeter, a wide-range audio-frequency oscillator is probably the most versatile and useful piece of equipment a radio enthusiast can possess, whether for servicing or pure experimenting. Fortunately, although they are rather expensive to buy, a very useful instrument of the type to be described can readily be assembled from components to be found in most spares-boxes. It should be mentioned at this stage that, while reference is made throughout to a mains chassis with an existing power-pack (i.e., mains transformer, choke, etc.), the circuit would work equally with battery valves, when practically the only alteration would be to replace the cathode bias resistor of the output valve by a suitable bias battery.



Figs. 1 and 2.—The Hartley (left), and the Colpitts circuits.



REQUIREMENTS

One medium- and long-wave S.G. 3 chassis (mains or battery), with two tuned circuits.
Various small condensers and resistors.
Three valves.

While there are several types of A.F. oscillators, the simplest for our purpose is the Beat Frequency Oscillator, or B.F.O. This depends for its action on the principle that if two frequencies, f_1 and f_2, are mixed, two other frequencies, f_1+f_2 and f_1-f_2 are produced. It is the second of these, sometimes called the Beat Frequency, which is of most use in radio, one example being the superhet. Clearly, if two R.F. oscillators are on adjacent frequencies, say, 100 kc/s and 110 kc/s, a beat frequency of 10 kc/s—well within the audio range—will be produced. If now one oscillator is fixed at 100 kc/s, and the other is variable between 100 kc/s and 120 kc/s, any A.F. note between 0 c/s and 20,000 c/s may be produced. You know the effect when you set a detector oscillating, and then tune in to a station. As the difference in frequency between the oscillating detector and the transmitter gets smaller, the beat frequency enters the audible range, and you hear a high-pitched whistle, rapidly dropping to a growl.

The next question which arises is the type of R.F. oscillator to be used. The most satisfactory types are the Hartley and the Colpitts, shown in Figs. 1 and 2. The disadvantage of the Hartley is that it requires centre-tapped coils, which creates difficulties if existing coils are to be used. It also complicates switching, but that will be discussed later.

The Colpitts is much more promising in the matter of coils, but in the conventional circuit all condensers must be in duplicate which, in practice, proves awkward. After some experiment, however, it was discovered that, if a virtual centre-tap, consisting of a smallist condenser between each side and earth (Fig. 3, C3 and C4) was provided, tuning could be controlled (within limits) by a single condenser, either across the whole coil, or between either side and earth. The latter position was found desirable for the main tuning control, as it permitted the use of a very large variable condenser (about .0007 mfd.), thereby eliminating hand-capacity effects, without exceeding the desired frequency shift. The fixed oscillator, of course, follows the conventional Colpitts circuit.

In an audio frequency oscillator of this type, the

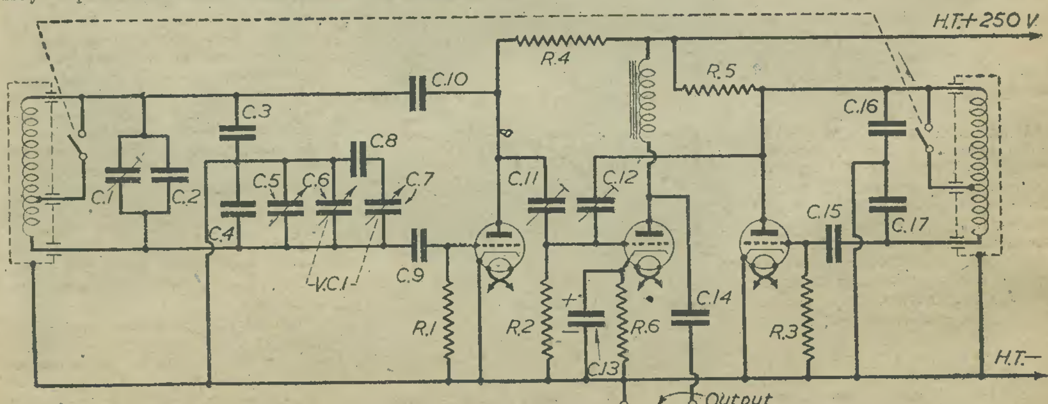


Fig. 3.—Circuit diagram of the beat-frequency oscillator; C1 .0003 mfd. preset; C2, C3 and C4, .0005 mfd. fixed; C5, .00005 mfd. set zero; VC1 (C6, C7, C8) .0007 mfd.; C6, C7, .0005 mfd. ganged; C8, .0003 mfd. fixed; C9, C15, .0001 mfd. fixed; C10, .01 mfd.; C11, C12, 10 mmfd. preset (see text). C13, 25 mfd. 25 v. fixed; C14, 2 mfd.; C16, C17, .002 mfd.; R1, R2, R3, 1.0MΩ; R4, R5, R6 depend on valve used (see text).

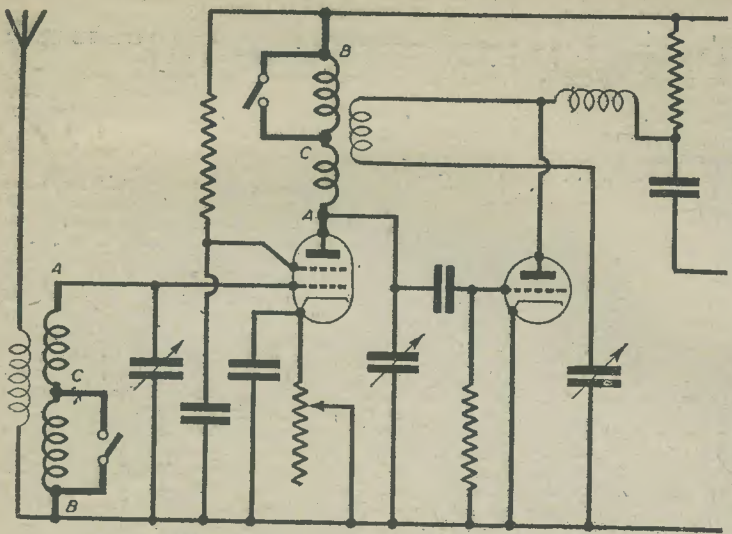


Fig. 4.—Windings and connections to be retained using two typical coils.

Power Supply

If the set is for A.C. mains, check the mains transformer and rectifier, etc., which should provide about 200 v. smoothed H.T., and 4 v. L.T. for the heaters; if for A.C./D.C. mains, the voltage dropping resistor should be tested. In any case, mark carefully the lead providing smoothed H.T.+. As it will probably be brought out to one of the speaker terminals, this may provide the most convenient connection. This done, make sure that H.T.— is connected firmly and directly to the chassis, and not through any bias resistors.

Tuning Coils

Remove all leads except those ("B," Fig. 4) going to earth, directly or through a large blocking condenser; those ("C") going to the wave-change switch, and those ("A") going to the fixed vanes of the tuning condenser. In the case of tuned anode coupling, the corresponding connections will be to H.T.+ ("B"), wave-change switch ("C"), and anode of S.G. valve ("A").

question of range is apt to be a difficult one. It is desirable that the frequencies obtainable extend slightly beyond the ordinary audible range, as supersonic oscillation in an amplifier may cause serious distortion and overloading, and yet be difficult to trace. If, however, the range is as wide as this would make necessary, the most commonly used frequencies—say, below 5,000 c/s—will be crushed into a relatively small space at the bottom of the dial. It is thus that the need for two ranges becomes evident. This may be achieved by using the existing wave change switching. If, when connected to the medium wave coil, the change in capacitance causes a change in frequency of 20 kc/s, when connected to the long-wave coil, the radio frequency will be lower, and the *change* of frequency (for the same change of capacitance) will also be less, in practice about 6 kc/s, which is suitable.

It may be noticed that no A.F. volume control is provided. The reasons are two-fold: firstly, it is difficult in a simple instrument such as this to fit a volume control which will not affect the frequency, and, secondly, its use would complicate the calibration of the oscillator's response curve. On the rare occasions when a control is required, it can be fitted externally: otherwise, it is better omitted.

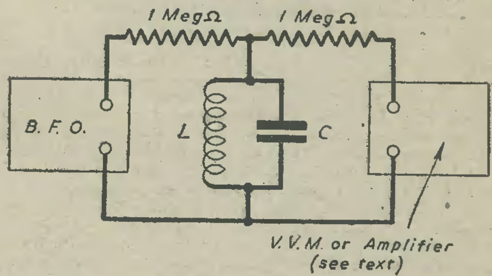


Fig. 5.—Method of coupling the B.F.O. and the amplifier.

Any primaries or reaction windings should be ignored, or, preferably, removed. You should now be left, in each case, with a medium-wave coil of perhaps 100 turns between A and C, and a much larger long-wave coil between C and B. Fig. 4 shows, in heavy line, the windings and connections to be retained for two typical coils.

Once these three connections to each coil, and H.T.+ and H.T.—, have been ascertained and carefully marked—and not before—all small intervalve condensers and resistors with their associated wiring should be carefully removed and preserved for subsequent use.

If all unnecessary pieces of wire are removed at this stage, it will help to avoid confusion when rewiring is commenced. The wiring to the power-pack and heater supplies should not, of course, be touched.

As the coils and their associated switching are the most important part of the oscillator, again check their connections A, B and C, and verify, preferably with a continuity meter, or with battery and bulb or head-phones:

That each coil is continuous, and

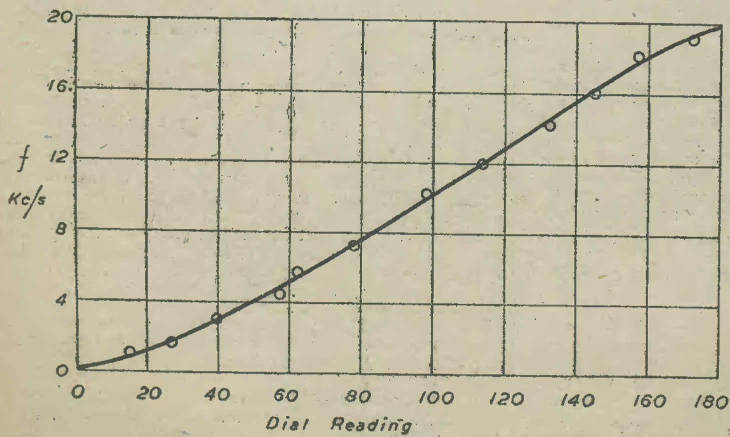


Fig. 6.—Calibration chart.

that, in each coil, the L.W. and M.W. windings are connected together at C.

That the wave-change switch, when set at M.W., short-circuits the L.W. coil.

That no part of either coil is connected to earth, through the wave-change switch or otherwise. The reason for this is evident from the circuit (Fig. 3).

If the coils are not already screened, cocoa tins of suitable size should be mounted over them, or, alternatively, a large vertical screen may be mounted between them, whichever is more convenient.

Assembly of Oscillator

Wiring may now be commenced. As far as possible, keep the circuits of the two R.F. oscillators well separated, but actual screening of individual leads should be unnecessary. The wiring diagram (Fig. 9) should be carefully followed, and each connection ticked off after it has been made. The actual layout, however, may be modified to fit any chassis which is to hand.

The mains transformer, rectifier, and valve heaters should be wired first, if this is not already done. The two smoothing condensers—and the bias decoupling condenser for V3—are shown as tubular electrolytics, but the cardboard types may be used if they are available. The mains terminals are connected with twisted flex through the mains switch on the front panel to the primary of the mains transformer.

The four leads to the rectifier should now be wired, care being taken that the rectifier anodes' leads go to the "Anode" and "Grid" of the 4-pin valveholder. One side of the rectifier filament is connected to the smoothing choke, and to one 8 mfd. condenser. The other side of the choke is connected to the other 8 mfd. condenser, and this forms H.T.+. Twisted flex should also be used for the 4-volt heater supplies to the three remaining valves.

The various small condensers and ½ watt resistors should now be mounted in the appropriate positions on the resistance panel, and the panel wired ready for mounting. Finally, when all coils and condensers are mounted, the .0003 mfd. pre-set and its associated fixed condensers should be wired to the appropriate terminals of the coil. The resistance panel should now be mounted in the chassis, and connections made to valves, H.T.+, earth, and the coils. The wave-change switch (D.P.S.T.) the main (two-gang) tuning condenser, the set-zero condenser, and the two coupling condensers, C11 and C12, should be connected up with fairly stiff wire which will remain rigid in use. The position of the two leads running from the anodes of V1 and V2 to the coupling condensers C11 and C12 should be particularly noted, as it is desirable to keep them separated.

Components

Although the values of individual condensers are not critical, the overall capacitances across each coil (excluding the large variable condenser), should be exactly equal, with the .0003 mfd. pre-set about half in. In this connection a capacitance bridge, such as that recently described in these columns, will prove invaluable. If, however, reliable condensers of the stated values are used, any deviation should be well within the range of the .0003 mfd. pre-set. The two small coupling condensers, C11 and C12, should have a maximum capacitance of about 10 mmfds. The well-known Phillips tubular porcelain trimmers are suitable, or trimmers from an old ganged condenser would probably be satisfactory.

Considerable latitude is permissible in the choice of resistors, except perhaps in the case of the bias resistor for the output valve, where the maker's value should be adhered to.

Valves

Should an A.F. choke not be available, the primary of an inter-valve or speaker transformer might be used. A resistor (of 20,000 to 50,000 ohms) could be used, and would provide a slightly more level frequency response, but the output would be considerably lower.

It will be noticed that, in the "Requirements," three valves of unspecified types were referred to. In point of fact, almost any valves of the appropriate filament voltage (or current, if the set is for D.C. mains) may be used, and, although the circuit is shown for triodes, screen grid valves connected as triodes, or with the screening grid fed separately, could be used in the two oscillators, while an output pentode might well replace the triode in the output stage.

Adjusting the B.F.O.

When the wiring is completed, verify that the three valves selected are in good order by trying them in an existing set, then insert them in the appropriate valveholders, together with the rectifier, if a valve. Set the coupling condensers, C11 and C12, about half in, and, after a final inspection, connect the output terminals to a pair of headphones, or the pick-up sockets of a good set, and switch on.

After allowing the valves about a minute to heat up, set the two-gang .0005 mfd. condenser (arranged to give .0007 mfd.: VC1, Fig. 3), full out, set the wave-change switch at "M.W.," and, from full out, screw in the .0003 mfd. pre-set gradually until a whistle is heard, which will slowly reduce in pitch until it becomes a growl, then stops altogether. At this position the pre-set should be locked. If now the tuning condenser is rotated towards maximum capacitance, the whistle should again appear, increasing rapidly in frequency until, towards the end of the scale, it becomes almost inaudible.

Should a whistle not be obtained on rotating the .0003 mfd. pre-set, first verify that the valves are oscillating. This may be done by inserting a milliammeter in each anode circuit in turn. If the valve is oscillating, the anode current should almost double on touching the grid with a wetted finger, as this stops oscillation. If both valves are oscillating—and failure to oscillate can only be due to faulty components or possibly inadequate H.T., due perhaps to excessive anode resistors—an absence of a whistle probably means a faulty condenser across one of the tuning coils, which results in the frequencies being too far apart to provide an audible beat. It should be emphasised, however, that, provided reasonable care is taken in the selection and fitting of these condensers, no difficulties will be experienced.

If now the wave-change switch is set at "L.W.," and the tuning condenser rotated, it will be found that the range covered is much shorter, and the highest frequency is well within the audio range.

The small "set zero" condenser (C5, Fig. 3) is arranged to compensate for frequency drift, and should always be adjusted in the following manner before using the oscillator, especially after the range has been altered.

1. Set the main tuning dial at zero.
2. Adjust the "set zero" so that oscillations just cease, but so that the slightest rotation of the tuning dial causes them to reappear as a low growl.

Last of all, adjust the coupling condensers C11 and C12, this being best done on the "M.W." range. Reduce both to zero, then increase them alternately until "chirps" (due to harmonics) begin to appear on rotation of the condenser. If necessary they may be increased further until the oscillators begin to pull together, and the lowest frequencies start to disappear. If, however, some care is taken over adjustment, it is possible to obtain reasonable volume, a full range of frequencies, and complete freedom from "chirps." In the original model it was found that best results were obtained when one condenser (that from the fixed oscillator) was half in, and the other was a quarter in.

Calibration and Use of the Spares-Box B.F.O.

While for many purposes accurate calibration is not essential, it considerably increases the scope of the instrument and the work should be done as carefully as possible.

Since it is convenient to have the dial marked directly in kc/s., carefully paste a piece of thin card over it, and mark this off in very light pencil, from zero to 180 deg.

As mentioned before, the range of the oscillator is about 0-6 kc/s. on the "L.W." band, and 0–20 kc/s. on the "M.W." band, so separate calibration graphs should be drawn for each band.

Calibration from a Piano

The first half of the 6 kc/s range can conveniently be calibrated from a piano by sounding a note, then finding the corresponding reading (in degrees) on the B.F.O. dial. As middle "C" is normally 256 c/s the other "Cs" can readily be worked out:

32 64 128 256 512 1,024 2,048

This, however, does not get us very far and, as it is difficult to distinguish between octaves and "fifths," it is rather perilous to attempt to estimate harmonics.

Other Methods of Calibration

Assuming that no special apparatus such as cathode-ray oscillographs and standard frequency generators are available, probably the simplest method of calibration involves the use of A.F. tuned circuits, since, if the inductance and capacitance are known, the frequency can readily be calculated. A suitable inductance is an H.F. choke, the one used for calibrating the original instrument being the Telsen "Standard" H.F. choke (Fig. 5) which has a stated inductance of 150,000 mHys and does not deviate much from it, while the Telsen Binocular H.F. choke has an inductance of 180,000 mHys. Any H.F. choke however, whose inductance is known, may be used.

With the Telsen Standard choke (150,000 mHys) a capacitance of 0.5 mfd. gives a resonant frequency of 580 c/s., while, with a capacitance of .0005 mfd. it gives a resonant frequency of 18,000 c/s. Thus the one inductance can readily be used to cover the entire audio range. A skeleton diagram of the circuit used is given in Fig. 6, and the 1 megohm (approx.) blocking resistors should be noted, as they help to minimise the effect of stray capacitances, which might cause serious errors, particularly in the upper register.

A valve voltmeter is ideal, but, failing this, the same effect may be obtained by connecting the leads to the pick-up sockets of an ordinary set. If an A.C. meter is available, this should be connected, through blocking condensers, across the primary of the speaker transformer in the set, but if not, it is quite possible to judge the resonant point by the loudness of the sound from the speaker.

Once the circuit has been arranged, the condensers should be selected. Generally speaking, the older bakelite condensers adhere more closely to their nominal values than do the more recent tubulars. In any case the better known makes should be chosen for preference. If it is possible to borrow a standard condenser box this would certainly be useful. If not, the simplest procedure is to attach two very short lengths of flex (not twisted) to the two terminals of the H.F. choke, attaching crocodile clips to the other ends, for clipping on to the various condensers.

The resonant frequency of the tuned circuit can readily be calculated from the formula:

$$f = \frac{10^6}{2\pi\sqrt{LC}}$$

where f is in c/s., L is in henries, C in micromicrofarads. For example, with the choke referred to, L = 150,000 mhys, = 0.15 hys., and if C = .001 mfds. = 1,000 mmfds., then f =

$$\frac{10^6}{2\pi\sqrt{.15 \times 1{,}000}} = 13{,}000 \text{ c/s}$$

At this stage it is desirable to draw up a table with four columns giving:

1. The nominal value of each condenser to be used.
2. The resonant frequency of this condenser in parallel with the standard inductance. This is calculated from the formula in each case.
3. The reading on the "M.W." scale.
4. The reading on the "L.W." scale (as far as it goes).

The oscillator is now ready for calibration.

Set the switch to "M.W." and adjust the set zero control as described earlier. Turn the tuning control to the high frequency end of the dial, attach a condenser which will give a frequency of between 12 and 18 kc/s, and rotate the dial so as gradually to reduce frequency till a resonance point is reached. This will be indicated by the meter reading rising to a maximum, or the volume from the speaker rising to a peak, as the case may be. The position of the dial should be read and noted in the appropriate column. The condenser should now be replaced by one of slightly larger capacitance, the frequency again reduced till resonance is reached, and the reading noted. The purpose of starting at the high frequency end of the scale and working down to resonance is to ensure that the fundamental is reached first, and that it is not a harmonic of a lower frequency that is causing the peak.

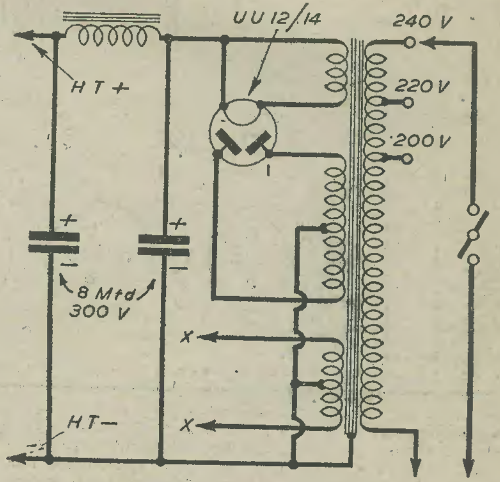


Fig. 7.—A suitable mains unit for Fig. 3.

When the whole "M.W." range below 15 kc/s has been covered in this manner—and the more readings that are taken, even if two or three condensers have the same nominal value, the less will be the chance of error—the readings should be plotted on graph paper, with frequency up the side, and dial readings along the bottom, and a curve drawn through as many points as possible. A typical calibration curve is shown in Fig. 7. The range between 15 and 20 kc/s should now be verified. As the approximate positions can be estimated beforehand from the curve of the graph, this reduces the chance of mistaking a harmonic for a fundamental. The upper register can now be drawn finally, and the graph completed, small kinks being, of course, neglected.

The "L.W." range is calibrated in a similar manner. First, the set zero is readjusted, then starting at 4 to 5 kc/s and working down, readings are taken as before, plotted, and the curve sketched. Then the range 4-6 kc/s is completed, estimating the position of readings from the curve, then determining them exactly by finding the resonant point. Finally the whole curve is carefully redrawn. If desired, the lower half of this range might well be calibrated from a piano, as described earlier, and this would provide a useful check of the resonance calibration.

Marking Out the Dial

While it is possible to leave the dial calibrated in degrees, and use the calibration curves for reference, it is much more convenient and well worth the extra trouble, to calibrate the dial directly in kc/s.

To do the 20 kc/s range, first find from the graph at what position of the dial 1.0 kc/s comes in. At this point, draw in a short thick radial line, preferably in Indian ink, *over* the initial pencil markings. In the same manner mark in 2, 3, 4, — — — 20 kc/s at the appropriate points, over the whole range. Finally, between each thick line draw in, free-hand, fine thin lines representing 0.2 kc/s each.

The 6 kc/s range is now dealt with in a similar manner except that points are plotted, and thick lines drawn, every 0.5 kc/s, and thin lines are drawn to represent 0.1 kc/s. When the marking-in is complete the numerals 1 to 6 and 1 to 20 should be carefully drawn in with a very fine pen, and after the ink has dried thoroughly the original pencil marks carefully erased with a soft rubber. The dial should now be carefully replaced and the oscillator is ready for use.

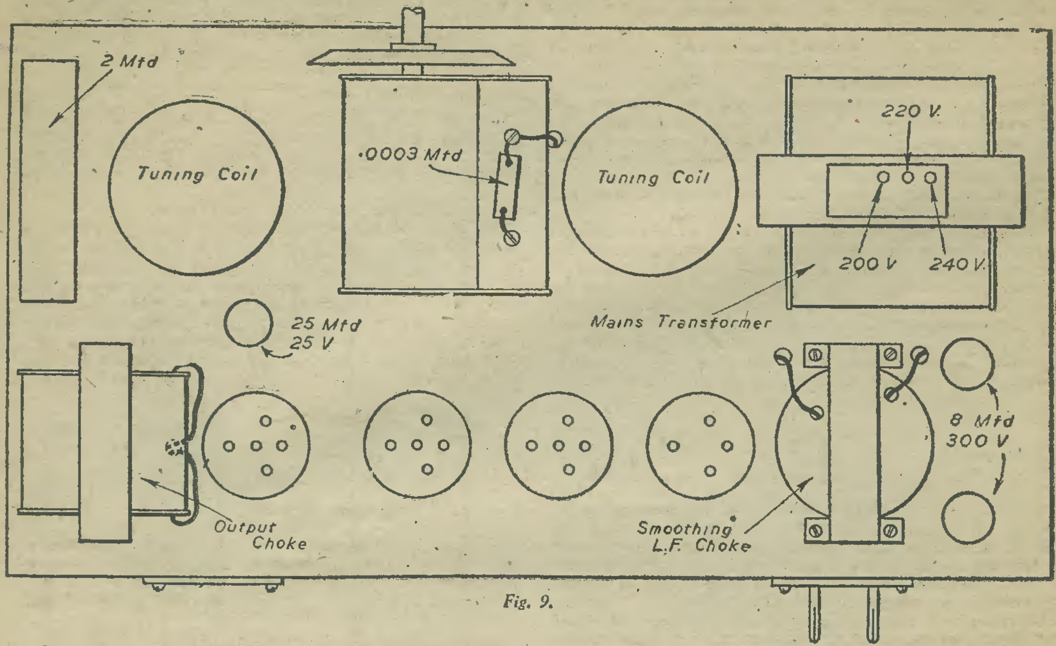


Fig. 9.

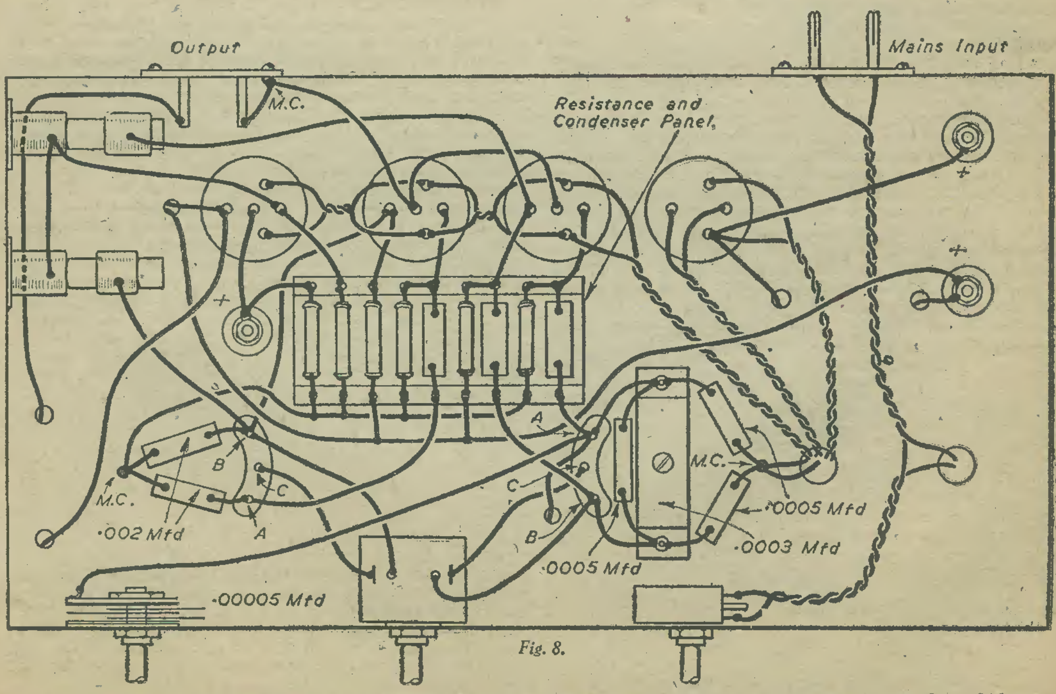


Fig. 8.

Figs. 8 and 9.—Layout and wiring diagram. Resistance and condenser valves, reading from left to right: 1,000 Ω; 1 MΩ; 50,000 Ω; 1 MΩ; .0001 mfd.; 50,000 Ω; .01 mfd.; 1 MΩ; .0001 mfd.

Output Response Curve

If an A.C. meter is available, the response curve of the oscillator should be drawn. This is done very simply by connecting the meter, on perhaps the 5-volt range, to the output terminals of the B.F.O. and plotting on a graph, with frequency along the bottom and voltage up the side, the output voltage at various frequencies, separate graphs being drawn for each range.

Uses of B.F.O.—Response Curves

Among its many other uses, perhaps the best known is that of determining the response curves of the A.F. sections of sets. While it is possible to draw a response curve very accurately, what is much more often required is an approximate check that:

The response is not excessively curtailed at either end.
There are no serious peaks or troughs.

This may readily be done by connecting the B.F.O. to the pick-up terminals, turning the receiver's volume control (if any) to about half and, if an A.C. meter is available, connecting this through 2 mfd. blocking condensers across the primary of the speaker transformer. The B.F.O. tuning control should now be turned to raise the frequency gradually from 0 to 6 kc/s, and then on the other range from 6 to 15 kc/s—few speakers reproduce above 15 kc/s Any peaks or troughs will at once become evident, and thinness, in either the bass or the treble, can also be seen.

If it is desired to graph the result, the output voltage at any frequency should be divided by the input voltage at that frequency (obtained from the B.F.O.'s response curve) and the logarithm of the resultant ratio plotted against frequency, preferably on logarithmic graph paper. This should be done every 100 c/s or so for the first kc/s, and thereafter at wider intervals.

Mechanical Resonances

The B.F.O. is also invaluable for tracing mechanical resonances in or near the speaker. Again the oscillator is connected to the pick-up terminals and the frequency gradually increased until the source of resonance is found.

Calibration of Condenser and Inductances

One less common use is in determining the values of unknown inductances and condensers. The set-up is the same as that used in calibrating the oscillator (Fig. 6), the unknown condenser being connected in parallel with the known inductance and (working down from 20 kc/s) the resonant frequency found. When L and f are known, C may be calculated from the formula given earlier. In the same way, an unknown inductance connected to a known condenser may be determined.

The Tuned Circuit

The effect of Resistive, Inductive and Capacitive Elements

IN an article on A.C. theory the tuned circuit, both parallel and series, was discussed, and formulæ for resonance, dynamic impedance and the like were tabulated. A simple tuned circuit consisting of an inductance and a condenser will now be considered and the effects which resistance and frequency have on its operation will be described.

Tuned Circuits

Tuned circuits, acceptors or rejectors, are composed of a capacity, an inductance and a resistance or resistances. The condenser supplies the capacity, the coil the inductance, and resistive elements are present in the turns of the coil and the connecting leads. Coils and condensers are generally measured in microhenries and microfarads respectively, and the wavelength to which a particular circuit will tune is given by:

$$\text{Wavelength } \lambda = 1.885\sqrt{LC}$$

the wavelength being expressed in metres.

Selectivity, an essential feature of all tuned circuits, is dependent upon the resistance of the circuit as we saw in A.C. theory; unlike D.C. practice the resistance of a coil at radio frequencies is a variable quantity; a coil wound with heavy gauge wire operating at radio frequency may have a resistance several times greater than that of a similar coil wound with thinner wire and measured normally on D.C. or power frequencies.

Resistance depends upon frequency, as does also the capacitance and inductance of the circuit. Capacity at high frequency is not the same as the capacity at D.C. Similarly the inductance of a coil for D.C. is generally a very different figure to the one obtained when the component is carrying R.F.

Changes in resistance, capacitance and inductance with change in frequency should not be confused at this stage with the change in the resistance of the components with change in frequency.

Resistance in the Tuned Circuit

In wireless calculations a definition of resistance is generally given by the formula:

$$P = I^2 R$$

where the total power consumption of the circuit under consideration is given as P watts and the R.M.S. value of the current flowing as I amperes. In a transmitting aerial, for instance, besides the ordinary ohmic resistance there is what is known as the radiation resistance of the aerial. This resistance can be looked on as "imaginary"; it is not clearly defined as is the case of the ohmic resistance, yet it is present and is of such a value that the equation

$$P = I^2 (R_1 + R_2)$$

is satisfied for the existing conditions. In the above R_1 is the ohmic resistance and R_2 the radiation resistance of the aerial; if P_1 watts of energy are radiated into space while P_2 watts are lost as heat then the total power is given by the sum of these two powers, resulting in the expression given above.

Therefore we see that the fact that power is dissipated as heat as well as useful radiation from a transmitting aerial, results in an increase in the aerial resistance from R_1 to $(R_1 + R_2)$ ohms.

Since, then, that losses of any nature can result in increased resistance, the design of tuned circuits not only calls for low ohmic values of resistance, but energy losses of every kind must be also avoided.

Effect of Frequency on Resistance

When a direct current flows through a conductor each part of the conductor carries a share of the current; that is, the current distribution is uniform. When the current is alternating this uniformity does not follow and as the frequency of the current increases the tendency of the current to desert the central portions of the conductor and confine itself to the outer portions also increases.

At very high frequencies this "skin effect" as it is called becomes extremely marked, the current flowing entirely on the surface of the conductor. Since this is in effect equivalent to reducing the cross-sectional area of the conductor it is quite evident that the ohmic resistance of the lead must substantially increase.

As the useful area of the conductor decreases as the frequency increases, the ratio of the R.F. to the D.C. resistance automatically increases with the frequency. In practical design, especially in transmitters, tuning coils are sometimes wound of copper tubing, since the removal of the central section makes no difference to the resistance.

The diameter of the conductor and the specific resistance of the material of which it is made most affect the radio frequency resistance of a conductor.

Generally, when conductors carrying R.F. currents are wound into coils the current distribution is such that the current tends to concentrate at the inner edge of the coil and is not so symmetrical as in the case when the conductor is simply straight. This effect can still urther increase the resistance of the component, especially in coils of several layers.

It can be shown by experiment that coils wound with fine wire have smaller R.F. resistances than coils in which heavier gauge is employed. Therefore in practice coils are sometimes wound with wire consisting of many separate strands, each insulated from the others and woven in such a manner that each strand moves equally from the centre to the outside edge of the cross section.

Since this results in more equal current distribution than that obtained in a solid conductor of similar dimensions, the overall resistance is kept reasonably near to its ohmic D.C. value.

Effect on Capacity and Inductance

The capacity of good air-spaced or oil-dielectric condensers is generally independent of the frequency of the applied current, but in the case of small paper types the frequency does exercise some effect on the capacity.

In rolled paper types attempts are made to reduce inductive effects by ensuring that the connecting leads are contacted at a large number of points along the ength of the foil plates. If this precaution is not taken, then at high frequencies portions of the plate area are ineffective, due to the inductance produced by the spiral construction of them.

Even in well-made condensers of this type where inductive effects are negligible, an effect known as dielectric absorption can cause the capacity to be affected by frequency. Condensers with solid dielectrics take longer to charge than condensers with air spacing; this is because dielectric absorption is much less in the latter variety.

As frequency increases the time taken for a condenser to charge and discharge becomes smaller and smaller; thus this is the same as reducing the amount of charge on the condenser and therefore effectively reducing the capacity.

The connection between the change of capacity of a condenser with the increase in frequency is rather a complex one, and as has already been mentioned is negligible in well-constructed air-spaced components.

In the case of inductances, coils used on R.F. are usually air cored, since ordinary iron cores cannot be employed as in the case of L.F. components, due to eddy current losses. These losses would increase the resistance very considerably and the coil would be of little use. Iron dust cores, however, may be employed, the finely divided iron of these resulting in low eddy current losses and the advantage of being able to obtain a given value of inductance with fewer turns of wire than would be needed in the case of an air-cored component.

The inductance of a coil can vary with the frequency due to the skin effect already discussed causing an unequal distribution of current. The self capacity of a coil can also have some bearing on this change of inductance with frequency effect.

Each turn of wire on a coil acts as a tiny condenser plate and a capacity exists between each section of the wire and the adjacent sections. All these little capacities add up into one larger capacity, virtually in parallel with the coil, known as the coil's self-capacity.

When R.F. is applied to a coil a certain amount of current must pass through the coil and a certain amount through the self-capacity; the energy losses of the latter due to dielectric absorption therefore increase the resistance of the coil, though this increase is generally much smaller than that caused by the skin effect.

The circuit becomes for all practical purposes a parallel rejector circuit, as we discussed in A.C. theory, the resonant frequency being given by

$$\frac{1}{2}\pi\sqrt{LC}$$

where C is the coil's self-capacity. Above this frequency the coil's impedance is capacitive, which means that the component behaves as a condenser; below the resonant frequency the impedance becomes inductive.

If an alternating p.d. of E volts is applied to the coil, and a current I flows from the generator then we can say:

$$I = E/\omega L - E\omega C$$
$$= E\,(1/\omega L - \omega C)$$
$$= E\,(1 - \omega^2 LC/\omega L)$$

and the current lags by 90 deg. behind the applied p.d. at all frequencies below resonance. The value of the inductance at all frequencies below resonance is given by:

$$E\,(1/\omega L_0) = E\,(1 - \omega^2 LC/\omega L)$$
$$L_0 = L/1 - \omega^2 LC$$

Thus it is a fairly simple matter to see that L_0, the effective inductance of a coil of calculated inductance L, will increase with the frequency due to the self-capacity C.

Self-capacity of multi-layer coils can be reduced by spaced layers or banked windings and in well-constructed components the effect can be practically eliminated.

Resistance Due to Capacity

A condenser can have a bearing on the resistance of a circuit due to several reasons. There is the ohmic resistance of the plates and connecting leads—generally quite small; then there is leakage resistance between the plates themselves across the dielectric—generally very high. Lastly, dielectric absorption causes a waste of energy due to heat losses in the dielectric material. As the frequency increases on the condenser the dielectric loss becomes less and less as the time for absorption gets smaller and smaller.

It can be shown that if the leakage resistance across the plates of a condenser can be imagined as a high resistance R shunting the condenser, then this is equivalent to a small resistance of value $1/\omega^2 C^2 R$ wired in series with the capacity.

Well-designed condensers introduce very small resistance effects in a circuit, unless they are subject to moisture and dust, which will have the effect of reducing leakage and increasing losses in the dielectric.

PRIZE PROBLEMS

Problem No. 457

JONES-SMITH'S battery receiver grew weak in volume. It was used in conjunction with an A.C. mains unit, and he suspected the output pentode, which was a 220 H.P.T. He replaced it by a 220 P.T., and the reception returned to normal. Returning the old valve to the makers it was sent back with the report that it was functioning satisfactorily. What, and where, was the defect in Jones-Smith's receiver?

Three books will be awarded for the first three correct solutions opened. Address your solution to the Editor, PRACTICAL WIRELESS, Tower House, Southampton Street, Strand, W.C.2. Envelopes must be marked Problem No. 457 in the top left-hand corner, and must be posted to reach this office not later than first post on Wednesday, June 14th, 1944.

Solution to Problem No. 456

Jackson's connections would have been quite in order if he had taken more care when joining one lead to the decoupling condenser. He intended making contact with the condenser terminal joined to earth, but, unfortunately, he soldered the wire to the other one, which was at a H.T. positive potential.

The three following readers successfully solved Problem No. 455, and books have accordingly been forwarded to them: L.A.C. A. L. Atley, R.A.F., Oxon; L. Shepherd, Esq., 11, Crompton Place, Preston New Road, Blackburn, Lancs; J. S. Rigby, Esq., 955, East Lynes Road, Boothstown, Nr. Manchester, Lancs.

Mains Transformers—2

Laminations, Winding and Assembly. By D. BARBER

(Continued from page 276, June issue.)

IT has been shown that the essential parts of a transformer are two coils, called the primary and the secondary, mounted on a soft iron core. These will now be considered independently in greater detail.

The Iron Core

The types of core usually met with in small transformers can be divided broadly into two types: firstly, the "core" type construction (Figs. 1 and 1A), and secondly, the "shell" type (Figs. 2 and 2A). The dotted lines indicate the path which the magnetic flux follows during operation, and t will be seen that in the "shell" type this flux divides into two paths on reaching the outer limbs or legs. The windings can be disposed in several ways; for instance, in the case of the core type, the primary can be wound on one limb and the secondary on the other, or the two coils can both be put on the same limb. In the same way, the shell type can have both these windings assembled on the centre limb, or one on each of the outer limbs. The most efficient way of mounting the coils is always to have them as near as possible to each other. Thus, Fig. 2 is from all points of view the best construction to adopt. Not only are the windings efficiently placed, but being wound on the centre limb, a large part of the barrel surface of the coils is mechanically protected by the two outer limbs.

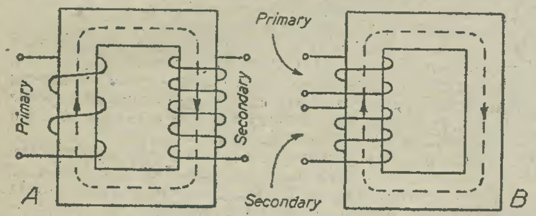


Fig. 1.—Core-type construction.

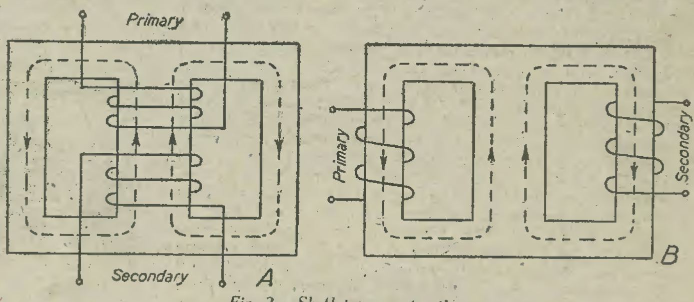


Fig. 2.—Shell-type construction.

The material used for building up transformer cores is always thin sheet iron, usually between .01in. and .02in. thick. Special ferrous alloys are manufactured, one of the most popular being marketed under the trade name of "Stalloy." In the absence of these special alloys, however, ordinary annealed sheet iron is quite suitable for amateur use. These punchings or laminations usually go in pairs to make up the desired shape of core. Figs. 3, 3A, 4 and 4A show several types commonly met with, of which Fig. 4A is the efficient shell type mentioned in the preceding paragraph. Without going into a technical explanation, it can be stated that it is absolutely essential that transformer cores are built up of these laminations. A solid core will *not* do. The reason for the laminations being marketed in pairs is to enable the constructor to wind his coils and then build up the magnetic core around it.

In the previous article it was emphasised that for a transformer coil to be most effective it must act on an iron core without air gaps. In actual core construction, there must always be bad magnetic joints where the two sections of the core meet. Some method of overlapping these joints must therefore be devised in order that the core as a whole is magnetically a good conductor. Fig. 5 shows how this is done. It will be seen that the joints of the "odd" laminations do not fall opposite the joints of the "even" laminations. Fig. 5A shows the appearance of the core when correctly assembled in this manner.

Coils

The importance of sound insulation cannot be too highly stressed when building transformers for mains use. The breakdown effect of alternating voltages is considerably higher than the equivalent D.C. voltage. One of the best ways to ensure adequate isolation of the secondary from the primary winding is to wind and insulate the two coils separately before mounting on the core. The common cause of the failure of small transformers is the breakdown of the insulation between adjacent layers of the winding. This is particularly the case with the high voltage windings. A strip of very thin paper placed between each layer of wire on the soil will effectively prevent this. In the case of windings operating at less than, say, 100 volts, it is not usual to

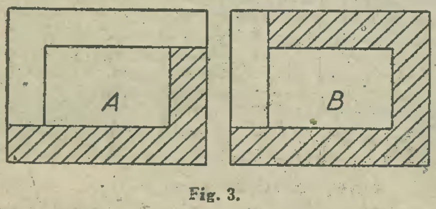


Fig. 3.

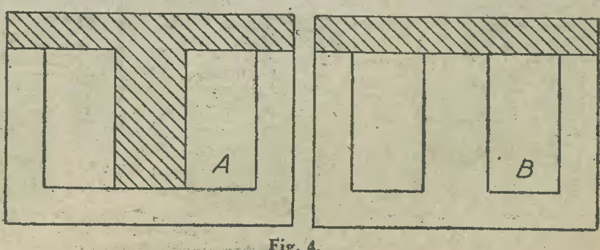


Fig. 4.

Figs. 3 and 4.—Core lamination.

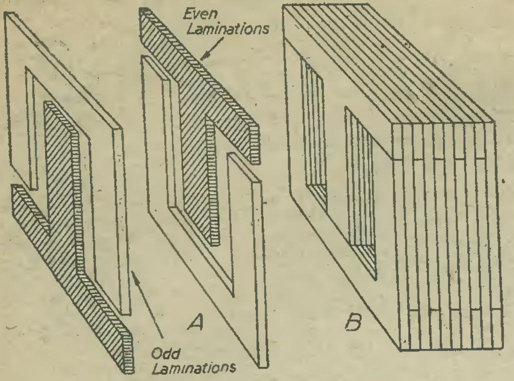


Fig. 5.—Method of interleaving stampings.

insert this as the wire covering itself is generally considered adequate insulation.

The only convenient method of winding transformer coils is by the use of "formers." These are frames made of wood or fibre of such dimensions that when the coil is wound on them, they can be dismantled and removed, leaving the coil correctly shaped so as to fit the core on which it is finally to go. Figs. 6, 6A and 6B show three stages in the winding of a coil using this method. Fig. 6 is a sketch of a typical former. It will be noticed that it can be taken into three parts—consisting of an inner block, with two outer cheeks.

Four slots are cut across the cheeks of such depth that they just cut the surface of the inner block.

The procedure when winding a coil should be as follows:

The former is held together by a threaded rod or screw, after the inner block has been rubbed with a little wax to facilitate its ultimate removal. The starting end of the wire is then passed through one of the slots and anchored to the outside of the cheek. Winding can now commence. This should be done neatly and care should be taken that the last turns of each layer do not drop down below the level of the preceding layer. When the necessary number of turns has been wound on, four pieces of thread are passed through the slots in the former and round the coil, the ends being tied together as shown in Fig. 6A. This will hold the coil together and the former can now be dismantled and the inner block gently tapped out from the middle of the coil. The taping up or insulating process can commence at this stage. Yellow "Empire" tape, about ½in. wide, is the best material to use, and a glance at Fig. 6B will make clear the manner in which this is put on. It should not be drawn too tightly, otherwise the coil will become distorted. As the taping progresses round the coil, the four pieces of thread can be cut off one by one. Two layers of this tape should be ample for voltages up to, say, 250 volts. For mechanical protection a further layer of cotton tape should be applied if this is available, or black adhesive tape may be used, although this is sticky, and will be found difficult to manipulate. Pieces of insulated sleeving should be threaded over the wire ends going out of the coil to give them the necessary protection. The taping should be taken some distance over these. If care has been taken in the various stages of winding, the result should now be a uniformly shaped coil of such proportions that the core laminations can be assembled with it so as to fit snugly without having to be forced in any way. If the constructor so wishes, he may dip the coil after winding in some good quality insulating varnish. This is instrumental in keeping out the damp and ensuring a long life. In the event of enamelled wires having been used, however, the coil should *not* be dipped, as many varnishes attack the enamel covering.

Assembly

No particular difficulty should be experienced in putting together the core and coils. The main thing to watch is that the laminations are handled carefully so that they remain flat, otherwise it may be found that the finished transformer will hum unduly when in operation. To minimise this humming the core should be clamped tightly so that no vibration can take place. Any suitable method of clamping can be used, a very common one being illustrated in Fig. 7, which shows a perspective sketch of a typical shell type transformer constructed on the basis of these notes. The core clamps, it will be seen, are extended to take the terminal board, which is usually of bakelite.

This article has dealt with the method of construction of transformers. The next and final article will deal with the procedure to be followed when figuring out core sizes, number of turns, and other aspects of design.

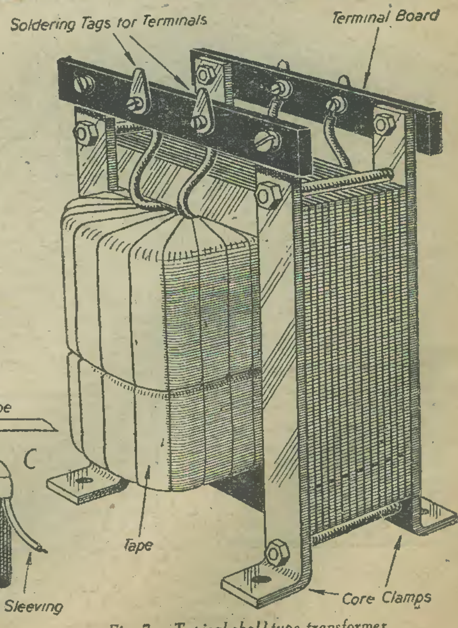


Fig. 7.—Typical shell type transformer.

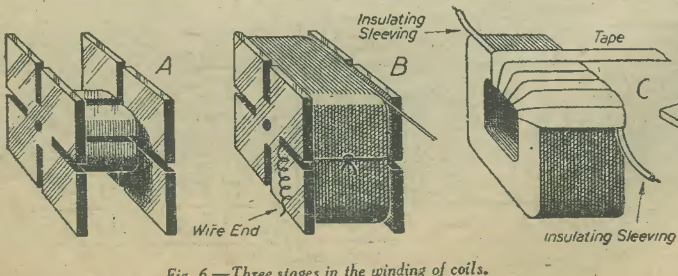


Fig. 6.—Three stages in the winding of coils.

ON YOUR WAVELENGTH

By THERMION

Our Brains Trust Suspended

THE word of the Editor is always final, legally binding, and no correspondence can be entered into regarding his decision. Therefore I read his decision in last month's issue to suspend the PRACTICAL WIRELESS Advisory Service with feelings of relief intermingled with regret. I have seen the Editor at work, ploughing through a deep pile of queries which ought never to have been sent. I have seen his staff wading through a positive morass of queries which have been answered some dozens of times in past issues. I have seen circuit diagrams arriving for modification, and I have seen requests for addresses which have appeared in every successive issue of this journal. I also have noted the painstaking care with which the staff prepares the indexes to the articles, replies, and paragraphs, which constitute the make-up of each issue. These indexes are prepared and sold for the special convenience of readers, so that they may have a key and rapid guide to information published during the year. These indexes are published at a loss.

As soon as a reader encounters some problem, it may be an address, a request for a circuit, or have we ever published, etc., he dashes off a letter to us. Has the world grown inherently lazy? Do readers realise when shooting off one of their complicated letters containing perhaps one dozen separate queries, that it takes a member of the staff two hours to deal with it? Some of the letters are quite unreasonable. No reader of this paper has a right to expect two hours of the service of a member of the staff. We, on the other hand, are entitled to expect that readers will go to some little trouble to help themselves before sending a query in to us. Some of the queries are childish, and could be answered if the reader would go to the nearest telephone box, and consult the telephone directory for a particular address. Some of the readers accentuate my point by saying that they have been readers from No. 1. That is, of course, an old tag. One reader the other day endeavoured to enlist our aid, in these days of staff shortage, by stating that he had taken the paper for the last twenty years! The journal is twelve years old!

So the fiat has gone forth. Until the labour situation changes queries may not be addressed here. In lots of ways I deplore it. Notwithstanding the annoyances and the aggravations which questions of the nature of a recurring decimal have upon an overworked and understanding staff, they have been cheerfully and promptly attended to. This is the only journal which has maintained a Free Advisory Service from its inception.

There is another point. Manufacturers of complete wireless receivers who, in the piping times of peace have wryly distorted their faces and distended their nostrils as if encountering the effluvia from a bad drain at the mere mention of home-constructed receivers, are not hesitating nowadays to direct purchasers of their receivers who are encountering difficulties therewith, to write to the Editor of this journal—having sacked their own servicing and technical inquiry staffs early in the war. This journal has always made it a rule that it will not deal with questions relating to commercial receivers. I can now disclose the reason.

In those halcyon days when we answered questions from all and sundry we often received queries relating to commercial receivers of which we had no personal experience. Upon telephoning the service managers concerning queries which only they could settle we were told to direct the querist to them. Very properly, therefore, we took the attitude that as they or their agents had sold the receiver and made the profit thereon they should have the expense and trouble of dealing with queries. I have the authority of the Editor for stating that this state of affairs will continue after the war.

A lot of queries are addressed to me personally, and I must refuse to answer any letters relating to commercial receivers. Readers in such difficulties should consult the local agents or the manufacturers concerned.

The PRACTICAL WIRELESS Brains Trust has functioned most efficiently for all these years. It is not a Brains Trust like that of the B.B.C. ilk. It is a Brains Trust which answers questions, whereas, the B.B.C so-called Brains Trust merely gives opinions as answers to questions.

If Howard Thomas is so anxious to claim the credit for having introduced it, then he is easily pleased and satisfied. I join with the Editor in expressing the hope that we shall shortly be able to reintroduce the service to readers which we have so cheerfully and promptly undertaken from the first issue. In the meantime it is regretted that readers will have to help themselves by consulting back issues, instead of expecting us to do so for them.

Our Roll of Merit

Readers on Active Service—Forty-third List.

P. Fisher (Cpl., R.A.F.).
C. Randall (L.A.C., R.A.F.).
J. W. Nott (L.A.C., R.A.F.).
D. Allan (A.C.I, R.A.F.).
G. Clouston (L.A.C., R.A.F.).
M. Hook (L.A.C. R.A.F.).
F. Williamson (Sgt., R.A.F.).

"WHY WE'RE GOING BARMY"

[Press Item.—The Vicar of Chorleywood, Hertfordshire, says Britain is on the verge of a national nervous breakdown and he thinks that a tremendous lot of illness and nervous disorder is brought about by the confusion that is operating over the wireless. He says: "One moment you are called upon to listen to some uplifting address, and the next moment you are switched off to some silly thrill which thrills not at all."]

Dear Vicar, your views,
As set out in the Press,
To many seem narrow,
We're forced to confess;
But grant you one point
We readily will,
Like you we just hate,
Those thrills which don't thrill.

Afflictions, it's clear,
Are greatly increased
By the programmes we hear.
One moment dull lectures,
The next gibbering croons,
Till all bilious we turn,
And see several moons.

Can you find us, kind sir,
Some remedy durable?
Oh! don't break our hearts
By verdict "Incurable."
For of manias many
We've more than enough,
Heaven spare us from more
"Programmania" stuff!

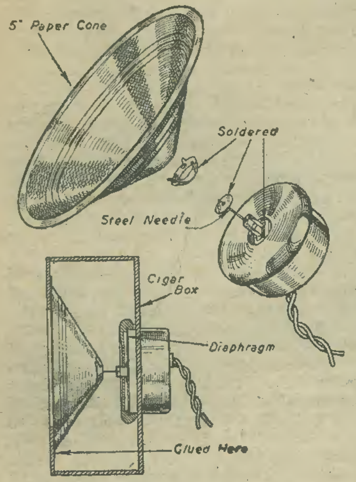
"TORCH."

Practical Hints

An Improvised Midget Speaker

SOME time ago I discovered that one of my speakers, which was mounted in my set, was out of order, so I decided to construct a simple substitute.

After a few weeks of experiment I devised a midget 5in. speaker from an old earphone and a 5in. paper cone



An efficient midget speaker made with an earphone.

which I purchased for a few pence. The results were outstanding, and the accompanying sketch gives the construction details. It is essential to use a steel needle for a connection between the cone and earphone and that all the parts are well soldered together. The cone and earphone are mounted in a cigar box, as shown.—C. G. KONASKI (Ludlow).

THAT DODGE OF YOURS!

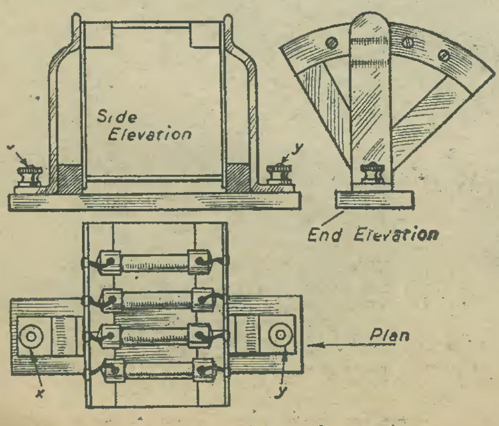
Every Reader of "PRACTICAL WIRELESS" must have originated some little dodge which would interest other readers. Why not pass it on to us? We pay £1-10-0 for the best hint submitted, and for every other item published on this page we will pay half-a-guinea. Turn that idea of yours to account by sending it in to us addressed to the Editor, "PRACTICAL WIRELESS," George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Put your name and address on every item. Please note that every notion sent in must be *original*. Mark envelopes "Practical Hints."

SPECIAL NOTICE

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

Making Quick Connections

THE accompanying diagram shows a device which may be successfully used to save continuous connection and disconnection of small components where results by trial and error are required. It comprises two pieces of spring metal, with terminals attached, mounted on an insulating base, the tops of which are free to press on to the ends of bolts on a rack, to which the small components are fastened. The ends of the rack are of insulating material joined by any suitable strip of metal, the whole being supported by metal strips on a spindle bedded in insulating material. To find the component giving the best results it is only necessary to push the rack from one side to the other. This device is extremely useful when using components which are not marked and the origin of which may have been forgotten.—J. ALDWINCKLE (Houghton-on-the-Hill).

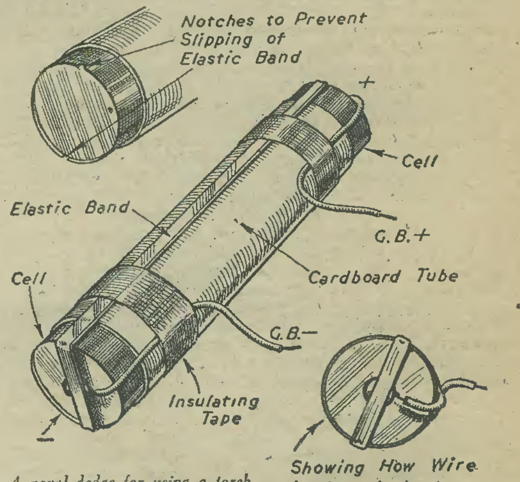


A simple method of making quick connections.

Portable Grid-bias

I RECENTLY required 3 volts for the grid-bias on a small portable set that I had constructed. Space and weight considerations did not enable me to use any other battery than a No. 8, and I adopted the following idea for connecting it up.

The cells are removed from the cardboard container and two small notches are filed at one end of one cell and at the other end of the other cell; these notches are diametrically spaced, as shown in the sketch. About ½in. is cut off the cardboard tube and the cells are



A novel dodge for using a torch battery for grid bias.

replaced in it, so that the notches are in line with one another; an elastic band is then placed over the notches. This holds the cells firmly together. For connections I used stranded rubber-covered wire, and the sketch shows how the negative wire is connected, two turns of insulating tape holding the wire firmly in position, and also preventing the elastic band from slipping off. At the positive terminal the wire is twisted round the brass top (care being taken that the wire does not touch the zinc), and the elastic band passes *over* the wire, and to one side of the carbon top. This connection is then secured with insulation tape as for the positive wire.

With this method, which involves no soldered joints, I have had no trouble due to loose connections during several months of travel on buses and trains, and it is only a matter of moments to replace the battery, when necessary.—CHARLES A. MARSHALL (Manchester).

Secondary Batteries—11

Repairing Accumulators. Fitting New Plates. By G. A. T. BURDETT, A.M.I.I.A.

(*Continued from page 299, June issue*)

WITH the aid of a few tools, repairs may be undertaken by the amateur in his own workshop, or by the mechanic of the service station. Large repairs and repairs to special types of batteries are usually beyond the scope of the small workshop, and manufacturers' specialist servicing agents should be consulted. General repairs include the following:

(1) Broken and corroded terminals.
(2) Broken or cracked celluloid, glass and hard rubber containers.
(3) Damaged plates (positive and negative.
(4) Broken separators.
(5) Broken connecting bars and terminal posts.
(6) Replating batteries.

Broken Terminals

All terminals should be examined for corrosion and security. Clean corroded terminals with a solution of ammonia and apply Vaseline. If the terminal studs are loose, tighten them carefully without damaging the thread. Terminals are usually severed at the base or in the insulated head. This is caused either by corrosion, over-tightening, or both, Fig. 1. The remainder of the stud is removed by drilling the stud, when the broken portion is easily removed. For drilling select a drill slightly smaller than the size of the stud or the thread of the locking nut will be stripped. 2BA is the usual size of a terminal employed on small wireless batteries. Where no locking nut is fitted a large hole should be drilled in the lead post and the new stud smeared with molten lead.

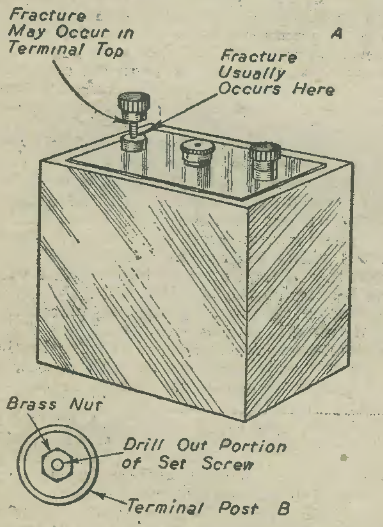


Fig. 1.—Usual sources of trouble, and their remedies.

Damaged and Broken Cell Cases

Broken cases are scrap and since they rarely contain electrolyte when received the plates will also be damaged beyond repair. Cracked glass cells also cannot be satisfactorily repaired and, when leaking, the electrolyte is drained off the plates and separators removed and placed in a new case. Slight cracks where no leaking occurs may be ignored though a new jar is recommended where the crack is likely to develop. Celluloid cases crack easily but fortunately are suitable to repair once the exact location of the crack is ascertained. Unspillable (jelly) cells will not leak, but any crack should be repaired to prevent its development.

Repairing Celluloid Cases

First drain off the electrolyte, and run a penknife blade along the joint between the lid and the case and prise off the lid. Lift off the block of plates complete with separator and place them in a vessel containing a weak solution of electrolyte. Rinse out the case with warm (not hot) water since hot water will warp the celluloid. When all the loose sediment is removed the precipitation of hard sulphate is removed with an ordinary blunt knife or butter knife. Wipe over the case and fractured parts with a rag damped, but not soaked, with ammonia. Procure a small strip of celluloid, such as an old photographic film, and a quantity of amyl-acetate and acetone. Mix the two ingredients together—two parts of amyl-acetate to one part of acetone. Into the solution place shavings of celluloid, which when dissolved will provide a strong adhesive cement. Cut the strip of celluloid to the desired shapes to cover the fractures, clean the patches and fractured portions and apply a thin film of solution. When tacky apply the patches—see Fig. 2.

Location of the fractures is sometimes difficult. The cells should be filled with water and the sides and bottom of the cells carefully examined for leaks. Where a battery contains more than one cell it often fractures at the dividing wall between the cells. Each cell in turn should be filled with water, when it is possible to ascertain whether water seeps through.

When the cement is hard the plates are replaced and the lid cemented on with the prepared solution.

Ebonite, or hard rubber cells, are more difficult to dismantle. Cracks in the case walls may be temporarily repaired by filling them with Chattertons' Compound provided the fracture is cleaned, but where the cell is to withstand rough usage a new case is advised.

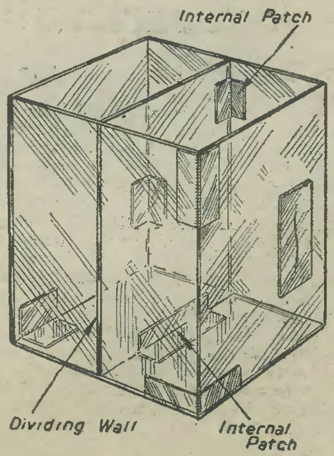
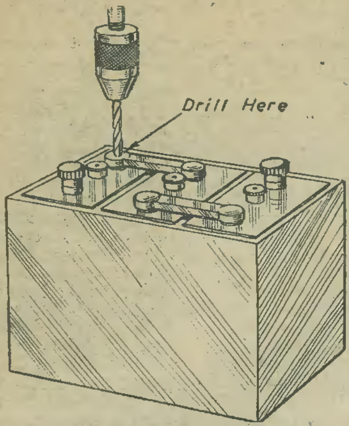
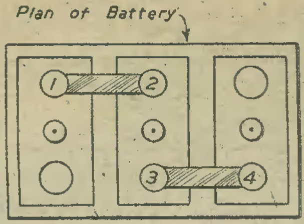


Fig. 2.—Method of repairing leaky containers.





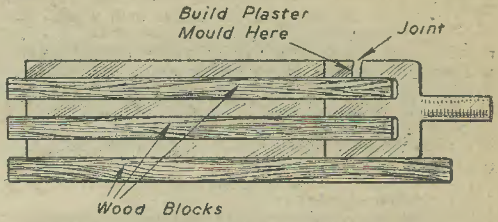


Fig. 3 (Left).—Releasing connecting bars.

Fig. 4.—Repairing plates.

Leakages frequently occur in the sealing compound on top of the battery. These are usually repairable by running a hot soldering iron over the compound.

The connecting bars of multi-cell batteries are first removed. The posts are drilled as illustrated in Fig. 3, and the connecting bar is released.

The sealing compound is then removed with the aid of a heated putty knife. Before removing the cover and gasket, the block of plates is withdrawn to facilitate the removal of the lead posts protruding above the cover, Fig. 4.

Some difficulty may be experienced in separating the plates, due to their being buckled. An attempt should first be made to remove the separator. This is achieved by slightly bending the plates, taking care not to damage them. Rarely is it possible to remove wooden separators without breaking them. Further, it is not advisable to replace separators and new ones should be obtained.

Now the sets of plates have been separated they should be straightened and the sulphate removed as described in a previous article. Should one or more plates be broken a new set should be obtained unless the battery is fairly new or new plates are not available.

Both lug and the portion of the plates where the joint is to be made are cleared and tinned with solder in the usual way with soldering jobs. A block of wood such as is used for straightening plates is inserted between the plates—Fig. 4. A plaster of paris mould is then formed round the joint and a hot soldering iron is applied and, with the aid of powdered resin and tin solder, the joint is made and left to cool. The plaster is removed, the rough edges scraped off and anti-sulphate enamel applied. This method should only be adopted for small batteries used for wireless and similar purposes and not for larger batteries since the latter are special heavy workshop jobs.

Wood separators may be purchased in either a dry or a wet state. When dry, they should be placed in a solution of weak electrolyte for a few days prior to use. If wet they should be left moist in a similar manner until required.

When replacing separators between the plates those in the centre of a block of plates are replaced in position first. Then fit the remaining separators alternatively on either side of the centre plates until all are placed in position. The complete assembly of plates and separators are then lined up with a block of wood, upon completion of which the assembly is placed in the case. Particular care must be taken to ensure that they are inserted the correct way in a multi-cell battery or incorrect polarity will result.

Before replacing connecting straps, first test each cell with moving-coil voltmeter to ensure the correct polarity relative to adjacent cell. The space between the jar and the cover must be warmed before sealing, and this is best carried out with the aid of a small gas flame to prevent the jar from cracking and to ensure that the compound will fill the crack. The hot sealing compound is poured in and then smoothed over with a warm putty knife or by placing the gas jet over it.

The connecting bars may then be placed in position on the terminal posts and burnt in.

The final operation is that of pouring in the correct quantity of electrolyte, which with a new cell will require topping up during the initial charge.

BOOK RECEIVED

ELEMENTS OF RADIO. By A. and W. Marcus. Published by George Allen and Unwin, Ltd. 700 pages. Price 27s. 6d. net.

AFTER reading the foreword by Robert P. Patterson, the Under-Secretary of War for the U.S.A., the Preface and Table of Contents, it soon becomes apparent that "Elements of Radio" has been prepared with great care and understanding by the two well-known American Radio Technicians Abraham and William Marcus.

The book is a complete edition, two volumes being contained within its covers, and it is intended to form a work capable of catering for the requirements of a student of radio, and in our opinion the authors have undoubtedly succeeded in their object. Although it naturally comes under the heading of a text-book, it does not take the form one usually associates with that type of book; it provides the information so essential to the student, in a simple, clear and concise manner, and as each of the 42 chapters contains its own summary, glossary, table of symbols and questions and problems, it also forms a most useful work for instruction. For example, pages 647 to 672 are devoted to suitable demonstrations, the procedure for which is given together with circuit diagrams. Chapters 1 to 28 constitute Vol. 1, which commences with the History of Communication, and proceeds, step-by-step, through the subject in what might be termed a semi-theoretical-practical form right up to radio direction finders. All sections are dealt with in a simple yet thorough manner and the student does not have to wade through masses of formulæ, in fact the authors have studiously avoided the use of formulæ in this volume to prevent the student from becoming confused. In Volume 2, one is taken in easy steps through theoretical matters, and naturally mathematics have to be introduced, but, even so, it consists only of simple algebra with a few principles of trigonometry, so the beginner should not find the going hard. Chapter 29, Volume 2, deals with direct current and the nature of electricity, while the others, up to Chapter 42, cover the essential subjects, including transmitters, in progressive sequence to the cathode-ray tube and its applications. Finally, there is included a 10 page Appendix covering eventful dates in radio development, theoretical symbols, abbreviations, units, colour code, etc., etc.

The book should prove most useful to the student and instructor, and the only adverse comment we have to make is the use of American terms and symbols which may, at first, confuse the beginner in this country.

Aerial Pointers

The Importance of Using a Good Aerial is Explained, and Some Notes on Aerial Design are Given

IN the early days of broadcasting a good deal of attention was given to the aerial-earth system, whereas to-day the matter is generally ignored almost completely. It is true that many of our early efforts were far from scientific, but by placing the aerial as high as possible, taking good care that the insulation was beyond reproach, and ensuring that the earth

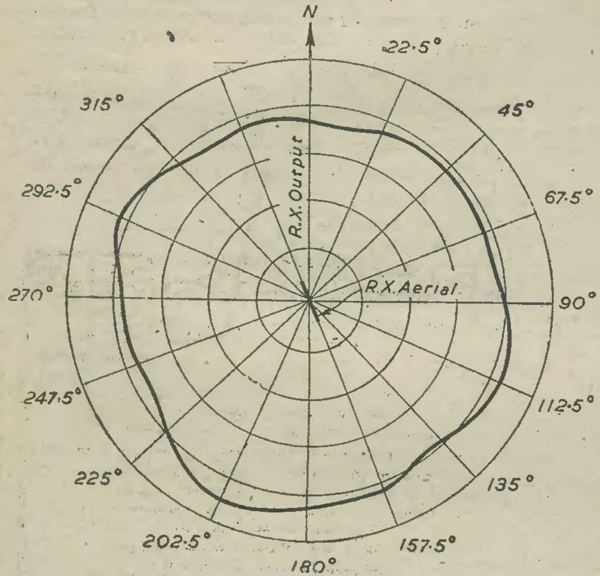


Fig. 1.—A polar diagram, showing the relative pick-up by a receiving aerial from various points.

connection really did make good contact with the ground, satisfactory results were generally obtained. Our early receivers were extremely insensitive as judged by present-day standards, which meant that "any odd bit of wire" just would not serve as a suitable "collector."

In the past 20 years we have learned a good deal about aerial design, with the result that it can nowadays be brought down to a mathematical problem. Unfortunately, however, these accurate mathematical results often fail to help us. The reason for this is simple: the average back garden is far too small to permit of the erection of an aerial of sufficient length for ideal reception on broadcast wavelengths. On short waves we can easily erect an aerial of one-quarter, one-half or even one wavelength long; on the broadcast band this is quite impossible.

Polar Diagrams

We will consider a few of the technical aspects of simple types of aerial, on the assumption that we are to use them for short-wave reception, for which these aerials are a practical possibility. In order to understand the pick-up by an aerial it is first necessary to have an outline knowledge of what are known as polar diagrams. These are of two kinds—horizontal and vertical—and show the sensitivity of the aerial to signals coming from different directions around the aerial. Polar diagrams may be plotted by two or three different methods, the simplest of which is by using a receiver with an output meter and a small low-power transmitter or signal generator. The signal generator is moved to a point at a certain distance from the receiver, and the output obtained from the receiver is noted. The generator is then moved to a different point at a known direction from the receiver. It is moved toward or away from the receiving aerial until the same output is indicated from the receiver. This is repeated at a number of different points along lines which are radial from the point at which the receiver is situated.

By drawing a number of lines radiating from a fixed point on a sheet of paper, the position of the signal generator along each of those lines, for equal receiver output, can be marked off to scale. By joining up those points we have a horizontal polar diagram. An example of this is shown in Fig. 1. In this case, it will be seen that the diagram is reasonably circular, although there is a "flat" to the north and also to the south-west of the aerial, which suggests that there is some slight screening in those two directions.

The above simple explanation is by no means complete, but is given to convey a rough idea of the meaning of a horizontal polar diagram. Vertical polar diagrams could be obtained, but they would normally involve the use of an aircraft climbing to different heights. In any case, it is the horizontal diagram with which the reader will generally be concerned.

Directional Effects

Different types of aerial have different polar diagrams. For example, a vertical aerial has a circular polar diagram. At least, that is true in theory; in practice, the diagram would be more like that shown in Fig. 1, and may, in fact, be far more irregular in shape than this if the aerial were fairly near to metal buildings, trees and the like, or if it were close to, and to the leeward of, a hill.

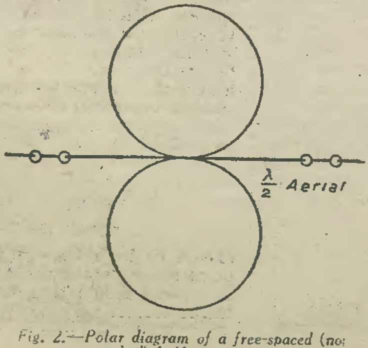


Fig. 2.—Polar diagram of a free-spaced (not earthed) half-wave aerial.

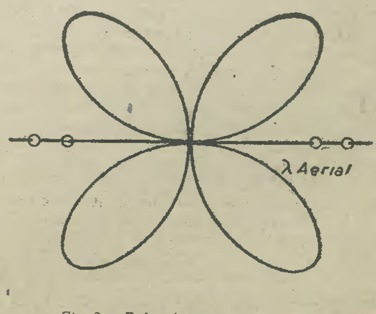


Fig. 3.—Polar diagram of full-wave aerial.

A horizontal aerial, one half-wavelength long, has a polar diagram of the pattern shown in Fig. 2. If the same aerial is extended to have a length of one wavelength, the polar diagram would assume the form shown in Fig. 3. The usual inverted-L aerial can be expected to have a polar diagram rather similar to that shown in Fig. 4, although the proportions of this diagram have been somewhat exaggerated to indicate the effect of the bent-over portion.

It becomes apparent from these diagrams that even the simplest types of aerial exhibit certain directional effects, although they would not be described as directional aerials. Moreover, the diagrams would be by no means as "clean" as those shown, and between the various "lobes" shown there would be numerous smaller "lobes." Thus, for example, although the horizontal half-wave aerial is directional broadside to the aerial wire, it would nevertheless pick up some signals from directions in line with the aerial. Similarly, the full-wave aerial would not show four nul points, though it would be less responsive to signals arriving in line with, or at right angles to, the wire.

Aerial Length and Frequency

It is all very well to speak of aerials as having lengths proportional to the wavelength of the signals to be received, but we do not always receive on the same wavelength. It is here that the transmitting station is at an advantage in that it can be provided with an aerial cut to a precise length, the length chosen being dependent upon the wavelength on which the transmitter is to operate and the directional effects required. But, fortunately, the length is not very critical in the case of the receiver, and an aerial cut to suit the middle of a short-wave band will give reasonably uniform results over the whole of the band. Moreover, if the aerial is cut as a half-wave one for the 40-metre band, it will act as a quarter-wave on 80 metres and as a full-wave on 20 metres. It is for this reason that a 40-metre half-wave aerial is probably most convenient for general short-wave reception.

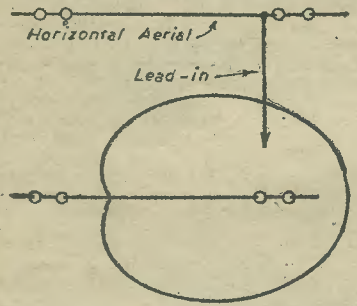


Fig. 4.—(Left) Exaggerated polar diagram (below), of a horizontal inverted aerial (above).

An All-wavelength Aerial

At this stage let us plan a half-wave aerial to meet the conditions just described. A so-called dipole or doublet will be found most satisfactory, and one of this kind is illustrated diagrammatically in Fig. 5. It consists of two halves, each one-quarter of 40 metres (say 32ft.) in length. The two halves are well insulated from each other and the ends of the aerial are insulated from the supports. A lead-in is taken from the centre of the aerial, and this consists of twisted twin flex. The flex must be of a type suitable for outdoor use, for otherwise the insulation would quickly rot. As an alternative, we could use bare wire for the lead-in, crossing this at intervals of about 18in., by using so-called transposition blocks. These are merely insulators specially designed so that the two wires may be crossed over each other and at the same time remain insulated from each other.

The lead-in should be at least one-quarter-wave long (that is, at least as long as one arm of the aerial) and the two leads should be insulated right to the receiver. There, they should be connected to the two ends of a small coil coupled to the input tuning coil. In general, the number of turns on this coil should be between one-quarter and one-half the number of turns on the tuned winding. It is also preferable that the coupling between the two coils should be fairly loose, in the interests of selectivity.

It may be wondered why the twin-lead-in should consist of twisted or transposed wires. The reason is that we do not want the lead-in to act as an aerial, and therefore we arrange that any signal voltage picked up by one wire is cancelled by the pick-up (which is in opposite phase) on the other. Provided that the horizontal portion of the aerial is well sited away from buildings and at the greatest height possible, this ensures a minimum of noise due to man-made static. And by having a long lead-in it is possible to arrange the aerial in the most suitable position in the immediate vicinity.

If an increased directional effect is required in one direction, a reflector can be placed behind the aerial at

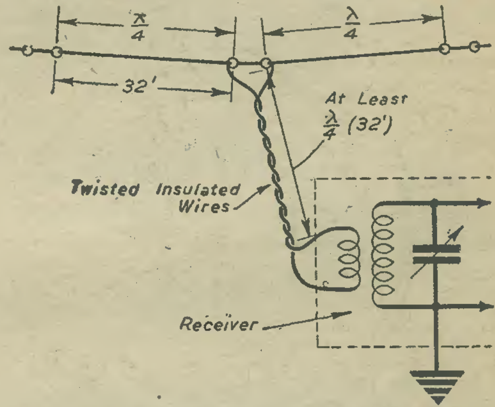


Fig. 5.—(Right) One of the best types of general purpose aerial systems. It will give good results on both medium and short waves.

a distance of one-quarter wave. This will tend to eliminate one of the two broadside "lobes" and increase the sensitivity of the aerial away from the reflector. The reflector, incidentally, should consist of a single insulated wire slightly longer than the full aerial length; that is, for the aerial in question, about 66ft.

Omni-directional Aerials

When omni-directional properties are required, a vertical quarter-wave aerial (bent over for a short distance at the top if a sufficiently high support is not available), is most satisfactory, especially for wavelengths below about 50 metres. The best arrangement for this is to use a tall mast situated as far as possible from the house and to mount the aerial wire between an insulator fitted to a projection at the top of the mast and another fitted to a short length of cord attached to an earth spike. With this type of aerial it is practically essential to employ a co-axial lead-in; that is, a low-capacity screened lead of the type specially produced some years before the war. There may be difficulty in obtaining a lead of this type to-day, but if one is available a very satisfactory aerial may be produced. The central feeder forms the actual aerial lead, while the outer screen must be earthed.

An earth connection of the radial type is most satisfactory for use with a vertical quarter-wave aerial. This consists of a metal plate with a dozen or so lengths of ordinary aerial wire soldered to it. These wires should, when possible, be of similar length to the aerial, and should be buried a few inches deep, radiating from a point approximately in line with the base of the aerial. The earth should then be well connected to the screen of the feeder.

An H.T. Line Unit

A Simple and Valuable Piece of Equipment Which Should be on the Work-bench of Every Constructor and Experimenter. By 2CHW

WHEN designing an H.T. eliminator it is not usually feasible to cater for all possible demands which might be imposed during experimental work. Factors such as overall size, complicated wiring, switching, layout and the difficulty of estimating likely requirements have to be considered, and these are usually sufficient to prevent the "ideal" design on paper from coming into being on the bench.

Experience shows that whatever voltage dropping arrangements, etc., have been incorporated in the mains units or eliminators I have made, conditions have always arisen which could not be satisfied without modifications being made, and, as these involve soldering and the loss of time, I eventually split the mains unit into two distinct parts. While it cannot be claimed that the result is a super multi-purpose piece of apparatus, it does form the nearest approach—so far as I am concerned—to the ideal H.T. supply arrangement. The two parts are known as the mains unit and the H.T. line unit of box, but, as any reliable rectifying and smoothing system can be used for the former, there is little need to discuss it in detail.

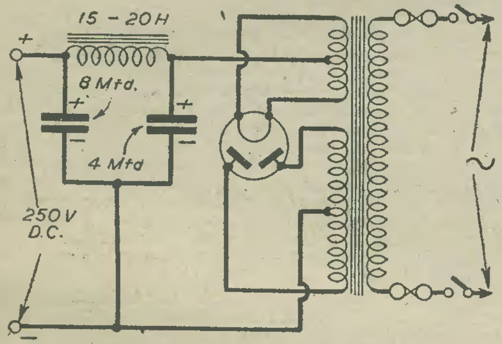


Fig. 1.—A standard full-wave rectifier complete with smoothing arrangements.

The two separate sections are shown in Figs. 1 and 2. The mains unit, which is a straightforward full-wave rectifier of the 250-0-250 volt 60 mA type, plus the usual smoothing choke and fixed condensers, is shown in Fig. 1. The components are mounted on a baseboard, and covered by a simple metal cover, which is provided with ventilation holes and earthed to the negative side of the circuit. To one end of the baseboard is fixed a fibre (ebonite will do) panel which carries the mains on/off switch, two H.T. terminals, three L.T. terminals and a small indicator lamp which tells at a glance whether the unit is alive or not. See Fig. 3.

This section of the installation normally rests on a shelf under the work-bench; the only time it is brought up on to the latter is when the A.C. L.T. output is required, the reason being to keep the L.T. leads reasonably short.

The theoretical unit of the H.T. line unit is given in Fig. 2. On the right of the diagram it will be seen that the H.T. supply from the mains unit or eliminator is connected to two terminals. The H.T. positive line proceeds through a single-pole switch to five positive terminals on the extreme left. H.T.+1 is taken straight through from the switch S, but H.T.+2, 3 and 4 are taken from another line which includes in its path an L.F. choke of the usual smoothing type, i.e., 15 to 20 henries at, say, 60 mA.s. Two terminals, G and F, are connected —one each side—to the L.F.C., thus allowing it, by means of a metal shorting-strip or link, to be bridged across if it is not required in circuit.

Similarly, the H.T.+lines 2, 3 and 4 are broken at the terminal points I and H, J and K, and M and L, respectively, and each pair is provided with its own shorting-strip. Coming back to the input side of the circuit again, it will be noted that the terminals A, B and C have only one shorting-strip, and on *no account* must the three terminals be short-circuited, otherwise the 250-volt input will be bridged across. Terminal B is connected to the H.T.+5 output terminal and C to the negative line.

The negative side of the unit passes through a fuse and the two pairs of terminals E and D, and P and Q —each of which has its own shorting-strip—to the H.T., terminal on left.

The 4 or 8 mfd. condenser is provided for use with the L.F.C. if additional smoothing is required, while the 0.1 mfd. and the three 2 mfd. condensers are intended for decoupling purposes.

Applications

During experimental, testing or servicing work one is practically bound to come up against the following demands:

1. For one or more H.T. voltage supplies between zero volts and 250 volts.
2. The introduction into any one of the H.T. feeds of anode decoupling, or, where such already exists, increased decoupling.

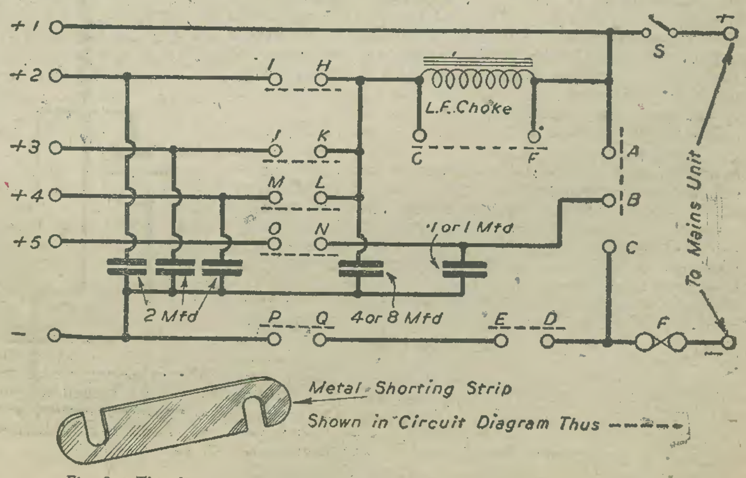


Fig. 2.—The theoretical circuit of the unit described in this article, together with a simple form of shorting-strip.

3. The checking of H.T. consumption on any particular H.T. feed, or checking the total H.T. current of a circuit.
4. The introduction of automatic grid-bias in circuits using directly-heated valves, or determining the most satisfactory valve of bias resistor and condenser for a circuit to which A.G.B. is not already applied.
5. Determining the beat value for, or effect of a "bleeder resistor."

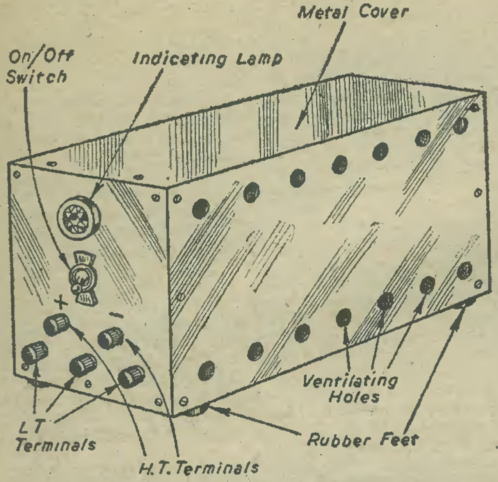


Fig. 3.—The completed mains unit as assembled by the writer. Note the well-ventilated protecting metal cover.

6. Determining the values of potentiometer networks across the H.T. feed.
7. A means of allowing more than one piece of apparatus to be supplied from one mains unit without back-coupling.

The output terminals 1, 2, 3, 4 and 5 and negative can be used to satisfy application 1. The full D.C. voltage is available between +1 and negative, i.e., 250 volts *at* 60 *mA.s*, but it should be remembered that if the current consumption is not approximately 60 mA.s the voltage will exceed 250 volts. Lower voltages can be obtained from any of the other output terminals —the negative terminal being common to all—by removing the shorting-strip from the terminals in the line concerned, and connecting in its place a resistor of suitable value. For example, supposing the L.F.C. is bridged by its shorting-strip, and 250 volts is measured across +2 and negative, and it is required to provide a voltage of 150 volts to a circuit which will be consuming 10 mA.s. A resistor must, therefore, be connected in the positive line, and the value of the resistor can be calculated from Ohm's Law, thus:

$R=\frac{E\times 1{,}000}{I}$ when E is the value of the voltage to be dropped, and I the value of the current flowing, so substituting actual figures for the case in question, we get $R=\frac{100\times 1{,}000}{10}$, or 10,000 ohms. The shorting-strip across terminals I and H is removed and a resistor having a value of 10,000 ohms used to connect the two terminals together.

The same procedure applies to terminals J and K for H.T.+3; M and L for H.T.+4. In an emergency H.T.+5 could be used in the same manner, the resistor being connected across A and B, but that output is really intended for such parts of a circuit which have to be fed from a potentiometer across the H.T. supply. A common example being the screening-grid of a tetrode or pentode valve. To form a potentiometer, the shorting-strip must be removed from across A and B, and two resistors—the values of which can be calculated or found by trial and error—connected across A and B, and B and C, the output being taken from +5, which, as shown in Fig. 2, is connected to B.

When H.T.+2 is being used, it must be remembered that if the L.F.C. is brought *into* circuit by removing its shorting strip, its D.C. resistance will affect the voltage value, therefore, if its resistance is known, and it is usually supplied by the makers or can be determined quite easily, it must be deducted from the calculated value of any resistor used across I, H, J, K or M and L. This applies in particular if the current flowing or the resistance of the choke is high.

Anode Decoupling

Application 2 calls for a combination of the details given above and the following. Anode decoupling can be secured by connecting in series with the H.T. line feeding the circuit in question, and H.F. choke, a resistor, or an L.F. choke—according to the nature of the circuit —the anode side of the component being connected to earth through a fixed condenser. Referring to Fig. 2 again, it will be seen that the series voltage-dropping resistors mentioned in procedure for application 1, can act as decoupling resistors, or, if so desired, they can be replaced by H.F. or L.F. chokes according to circuit conditions. The decoupling fixed condensers are embodied in the unit, namely, the three 2 mfds. and the one 0.1 mfd., but should a case arise where a higher value is needed, say 4 or 6 mfd., the following scheme could be used *provided* outputs +3 and +4 are not being used. Take the H.T. from H.T.+2. Connect decoupling resistor across I—H after removing shorting-strip. Remove shorting-strips from J—K and M—L and then join terminals I, J, and M together. This will place the three 2 mfd. condensers in parallel, giving a resultant value of 6 mfd.

If the decoupling is required in the anode circuit of an H.F. valve, it would be sufficient to use H.T.+5 and connect the decoupling resistor across terminals A—B.

Checking Current Consumption

The H.T. current consumption on any of the lines +2, +3 and +4 can readily be checked by removing the appropriate shorting-strip and connecting in circuit a suitable milliammeter. If, however, the total H.T. consumption is required, the terminals E—D should be used, as they would allow the meter to be connected in series with the H.T. negative line.

It is sometimes necessary to check the current being consumed by the screening-grid of a tetrode or pentode valve, and this can be done quite easily, if the poten-

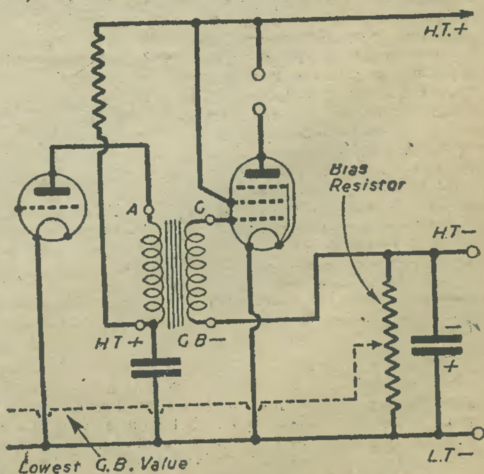


Fig. 4.—The normal arrangements for automatic grid-bias with battery operated valves.

tiometer terminals A, B, C, are being used, by connecting the meter between the two terminals O and N.

Automatic Bias Tests

With battery operated or indirectly heated type of valves, automatic bias voltages can be obtained by inserting a suitable resistor between the H.T. line and the earth—L.T. negative line, the grid-bias lead being connected to the *H.T. negative side* of the resistor, which should be shunted by a high (12, 25 or 50 mfd.) capacity condenser. The theoretical circuit of a typical arrangement is shown in Fig. 4.

If, therefore, it is desired to apply auto-grid-bias to a suitable circuit, or to determine the most satisfactory value of resistor or condenser—Application 4—the terminals P—Q should be used, the bias lead (negative) being connected to Q. The need may arise for two different values of bias voltage to be provided, and in

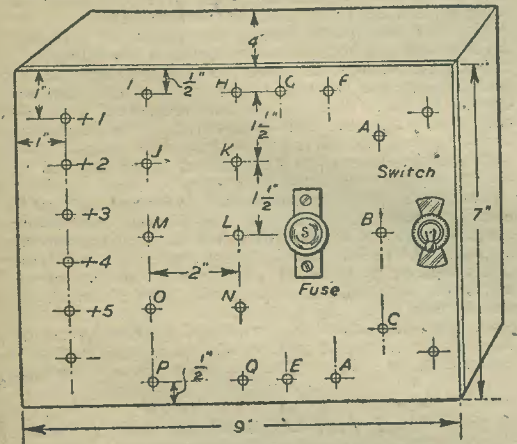


Fig. 5.—Layout and drilling template of the panel. Dimensions of a suitable case are also shown.

such cases, the additional resistor can be connected between E and D. The higher bias voltage will then be present at D and the lower at Q. The possible second bias lead is shown in Fig. 4 by the broken line. When using the unit for this purpose, there is one point which must be observed. In the majority of battery operated sets, the H.T. and L.T. negative leads are connected together in the set—usually very easy to see—and this connection *must be broken*, and the H.T. negative terminal on the Unit connected to the *L.T. negative lead on the set*, NOT the H.T. negative lead.

The value of the bias resistor is calculated from the same formula as for voltage dropping resistors, namely, $R = \frac{E \times 1{,}000}{I}$ when E represents the bias voltage required and I the *total* H.T. current consumption of the circuit. When two voltages are needed, the lower one is obtained by tapping it on the resistor, but as this is not too easy to do, it is more usual to use two resistors connected in series, the two forming the total resistance required to produce the higher bias voltage, and the resistor used in the lower part of the potentiometer thus formed, having a resistance sufficient to give the voltage for the lower valve of bias.

"Bleeder Resistors"

This is the name given to a resistance connected *across* a supply to consume surplus current or to provide a high resistance leakage path between H.T. positive and negative. The latter is used in the case of high-voltage mains units, i.e., above 350 volts, to allow the smoothing condensers to discharge when the supply is switched off, thus preventing the operator from getting a nasty shock if he should make contact with the charged condensers.

The terminals A—C can be used for any tests of this nature, provided the shortening-strip is removed from across A—B.

Potentiometer Networks

It is frequently required to determine values of the resistors forming a potentiometer network, and it is not always satisfactory to have two resistors hooked together, etc., loose on the test-bench. With the unit, the terminals A—B—C form safe anchoring points for such resistors, and allow easy and rapid changes to be made without the risk of unwanted contacts being made with the other parts of the equipment or the operator.

Eliminating Back-coupling

If two or more associated pieces of apparatus are fed from a common supply unit, there is always the danger of back-coupling between the various circuits being produced via the H.T. feeds. The most satisfactory way of preventing this is to provide adequate decoupling in the individual H.T. positive lines, and tests in this direction can conveniently be made by using the decoupling arrangements already embodied in the Unit, and which have been described earlier in this article.

Construction

The actual construction of the apparatus calls for little comment. As long as the circuit shown in Fig. 2 is adhered to, and the layout depicted by Fig. 5 is used as a guide, the actual assembly of the few parts can be left to the constructor, as there are no critical points to watch. The writer used a case made out of 5-ply wood, and mounted the L.F. choke on the underside of the ebonite panel, and the fixed condensers to the bottom of the case. Flexible leads of sufficient length to allow for the removal of the panel were used to couple the components to their appropriate terminals. The fuse is of the pocket-lamp bulb type, fitted into one of the base-board type of screw holders, the terminals of which were taken out and reversed, thus bringing their shanks and terminal heads on the underside of the panel for easy connection, and also to act as fixing bolts.

D.C. Supplies

The H.T. line unit could be used on D.C. supplies without any eliminator, provided the following points are observed.

Connect D.C. supply to the two terminals normally connected to the mains unit, after making quite sure that the *polarity is correct.* Ignore H.T.+1, as this is now directly connected to the positive side of the mains without any smoothing choke being interposed. H.T.+ terminals 2, 3, 4 and 5 can be used as previously described, but if the mains are at all "rough" it may be necessary to connect another smoothing choke in series with the negative line, this being done between terminals E and D. In any case, it will be advisable to include another smoothing condenser of, say, 6 or 8 mfd. between terminal F and the negative line, to improve existing smoothing arrangements.

Earthing

When used on D.C. supplies, it is vital to remember that the negative side of the H.T. circuit *must not be* connected directly to earth. This is due to the fact that one side of the mains is earthed, therefore, in certain circumstances a direct short could be produced. To eliminate this possibility, remove the earth wire from the earth terminal on the set or apparatus under test, and connect between these two points a fixed condenser having a capacity of, say, 0.1 mfd. and a working voltage rating well above that of the mains.

In case anyone anticipates trouble in securing sufficient terminals for the job, the writer made good his inadequate supply by stripping down old or broken down components which were fitted with suitable types.

Recording and Reproduction of Sound

Précis of a Discussion at a Meeting of the Wireless Section of the Institute of Electrical Engineers

CONSIDERABLE interest is being shown in the future processes likely to be developed to secure a more satisfactory form of recording and reproduction, and we give below a précis of a very interesting discussion which took place recently, and which was introduced by Dr. G. F. Dutton.

The disc system, in spite of its age, offers a great many facilities for home use and for broadcasting. It is relatively easy to handle; it provides a self-contained and compact unit; processing is relatively cheap; short numbers can be catered for, and the record is accessible for extracting short portions for programmes or educational use.

The development of the cellulose recording-disc has given the recording companies a new tool. We are now able to assess the quality of the recording and reproducer by direct playback, without the doubtful intermediary stage of processing as was necessary when wax discs had to be made. The reproduction from a few direct cellulose records will be given.

The relative merits of the lateral-cut and the hill-and-dale systems are very close. The hill-and-dale system is the older and has now been largely replaced by lateral-cut.

Suggested Improvements

THE chief improvements required for the disc system are: signal to noise ratio; intensity range; frequency range; freedom from non-linear distortion; constancy of results and life; storage, and playing time.

The frequency range on the average pre-war record was limited at the high end to 6,000 c/s. Very few gramophones could utilise even this limited range because of the response characteristics of the pick-ups and the surface noise of the records.

The recording range can be taken up to 12,000 c/s, and this range can be preserved without appreciable loss during the factory processing, provided certain precautions are taken. The desirability of an extended range has been a debatable point, and the issue has always been clouded by the intervention of noise. With the direct cellulose playback, we can now better appreciate the advantages of extending the frequency range.

Before an extended frequency range can be utilised, attention has to be paid to the record processing, record material, needle point, and the pick-up system. The size and shape of record grooves and of the needle point must receive special attention. Only by use of the correctly-shaped needle tip can quiet surface records be used. Broadly speaking, the record disc consists of a mixture of thermoplastic resins in suitable proportions to give strength, good plastic flow in the press, and ultimate stability. Whether or not a mineral filler is to be added, depends on the type of needle to be used in the pick-up, and the pressure of the needle point when playing. The optimum shape of needle has a hemi-spherical end 0.0025in. radius, when working with the accepted standard shape of groove. Ordinary commercial needles depart from this ideal shape, many presenting extremely sharp points which exert such a pressure on the record that the surface is broken. In the past, therefore, a record filler has had to be used to grind these sharp points to a reasonable bearing surface within a few inches of travel. A practically noiseless record without a filler is possible, and any introduction of filler will increase noise in proportion to the amount and to the particle size. The wear on the needle will also depend on the filler used. The war has seen the development of a number of plastics which are extremely interesting from a record-manufacturing point of view, and no doubt these will be tried out when they become available for this type of work after the war.

The introduction of ultra-violet recordings has increased the resolution to such an extent that the film may be taken with little or no loss up to 12,000 c/s, using the standard film speed of 90 ft./min. The inter-modulation, which was at one time a common type of distortion, is now reduced to a small value by the aid of special tests. The use of normal silver photographic emulsions for printing copies is expensive for domestic gramophones. There are, however, several diazo-dye printing processes which are a great deal cheaper. It is also well known that film can be arranged with two tracks working in opposite directions, so that one track can be used when unwinding, and the other track for re-winding the spool. The future of the strip or film reproduction depends on the processing costs.

No sound-recording system can claim to have high fidelity unless it records and reproduces the direction of the original sounds. At least two channels are necessary and the expense is considerable. The lack of binaural effect in single-channel normal recording has been corrected to a large extent by positioning the microphone and by special acoustic conditions of the studio.

Demonstrations were given from recordings of the disc type and also of the film type.

Two speakers later emphasised the great interest of sound recording to the British Broadcasting Corporation, especially in connection with repeat programmes, an interest which has been greatly increased under war conditions. An indication was given of the manner in which the technique has developed and improved. At the moment discs play a large part in the B.B.C. recordings, but some are of larger diameter than the normal 10in. or 12in. record and revolve at a lower speed to secure a longer playing time.

Portable Apparatus

A SPECIAL feature in this connection is the design of portable apparatus for securing material which cannot be brought to the studio. On the general question of high-grade recording, the comment was made that the B.B.C. is unable to purchase in this country equipment which will fill their requirements and they are now using their own design of equipment which will take 17in. discs having 150 grooves per inch. 10,000 cycles has been adopted as the upper limit of the frequency range.

More than one speaker saw in the discussion an excellent opportunity of taking stock of the present position of the art and assessing the prospects for the future. In this connection the comment was made that in the past there has been a tendency to disregard the fact that the reproduced sound should at least resemble the original! Cheap gramophones were blamed for this and although it was suggested that as regards film reproduction of sound the same criticism did not apply, it was hinted that in this field also the cheapjack was beginning to make his influence felt. The importance of the co-ordination of electro-acoustic research work was stressed, there being various lines of development under investigation at the present time. A published list of standards was necessary, but nothing authoritative had yet been done in this country. The warning was given that this question would have to be faced very soon. The demand was made for standards of speeds, disc cutters, dimensions of grooves, etc., and dissatisfaction was expressed as regards the present position concerning background noise.

The weight of pick-ups received considerable attention and the hope was expressed that there would be no more 120 gm. pick-ups and no more motors of uncertain speeds. Pick-ups of not more than 40 gm. were recommended. The 120 gm. pick-up was said to give a pressure of some 20 tons to the sq. inch. on the needle point.

For home use, at least for a long time, it was felt that the disc must predominate over the film owing to the higher cost of film apparatus and the greater expense of processing.

Kirchoff's Laws

How They are Employed in the Solution of Network Problems.

By S. A. KNIGHT

WHILE everyone who has dabbled in wireless and electricity has a thorough knowledge of Ohm's Law and its many applications, there are many who do not fully understand Kirchoff's Laws and their application, particularly to the solution of network problems. Kirchoff's Laws are in some ways closely related to Ohm's Law, but the former enable us to solve problems which we could not manage with the latter alone.

Consider Fig. 1, which shows a battery connected to a network of four resistances. Suppose it is required to find the current delivered by the battery, the currents in each of the resistors, and the p.d. across the ends of

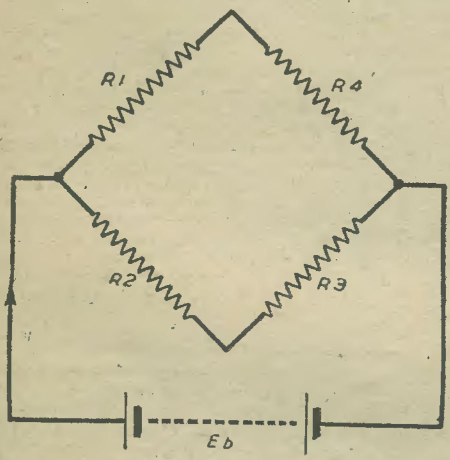


Fig. 1.—A simple series-parallel circuit, involving only an application of Ohm's Law.

the resistors. The problem is a very straightforward one, and most people above the age of 14 interested in wireless could probably quickly supply the right answer. The resistors are in a simple series-parallel arrangement and the problem necessitates only a systematic application of Ohm's Law and the law connecting e.m.f. and current in a simple circuit to arrive at its solution.

Now suppose that a resistor is added to the arrangement and it is required to find out exactly what is occurring in the network of five resistances shown in Fig. 2. This is not so simple, and, in fact, Ohm's Law and its associated formulæ are not sufficient to cope with the problem. Attempt to work the problem out using the methods suitable for dealing with the arrangement of Fig. 1, and it will soon be found that the fifth resistor connecting the points C and D has complicated the matter far more than an initial comparison of the two systems might suggest.

The problem can be solved by the application of Kirchoff's Laws.

Kirchoff's First Law

The algebraic sum of the currents meeting at a point is zero. This is Kirchoff's first law, and to understand the meaning of this consider Fig. 3, where six conductors are seen meeting at a point. Currents are flowing along the conductors in the directions indicated by the arrows; and these are designated i_1, i_2, etc. It will be seen that the current flowing into the point is i_4+i_6, and this must equal the total current flowing out of the point, $i_1+i_2+i_3+i_5$, or:

$$(i_4+i_6)-(i_1+i_2+i_3+i_5)=0$$

If it agreed to distinguish a current flowing into a point from a current flowing out of a point by assigning to the former a positive sign and to the latter a negative sign, then the currents meeting at the point in Fig. 3 are i_4 and i_6 positive, and i_1, i_2, i_3 and i_5 negative. The sum of these six currents is:

$$i_4+i_6-i_1-i_2-i_3-{}_5i$$

and Kirchoff's first law states that this sum is equal to zero, that is:

$$i_4+i_6-i_1-i_2-i_3+i_5=0$$

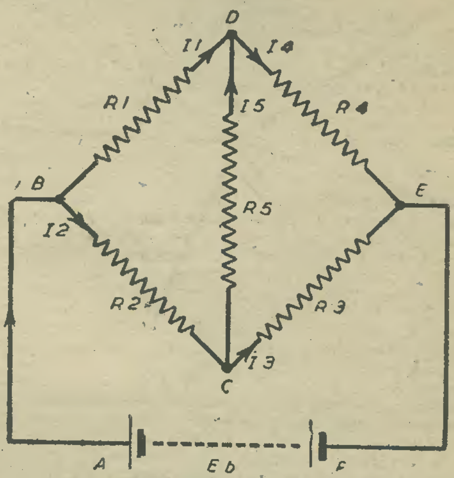


Fig. 2.—The additional resistor R5 which complicates the circuit of Fig. 1.

This is the same expression, except that the brackets are removed, as that already obtained by equating the current flowing into the point to the current leaving the point, so that the first law is simply a mathematical way of putting the self-evident fact that when several conductors meet at a point the total current entering the point is the same as the total current leaving the point.

Kirchoff's Second Law

In any mesh of a network the sum of the electromotive forces is equal t the sum of the products of the resistances of, and currents in, the various parts of the mesh. This is Kirchoff's second law and to understand its meaning go back to a consideration of Fig. 2. A mesh means a completely closed circuit and in the figure there a e five such meshes: BCDB, BDECB, FABDEF, FABCEF and FABDCEF. The last three of these mesh s include the battery, so that the total electromotive orce in each of them is the electromotive force of the battery, and the other two meshes BCDB and BDECB do not include the battery, and the total e.m.f. in each of them is zero. Kirchoff's second law applied to the above-mentioned meshes gives the following equations:

For mesh BCDB $E=I_2R_2+I_5R_5-I_1R_1=0$
For mesh BDECB $E=I_1R_1+I_4R_4-I_3R_3-I_2R_2=0$

For mesh FABDEF $E=I_1R_1+I_4R_4$

For mesh FABCEF $E=I_2R_2+I_3R_3$

For mesh FABDCEF $E=I_1R_1-I_5R_5+I_3R_3$

When working round the various meshes in a clockwise direction, a positive sign is affixed to clockwise currents and a negative sign to anti-clockwise currents. A convention of this sort is an obvious necessity; clearly the product I_1R_1 is the potential difference between B and D and, since the current is flowing from B to D the potential of D is lower than the potential of B. The product I_5R_5 is the potential difference between D and C and with the current flowing as the arrows in the figure indicate, the point C is at a higher potential than D. If, then, the change of potential from B to D is given a positive sign, it is necessary to accord a negative sign to the potential change from D to C, since this change is a rise and not a fall of potential.

Having obtained a series of equations similar to those above, it is a simple matter to solve these simultaneously and obtain the currents flowing in the various

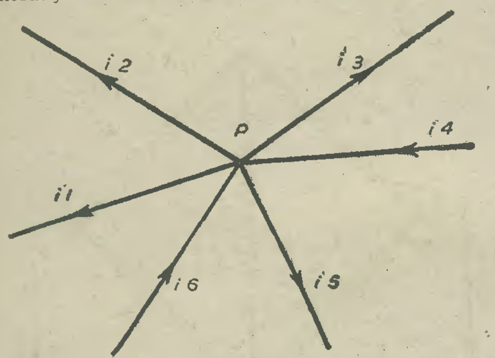


Fig. 3.—Currents flowing to and from a point, demonstrating the first law.

branches. The solving of simultaneous equations is a laborious though by no means difficult task, and in applying Kirchoff's Laws to practical problems care should be taken to keep the number of unknown quantities at a minimum. The number of equations required is always the same as the number of unknowns, so that the fewer the unknowns the fewer the number of equations required. Some examples are now given, fully worked out, and a study of these should enable the reader to fully understand the method of employing, and the great importance of, Kirchoff's Laws.

Worked Examples

In Fig. 4 is shown a battery of e.m.f. 10 volts and negligible internal resistance connected to a network of resistances. It is required to find the battery current and the current in the various resistors.

The first thing to do in a problem of this nature is to mark in on the diagram symbols and arrows to denote the various currents. This means an application of Kirchoff's first law. Let the current from the battery be i, and the current out along BD be x. Then obviously the current out along BC will be $(i-x)$. In the same way let the current out along CD be designated y, so that the currents in CE and DE will be $(i-x+y)$ and $(x-y)$ respectively. These are marked on the diagram. Notice that there are only three unknown quantities, i, x and y, so that only three different equations need be found to provide a complete solution of the problem.

The reader may object at this stage and say that as it is not always possible to tell at sight in which direction a particular current may flow, the arrow indicating that current may be inserted in the wrong direction. This does not matter, however, as the solution of the problem will then show this particular current with a negative sign, indicating an incorrectly marked arrow.

Having now marked off the circuit, Kirchoff's second law is applied to form three equations from *any three meshes* in this manner:

Mesh BDCB—

$E=0=5x+10y-5(i-x)$

$\therefore \quad 10x+10y-5i=0$ .... (1)

Mesh BECD—

$E=0=3(x-y)-2(i-x+y)-10y$

$\therefore \quad 5x-15y-2i=0$ .... (2)

Mesh ABDEFA—

$E=10=5x+3(x-y)$

$\therefore \quad 8x-3y=10$ .... (3)

These three equations can now be solved simultaneously:

$$10x+10y-5i=0$$
$$5x-15y-2i=0$$
$$8x-3y \quad =10$$

Eliminating i from the first and second equations gives:

$5x-95y=0$ .... (4)

and combining this with the third equation gives the simultaneous

$$5x-95y=0$$
$$8x-3y=10$$

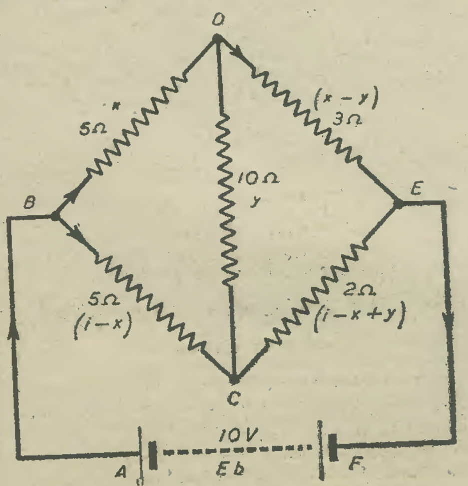


Fig. 4.—The example network solved by the application of Kirchoff's Laws.

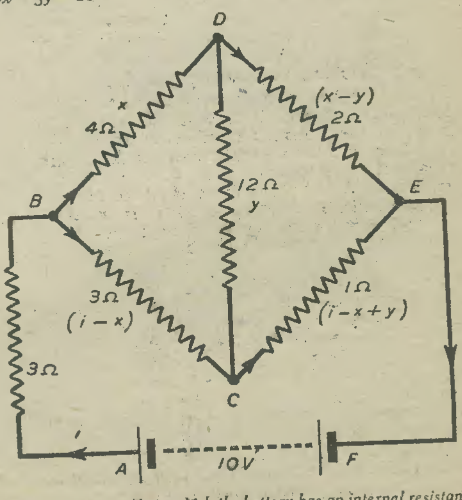


Fig. 5.—An example in which the battery has an internal resistance of 3 ohms.

Solving for x and y from this equation gives

$x = 190/149$

$y = 10/149$

and, finally, substituting these values in any one of the first three equations gives

$i = 400/149$

The complete answer to the problem is therefore as follows:

Current from battery $= i = 400/149$ amps.
Current in BD $= x = 190/149$ amps.
Current in BC $= (i - x) = 210/149$ amps.
Current in CD $= y = 10/149$ amps.
Current in CE $= (i - x + y) = 220/149$ amps.
Current in DE $= (x - y) = 180/149$ amps.

The solving of simultaneous equations is always laborious, but with care there is no great difficulty in arriving at answer.

Example No. 2 is very similar to the first except that it is now supposed that the battery has internal resistance. The arrangement is shown in Fig. 5, where the internal resistance of the battery is represented by a 3-ohm resistance in one of the battery leads. The procedure of marking in symbols and arrows is just the same as the first example, and three equations are obtained from any three meshes as before.

Mesh DECD

$E = 0 = 2(x - y) - 1(i - x + y) - 12y$

$\therefore \quad 3x - 13y - i = 0 \qquad \ldots\ldots (1)$

Mesh BDCB

$E = 0 = 4x + 12y - 3(i - x)$

$\therefore \quad 7x + 12y - 3i = 0 \qquad \ldots\ldots (2)$

Mesh FABDEF

$E = 10 = 3i + 4x + 2(x - y)$

$\therefore \quad 6x - 2y + 3i = 10 \qquad \ldots\ldots (3)$

Eliminating i from the second and third of these equations gives

$13x + 10y = 10 \qquad \ldots\ldots (4)$

and eliminating i from the first and third equations gives

$15x - 41y = 0 \qquad \ldots\ldots (5)$

Solving for x and y from (4) and (5) we get

$x = 510/683$

$y = 20/683$

and substituting these values in any one of the first three equations gives

$i = 1{,}270/683$

The complete answer to the problem is therefore as follows:

Current from battery $= i = 1{,}270/683$ amps.
Current in BD $= x = 510/683$ amps.
Current in BC $= (i - x) = 760/683$ amps.
Current in CD $= y = 20/683$ amps.
Current in CE $= (i - x + y) = 780/683$ amps.
Current in DE $= (x - y) = 490/683$ amps.

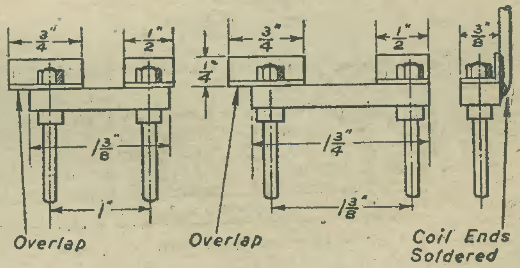
A few examples of this nature will soon enable the reader to become fully conversant with the application of Kirchoff's Laws to complicated networks.

Air-spaced Coils for S.W. Superhet

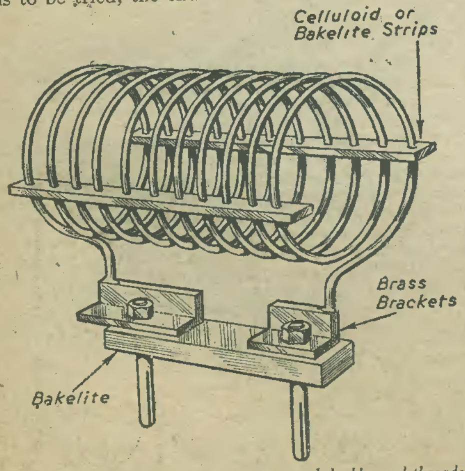
THE rigid type air-spaced coils illustrated were constructed by the writer for the Short-wave Superhet, to try out this type of coil.

The coils were wound with 16-gauge tinned copper, two lengths being gripped in a vice and wound on a brass tube 1½in. diameter. After being carefully unmeshed, strips of thick celluloid (previously drilled with clearance holes) were threaded through the turns, and finally positioned as shown to give added support to the coils.

The plugs were made from pieces of bakelite, split pins, and were fitted with the small brass brackets as shown. The widths of the latter allow of varying sized coils to be tried, the ends of the coils being soldered to the brackets. The dimensions are given for making the two sizes of coil holders necessary for the Short-wave Superhet.—R. L. GRAPER.



Details of the coil holders.



An air-spaced coil of 16-gauge wire, wound double, and threaded through bakelite supporting strips.

Some Applications of Thyratrons in Radio Engineering

A Paper Read Before the Institution of Electrical Engineers

By A. J. MADDOCK, M.Sc., Associate Member

(*Continued from page 283, June issue.*)

FOR a velocity-modulated television system a velocity modulated time base is required. This differs from an unmodulated one only in that the charging pentode has the video signal applied to its grid so that the rate of charge of the condenser is dependent upon the instantaneous value of the light falling on the light-sensitive device; the pentode grid circuit is then opened and the video signal inserted between "x" and "y" (Fig. 13).

Frequency Divider.—Among the best-known applications of frequency division are those in frequency-measuring equipment and in the generation of carrier frequencies for wire-line carrier systems.

The relaxation oscillator offers a basis of design, and the frequency stabilisation by selective feedback and synchronisation of such an oscillator as a frequency divider, at high orders of division, has been discussed by Builder. A basis circuit is given in Fig. 16 in which

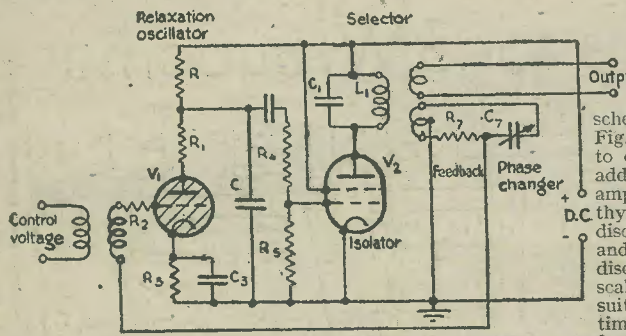


Fig. 16.—Frequency divider.

the functions of relaxation, selection and feedback are substantially independent, but in the paper a circuit more economical in components is described. The oscillator is of the simple type already dicsussed in which the natural frequency is determined by the time-constant *RC*, the H.T. voltage and cathode bias developed across R_3. R_1 limits the discharge current of C, and R_2 has a high value (0.25 MΩ) to prevent the grid of the thyratron V_1 from attaining any substantially positive value. The selector L_1C_1 is tuned to the frequency to be generated and is fed from the oscillator via the isolating valve V_2. Secondary windings on L_1 provide output and feedback voltages, that for the latter having condenser C_7 and resistor R_7 connected across it to act as a phase-changer as previously described.

Fig. 17 gives the waveforms of the voltages, in which e_s is the voltage across the tuned circuit and is substantially sinusoidal; a voltage proportional to this is fed back to the grid circuit of the oscillator. e_c is the actual grid voltage of V_1, being the combined effect of the feedback and cathode bias voltages. Because of resistance R_2 the grid voltage e_c does not rise appreciably above zero, and during this period, i.e., during the greater part of the positive half-cycles of the feedback voltage, the thyratron is conducting and the anode remains at the ionisation potential; but, as soon as the grid voltage e_c becomes negative, anode current ceases owing to the condenser C extinguishing the arc and the critical striking voltage rises rapidly to high values (since the grid is becoming increasingly negative). Condenser C then starts to charge up and this continues until the grid potential again rises towards zero when the arc is again struck; the resulting waveform e_a is of "saw-tooth" form, alternating with periods of about eqdal length during which the voltage is zero. The instant of striking is precisely determined by the simultaneous rise of anode and grid voltages. Curve e_a also gives the form and phase of the potential applied to the isolator valve, and, for equilibrium, it is apparent that the fundamental component of e_a must be in exact anti-phase with the voltage e_s; the phase-shifter provides means of effecting this.

A control voltage may be inserted as shown, and frequency division by factors up to 10/1 is readily possible.

Frequency Comparator

To check the frequency of an oscillator against a standard of frequency so that comparisons are given for close-spaced intervals of time is not easy, but a circuit recently developed has enabled accurate comparisons to be made. An elementary schematic to illustrate the principles is shown in Fig. 18. The two oscillators O_1, O_2 are adjusted to differ by 0.1 c/s, the output voltages being added together in the hybrid coil, and their sum amplified and rectified to control the firing of thyratron V once each beat cycle. V in turn discharges condenser C through the spark coil T and causes a brief flash of light in the mercury-discharge tube G which illunmiates the translucent scale S driven from a frequency standard. S is suitably engraved and gives an indication of the time, which is recorded photographically on the slowly moving film so that images of the scale due to successive flashes are just separated. Thus the time elapsing during a single 10-sec. beat cycle is recorded to the nearest 0.001 sec. and any irregularity in the beat frequency of greater than 1 part in 10,000 is apparent. As the frequency of the beat pulses is only 1/(10 × 100,000) of the frequency of either 100 kc/s oscillator the precision of comparison between oscillators is 1 part in 10^{10}.

To ensure accuracy, the thyratron must fire at the same part of the cycle and do so abruptly. Fig. 19 represents the vector diagram of the voltages at the input of the measuring circuit and, as E_1 rotates at the beat frequency with respect to E_2, the vector (E_1+E_2) varies in length over the beat cycle. This vector is amplified and rectified to provide a negative bias on the

(*Continued on page 339.*)

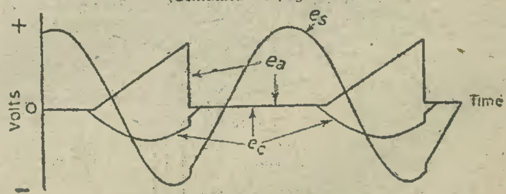


Fig. 17.—Waveforms in circuit of Fig. 16.

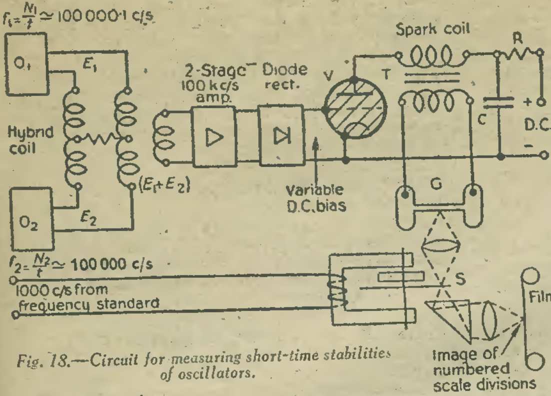


Fig. 18.—Circuit for measuring short-time stabilities of oscillators.

Fig. 19. — Vector diagram of voltages in circuit of Fig. 19.

thyratron grid, and the tube fires when the voltage falls below the critical value represented by circle "c." If the point of entry is "a" (i.e. voltages equal), the firing will be earlier than if the voltages are slightly different and barely graze the circle at "b" or "b'." The possible error is thus approximately determined by the ratio of the radius of "c" to the circumference of the circle swept by E_1, and the error is made small by amplifying (E_1+E_2), thus increasing the sensitivity or effectively reducing "c." When the voltages are thus critically compared their amplitudes must be almost identical or no record is obtained, but if the thyratron fires at all it does so at a time known within exact limits. The value chosen was 65 db larger than the critical value of the sum required to fire the thyratron, and thus the voltages had to be alike in amplitude within about 0.05 per cent.

Applications as Current and Voltage Regulators: Torque Amplifiers

Torque amplifiers are particularly useful for remote operation of equipment such as tuning elements in large transmitters, earthing or connecting switches, and where it is desired that any driven apparatus shall follow accurately the movements of the driving mechanism without mechanical connection. In all such amplifiers the driving element operates to alter the phase of the thyratron grid voltage so that a corresponding change in anode current takes place, the anode current controlling directly the driven device (usually through the intermediary of a D.C. motor). In addition the driven mechanism has some means attached to it, also operative to control the phase of the grid voltage, to render the thyratrons non-conducting when the driven mechanism has followed the driver. The phase-controlling device may be a phase-shafting transformer or a variable element such as a condenser, etc.

The fundamental schematic diagram of one such amplifier operating on a single-phase A.C. supply is given in Fig. 20. With this arrangement extremely accurate and rapid control is possible. One instance of its use is on a large boring mill in which the positions of the tools are set to an accuracy of 0.001in. by adjusting the dial of the controlling mechanism.

Two groups of thyratrons A and B are so connected that one group, when rectifying, gives rotation of the motor in one direction and the other group rotation in the opposite direction. In addition each group can operate as an invertor if the D.C. motor is overspeeded a little, as the motor counter-e.m.f. will exceed the rectified voltage and no current then flows from the rectifying group, but the inverting group passes current and regenerative braking is obtained. The phase-shifting transformers T_1 and T_2 are rigidly coupled together and are moved simultaneously but have their connections so arranged that the electrical rotation of one is opposite to that of the other.

As the controlling handwheel of the synchronous motor X is rotated one way or the other a corresponding torque is given to the receiver synchronous motor Y and the grid voltages are altered in phase accordingly. The D.C. motor then rotates to correspond and in so doing rotates the stator of the receiver Y, through gearing, in such a direction as to restore the grid voltage phase-shift to the position corresponding to the rest position, and the main motor thus comes gradually to rest.

As shown, full-wave rectification and inversion takes place.

Simpler and less accurate circuits have been used in which change of the alternating bias on the grids of a pair of thyratrons is effected rather than change of phase.

Applications as Commutating Devices: Rectifiers

Probably the widest field of application of thyratrons in radio engineering has been in grid-controlled rectifiers for delivering a direct voltage which can be varied smoothly and easily from a low value to full output; such rectifiers have found particular application in converting plant supplying anode voltage for transmitting valves at high voltages. The efficiency of these rectifiers is high, particularly in the larger sizes, owing to the very low voltage-drop across the valves and the high efficiency of the cathode, especially those of the heat-shielded type.

Thyratrons may be used in any of the usual types of rectifier circuit and it is not proposed here to discuss these circuits in detail but rather to consider briefly

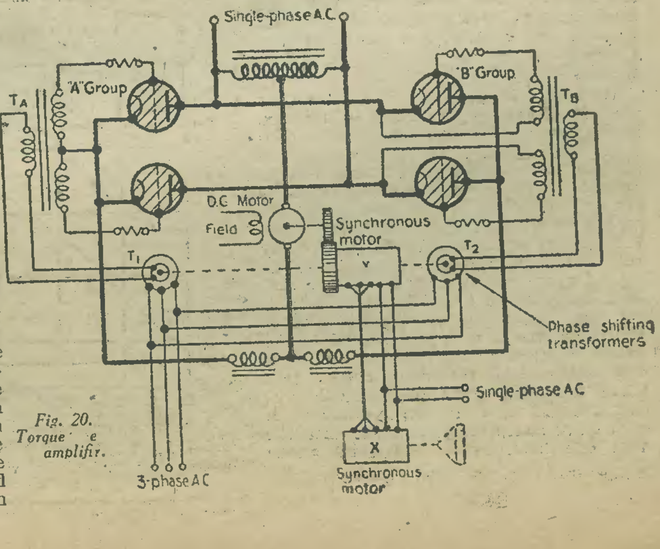


Fig. 20. Torque e amplifir.

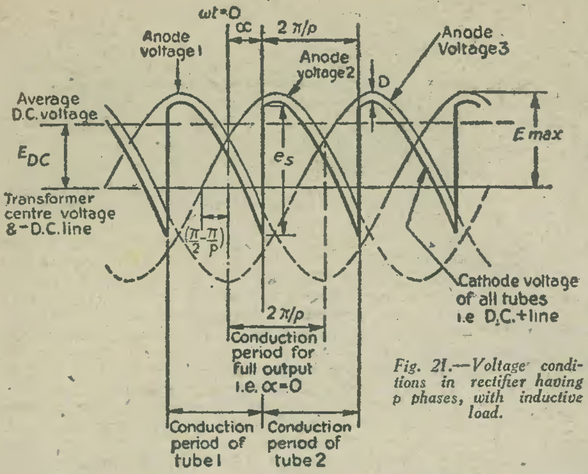


Fig. 21.—Voltage conditions in rectifier having p phases, with inductive load.

negative output terminal of the rectifier; and also, at the instant of firing, each valve has a greater voltage impressed across it than the amplitude of its sine wave at that instant. As the angle $\propto$ is increased the amount the cathodes are driven negative increases until eventually, at the point at which firing should occur, one cathode becomes as much negative below the negative output terminal as the succeeding one is positive, and the net effect is to obtain zero output voltage; it can be seen that this occurs when $\propto = 90$ deg. in any such circuit. Thus the presence of sufficient inductance to ensure continuous conduction under all conditions also decreased the angle over which the grid voltage must be shifted, to obtain control between full and zero output (compared with that for a resistive load), to a value of 90 deg. The total angle of current flow is always $2\pi/p$, which is shifted bodily through the angle $\propto$, and, as mentioned above, the current eventually consists of equal positive and negative components.

The average direct output voltage may be expressed as

$$E_{DC} = \frac{pE_{max}}{\pi} \sin \frac{\pi}{p} \cos \propto - D \quad \ldots\ldots\ldots\ldots (2)$$

so that the output voltage is proportional to the cosine of the angle by which the grid voltage is delayed with respect to the anode. This expression and the above remarks apply equally to the 3-phase full-wave series circuit, except that E_{max} is to be taken as the line voltage and p the number of valves in use, i.e., 6. Since conduction continues even after reversal of polarity of the driving voltages due to the inductance, peak waves can be employed for the full range of control in the grid circuits.

three-phase rectifiers as bringing out certain points of operation on polyphase circuits that have not so far been discussed in this paper and to add further methods of effecting the grid control.

For radio work, where a steady value of direct current is nearly always required, a filter circuit is inserted before the load to absorb the variations in output voltage, and it is now generally realised that a filter with inductive input should be used. When this is done the inductance of the choke tends to maintain the flow of anode current through a valve even after the applied voltage has passed through zero, and, instead of the current being broken up into pulses separated by periods of no conduction, continuous flow, though variable in magnitude, may be obtained into the filter input if the inductance is greater than a certain critical value, when each valve conducts until the next one starts. Under these circumstances the regulation of the rectifier is greatly improved, the form factor of the current pulses through the valves and transformer is decreased, and the peak current requirement of the valves is lowered. The importance of providing sufficient inductance to allow of this method of operating was first established by Dunham for a single-phase rectifier without grid control, and has since been extended by Overbeck for polyphase circuits employing thyrations.

When the input choke is greater than the critical value, operation is as indicated in Fig. 21, which shows the voltage relations existing in a polyphase half-wave rectifier of p phases. Maximum voltage output occurs when the grid control is set for one phase to take over from the preceding one when the respective phase voltages are equal, and the angle of delay $\propto$ is reckoned from this point. Since the cathodes are all connected together and form the positive d.c. line of the output, the thick line represents the variation of rectified voltage, this being equal to the anode voltage of whichever valve is conducting, less the drop across that valve (taken as constant for all values of current). Thus, with a firing delay of $\propto$ each valve continues to conduct until the next one fires, even though its anode voltage becomes more negative than the

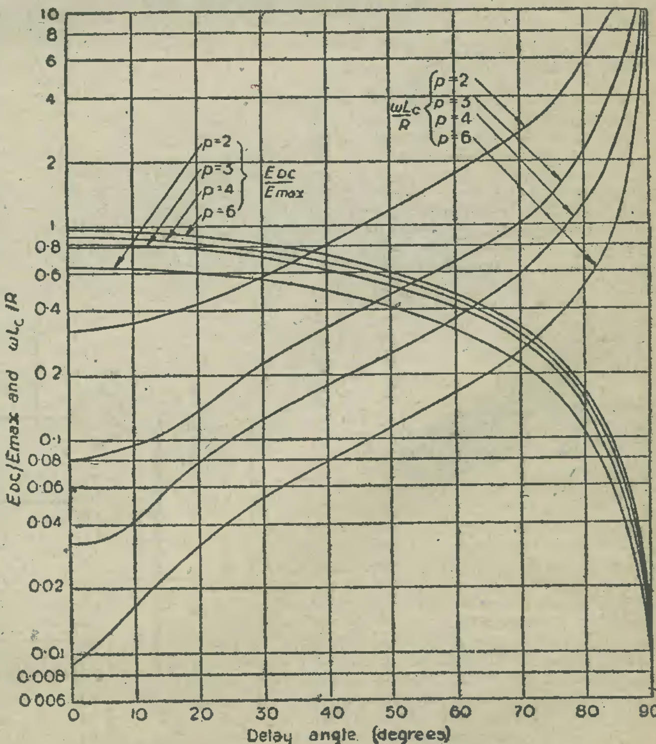


Fig. 22.—Critical inductance and direct output voltage as a function of delay angle. p = number of rectifying phases.

As the question of critical inductance is important, the curves relating the several factors have been abstracted from Overbeck's paper in Fig. 22 (his Fig. 5) as being of general usefulness. Here the values of E_{DC}/E_{max} and $\omega L_C/R$ ($\omega = 2\pi \times$ line frequency, L_C= critical inductance in henrys and R=load resistance in ohms) are plotted against firing delay angle α for rectifiers having 2, 3, 4 or 6 phases (p). The valve-drop correction (D) is left out so that the values of $\omega L_C/R$ must be multiplied by $(1+D/E_{DC})$ and the values of E_{DC}/E_{max} must be divided by the same factor.

The voltage (e_s) available to start the discharge at any value of α is

$$e_s = 2E_{max} \cos\left(\frac{\pi}{2} - \frac{\pi}{p}\right) \sin \alpha \quad \ldots\ldots\ldots\ldots\ldots (3)$$

In high-voltage circuits the valve drop becomes negligible and the delay angle calculated from equation (3) for the minimum striking voltage of the valve, under maximum voltage output conditions, may also be neglected as being an extremely small angle. In order that the firing voltage of the valves shall not be too large, a high positive peak voltage is usually applied to the grids at the instant of firing.

The value of inductance so calculated is the minimum required to ensure continuous conduction and should always be checked, though two other factors may dictate a higher value being used, namely, ripple attenuation and non-resonance of the filter circuit at the supply frequency. To avoid the latter on supplies at 50 c/s, the product of inductance (henrys) and capacitance (microfarads) should be not less than 30.

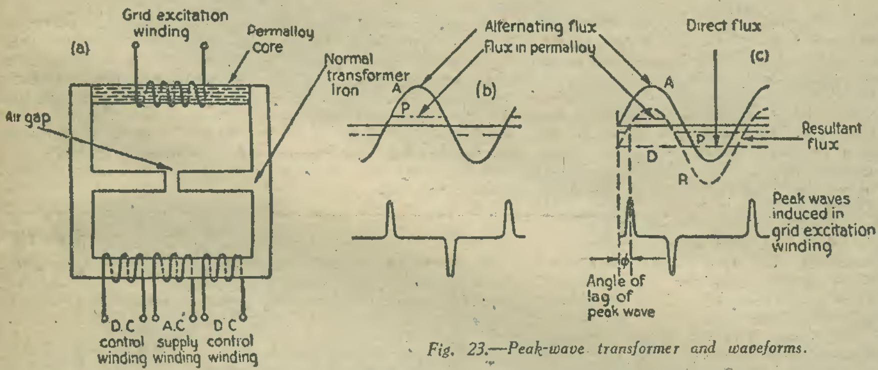


Fig. 23.—Peak-wave transformer and waveforms.

The diagrams and equations given above treat the rectifier ideally as having no internal reactance, but reactance is always present practically and produces a delay in commutation (overlap). However, the angle of overlap is less in grid-controlled rectifiers (for values of $\alpha > 0$) than in those without grids because, due to the delay in commutation brought about by the grid-control process, a higher voltage is actually available when commutation eventually does take place.

When the effects of the reactive and resistive voltage drops in the rectifier transformer are taken into account, the output voltage in half-wave circuits is given by

$$E_{DC} = \frac{pE_{max}}{\pi} \sin\frac{\pi}{p} \cos\alpha - D - \frac{pXI}{2} - \frac{P_R}{I} \quad \ldots\ldots (4)$$

where X is the effective commutating reactance per rectifier phase, I the effective phase current in each secondary winding, and PR the transformer resistance loss in each winding.

In designing the rectifier transformer, consideration must be given to the limitation of the short-circuit current to a value within the surge-current rating of the rectifying valves. It is customary to limit this current by the reactance of the transformer and feeders on the primary side considered as a whole, and, where necessary, to obtain the required value by connecting small anode chokes in series with the transformer secondary terminals (in practice these chokes may be mounted inside the tank and form an integral part of the transformer).

In connection with the possibility of arcbacks, it should be noted that there may be a greater tendency for these to occur with inductive load circuits, for then current conduction in a valve ceases when the anode voltage has reached a comparatively high negative value, so that the space between the electrodes then contains a large number of positive ions.

Considering now the question of grid control, one simple method, used with success, is to apply to the grids (through isolating transformers since, in most rectifiers, the cathodes and grids are at high potential relative to earth) an alternating potential greater in amplitude than the critical bias corresponding to the peak of the applied anode voltage, but whose phase can be changed by means of a phase-shifting transformer. Where, however, accurate control of timing and high-speed overload protection are required the method commonly employed is to maintain the grids normally at a negative potential, thereby preventing the establishment of the arc, and to apply momentarily a positive potential impulse to each grid in succession, the phase of these impulses relative to the anode potentials being altered to obtain variation of the output voltage. The impulses may be derived from a source of positive direct voltage in conjunction with a synchronously-driven distributor, or from peak-wave transformers or saturable core reactors, in which latter cases completely static devices only are required. Where a distributor is employed the requisite phase displacement of the impulses is obtained by adjusting the angular position of the rocker supporting the distributor segments, and overload protection is afforded by making the overload relay(s) interrupt the grid positive d.c. supply.

The peak-wave transformer shown diagrammatically in Fig. 23 has one limb of the core made of permalloy, which saturates at a very low flux level so that sudden reversals of flux occur in this limb as the alternating flux changes sign. Thus a voltage impulse of short duration is induced in the excitation winding which is connected, in series with a constant negative supply, between grid and cathode of the thyratron, causing ignition to take place whenever such positive impulse is generated. When the permalloy becomes saturated, the main a.c. flux passes through the shunt centre limb in which an air-gap is provided.

To obtain a shift of the peak waves, a steady flux is superimposed upon the alternating flux by current supplied to one of the d.c. control windings; with a negative flux as in Fig. 23(*c*) the position of reversal of the resultant flux is such as to give a lag between the position of the peak wave and the reversal of the alternating magnetic flux, and hence between its original position with no steady flux, whilst a positive flux leads to an advance in similar manner. A range of adjustment of the instant of generation of the peak wave is thus produced by variation between positive and negative values of the steady flux, and, since the alternating flux is obtained from the same supply as is fed to the thyratron anodes, it follows that phase control of the instant of firing is readily possible. This variation in both directions is used in order to obtain the necessary range of angular change since, as the steady flux is increased beyond a certain value, saturation of the whole core occurs.

Radio Examination Papers—32

Car-radio Design, the Frequency-multiplier, Moving-coil Loud Speaker Repair, Short-wave Receivers, Reflection of Radio Waves and Crystal-controlled Transmitters, Form the Subjects for Questions and Answers This Month. By THE EXPERIMENTERS

QUESTIONS

1. *State the principal essential requirements of a car-radio receiver, and explain briefly how they can be provided.*
2. *Describe in a concise manner the action of a frequency-multiplier stage.*
3. *What are the chief advantages conferred by the use of a pre-detector H.F. stage in a simple type of short-wave receiver?*
4. *If an energised moving-coil speaker were "dead" what steps would you take to test and, if necessary, repair it?*
5. *Write a short account of the reflection and re-radiation of radio waves.*
6. *Is it possible for a crystal-controlled transmitter to radiate on a frequency other than that of the crystal, or a harmonic of the crystal frequency?*

1. Car-radio Requirements

APART from the obvious requirements of compact construction, sensitivity and ease of control, there are several other technical points which call for careful consideration in designing a car-radio receiver. One very important necessity is that there shall be a very reliable A.V.C. system; amplified A.V.C. is to be desired. In the absence of full automatic volume control, very marked fading is bound to occur as the car is driven past buildings, metallic objects and even trees.

Partly to enhance the A.V.C. action, and partly to ensure increased sensitivity, an H.F. stage prior to the frequency-changer is very desirable, although not essential. In this connection it should be stated that a superhet circuit is necessary for satisfactory operation, and in order to obtain the required sensitivity and selectivity in the simplest possible manner.

Another requirement is that the complete receiver should be enclosed in a metal container which will act as a screen. The various parts of the container should be well bonded together, and earthed to the car chassis. It is also wise to screen all external leads, including that to the aerial, unless they are very short.

All components and wiring associated with the tuning circuits should be absolutely rigid; this applies particularly to the vanes of the tuning condenser. Midget all-metal valves are in many ways preferable, both because of the electrode rigidity and of their compactness.

2. Frequency Multiplication

A frequency-multiplier stage looks in every respect the same as an ordinary R.F. (or H.F.) amplifier, except that the tuning coils in the grid (input) and anode (output) circuits are of different electrical dimensions. Thus, for a frequency doubler, the anode coil, with its associated tuning condenser, must be designed to tune to twice the frequency of the grid-tuning circuit.

Even if the circuit constants were the same as for an R.F. amplifier there would be some frequency doubling, but the stage would be inefficient. Efficiency is greatly increased if the grid-bias voltage is increased almost to cut-off. The reason for this is that when the valve is biased well back, strong "kicks" of anode current occur each time a positive half-cycle is applied to the grid. Each "kick" gives a strong impulse to the anode tuning circuit and so maintains oscillation at the resonant frequency of that circuit. Although only one kick is given for each two cycles of the anode circuit, there is only slight attenuation on the second cycle provided that efficient tuning circuits are used.

A circuit of a frequency-doubler, showing the waveform in both grid and anode circuits (assuming sine-wave input) is illustrated in Fig. 1. This does not show the action of the biased valve, but it is not difficult to understand that if the valve is biased to a point slightly beyond the bottom bend of its characteristic, each positive half-cycle will cause a sudden and sharp peak of anode current to flow; on negative half-cycles the valve is virtually cut off, with the result that there is no marked change in D.C. anode current to affect the output tuning circuit.

3. T.R.F. Short-wave Receivers

The pre-detector R.F. stage of a short-wave receiver produces little, if any, radio-frequency amplification. It does, however, minimise the effect of aerial damping on the tuned circuit which feeds the detector. In consequence, a lesser degree of feed-back is required to bring the detector into a state of oscillation. This, in turn, generally means that the smoothness of reaction control is greatly improved. This applies whether the R.F. stage is tuned or aperiodic.

Another and even more important advantage of the R.F. stage is that it prevents the regenerative detector from being "pulled" off frequency by a strong incoming signal. Without the pre-detector stage, there is a very strong likelihood that, in the presence of a strong incoming signal, the tuning of the detector will be pulled right away from the nominal frequency to which the condenser is adjusted. This gives the impression of—and exactly the same result as—poor selectivity, because a strong signal several kc/s re-

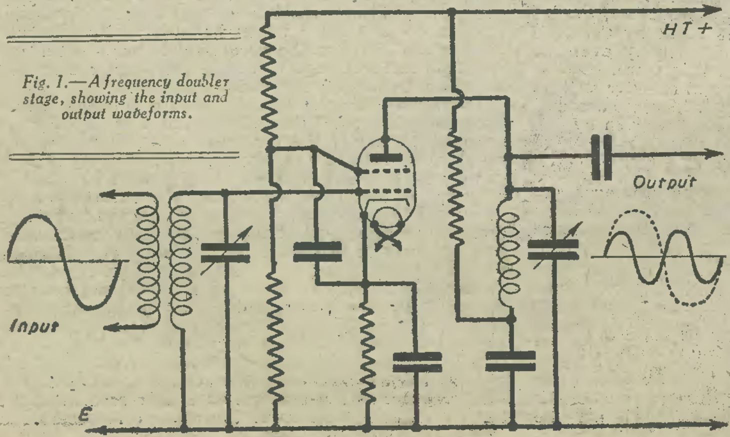


Fig. 1.—A frequency doubler stage, showing the input and output waveforms.

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).

Economy DX Three: B.B.C. Transmissions

SIR,—As a regular reader of PRACTICAL WIRELESS, I should like to point out an error in your May, 1944, issue.

On page 235, in the "Economy DX Three" article, the diagram shows incorrect connections to the holder of the detector valve. The grid and anode pegs of the valve are shown connected to the L.T. and the filament pegs to where the grid and anode connections should be.

I would like to congratulate you on the high technical standard of PRACTICAL WIRELESS. I regularly read "Open to Discussion" and would like to expose the distortion of B.B.C. transmissions in this district. Distortion, fading, sideband scrapes, and all sorts of faults run riot.

I spend my spare time listening for commercial morse stations. I have received 33 American Morse stations (and 15 American speech stations) including two Canadian ones: CGX2 and CZG7. These include WQL, WQS, WQV, etc. WIJ and WIY, also WAR, WDG8, WLYA and WSC.

If any reader can supply me with information regarding these latter stations I should be greatly obliged.

Other extracts from my log include ODK, TFJ, EPB, SUP3, JKZA, THD2 and SDMH6.—G. C. BAGLEY (Ironbridge).

[*We thank you for pointing out the discrepancy in the wiring diagram on page 235 of the May issue. A correction was published in the June issue.*—ED.]

The "Midget Three"

SIR,—I have constructed the "Midget Three" from particulars published in PRACTICAL WIRELESS for December, 1943, and obtained excellent results both with volume and quality. The tuning is rather sharp, but I can receive about ten stations during the day and forty during the night. I greatly appreciate the improved standard of PRACTICAL WIRELESS, and especially the series on elementary theory.—J. C. JACKSON (Norwich).

Logged on a P.W. One-valver

SIR,—The following particulars of my short-wave pickups may be of interest to other readers. The receiver I am using is the simple S.W. one-valver (blueprint No. P.W. 88).

At present I am using a forty-metre doublet (half wave), and also a full-wave doublet designed for 25.6 metres. It is erected in a north-south direction.

Here are the details: all times are B.S.T. HER4 and HER3 Schwarzenburg on 31.46 m. and 47.28 m. respectively; news given at 9.50 p.m. Also news at 8.45 p.m. from HER4, announces as Berne, and gives programme summary at 9.15 p.m. approx. News from FZ1 Brazzaville on 25.06 m. at 8.45 and 9.45 p.m. Leopoldville uses 30.66 and 16.88 m. and gives news and music on 19.33 m. from 12–12.30 p.m. PRL8 (Rio de Janeiro), 25.60 m., gives English programme from 8.30–9 p.m. approx. There is a new station, PRL9, on 16.81 m. It gives a programme of Brazilian music for Brazilian listeners over here from 1–2 p.m.; reception is excellent. TAP (Ankara), 31.70 m., news at 6 p.m. CSW6 Lisbon, 27.17 m., news at 8 p.m. Moscow calling N.B.C., New York, at 12.10 p.m. on 28.72 m., with despatches—listeners told to switch over to 25.11 m. SBU, Motala, Sweden, news at 10.20 p.m. on 31.46 m. and SBP on 25.63 with news at 5 p.m. HCJB Quito, Ecuador, 24.09 m. broadcasts at 8.30 p.m., with a power of ten kilowatts; reception good. Vatican Radio, 50.25 m., news at 8.15 p.m. Radio Andorra, with music at 10 p.m. on 49 m. Free India Radio, 4.30 p.m. on 26.16 m., and 19.71; news and talks. Radio Tokio, JLG4, 19.86 m. English talk at 10.30 a.m. WLWK, owned by the Crossley Corporation, gives news in Basic English at 3, 4 and 5 p.m. on 19.67, also relayed by UNR. Algiers on 31.45 m. at 4 p.m. There are two new American stations, WOOC, 19.75 m., and WOOW on 25.3 m.; both are operated by CBS, news given at 2 p.m. News from WCBZA at 8 p.m. on 26.9 m. Here are some well-received American stations: WEL, WCBX, WCRC, WCDA, WLWO, WLWK, WRUW, WBOS, WRUS, WGEO, WKLJ, WGEA and WKTS, New York, 49.03 m. UNR, Algiers, uses 49.67, 33.46 and 33.45 and also 24.17 m. for its English broadcasts. Radio Metropole uses 25.65 m., 31.63 m. and a wavelength in the 49 m. band. I also picked up WQV calling Stockholm in the 19 m. band at 1.54 p.m. Press messages for London and New York from the American Advanced H.Q. in Italy on the 19 m. band from 12–4 p.m. at irregular intervals.—W. J. G. HECTOR (Shrewsbury).

A Bouquet!

SIR,—I would like to congratulate you on "P.W." I have read it ever since I chanced to come across a copy about ten years ago, and it is *the* wireless journal without doubt. Well, the paper is controlled by the Editor, and the care with which he excludes material that is unsuitable or not of general interest is responsible for the success of his paper. In these days other difficulties are doubtless added to the peacetime ones, yet every radio enthusiast who reads "P.W." can feel when he takes it up that it will be eminently readable right through. Apart from that, old issues are a valuable reference in many ways. The pile I have I certainly would not cash at cost price—I would prefer to sell the chest they stand on!

In short, I reckon the paper stands on a pinnacle all its own. I would class it with the Brains Trust but for fear of giving poor old ridicule-pouring "Thermion" sleepless nights.—F. G. RAYER (Longdon).

"Stroboscope Calculations"

SIR,—Mr. D. W. Aldous, in a letter headed "Stroboscope Calculations" (PRACTICAL WIRELESS, May, 1944), says "this useful stroboscopic idea was due to Dr. Stampfer, of Vienna, in 1830, although it is usually attributed to Dr. J. Plateau, the Belgian physicist, who apparently invented the same device."

The attribution of the stroboscope is not quite so easy. It is to be regretted that there is no really adequate history of physics in English, but the fullest German history, Rosenberger's "Geschichte der Physik," states, Part 3, p. 318 (free translation): "Much interest was aroused by stroboscopic disks, which Stampfer described in 1834 in the Yearbook of the Vienna Polytechnic Institute, Vol. 18. Plateau claimed priority in this invention for himself, since he had already put forward the idea of these disks in 1833 (June number of the Math. and Phys. Correspondence of Brussels Observatory). Berzelius in his Reports on the Progress of Physics and Chemistry (Vol. 14, p. 22) took a dim view of this claim, since he had already seen such disks in Stockholm at the beginning of August, 1833. A wheel, showing the same phenomena as stroboscopic disks . . . was described by W. G. Horner under the name Dädaleum in the *Philosophical Magazine* (Vol. 4) in the year 1834."

I have not been able to consult the originals mentioned, and the discrepancy in the Stampfer dates (Aldous, 1830; Rosenberger, 1834) needs explanation, but on Rosenberger's evidence it would seem that the honour of invention lies either with some unknown Swede or with Plateau.—W. H. DOWLAND (West Hartlepool).

A Naval Reader's Activities

SIR,—Being a regular reader of PRACTICAL WIRELESS for over a year now, I would like to inform you of my radio work. At the time of writing I am serving at sea as 3rd Radio Officer in the Merchant Navy and hope to sit for my 2nd P.M.G. examination in the near future.

Before coming to sea, I rarely did very much DXing, as most of my time was taken up in the construction of sets, amongst which were, 1 valve, S/W and 2 M.W. sets, also a number of others. Another effort of mine was to construct a wind charger for battery-charging purposes, but after trying many types and designs of propeller and generators, I have put the idea and apparatus on one side until the present hostilities have ceased.

On my last leave I was busy constructing a new aerial, and have constructed a "twin" inverted "L" facing due N. and S. with three feet "spreaders." This gives good results on my 1 valve M.W. set and also on my 3 valve Osram, which is connected through a D.P.D.T. switch. I am looking forward to obtaining, if possible, a S/W Xmitter after hostilities have ceased and intend becoming one of the post-war amateurs who must be anxiously awaiting that time.—R/O. H. FROGGATT (Stockport).

American Forces Network

SIR,—Herewith further details of stations of the American Forces network:

216 metres—Broadcasting from 11 a.m. to 11 p.m. B.D.S.T. (with co-operation of B.B.C.); 305 metres—A.E.F. station, Algiers, broadcasting from 7.30 a.m. to 9 a.m. and 12 noon to 12 midnight B.D.S.T.; 461 metres—Armed Forces Radio in Oran—on the air from 11 a.m. to 11 p.m., with an early morning transmission in addition.

Two further broadcasting stations on the medium waves which may be of interest are:

255 metres—United Nations Radio in Algiers. Relays certain B.B.C. and U.S. "Voice of America" transmissions. News in English at 10 p.m. B.D.S.T.; 345 metres—Gibraltar—announcing in English and Spanish. Broadcasts programmes of the B.B.C. Transcription Service in addition to transmissions of local origin.

It should be noted, too, that Moscow has returned to its position on 1744 metres, where it has not been heard since Russia's entry into the war. (Power presumably still 500 kW.).—DENNIS J. HOSKING (Saltash).

A Good Log

SIR,—The following extracts from my log may interest other readers. First my reception of U.S.A. stations: WCBX, 19.65 m.; WGEA, 19.57 m.; WCDA, 16.83 m.; WLWO, 31.28 m.; WCRC, 25.36 m.; WBOS, 19.72 m.; WRUL, 16.90 m.; WLWK, 19.67 m.; WKLJ, 30 m.b.; WKRX, 30 m.b.; WRUA (?), 39 m.b.; WOOZ, 49 m.b.; WOOW, 38 m.b.; WOTM, 47 m.b.; WGEO, 31.48 m.; WNBI, 19.75 m.; WLWO, 16.85 m.; WBAX, 19.72 m.; WOOZ, 19 m.b.; WGEA, 25.33 m.; WOLZ, 30 m.b.; WKRK, 30 m.b.; also DXJ, 41.44 m.; TPZ2 (Algiers), 33.46 m.; TAP (Ankara), 31.70 m.; OPM (Leopoldville), 30 m.b.; HVJ (Vatican); PRE9 (Fortaleza), 49.14 m.; EAQ (Aranjuez), 30.43 m.; Radio National, 30 m.b.; Moscow, 43.01 m., 41.61 or 7 m., 40.76 m.; The Mediterranean Short-wave Transmitter, 30.20 m.; Radio Shonan (Singapore), 31 m.b.; German Overseas Service, 50 m.b., 31 m.b.; "Jerry's Front," 28 m.b., 39 m.b., 40 m.b., 31 m.b.; Canadian Broadcasting System in London, 31 m.b.; "Voice of American Soldier and Sailor," 37 m.b.; AF.H.Q., 20 m.b., 33 m.b.; Radio Metropole, 49.18 m.; Ireland Calling Berlin, 32 m.b.; Radio Jowa, 16 m.b.; British Mediterranean Station, 31 m.b.; The N.B.B.S. (Anti-British), 48 m.b.; Jerez, "The Far Eastern Station," 31 m.b.; Berlin, 31 m.b.; FZI (Brazzaville), 25.06 m.; Norman McDonald Calling B.B.C. from Stockholm, 31 m.b.; French National Radio Broadcasting System, 19.68 m.; HER3 (Schwarzenburg), 48.66 m. My set is a 5-valve superhet and all reception is on L.S. I am afraid m.b. enters into this letter quite often, but it cannot be helped as my receiver is not very well calibrated. It of course stands for metre-band. I would greatly welcome letters from other S.W. DX fans and especially the full address of T. B. Williamson and J. J. Earler (June issue) with a view to corresponding on S.W. reception.—J. COOPER, "Nairobi," Cairo Avenue, Peacehaven, Sussex.

Deaf-aid Improvement

SIR,—May I suggest one or two slight modifications to the circuit diagram of the "Deaf-aid Arrangement" (p. 240, May issue) which would make it still safer? As shown, a short-circuit across the leads to the deaf-aid unit would place the full H.T. supply across the receiver's speaker transformer—probably with disastrous results! I therefore suggest that the 2 mfd. capacitor be connected directly to the anode of the output valve inside the receiver itself, and the lead from the deaf-aid unit be then connected, either directly or through a plug and socket, to the other end of the capacitor. I also suggest that the on/off switch in the unit be connected between the lead from the capacitor and the transformer, as it would then isolate the transformer from the A.F. voltage but leave it connected to earth. Just one other point—remember to use a capacitor having an adequate working voltage, which, for mains sets, should be at last 250 v., but preferably 350 v., D.C.—R. V. GOODE (York).

Our Query Service

SIR,—I note with regret the suspension of your query service, as it was a most interesting and informative section of your journal. Under the conditions that have been in existence during wartime your query service has been a praiseworthy contribution.

This suspension will do us all some good, perhaps, by making us use our brains a bit more, instead of rushing off a letter to you when some small difficulty presents itself, which can often be solved on the spot with a little more thought.

I trust that the time is not far distant when conditions will be back to something like normal, when the suspension of your query service can be lifted.

With many thanks for the help you have given me in the past.—D. SMITH (Stockport).

Continental Programmes

SIR,—I heartily support the opinions expressed in various letters from readers published in recent issues. I regularly listen in to continental programmes, which, as stated, come in with remarkable strength and clarity, in preference to the B.B.C. broadcasts which, with the exception of the news, appears to me to be childish, and almost infantile; but I suppose this is to satisfy the rising trend of the so-called modern education.

It is pathetic, as one reader states, for some of us to have to pay for what we do not want, when the other good programmes are provided free, gratis and for nothing! Meanwhile, good luck to PRACTICAL WIRELESS for carrying on.—C. W. CASTLETON (Aldeburgh-on-Sea).

P.W. in Madagascar

SIR,—Although rather belated, I feel I must congratulate you for having turned out the new series of P.W. This is just the kind of technical journal that the British radio man has been waiting for. I am not able to get a copy regularly out here as the radio man is not very well catered for in this part of the world, but from those I have managed to obtain I see that it is now a book for he who wishes to advance his technical knowledge at the pace of the advance of radio progress itself.

I have read with interest from time to time the activities and vigilance of the members of the B.L.D.L.C. and should like to know if any one of them have picked up the station to which I am engineer. This is "Radio Diego Suarez" (41.72m., 500 watts), which is run by the British Army for the information and entertainment of the Forces stationed in this area. The daily times of broadcast are: 0900-1000 hrs., 1445-1715 hrs. and a test broadcast every Sunday night at 2100-2130 hrs. Times are G.M.T.—W. B. MANSELL (Diego Suarez).

Logged on an 0-v-1

SIR,—Here are a few items from my log which may interest other readers: Shonan (formerly Singapore), 31.42, 2130–2205 (R7); TAP, as well as daily news at 1800 there are news talks at 2130 on Thursdays, dispatches for WLW on Wednesdays at 2200, also topical programmes for America at 0215; FETI, Valladolid, "Radio Nacional d'España"—no English announcements—2200 hrs., 42.43 metres; Radio Dakar, 26 metre band, 2115, in French; EFT, "Radio España Independente," 2200 hrs., 40.4 metres. The American Telephone and Telegraph Company may often be heard testing on the 20 metre band. All times B.S.T. My receiver is an 0-v-1, and aerial N.-S., is 50ft. long.—C. COLSON (Bristol).

Repairing Electrolytic Condensers

SIR,—I find the information in the June issue on cardboard electrolytics, by H. S. G. Bray, very useful. I thought perhaps my experience on wet electrolytics might be of use to other readers.

If the electrolytic is of the can type, for metal chassis mounting, the top is usually embossed over to form an airtight fit in a rubber cushion ring. Inside this top is another fitting, in which is the safety valve. Usually it is not necessary to open this, but the aforementioned top should be eased out gently, and the liquid poured into a jar (if it has not evaporated).

If it is a short circuit, the gauze round the inside of the can should be drawn out and examined. If it has broken up it should be replaced with a suitable porous material. I find unglazed stiff linen gauze, used for bookbinding, satisfactory. If the gauze is quite sound the fault may be due to a broken plate. The plates are fixed in position by a nut or an expandable washer at the base; if the former, the plates can easily be removed, but in the latter case I find a great deal of trouble in obtaining a watertight fit when replacing. In this case the joint should be dipped in molten candle fat.

If the condenser is open circuit, on test, or its capacity down, it may need topping up, with distilled water, to ¼in. above the plates. If this does not answer, refill with new electrolyte. When the top is replaced this should be dipped in candle fat.—A. J. COLLETT (Wolverhampton).

A Beginner's Activities

SIR,—The following short account of my radio activities may prove interesting to other young readers. I first took up radio about four years ago. The first set I built was the "A.R.P. Single Valver," as described in PRACTICAL WIRELESS. After some preliminary difficulties, which I suppose all beginners meet, I was thrilled to have the set working, and very well it worked indeed. For some months I experimented with this set and an L.F. stage, but never obtained any combination which worked very satisfactorily.

In the meantime I had purchased a moving coil P.M. speaker, for which I had to find a cabinet. Eventually I converted an old set cabinet, and lined this completely with cotton wool to a depth of one inch, after which I filled the intervening air space with loose cotton wool. There was an excellent response. At this time I had, of course, very little equipment and things proceeded rather slowly.

I think I have been rather ill-fated in making one-valve S.W. Rx's; to date I have made six, none of which worked satisfactorily. In the past I also made a simple tester (continuity, transformer, etc.) and microphone. I also made a one-valve morse oscillator, but unfortunately I don't get much time for practice.

The next set I built from PRACTICAL WIRELESS was the "Rapid Two," which was most successful, and I would like to congratulate you on turning out such a fine set. During this time my urge for S.W. Rx. was growing, but I had to build a two-valver to obtain successful results. At the end of last year I built the 0-v-1 described in PRACTICAL WIRELESS, March, 1943, by F. G. Rayer. The set embodies chassis construction, but is made of plywood—not metal. The set was painted with aluminium paint to give a pleasing finish and (for the first time) all connections were soldered. One difficulty I met with was, what terminal junctions to use for A, E, and Phs. I finally used small stand-off insulators for all. Connecting up is slightly longer, perhaps, but good insulation is assured. It is interesting to note that 30 minutes after first switching on I received New York City.

All work on the set, prior to about Easter, was done using the set in conjunction with an H.T. battery. I did not use an earth as I found it offered no advantages. Then I used it with the A.C. mains eliminator.

In the May issue of PRACTICAL WIRELESS came Mr. Rayer's "Economy Three," and it is interesting to compare the two circuits; it definitely looks as if this "Economy" is a development of the 0-v-1. I was interested to note that the small fixed condenser I had found necessary had been added. I added the untuned H.F. stage, as in the "Economy," but left the L.F. side as it was. The combination worked excellently, and the set soon brought in stations from four continents, but so far I haven't received Australasia.

I am at the present studying applied mathematics, physics, pure mathematics and chemistry. This in many ways suits my radio.

Finally, congratulations to the Editor, his staff and all concerned in the publication of PRACTICAL WIRELESS, who are doing an excellent job, which I feel is appreciated by all.—B. K. HOLDER (Birmingham).

Telling Us Off

SIR,—Your contributor "Thermion" is a nasty, horrible creature, and ought to be ashamed of himself. How dare he poke fun at what he so rudely describes as the "quick-fire back-chat of some females afflicted with that most terrible of female afflictions, wagging tongues." What other weapon have we against the arrogant bullying of his own brutal sex?

I wish I had this monster to deal with! I'd stand him in a corner and treat him to quick-fire back-chat for hours on end, and poke pins into him if he showed signs of falling asleep. But for our sex, it is more than likely that there would never have been such a thing as human speech, for in the early history of the race, the male creature merely grunted and roared, whereas the females were compelled to develop something more intelligible to make it clear to their tyrants that they must not come home empty-handed from the chase, or make presents of nice warm bear or wolf skins to the blonde in the next-door cave.

Does "Thermion" imagine, for one moment, that women are prepared to give up this prehistoric discovery of theirs, which, in the course of the ages, they have developed into the most effective weapon in their armoury? Never! Rather let us strive to cultivate it by every means in our power. Let every woman set herself this goal: To fit herself to talk any mere male squirt to death if necessary. Many of us are almost perfect already; but we must lend all possible assistance and encouragement to our weaker sisters.

And let us be thankful to the B.B.C. for the many opportunities it offers us in front of the mike and during the Brains Trust sessions; by which means we are able to strike terror and alarm into our oppressors.

Wagging tongues, indeed! Huh, the beast; the brute; the big bully! I'll show him what a wagging tongue can do, if ever I come into personal contact with this nasty creature—which heaven forbid! Pah! The very sound or sight of his name will never cease to provoke me in future, even if it does help to keep my own "wagger" in good form.—Yours indignantly, (Miss) PRISCILLA TRYPHENA SMART.

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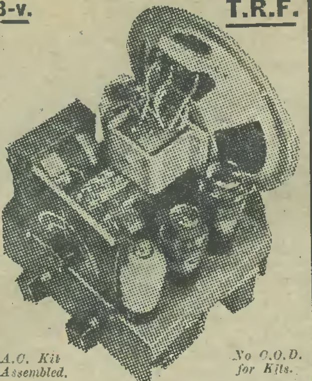

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HIGH - VOLTAGE MICA CONDENSERS. .01 mfd., **1/6.** **Valve Holders,** 4, 5, 6, 7-pin paxolin, **6d.**; International Octal **9d.**; W.B. 7-pin, **10½d.**; **Terminal Strips, 2d., 3d.** and **6d.**

PAXOLIN PANELS, 12 × 9 × ⅛ ins. **3/6.** **Yaxley Type Switches,** 2 bank 2 pole 4 way, **4/6.**

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SALE.—D.C. AvoMinor, as new, £3 10s. Also 0-½ m.a. M.C. Meter, 2in. dia., Res. 78 ohms, **£3**, new.—F. J. Glover, 18, Knapmill Road, Bellingham, S.E.6.

FOR transformers, all types, try BM/PLWC, London, W.C.1.

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25 YARDS PUSH-BACK INSULATED WIRE, 5/-; Insulated Sleeving, assorted yard lengths, 3/6 doz.; Single Screened Wire, dozen yards, 10/-; Metal Cased Condensers, .1, .1, .1, 2/6; **POWER RHEOSTATS,** Cutler-Harmer, 30 ohms., 4/6; **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; Knobs for P.B. Switches, **6d.**; Coil Formers, Ceramic and Paxolin, 12 assorted sizes, 7/6; 20 Assorted Tubular Condensers, up to .1, 15/-; 24 Assorted Mica Condensers, 12/6. **Hundreds More Bargains.**

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WANTED.—Wiring diagram Calibrator A.C. set, Jan., 1933 *W. Magazine.*—Jones, 17a, King Street, Ludlow.

FRED'S RADIO CABIN.

TUBULARS, 0.1 mfd., **9d.** each, **8/6** doz. also .01 mfd. at **6d.** each, **6/-** doz.

AMPLION twin H.F. binocular chokes, **1/9.**

INTERNATIONAL Octal Base valve-holders, **8d.** each, **7/6** doz. UX 4-pin **8d.** 7-pin **8d.**, 6-pin **8d.**, 7-pin English **7d.** Clix 7-pin chassis mounting, **7d.**

COPPER WIRE, TINNED, 18, 20, 22-gauge, **1/-** ¼lb. reel.

T.C.C. CONDENSERS, .1 mfd. 5,000v. wkg., **5/6.**

PUSH BUTTON UNITS, 6-way, 7-way, **2/6** each, 8-way, 9-way, **3/-** each; knobs, **2d.** each.

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(Continued in next column.)

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TAPPED TONE CONDENSERS, consisting of 7 condensers, **2/-** each.

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WIRE. Heat resisting connecting, 12ft. coils, **6d.** each. Double cotton covered wire, per ¼lb. reel, 18g. **1/9**, 20g. **1/10**, 24g. **1/11.** Single cotton covered, enamelled, 22g. **1/9**, 26g. **2/-.**

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MAINS DROPPERS, with variable sliders, total 1,000 ohms, .2 amp., **4/6** each. "Metway" .3 amp. variable, 750 ohms, completely covered in porcelain, **10/-** each.

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F. J. Camm's Silver Souvenir (HF Pen, D (Pen), Pen) (All-Wave Three)	PW49*
Cameo Midget Three (D, 2 LF (Trans))	PW51
1936 Sonotone Three-Four (HF Pen, HF Pen, Westector, Pen)	PW53
Battery All-Wave Three (D, 2 LF (RC))	PW55
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Nucleon Class B Four (SG, D (SG), LF, Cl. B)	PW34B
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Battery Hall-Mark 4 (HF Pen, D, Push-Pull)	PW46
"Acme" All-Wave 4 (HF Pen, D (Pen), LF, Cl. B)	PW83*
The "Admiral" Four (HF Pen, HF Pen, D, Pen (RC))	PW90*
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Mains Operated

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Double-Diode-Triode Three (HF Pen, DDT, Pen)	PW23*
D.C. Ace (SG, D, Pen)	PW25*
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"All-Wave" A.C. Three (D, 2 LF (RC))	PW54*
A.C. 1936 Sonotone (HF Pen, HF Pen, Westector, Pen)	PW56
Mains Record All-Wave 3 (HF Pen, D, Pen)	PW70*
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MISCELLANEOUS

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1934 Crystal Set	AW444
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B.B.C. Special One-valver	AW387*
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Melody Ranger Two (D, Trans)	AW388
Full-volume Two (SG det. Pen)	AW392*
A Modern Two-valver	WM409*
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£5 5s. S.G. 3 (SG, D, Trans)	AW412*
Lucerne Ranger (SG, D, Trans)	AW422*
£5 5s. Three De Luxe Version (SG, D. Trans)	AW435*
Transportable Three (SG, D, Pen)	WM271
Simple-Tune Three (SG, D, Pen)	WM327
Economy Pentode Three (SG, D, Pen)	WM337
"W.M." (1934 Standard Three (SG, D, Pen))	WM351*
£3 3s. Three (SG, D, Trans)	WM354
1935 £6 6s. Battery Three (SG, D, Pen)	WM371
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Certainty Three (SG, D, Pen)	WM393
Minitube Three (SG, D, Trans)	WM396*
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Lucerne Straight Four (SG, D, LF, Trans)	WM350
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The Auto Straight Four (HF, Pen, HF, Pen, DDT, Pen)	WM404*
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Mains Operated.

Two-valve : Blueprints, 1s. each.	
Consoelectric Two (D, Pen) A.C.	AW403
Economy A.C. Two (D, Trans) A.C.	WM286
Three-valve : Blueprints, 1s. each.	
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Mantovani A.C. Three (H.F. Pen, D, Pen)	WM374
£15 15s. 1936 A.C. Radiogram (HF, D, Pen)	WM401*
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All-Metal Four (2 SG, D, Pen)	WM329
Harris' Jubilee Radiogram (HF, Pen D, LF, P)	WM386*

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 indicate the periodical in which the description appears: Thus P.W. refers to PRACTICAL WIRELESS, A.W. to *Amateur Wireless*, W.M. to *Wireless Magazine*.

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