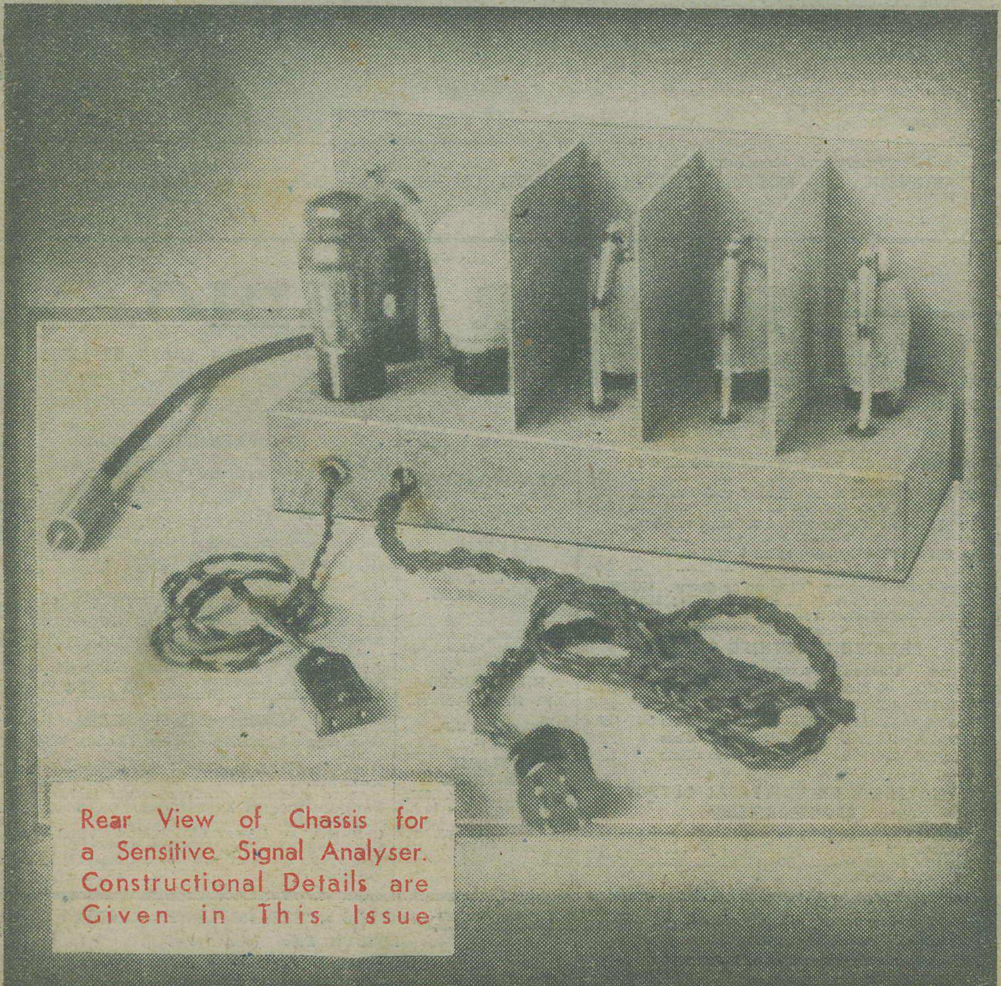
MAKING A TEST BRIDGE

Practical Wireless

9D EVERY MONTH

Editor F. J. CAMM

Vol. 20 No. 458 NEW SERIES AUGUST, 1944



Rear View of Chassis for a Sensitive Signal Analyser. Constructional Details are Given in This Issue

Practical Wireless

and PRACTICAL TELEVISION

12th YEAR OF ISSUE

Vol. XX. EVERY MONTH. No. 458. AUGUST, 1944

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Comments of the Month

By F. J. C.

Post-war Development

AN important memorandum on post-war development in radio engineering has been prepared by The British Institution of Radio Engineers. In view of the many announcements which have been made regarding post-war television the statement points out that whilst this may be the most spectacular radio product, and will probably be the most important commercially, the scope of electronics is much wider when one considers its more general application to other industries. It is in the development of these applications that the greatest opportunity of expansion exists. The tremendous possibilities of this new industry have been demonstrated during the war, due to the improved facilities for research and development. Before the war this was financed by private enterprise, but during the war the taxpayer has footed the bill.

The Institution now proposes the formation of a British Radio Research Institute, and the proposal was lodged with the Government and the radio industry in January, 1944. We would also draw the attention of our readers to our own suggestions in this connection contained in last month's leader.

Development of radio in wartime has led to so many new applications in the ultra high frequency spectrum that some control must be exercised by the Government in order to make the most useful and economical allocations in the newly available waveband. Some of the applications of radio and electronics are entertainment, education, of which sound broadcasting, television, gramophone, film, electronic musical instruments, the cinema and the theatre, and public address are some of the branches; communications—point to point, mobile, carrier, telephone and facsimile, navigation and radar devices, whilst in the technical and industrial field, medicine, measurement, control and power are applications which have made formidable inroads, and have largely replaced older methods.

We agree with the B.I.R.E. that activity in the electronic field will certainly be highly intensive in the post-war years, and that much confusion and disorder, as in the early days of radio, will result unless projects are based on sound scientific progress. Adequate development is necessary before new devices are put upon the market, since premature marketing of undeveloped apparatus can do considerable harm. We must see that the new industry is kept free from the racketeers who rifle the purses of radio enthusiasts. Obviously the greatest activity will be in the spheres of education and entertainment, communications and navigation devices.

Sound Broadcasting

SINCE 1920 home area broadcasting has mainly been carried out on the medium and long wave band, using amplitude modulation, but more channels are required. An excellent case can be made for the introduction of a frequency modulation service on ultra high frequency, as has already been accomplished in the U.S.A. It was a pitiable error that we did not use frequency modulation in connection with our television service. Even when that was introduced, frequency modulation television was superior to any other system. It is a mistake which the Television and Advisory Committee should explain, and give its reasons for rejecting it, giving preference to systems which were half-developed, and unsatisfactory.

It is very desirable that a Government statement on the national policy regarding the use of transmission systems during the early post-war years be issued very soon; without such statement, designers cannot get to work.

About half-a-million homes in this country make use of sound broadcasting over wires. These listeners receive programmes by direct wire connection from the B.B.C. studios, while in peacetime foreign programmes are picked up at remote receiving stations with superior aerial and equipment facilities. This distribution is carried out by the audio-frequency method, the number of wires used limiting the number of programmes distributed. As the report points out, if the number of programmes is to be increased radio frequency carrier-distribution can be used, and wired distribution of television programmes by this method is also a possibility. We established the lead in television before the war, and we must regain this position quickly.

The B.I.R.E. make the following recommendations: That the service be "broadcast," i.e., there shall be a (generally) non-directional transmission without wires. That the vision and sound transmissions be of the same order of carrier frequency as pre-war. With regard to the assignment of any new frequencies required, a conservative policy is advocated having regard to the possibility of echo trouble at higher carrier frequencies. That the radio bandwidth for vision transmission be of the same order as pre-war, viz., 4 mc/s approximately.

Our Query Service Suspended

MAY we remind our readers that our Free Advisory Service is suspended until further notice, and we are unable to answer any further technical queries. A large number of firms who have closed down their own Service Department are directing their customers to send queries here. We have never undertaken to answer queries relating to commercial receivers, and we would remind such firms that we are not able to take on the work of their defunct service departments.

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

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

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

New Syrian Transmitter

IT is reported that Syria is to have a powerful broadcasting station in the near future.

Britain and Uruguay Link-up

THE first direct wireless channel between Britain and Uruguay was established recently by Cable and Wireless, Ltd., in London, and by the Uruguay administration in Cerrito.

Fewer Organ Broadcasts

REPLYING recently to protests by organists at the cutting down of organ music the B.B.C. said: "We are broadcasting rather less theatre organ music. Whereas on the old Forces programmes it was all right, on the General Forces short wave the organ is not good. In the Home programme space is limited."

Wireless Licences

WIRELESS licence holders in Great Britain and Northern Ireland have now reached the record total of 9½ millions. There are still, however, wireless sets in use for which no licences are held. This results in the prosecution of offenders from time to time, and fines up to £10 have been inflicted. In Scotland recently an offender, in addition to being fined this amount, had his set confiscated by order of the Court.

Each householder (including the occupier of a flat, whether self-contained or not) using wireless receiving apparatus should have a licence. Licences are required not only by householders operating their own sets, but also by those using sets which are rented or hired.

Wireless Operator Commands Squadron

A WIRELESS operator has for the first time been given command of a bomber squadron.

Wing-Commander Markland, D.F.C., D.F.M., who last autumn took over a flight, now leads a whole Halifax squadron, based in the north of England.

Radio in Trains

ACCORDING to a recent report radio transmitters and receivers will, if experiments now being conducted are successful, be installed in nearly all trains throughout the United States.

They will provide for connection between trains and stations and signal boxes between different trains on the same routes, and between the front and rear ends of trains.

New American Stations

FOLLOWING up the plan of the U.S. Office of War Information to increase the number of international short-wave stations in the States, four 50-kW. transmitters are to be erected on the Pacific Coast. It is expected that these transmitters will be in operation by October, and they will be operated by the N.B.C. for the U.S. Government under the call letters KNIB and KNBC.

Television in New York

THE National Broadcasting Company recently carried out a survey of television receivers in the New York area, which showed that only slightly over 80 per cent. of the 4,600 sets in the area are in working order. Apparently the survey also revealed that there was a television audience of approximately 40,000 in the New York area.

The B.B.C. and D-Day

THE first announcement of the Allied invasion of Europe was given at 9.32 a.m. on the morning of June 6th, by every service of the B.B.C., both Home and Overseas. The service was then divided into two programmes. One, chiefly in English, gave the actual words followed by English translations, of the rulers and premiers of many of the occupied countries of Europe, who talked to their own people. These included King Haakon of Norway, and the Prime Ministers of Poland, the Netherlands, Belgium and Luxembourg. The second Service was concentrated on all countries of Europe and given in their own languages. Later in the day General de Gaulle spoke to France and the Acting Foreign Minister of Czechoslovakia to his own countrymen and women.

At 9 p.m. on "D" day, His Majesty the King spoke to his people, calling on them to join in prayer throughout the great operation now in being.

A Chinese soldier operating a portable field radio set in the front line in Northern Burma.

Special Bulletins

AT intervals throughout the day news of the landings and eye-witness accounts were sent through B.B.C. transmitters all over the world. Special bulletins were broadcast in the Pacific Service. The Hindustani entertainment programme was interrupted to give the invasion news. The Near-East Service added flashes in Arabic and Persian to the Turkish news normally on the air at the time. The news was sent out in Afrikaans, broadcast in Japanese in the Eastern Service, followed by Cantonese. English directed to Malaya, Burmese, Sinhalese, Thai, Hindustani, Kuoyu and Marathi. "Radio Newsreel" brought it to the North American continent at breakfast time on the East Coast. The Latin-American Service was completely rearranged to give the news full coverage in Spanish and Portuguese. Later on the African Service was interrupted to broadcast Mr. Churchill's statement and the North American Service gave the news in its bulletins.

The European Service carried the first liberation announcements and programmes, which were also given in the Home Service and the General Forces Programme from 9.30 to 10.30 a.m. Afterwards news went out in all B.B.C. European transmissions in twenty-three languages throughout the day. Thirteen transmissions were made to France, including General de Gaulle's broadcast at 5.30 p.m. Ten transmissions were directed to Italy, where the news was jubilantly received in Rome.

First news of the invasion was given to Germany by the European Service, as an earlier enemy agency's story was not given by the Germans on their Home Service.

"Workers' Playtime"

WORKERS' Playtime," the B.B.C. variety programme taken direct to workers in their factory canteens was three years old on June 1st. Australian-born Bill Gates, whose cheerful "Hallo, war workers" is known to almost every listener, and pianist George Myddleton, have taken part in all but the very first few.

Since "Workers' Playtime" began on May 31st, 1941, there have been 451 broadcasts, more than 400 of them from factories, and others from rest centres, hostels, emergency hospitals, constructional sites and G.P.O. sorting centres. Dockers, fishermen, agricultural workers, miners and every form of civilian labour working for the war have been entertained. Since the programme began a third of a million workers have *seen* a "Workers' Playtime." The number who have *heard* one, either by rediffusion in the factories, or at home, cannot be computed.

Mobile Unit

THE "Workers' Playtime" unit has visited factories throughout the British Isles; whenever possible the choice falls on a factory where entertainment is hard to come by. In fact, the remoter the spot, the more valuable the programme. It is, of course, given in large factories in industrial centres, but no factory is too small to be paid a visit. One Christmas Day in Wales, "Workers' Playtime" played to an audience of only 150. The largest audience was 10,000 men and women when the show was given in the open air in a Scottish shipbuilding yard.

"Workers' Playtime," originally broadcast on Saturdays, quickly became so popular that in October, 1941, the broadcasts were extended to three a week on Tuesdays, Thursdays and Saturdays. In June, 1942, the Saturday broadcast was dropped and a midnight programme, broadcast to America during the night shift, was instituted. A recorded version was included in the Forces programme on the following Sunday. This series ended last February and a new one began on April 26th.

American factory listeners prefer singing to comedy and the new midnight "Workers' Playtime" is all musical, with three or four singers, and sometimes an instrumentalist. The last half of the programme is devoted to community singing by the workers themselves, led by the visiting artists. The show is recorded and repeated on the G.F.P. on Saturdays at 11.30 a.m.

"Factory Flash"

AN unusual feature of "Workers' Playtime" for the U.S. is the "Factory Flash." In the middle of the programme Bill Gates, who both produces and introduces these midnight shows, tells of some outstanding exploit performed during the day by workers in the factory he is speaking from, bringing home to listeners on each side of the Atlantic the stalwart part the workers at bench and lathe are playing in the fight for freedom.

Anniversaries

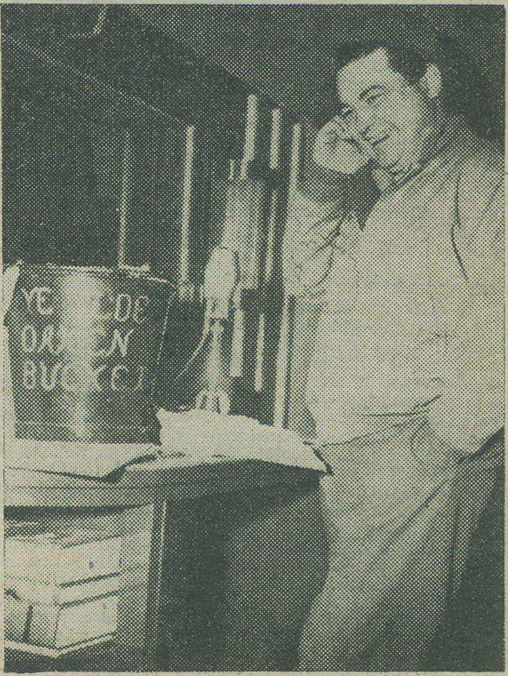
THE Minister of Labour has taken a lively interest in "Workers' Playtime" from the beginning and when first of the three-times-weekly began he broadcast himself. On each anniversary he has sent a message, and another was included in the third anniversary programme. The first anniversary was broadcast from England, the second from Scotland, and the third came from Wales.

This "Workers' Playtime" was a double-sized one. The first 30 minutes came from one of the works canteens, the second from another canteen in the same factory. Among the artists were David Lloyd, the popular Welsh tenor Robb Wilton, and Evelyn Laye.

Garden Talks

C. H. MIDDLETON'S Sunday talks, "In Your Garden," are a household word. His temporary absence from the microphone is to allow him to attend his numerous "Dig for Victory" engagements up and down the country.

"Radio Allotment," which alternates with "In Your Garden" on Sundays, started in 1942, when the Director of Outside Broadcasts, Michael Standing, and other members of his department, all of them equally ignorant of vegetable gardening, began to cultivate a plot of ground in a London square. They broadcast as they worked, under the expert eye of Tom Hay, formerly Superintendent of the Royal Parks. Some of the original team are away now. Tom Hay's son, Roy Hay, is in Malta, advising on the island's crops Vaughan Thomas is B.B.C. commentator in Italy.



T/Sgt. B. Weadlock, of New York City, chief announcer of a mobile radio station in Italy. He gives out the gags on the "Old Oaken Bucket" in an all-request programme for the entertainment of all allied Fifth Army men.

A Sensitive Signal Analyser

New Design Incorporating Inductance-compensation Giving a Level Frequency Response Up to Three Megacycles. By DOUGLAS BYRNE and COLIN E. BRIDGEWATER

MOST readers will agree that peculiar types of distortion head the list of radio faults, followed by the "intermittent" and the "low sensitivity/low selectivity."

If one is the possessor of a modulated oscillator and a "scope," it is not difficult to trace the source.

The analyser here described will form a useful substitute for the 'scope in diagnosing many obscure radio faults. It does not in any way supplant the 'scope in all its various applications, but will be found to take its place in very many wireless tests.

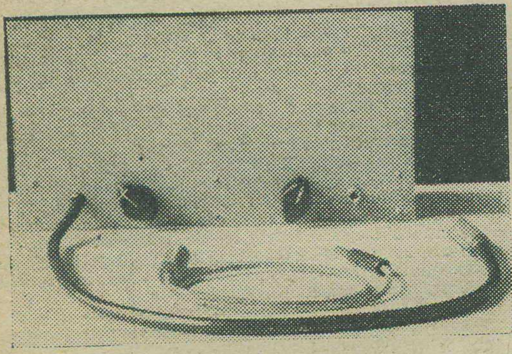


Fig. 1.—Front view of panel.

Everything must be completely screened to prevent unwanted pick-up. The input and output circuits of each valve should be kept well apart, and it is advisable to use a fairly long narrow chassis, so that R.F. input is at one end, and A.F. output at the other.

One advantage the analyser has over the oscilloscope is that it is much easier to manipulate. Instead of a multiplicity of knobs and switches, there are but two controls, a radio-frequency and an audio-frequency gain control.

The Circuit

The circuit is illustrated in Fig. 3. It will be seen to bear a close resemblance to a straight broadcast receiver, with three untuned radio-frequency stages. These latter are all resistance-capacity coupled, with inductance compensation. The component values were arrived at after considerable experiment with the Mazda SP41 valve, and give a flat response from 100 kc/s. to 3 mc/s. (3,000 metres to 100 metres). This frequency band covers all the intermediate frequencies, as well as the long and medium wavelengths. The anode load resistor is purposely made low (only 2,000 ohms) in order to minimise the deleterious shunting effect of stray capacities and the input capacity of the following valve. Even with such a low load, the losses at high frequencies would be severe, were it not for the small inductance of approximately 50 μh., wired in series with the anode resistor. This inductance is of such a value that it resonates with the stray capacities at a frequency just above the high frequency end of the wavelength coverage—thus actually giving a slight rise in amplification instead of a loss. However, the response drops sharply after this point of resonance is reached.

The chokes can be made in the workshop by simply winding approximately 90 turns on a ½in. cardboard former.

Valves

The analyser will often be called upon to trace very weak signals, so that considerable radio-frequency gain is required. Of course the gain is greatly reduced as a result of using such a low impedance anode load, and in order to make up this loss, valves of an exceptionally high mutual conductance are necessary. Here it was found that the Mazda SP41 ideally filled the bill, for it has a gm. of 8.5 as well as a high amplification factor. To maintain the level frequency characteristic of the amplifier at all settings of the gain control, the input capacity of the SP41 must be kept constant. For this reason, the circuit recommended by the manufacturers is used, with full negative bias applied to the suppressor grids and approximately one-seventeenth to the control grids. It will be seen that the radio frequency gain control consists of a potentiometer in the common cathode circuit of the R.F. amplifiers—it was found that three SP41's in cascade give adequate gain.

The detector is of the infinite impedance type, or cathode follower. Unlike most other types of detectors, the one used does not damp the previous stage at all, and yet has good signal handling properties and very high fidelity.

Next is a pentode audio-frequency amplifier, the variable grid leak acting as the audio-frequency gain control. Also fed into the grid of this valve is the A.F. probe, which is fully screened, and has a .1 megohm resistor at its tip. The beam tetrode output stage has 10 per cent. negative feedback applied via the fixed potentiometer, R27 and R28.

Layout.

Fig. 2 gives an idea of the layout of the analyser, with the R.F. input on the left, followed by the R.F. gain control, the A.F. gain control, and the jack for the A.F. probe.

The R.F. lead should preferably be low-loss co-axial cable of about 3ft. in length, but if co-axial is unobtainable, then heavy rubber covered cable can be used, provided it has a low capacity between inner conductor and outer screening. By the way, it must be thoroughly screened, right up to the end, which terminates in a small mica or ceramic condenser of 5 pf. One tag of this condenser forms the R.F. probe.

It is certainly worth while mounting a jack for the audio probe, in order to reduce any chance of unwanted

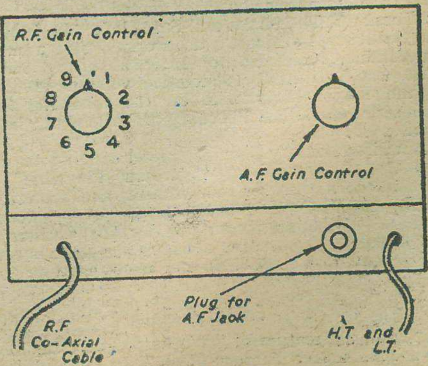


Fig. 2—Layout of controls.

pick-up of hum or mains-borne interference. Low-loss cable is not necessary here.

Any H.T. supply giving 200 or 250 volts at 60 m.a. and 4 volts for the heaters will be satisfactory. If one is not available, then a mains transformer and rectifier can be built into the apparatus, together with associate smoothing choke and condensers.

In the first place, keep the A.F. gain control at maximum when using the R.F. probe, and control the volume by means of the R.F. gain knob. This will result in reduction of valve noise, shot effect, etc., giving a clearer background. As the R.F. stages are not required when using the A.F. probe, turn the R.F. gain right down to reduce this va've noise.

The speaker in the set under test should be disconnected or short-circuited by some means or other. One method is simply to place a shorting wire across the grid leak of the output valve. It is not wise to short the primary of the output transformer, as the valve might be damaged through working under no-load conditions. If the fault is traced as far as the final stage, it will be necessary to keep the output valve and transformer in circuit. Therefore the speech coil circuit should be broken, and a load resistor wired across the transformer secondary to take the place of the coil impedance.

If a service oscillator is available with external modulation, this should be connected to the output from a pick-up, and the R.F. modulated with a first-class quality record. The quality of reproduction can be checked by connecting the input of the analyser direct to the output of the modulated signal generator.

Suppose that the receiver on the test bench is distorting, the stage in which this distortion is taking place can be quickly found by merely connecting the signal generator to the aerial terminal, tuning in the signal, and then running the R.F. probe along the receiver chassis—touching first grid and then anode of each valve.* If there is found to be no distortion up to the second detector (we take it that the set under discussion is a superhet), then transfer to the A.F. probe, not forgetting to turn the R.F. gain control to zero. Once the faulty stage is located, the actual component which is causing the trouble can often be determined by injecting the signal from the oscillator at the input to the stage, and touching the probe on various points.

If an externally modulated signal generator and gramo pick-up are not to hand, then the receiver can be tuned to the local station.

An excellent idea of stage gain can be obtained by sensible use of the probe, and for this purpose the R.F. gain control should be calibrated—preferably by means of a first-class signal generator. If this is not possible, then the gain knob should be marked from one to 10, which will be satisfactory for purposes of comparison.

If one is to hand, an output meter or A.C. reading voltmeter should be wired across the speaker transformer of the analyser. This can then be used in a similar manner to a slide-back valve voltmeter. The R.F. input to the set should be modulated with an audio note of fixed amplitude (400 or 1,000 cps.), and the R.F. control advanced until a clear indication is given in the output meter dial. The probe can then be changed from stage to stage, and the R.F. gain control altered each time in order to bring the meter needle back to the fixed datum line. The actual voltage gain per stage will be indicated by the difference in reading of the gain control knob.

Owing to the extremely small input capacity, the use of the analyser does not affect many circuits under test the only place where the attachment of the probe was found to cause any noticeable change in frequency being in the oscillator circuit of a superhet.

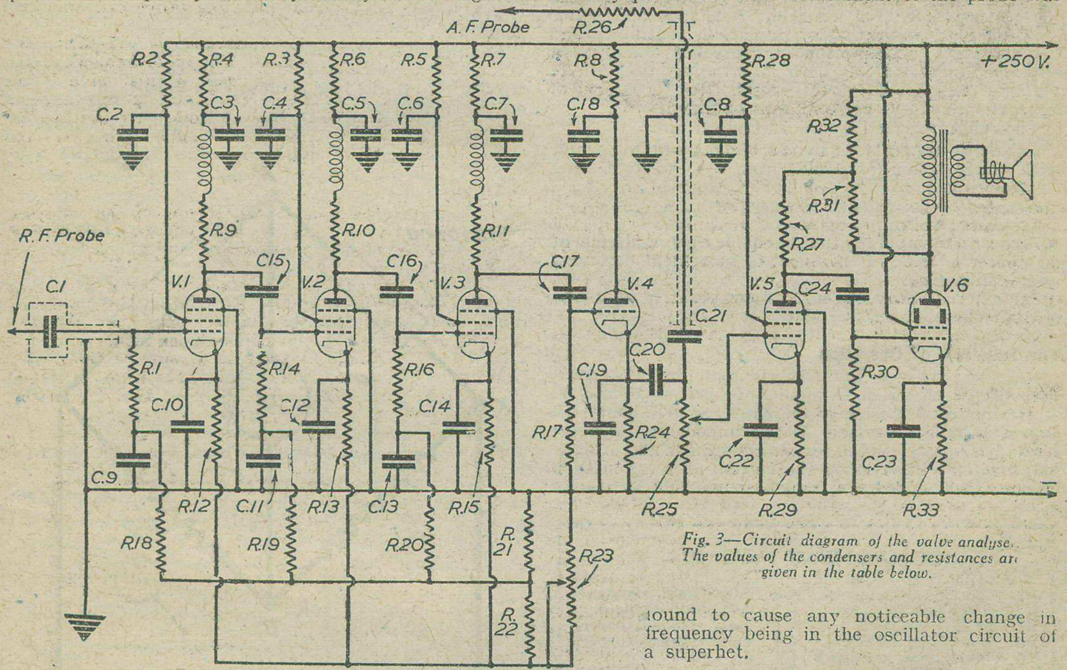


Fig. 3—Circuit diagram of the valve analyser. The values of the condensers and resistances are given in the table below.

COMPONENT VALUES

C1—5 pf.	C22—25 mfd.	R14, 16, 17—0.1 megohm.	R27—.25 megohm.
C2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13—0.1 mfd.	C23—50 mfd.	R18, 19, 20—50 k.ohms.	R28—1.5 megohms.
C15, 16, 17—.002 mfd.	C24—0.1 mfd.	R21—75 k.ohms.	R29—2 k.ohms.
C18—2 mfd.	R1—2 megohms.	R22—5 k.ohms.	R30—.5 megohm.
C19—.0003 mfd.	R2, 3, 5—20 k.ohms.	R23—20 k.ohms (pot.).	R31—50 k.ohms.
C20, 21—.05 mfd.	R4, 6, 7, 8—10 k.ohms.	R24—50 k.ohms.	R32—9 k.ohms.
	R9, 10, 11—2 k.ohms.	R25—.5 megohm (pot.).	R33—100 ohms.
	R12, 13, 15—100 ohms.	R26—.1 megohm.	

A General Purpose Test Bridge

Full Constructional Details

By JOHN JAY

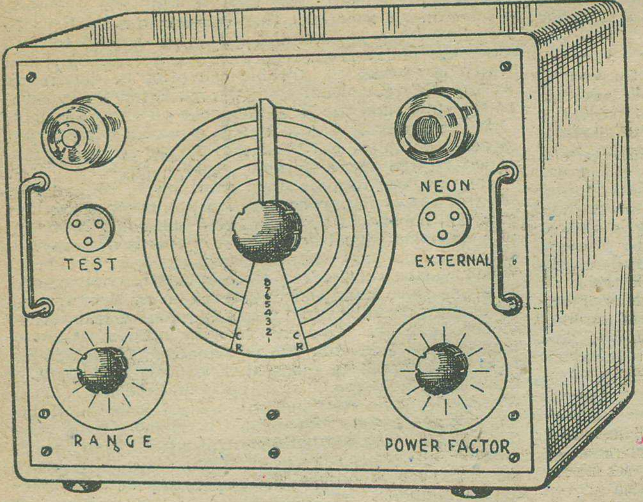


Fig. 2.—The completed instrument.

THIS bridge was designed and constructed for the measurement of capacity, resistance and power factor; indication of insulation, continuity and CR constants; comparison of components, and as a sensitive indicator of both alternating and direct voltages for A.V.C. circuit tests. An accuracy of approximately ± 5 per cent. was obtained.

The ranges covered by the instrument are:

Capacity—10 mmfd. to 10 mfd. and 0.4 mfd. to 40 mfd. with power factor (per cent.) from 0 to 50 for testing electrolytics.

Resistance—10 ohms to 10 megohms.

Insulation indication up to 400 megohms.

A control position is fitted to enable easy re-alignment of pointer or scale in the event of movement occurring after calibration.

An external position enables comparative measurements to be obtained.

The Principle of Operation

Referring to Fig. 1, T_1 is the bridge supply transformer, the voltage of which is applied to points X and Y. M is any suitable voltage indicator, St represents the standard impedance and T the impedance on test; R_1 and R_2 complete the remaining arms of the bridge.

If R_1, R_2 = St, T, then the currents flowing in each branch XAY and XBY, will be equal and if St = R_1 and T = R_2 then the potential difference across points A and B will be zero; thus M will read zero only when this condition is attained.

Substituting a potentiometer for R_1 R_2 and letting B be the moving arm will permit balance to be obtained for any value of T within the range of the bridge.

Say that T = 2St, then for a zero reading in M R_2 must equal $2R_1$, adjustment of the potentiometer could ensure this condition and its scale calibrated accordingly.

The Circuit

Fig. 2 shows the completed instrument and Fig. 3 the theoretical circuit diagram.

R_1 R_2 of Fig. 1 is R_6 in Fig. 3; St is chosen by switches S_1–S_8 T is placed across terminals. Test. M the indicating device is V_1, a cathode-ray tuning indicator the use of which enables sharp and easy observation of the balance condition.

Dealing with the bridge section first, T_1 supplies a voltage of approximately 70 v. via limiting resistances Ra and R_{10} to the bridge input. T_1 must be fitted with an electrostatic screen and this screen should be connected to the chassis of the instrument: inaccuracy,

COMPONENT VALUES

R1		C1	0.0001 mfd. standard.
R2	100 ohms standard.	C2	0.01 mfd. standard.
R3	10 K Ω standard.	C3	1 mfd. standard (paper)
R4	1 megohm standard.	C4	4 mfd. standard (paper)
R5	1,000 ohms standard.	C5	0.1 mfd.
R6	10 KΩ {Wire-wound potentiometer	C6	8 mfd. electrolytic.
		C7	8 mfd. electrolytic.
R7	See text.	L1	Smoothing choke.
R8	1,000 ohms standard.	T1	3 : 1 step-down (screened).
R9	1,000 ohms.		
R10	1,000 ohms.	T2	350-0-350, 4.
R11	5 megohms.	V1	TV4 Mullard.
R12	48 KΩ } See the text.	V2	UU4 Mazda.
R13	2 KΩ } See the text.	N1	Instrument neon (low voltage).
R14	1 megohm.		

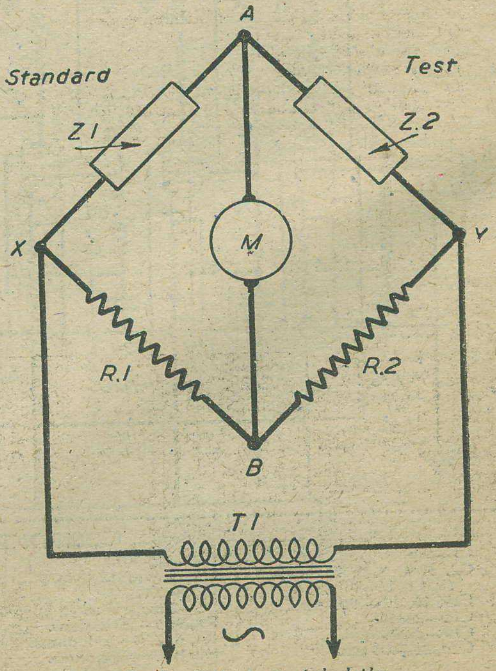


Fig. 1.—Basic circuit of the bridge.

especially on the lowest capacity range, will be noticeable if this is not done.

A direct potential of approximately 12 v. is applied to the bridge via S13 from the voltage drop across R13 to act as a polarising potential for electrolytic condensers.

The standards, a control resistance and terminals for external standards are switched into circuit as required. R8 in conjunction with S11 completes the control circuit.

V1, the tuning indicator, has its control grid and cathode connected via C5 and R11 respectively to the output from the bridge circuit. When the bridge is off balance an alternating voltage appears across its output and is fed to V1, a direct voltage appears across R11 due to the detector action of the valve's grid C5 and R11, thus the "eye" of the tuning indicator is closed (maximum light); when the bridge is balanced, its output and consequently the bias voltage across R11 will disappear, thereby permitting the "eye" to open.

The neon or insulation, continuity and CR constant test circuit is fed via S14 to the Ex terminals, and from these terminals to R7 and N, via Sa to H.T. negative.

Indicator position on the bridge enables the tuning indicator to become available for external use through the test terminals by connecting the grid of the tuning indicator via S12 to one of the test terminals and the cathode via S15 to the other "Test" terminal.

The power circuit consists of the usual transformer, full-wave rectifier and smoothing circuit. If block type condensers are used for C6 and C7 a line cord may be used in the heater circuit and direct connection made to the mains for the high-tension circuit, thereby saving the expense of transformer and rectifier.

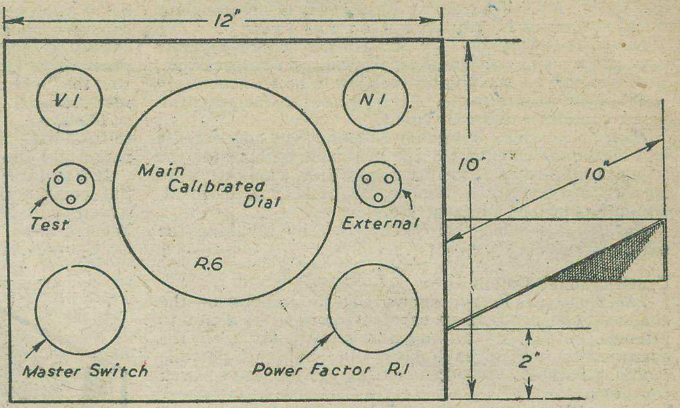


Fig. 4.—Chassis dimensions

The Master Switch

The master switch has 12 positions, e.g.—

(1) .00001 mfd.–.001 mfd.
(2) .00.1 mfd.–.1 mfd.
(3) .1 mfd.–10 mfd.
(4) .4 mfd.–40 mfd. with power factor (per cent.) indication from 0 to 50 for electrolytic condensers.
(5) 10 ohms–1,000 ohms.
(6) 1,000 ohms–100 k.Ω
(7) 100 k.Ω–10 megohms.
(8) External.
(9) Neon or Insulation.
(10) Control.
(11) Tuning Indicator
(12) Off.

Range 1—(0.00001 mfd.–0.001 mfd.)

S1 closes, thereby placing an 0.0001 mfd. (100 PF) across the St position.

Self-capacities existing in the wiring, omission of an electrostatic screen between the primary and secondary of T1, temperature changes, etc., will all contribute to affect the accuracy of this range. Balance may be obtained without a condenser plugged into T, this is not serious providing that balance occurs on the lowest capacity reading.

Ranges 2 *and* 3 (0.001 mfd.–0.1 mfd. and 0.1 mfd.–10 mfd.)

C2, a 0.01 mfd. standard condenser is switched in by S2 for Range 2; and C3, a 0.1 mfd. condenser by S3 for Range 3. No difficulty should be experienced with these ranges.

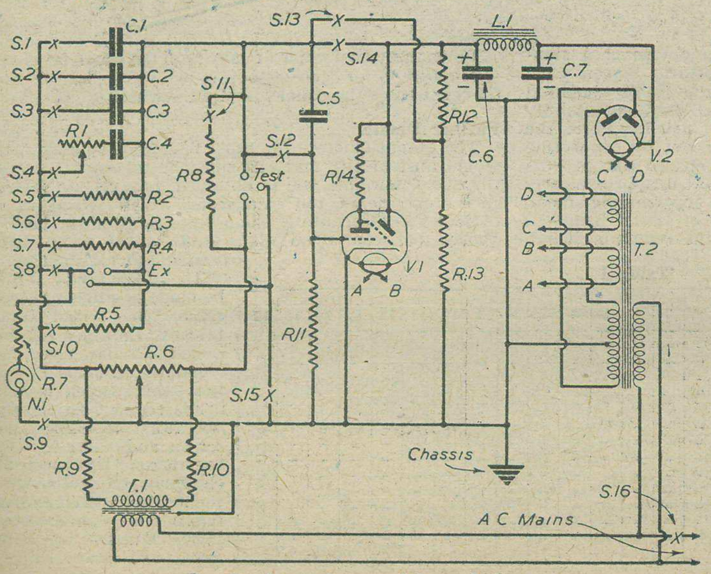


Fig. 3.—Circuit diagram of the test bridge.

Range 4.—0.4 mfd. to 40 mfd. and power factor (per cent.) from 0 to 50 for testing electrolytic condensers. C4 is a good quality paper condenser of 4 mfd. connected in series with R1, a 500 ohm potentiometer, and switched into the bridge circuit by means of S4. Approximately 12 v. direct potential is switched by S13 from the potential difference across R13 for polarising purposes, thus, the positive lead of the test prods must be marked for use on this range

Ranges 5, 6 *and* 7.—10 ohms to 1,000 ohms; 1,000 ohms to 100,000 ohms and 100,000 ohms to 10 megohms respectively, switched in by S5—Range 5; S6—Range 6 and S7 Range 7. If R9 and R10 overheat on Range 5, reduce the current through them by increasing their values, or, alternatively, increase their wattage rating.

Range 8.—External test.

S8 switches "external and neon" terminals into circuit, thereby enabling the use of an external standard and comparative measurements.

Range 9.—Neon. The full voltage of the power-pack is switched via S14 and S9 across "external and neon" terminals and the neon lamp with its safety resistance, R7. Continuity, insulation, C—R constant tests, etc., may be carried out on this range.

Range 10.—Control. R5 and R8 are switched across opposite arms of the bridge by S10 and S11 respectively, thereby enabling the pointer position to be set accurately in the event of movement of the pointer on the potentiometer spindle or dial movement.

Range 11.—Eye. Switches S12 and S15 connect the test terminals directly to the grid and cathode of the triode amplifier of the tuning indicator, enabling it to be used for any other purpose, i.e., A.V.C. adjustment, trimming, bridge, circuits, etc.

Position 12.—Off. S16 opens, thereby breaking the mains circuits.

Constructional Details

The Chassis.—Fig. 4 shows the dimensions of the chassis. The prospective constructor is advised not to attempt cutting or drilling the chassis until *all* the components needed have been obtained and possible modifications to the dimensions given have been considered.

The finished chassis was well braced with steel stays, which were drilled and tapped to facilitate chassis fixing to the cabinet, etc. See Fig. 5.

Wiring.—Screened cable was used in the bridge circuit, giving an improvement in range and stability of calibration upon the lowest capacity range. If the constructor uses screened cable great care must be taken to ensure that all screening is connected to the chassis and also, that screens are adequately insulated from all other points.

Wiring was carried out with No. 22 S.W.G. tinned copper wire insulated with 1 m.m. Systoflex, with the exception of main supplies and heater circuits, the latter being wired with 5 ampere flex.

The Master Switch

The master-switch has four banks operated from the same spindle. The stops on the location-plate of the switch were removed to permit complete rotation—twelve positions—to be obtained.

Figs. 6 (a), (b), (c) and (d) show full details of each bank, whilst Table 1 gives details of each switch operation for the twelve positions.

S1, S2, S3, S4, S5, S6, S7, S8 and S10 are located on Bank 1.

S9 and S15 are on Bank 2.

S12, S13, S14 and S11 are on **Bank 3.**

S16 is on Bank 4.

The Bridge Supply Transformer

Difficulty may be experienced in obtaining a **step-**down transformer with an electrostatic screen of a 3 : 1 ratio. A good quality inter-valve (radio coupling) transformer of 3 : 1 ratio may be used successfully provided an electrostatic screen is fitted. Place the inter-valve transformer obtained on test by connecting its *secondary* across A.C. mains to ensure that it does not overheat, etc., and that its output is approximately 70 volts. The laminations and the top winding should be carefully removed and a piece of tinfoil insulated with waxed paper wrapped round the remaining winding. Care must be taken to ensure that this screen is *not* a complete circuit, i.e., its ends must not touch; a bare copper wire has one end of the tinfoil wrapped round it and Systoflex placed on the piece of wire protruding from the screen; this connection is taken to the chassis when the transformer has been re-assembled.

The top winding is now carefully re-wound and re-insulated, the laminations re-inserted connections made and the completed transformer tested.

If a suitable inter-valve transformer is not obtainable, full constructional details with the exception of the screen can be found in "Wireless Coils, Chokes and Transformers" edited by F. J. Camm and published by George Newnes, Ltd. 5s. net.

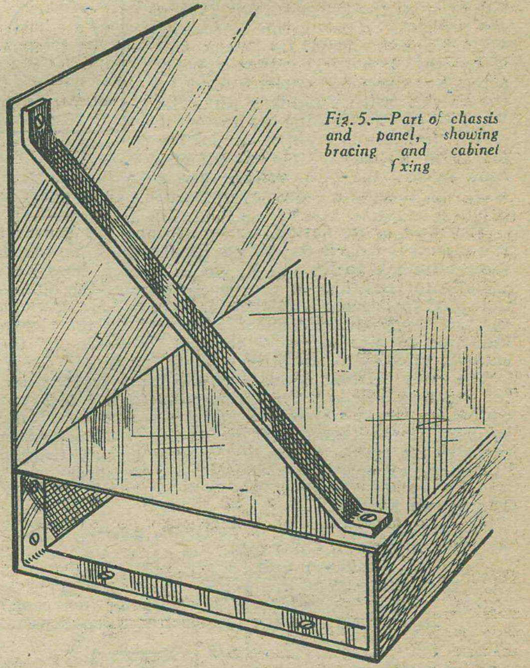


Fig. 5.—Part of chassis and panel, showing bracing and cabinet fixing

The mains transformer T1 may be of the usual type, i.e., 350–0–350 v. or 300–0–300, .4 v. .4 v. L1, C6 and C7 constitutes the usual smoothing circuit.

Further Details

The potentiometer, R6, must be a good quality wire-wound instrument, and care must be taken that a continuously variable one is obtained, i.e., certain instruments operate in 100 ohm steps, which would cause difficulty in ascertaining balance positions on the bridge. Values between 1,000 ohms and 50,000 ohms have been found satisfactory.

The test prods should be made of single screened cable, the screen being taken to the third pin and socket of the test and standard terminals. Ensure that this screen is fully insulated to prevent the operator touching the screen and a live test clip together. R7 must be chosen in conjunction with the neon tube used, to give maximum permissible glow. R12 and R13 must give 12 v. across R13.

Table 1

Position	Function	S→1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.00001 to .001 mfd.	Closed	–	–	–	–	–	–	–	–	–	–	–	–	–	–	C
2	.001 to .1 mfd. ..	—	C	–	–	–	–	–	–	–	–	–	–	–	–	–	C
3	.1 to 10 mfd. ..	—	–	C	–	–	–	–	–	–	–	–	–	–	–	–	C
4	.4 to 40 mfd. .. 0 to PF	—	–	–	C	–	–	–	–	–	–	–	–	C	–	–	C
5	10—1,000 ohms ..	—	–	–	–	C	–	–	–	–	–	–	–	–	–	–	C
6	1,000 ohms—100 KΩ	—	–	–	–	–	C	–	–	–	–	–	–	–	–	–	C
7	100 KΩ—10 megohms	—	–	–	–	–	–	C	–	–	–	–	–	–	–	–	C
8	External	—	–	–	–	–	–	–	C	–	–	–	–	–	–	–	C
9	Neon	—	–	–	–	–	–	–	–	C	–	–	–	–	C	–	C
10	Control	—	–	–	–	–	–	–	–	–	C	C	–	–	–	–	C
11	Eye	—	–	–	–	–	–	–	–	–	–	–	C	–	–	C	C
12	Off	—	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Calibration

The degree of accuracy obtained in calibration depends upon the stability of the circuit constants of the instrument, the accuracy of the standard condensers and resistances within the standard side of the bridge and the accuracy of the calibrating components. Every constructional detail should be completed before calibration is attempted.

A precision standard condenser and a decade box would be very desirable to ensure accurate calibration, but as these are beyond the attainment of most constructors, use must be made of the more easily obtainable but less accurate components.

Several methods of marking out the dial are available, such as the use of a degree scale and calibration charts, a ratio scale or a direct scale. The author used a ratio and direct scale, thereby preventing the use of tedious calibration charts and enabling direct comparison of any two components to be obtained. Before all calibration, set the master switch to Range 10—control—and mark the balance position.

The Ratio Scale

Set the master switch to Range 6 and connect a 10,000 ohm high accuracy resistance across the test terminals, balance should be obtained upon the line marked for balance on Range 10. Mark this point 1, i.e., unity.

Mark the points obtained with a 12,000 ohm, 14,000 ohm, 16,000 ohm, etc., 1.2, 1.4, 1.6, etc., respectively; also 8,000, 6,000, 4,000, etc., will be marked 0.8, 0.6, 0.4, etc., respectively.

Now set the master switch to Range 2 and connect a 0.01 mfd. high accuracy condenser across the test terminals. Balance should be obtained upon 1 (unity). Proceed as for the resistance ratio calibration with an 0.02 mfd., 0.03 mfd., etc., marking the scale 2, 3, etc., respectively, also 0.008 mfd., 0.006 mfd., etc., giving 0.8, 0.6, etc., respectively. Note that the resistance and capacity scales read in opposite directions.

These ratio calibrations will be good for all ranges including Range 8—external.

Direct Calibration

Range 1 may be calibrated with the use of ±5 per cent. padding condensers. Calibration will be found increasingly difficult as the capacity readings decrease, whilst the 100 P.F. test condenser will probably balance off the centre line due to self-capacities within the instrument.

Leave the apparatus on for at least 15 minutes before attempting to calibrate this range, thereby enabling a constant temperature to be attained.

Ranges 2 *and* 3 will be found quite easy to calibrate with the use of ±5 per cent. condensers, or better, if obtainable.

Range 4 must be calibrated for capacity first and then for power factor.

Set the power factor control to zero and calibrate the main dial with the aid of standard condensers connected to Test in turn, and their balance positions and values marked on the dial.

Short circuit the 4 mfd. test condenser within the instrument upon this range and proceed to calibrate the power factor scale as follows:

For the series case:

$$\text{P.F.} = \frac{R}{X_C} = \frac{R}{\frac{1}{wc}} \qquad \therefore R = \frac{PF}{\frac{1}{wc}}$$

thus, for 10 per cent. P.F. $R = \frac{1}{wc} \times \frac{10}{100}$ ohms

20 per cent. P.F. $R = \frac{1}{wc} \times \frac{20}{100}$ ohms.

Using a 4 mfd. condenser at 50 cycles per second.

P.F. = 10 per cent. = 79.61 ohms.
P.F. = 20 per cent. = 159.22 ohms.
P.F. = 30 per cent. = 238.83 ohms.
P.F. = 40 per cent. = 318.44 ohms.
P.F. = 50 per cent. = 398.05 ohms.

Place the main dial reading at unity, i.e., balance as indicated on Range 10—control, connect a 2,000 ohm resistance across test terminals and rotate the power factor potentiometer, R1 until balance is obtained, mark 1 on the power-factor scale. Proceed in this manner to the limits imposed by the potentiometer.

Ranges 5, 6 *and* 7.—Obtain balance with the highest accuracy resistances obtainable, and mark balance and values.

Range 10.—Balance should be obtained at unity providing R5 and R8 have been carefully chosen for equality. When values on test equal the internal standards balance should always occur at control balance position.

In the event of the constructor finding it difficult to calibrate the direct reading scale by the use of components, and provided that a ratio scale has been completed; he may transfer readings from the ratio scale to the direct scale, but a lower order of accuracy may result.

Using the Bridge

Checking the Value of a Resistance or Condenser.—Switch to the appropriate range, place the unknown resistance or condenser across the test clips and rotate R6 for balance; read off the value.

Testing an Electrolytic Condenser.—Switch to Range 4, and connect the condenser to the test clips, ensuring

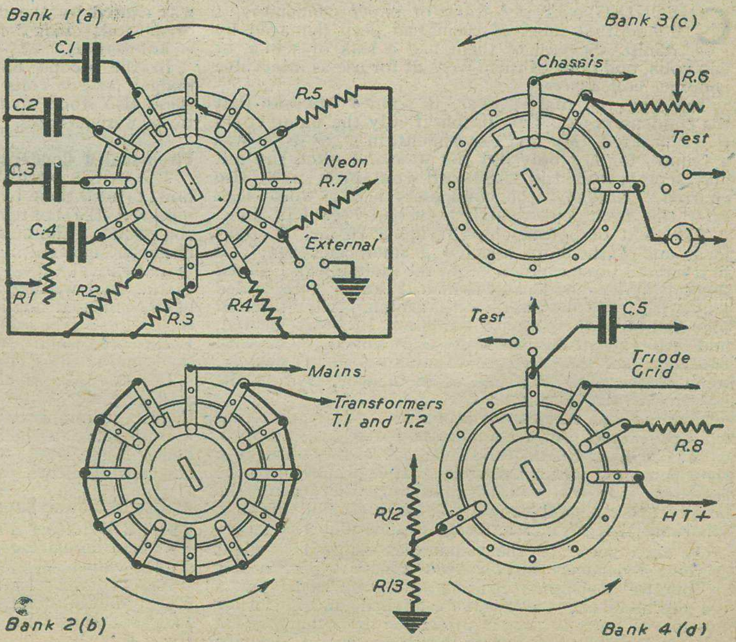


Fig. 6.—Diagrams showing connections for master switch banks (rear views).

correct polarity. Set PF control to zero and rotate the main control for balance, now rotate the PF control for clear-cut edges to the light in the tuning-indicator. Read off capacity from the main dial and power factor from the PF scale.

Finding the Capacity Range of a Variable Condenser.—Switch to Range 1, and connect the test clips to the variable condenser. Place the variable condenser at minimum capacity; the point of balance gives the capacity remaining in the condenser. Now set the variable condenser to maximum capacity, switch to the appropriate range and obtain the reading for maximum capacity.

Testing the Self-capacity Between Transformer Windings.—Switch to Range 1, and connect one test clip to primary and the other to secondary of the transformer under test. Read off the capacity at balance position.

Insulation Tests.—Switch to neon, and connect the condenser, etc., to the "external" clips. The neon should not strike. If a condenser of above 0.1 mfd. 350 v. working is to be tested, flashes will occur in the neon, the duration of the spaces between the flashes indicating the insulation of the condenser, i.e., a 0.1 mfd. condenser flashes the neon once per second, thus its insulation is:

$$CR = t \text{ seconds}$$

$$R = \frac{\text{seconds}}{c} = \frac{1}{\frac{0.1}{10^6}} = \frac{10^6}{0.1}$$

$$R = 10{,}000{,}000 \text{ ohms.}$$

A continuous glow in the neon tube indicates leakage.

Care must be taken to avoid placing a condenser with a voltage rating below 350 volts working, across a neon test, otherwise the condenser may be damaged.

Continuity Tests.—The neon will glow if a continuous circuit is connected across the "external" clips upon Range 9—neon.

Calibrating a Potentiometer (1 megohm).—Switch to Range 7, or the resistance range concerned, and connect the centre and outside terminals of the potentiometer to the test clips. Set the main control of the bridge to the first value it is desired to calibrate, adjust the *potentiometer* for balance and mark the value upon the potentiometer's scale. Proceed in this way until calibration is complete.

The same procedure may be adopted for the calibration of a variable condenser.

Comparing Two Components.—Switch to Range 8—external—and place one component across the "test" clips and the other across the "external" clips. Rotate the main control for balance and obtain the reading from the ratio scale, i.e., say a reading of 2 : 1 is obtained then the condenser or resistance on "test" is twice as large in value as the one on "external."

The Use of "Control."—In the event of calibration being lost, due to slipping of knob, pointer or scale, switch to control—Range 10, and adjust R6 to give balance when the pointer shows unity upon the scale.

Using the "Eye" Position.—The tuning-indicator may be used to show alternating or direct voltage by switching to Range 11. When used with A.C. a 0.1 mfd. condenser should be inserted in the test clip going to the grid of the triode amplifier of the tuning-indicator.

A.V.C. circuits may be checked, receivers trimmed, experiments with other bridge circuits, etc., carried out upon this position.

Hundreds of other uses may be found for this instrument, only a few being suggested in this work. When using "neon" test ensure that the "test" leads are disconnected from the instrument, otherwise damage may occur to the main potentiometer.

Reclaiming Leaky Tubular Condensers

A Simple Method of Treating Wax-sealed and Pitch-sealed Condensers. By P. B. STEARN

CHECKING over my stock of paper condensers, I found that most of them had been damaged by damp. Several of them had a leak of 5 m.a. at 200 volts, and none of them were fit for use as intervalve coupling condensers.

Thinking the matter over, it seemed obvious that the condensers would be usable if only the damp could b evaporated. My first experiment, in a gas oven, was a failure, for not only did the wax and pitch run out and scorch, but the cardboard containers were also charred. Actually, the condensers had a worse leak after this treatment than if they had been left alone.

The sight of potato chips frying gave me the right idea, and I therefore selected a small saucepan, and in it melted three candles. Into the molten wax I placed several faulty condensers which I knew were sealed only with wax, and contained no pitch. After three or four minutes of energetic bubbling, the wax cleared, and after five minutes more, I removed them with tweezers. Only one unexpected thing was noted, namely, some of the wire ends had come unsoldered from the foil, due to the intense heat.

None of the cases were scorched, and the lettering was still intact. After cooling, they were again dipped, to seal off from the air, and soft wax was moulded into the open ends where necessary. It is worthy to note however, that the wax becomes very dirty after the boiling process, and should not be used for dipping, otherwise the original lettering is unreadable.

On test, some of the condensers showed a slight decrease in capacity, but on a 500-volt "Megger" nearly an infinite resistance reading was obtained. On a We rite analizer, 500-volts were applied, and no visible amount of current flowed after the first charge. On investigation, it seemed that the slight loss of capacity was caused by the disintegration of the outside layers of the foil. This defect arises in only a few cases, and is not serious.

In the second batch, I included several American midget .05-200-volts working types. After treatment, these also stood up to 500-volts test! Out of 35, only three were failures.

Pitch-sealed Condensers

The British pitch-sealed types were rather a problem, but I opened them by cutting the cardboard with a knife, removed the contents, and discarded all the sealing compound. The actual condenser was then cooked by itself, and encased in a 9-inch strip of paper immediately upon removal. These strips can be written upon or typed, as the final waxing affects neither. If the condensers have been used previously, and the wires are too short fresh wires can be soldered to the foil during the operation. Resin-cored solder without additional flux should be used, and nothing else.

For the sake of curiosity, I left two of the finished articles under water for three days. No difference in their performance was noted.

In conclusion, I might add that this process is very handy these days, as most of the condensers sold as new are old stock and leaky.

A Useful Power Supply

REFERRING to Fig. 2 of our article under the above heading on page 271 of our June issue the following are the valves:—

A1, 14 mfd. electrolytic; C2, 14 mfd. electrolytic; R3, 2,700 ohm; R4, 500,000 ohms; R1, 20,000 ohms; R2, 3,000 ohms; R5, 220,000 ohms; R6, 220,000 ohms; R7, 1,800 ohms.

Wartime Civilian Receivers

FIRST releases of the new wartime civilian receivers are likely to be made in the near future according to a statement just issued by the Radio Manufacturers' Association. A quarter of a million sets (175,000 A.C. Mains, 75,000 Battery) are to be made during the next twelve months by radio set manufacturers, all using the standard designs evolved by the Radio Manufacturers' Association in collaboration with the Board of Trade. Distribution on a national scale is to be carried out through the normal trade channels, and the sets will be retailed at the following prices, inclusive of purchase tax: A.C. model, £12 3s. 4d.; Battery model, £10 19s.

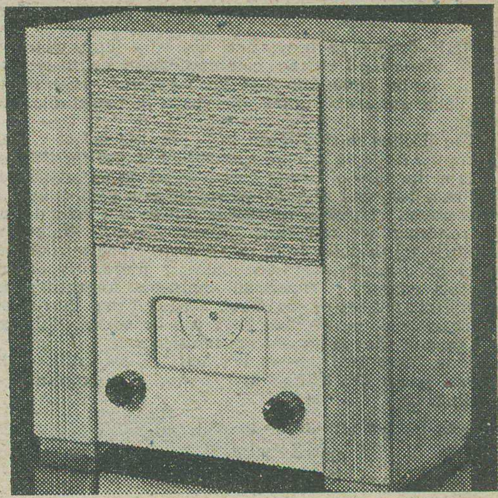
Here is the text of the Association's statement:

The wartime civilian receivers are the result of protracted negotiations between the industry, represented by the Radio Manufacturers' Association, the Board of Trade, on behalf of the Government, and the B.B.C. The Government gave very full consideration to evidence of the acute and growing shortage of wireless sets, due both to obsolescence and to the inevitable wartime limitations of repair facilities and spares.

The Government's desire was that the civilian listening audience should be, as far as possible, maintained. This has been partly achieved by the release of valves and components for repair work and by the trade's efforts in maintaining sets in service very much beyond their normal life. As a further contribution, the Government authorised the release of sufficient material for the production of 250,000 standard domestic receivers to be made and sold under conditions agreed between the industry and the Board of Trade.

The firms who are taking part in the plan were manufacturing radio sets before the war, but since the production of these sets has been planned as an industry effort, the names of individual manufacturers will not appear on them. The radio manufacturers are so fully occupied with essential production for war purposes that it is only by the collaboration of all concerned in this way that the manufacture of sets for civilian use has been made possible at all, and the manufacturers have to fit the production of these sets into their factories as and when the demands of high priority war production will allow.

Although both sets have been designed on "economy" lines in order to make the least demands on the limited materials and labour available, performance in each case is well up to the standard of the typical popular-priced superhets f before-the-war. The principal differences are that they cover only the medium wavebands (200 metres to 560 metres) and a very simple type of tuning scale is used on which the Home and Forces programmes are indicated by name.

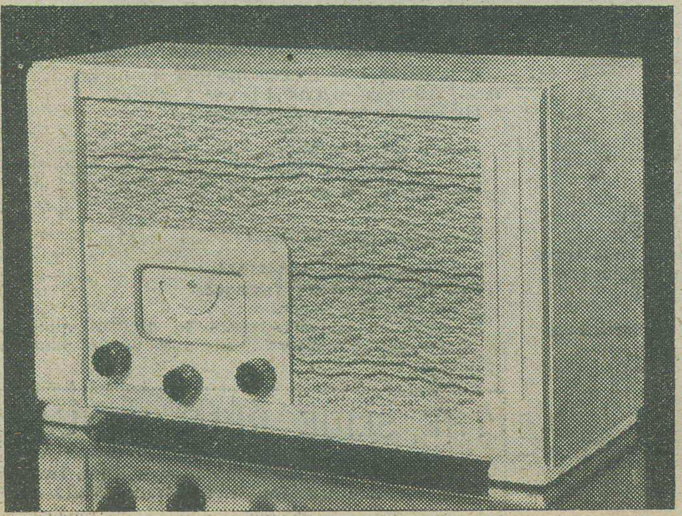


A.C. mains model.

The A.C. model (195-250 v., 50 cycles only) uses a three-valve (plus rectifier) circuit, with frequency changer, I.F. stage, Westector and pentode output, and delayed AVC is incorporated. No D.C. version is to be made. The two-volt valves used in the battery set are frequency changer; I.F.; double-diode triode giving AVC and L.F. amplification, and pentode output, and the set has been designed to work with any standard 100 or 120 v. H.T. battery.

Both sets, including valves (but excluding batteries and accumulators) are guaranteed for a period of three months against faulty materials and workmanship.

Prices, both to the trade and the public, will be controlled by a Maximum Price Order to be issued by the Board of Trade.



Battery model.

Distribution

The Board of Trade have asked the Radio Manufacturers' Association to ensure national distribution of the wartime civilian receivers, which are intended to maintain the level of civilian listening in this country, and all possible care will be exercised to secure the fairest distribution of the supplies available and to pay due regard to the needs of those who are completely without radio.

As indicated earlier, the radio manufacturers are so occupied with war production of the highest priority that the full quantity of 250,000 sets is likely to take a year to complete. This means that the monthly output will be comparatively small, and present information suggests that the bulk will not be available until the latter part of the year.

Introduction to the Decibel and the Neper

An Explanation of Two Units Used in Communication Engineering

By C. HEYS

THE decibel (abbreviation db) is a unit which is much used by the communication engineer, and has the advantage that it can express conveniently the large ranges of power met with in communication work.

The decibel is one tenth of a bel, the bel as a unit being too large, it is more convenient to use the decibel. It is a measure of power ratio, based on logarithms to the base ten, and may be expressed as a gain or loss; it does not express absolute values, but by having a datum of reference we can thus express absolute values in decibels, up or down from this datum. The zero output level of 1 milliwatt in 600 ohms is frequently chosen in this country. American engineers frequently use 6 milliwatts in 600 or 500 ohms. The fact that the decibel is logarithmic means that they can be added, although the powers they represent are multiples.

If we have two powers W_1 and W_2 the gain of the second power W_2 on the first power W_1 expressed in decibels is

$$\text{Gain in decibels (db)} = 10 \log_{10} \frac{W_2}{W_1}$$

Decibel Table

Power Ratio	Decibels
100,000 : 1	Gain 50
10,000 : 1	,, 40
1,000 : 1	,, 30
100 : 1	,, 20
10 : 1	,, 10
5 : 1	,, 7 (approx.)
1 : 1	,, 0
1 : 10	Loss 10
1 : 100	,, 20

Expressing Voltage and Current Ratios in Decibels

Although the decibel is used as a relation of power, it can also express voltage or current ratios. If the input and output resistances are equal the power ratio will be proportional to the square of the voltage or current ratio as shown below:

Let $W_2 = I^2_2 R \qquad W_1 = I^2_1 R$

Therefore the db gain of W_2 on W_1

$$= 10 \log_{10} \frac{W_2}{W_1} = 10 \log_{10} \frac{I^2_2 R}{I^2_1 R}$$

As the input and output resistances are equal.

$$\text{Gain in db} = 10 \log_{10} \frac{I^2_2}{I^2_1}$$

$$= 20 \log_{10} \frac{I_2}{I_1}$$

It can also be similarly shown that, as

$$W_2 = \frac{V^2_2}{R} \text{ and } W_1 = \frac{V^2_1}{R}$$

$$\text{Gain in decibels of } W_2 \text{ on } W_1 = 20 \log_{10} \frac{V_2}{V_1}$$

The above only holds good in the case of equal input and output resistances. If the input and output resistances are unequal the following is obtained:

Expressed as Current Ratios with Unequal Resistance

Let $W_2 = I^2_2 R_2 \qquad$ and $W_1 = I^2_1 R_1$

Gain in db of W_2 on W_1

$$= 10 \log_{10} \frac{I^2_2 R_2}{I^2_1 R_1}$$

$$= 10 \log_{10} \left(\frac{I_2}{I_1}\right)^2 + 10 \log_{10} \frac{R_2}{R_1}$$

$$= 20 \log_{10} \frac{I_2}{I_1} + 10 \log_{10} \frac{R_2}{R_1}$$

Expressed as Voltage Ratios with Unequal Resistances

$$W_2 = \frac{V^2_2}{R_2} \qquad W_1 = \frac{V^2_1}{R_1}$$

Gain in db of W_2 on W_1

$$= 10 \log_{10} \frac{V^2_2 / R_2}{V^2_1 / R_1} = 10 \log_{10} \frac{V^2_2 R_1}{V^2_1 R_2}$$

$$= 10 \log_{10} \left(\frac{V_2}{V_1}\right)^2 + 10 \log_{10} \frac{R_1}{R_2}$$

$$= 20 \log_{10} \frac{V_2}{V_1} + 10 \log_{10} \frac{R_1}{R_2}$$

as $\frac{R_1}{R_2} = \left(\frac{R_2}{R_1}\right)^{-1}$ the above can be written as—

$$\text{db Gain} = 20 \log_{10} \frac{V_2}{V_1} - 10 \log_{10} \frac{R_2}{R_1}$$

Example

Calculate the current in a 600 ohm resistance in which the power dissipated is 6 db above 1 mW.

$$\text{Gain } 6 \text{ db} = 10 \log_{10} \frac{W_2}{W_1}$$

$$.6 = \log_{10} \frac{W_2}{W_1}$$

$$\text{or } 10^{.6} = \frac{W_2}{W_1} = \frac{W_2}{1}$$

Therefore $W_2 = 10^{.6}$ mW $= 3.981$ mW.

The current flowing in the 600 ohm resistance—

$$W_2 = \frac{3.981}{1,000} = I^2 R$$

$$\therefore I = \sqrt{\frac{3.981}{6 \times 10^5}} = .002575 \text{ amps.}$$

$= 2.575$ mA

The Neper

On the Continent the power ratios are generally based on natural or naperian logarithms to the base and the gain or loss of two powers W and W_2 expressed in nepers is given by—

$$\text{Gain of } W_2 \text{ on } W_1 \text{ in nepers} = \tfrac{1}{2} \log_e \frac{W_2}{W_1}$$

Relation Between the Neper and the Decibel

It is possible to convert decibels to nepers or vice versa, the proof of this is below.

The equivalent of 1 db in Nepers.

$$10 \log_{10} \frac{W_2}{W_1} = 1 \text{ db}$$

$$\text{Therefore } \frac{W_2}{W_1} = 10^{.1} = .1$$

$$N = \tfrac{1}{2} \log_e \frac{W_2}{W_1} = \tfrac{1}{2} \log_e .1$$

$$= \tfrac{1}{2} \times 2.303 \times .1 = 0.11515$$

Therefore 1 db $= 0.11515$ nepers or 8.686 db $=$ 1 Neper.

Therefore to convert nepers to decibels multiply by 8.686 and to convert decibels to nepers multiply by 0.1151.

An 0-v-0 S.W. Receiver

A Simple Battery Model. By A. JOTCHAM

Circuit

THE circuit (Fig. 1) needs little explanation. A simple leaky grid detector stage, using a high slope valve, a small semi-variable condenser (of the stamp type) in the aerial, and three four-pin plug-in coils are used, covering 11–100 metres, band spread tuning, .00016 mfd. band set condenser, 15 mfd. band spread, a .00015 mfd. or .0002 mfd. for reaction, mounted on a bracket on the left-hand side of the chassis.

Construction

The chassis (Fig. 2), measuring 10in. x 8in. x $2\frac{1}{2}$in. is of the inverted box type and can be constructed

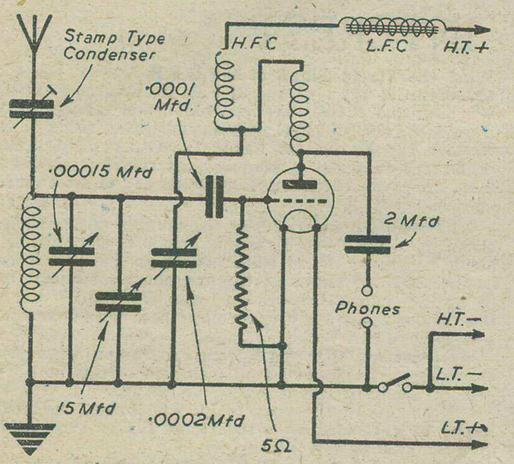


Fig. 1.—Circuit diagram.

from plywood and covered with perforated zinc. The perforated zinc provides efficient earthing connections, it can be painted or left plain. The panel, measuring 10in. x $7\frac{1}{2}$in. x $\frac{1}{8}$in.–$\frac{1}{4}$in., can be cut from $\frac{1}{8}$in.–$\frac{1}{4}$in. ply provided one side is free from joins. The panel can be given a coat of light or dark varnish; this tends to make the panel more rigid. The panel is fitted to the chassis with small brackets. The chassis construction should be completed before the panel brackets are fitted.

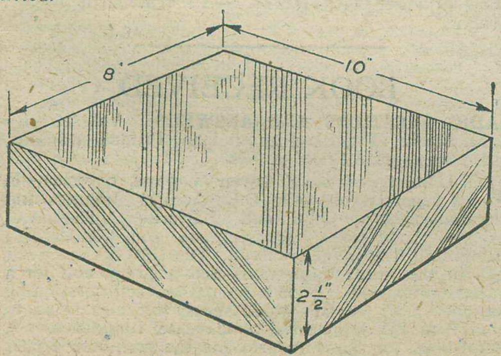


Fig. 2.—Details of the chassis.

Layout

The general layout (Fig. 3) viewed from the back. The valve and coil holders are mounted side by side for short wiring. The band set condenser is on the right and the band on the left. The reaction condenser is mounted on a bracket on the side of the chassis. The

COMPONENTS.

- One aerial condenser, stamp type (Eddystone, Bulgin, Raymart).
- Three S.W. coils, 4-pin (Raymart, 11-25, 22-45, and 44-100 metres.)
- One .00016 var. condenser (Raymart).
- One 15 mfd. var. condenser (Raymart).
- One .00015 or .0002 var. condenser (Raymart (Premier .00015.))
- One H.F. choke (Bulgin, Raymart).
- One L.F. choke (100 h., 6 milamp.) (Lissen, Hi.Q., Telsen, Varley, Bulgin).
- Two 4-pin S.W. valve holders (Eddystone, baseboard type).
- One .0001 fixed condenser (T.C.C., Lissen, etc., Dubilier).
- One 5 meg. grid leak (Dubilier, T.C.C.).
- One "Utility" dial (Raymart).
- One dial for reaction condenser (Raymart, Bulgin, etc.).
- One dial and knob for band set (Eddystone, Bulgin, Raymart).
- Two spade terminals ("Clix," etc.).
- Two wander plugs ("Clix," etc.).
- Quarter pound 18 s.w. tinned copper wire.
- Two yards Systoflex.
- Screws, etc.
- One valve (Mullard PM2HL, or similar).
- One pair headphones (B.T.H., Browns, etc.).
- One 2 v. accumulator (Exide).
- One 120 v. or 100v. H.T. battery (Drydex, G.E.C.).

grid condenser and grid leak should be of the wire end type. The L.F. choke and 2 mfd. condenser are on the left. The on and off switch and the 'phone plug are mounted below the chassis. The panel layout, Fig. 4.

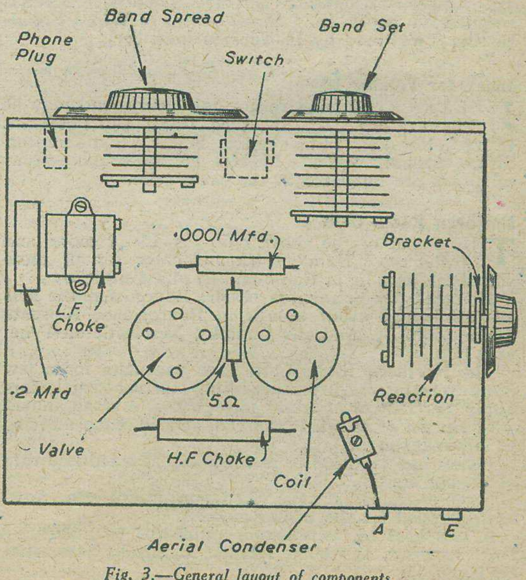


Fig. 3.—General layout of components

Note

The marking out of the panel should not be done before the slow-motion drives for the band set and band spread are on panel.

Operation

Check over all wiring, connect up aerial and earth, H.T. and L.T. batteries; plug in a Mullard PM2HL or similar valve, and the 40 metre coil. With the reaction condenser set at zero and the band set condenser at max. capacity (all vanes in) switch on and advance reaction condenser until a "breathing" sound is heard; tuning in on short waves needs to be done more slowly than on the broadcast bands, as the tuning is more sharp. With the receiver gently oscillating rotate the band spread condenser till you hear a whistle or carrier wave, slacken off the reaction condenser a little, then speech or music should be heard; a little retuning may improve it. A few hours spent with the Rx will soon remove any faults that the new operator may experience at first.

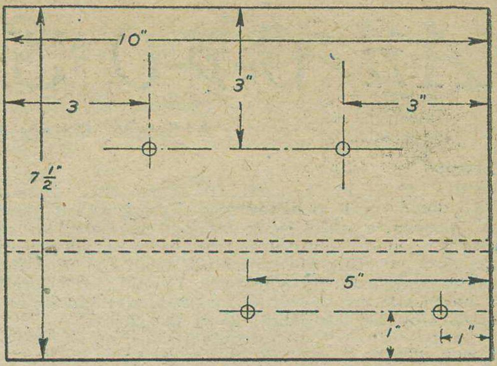


Fig. 4.—The panel layout.

NOTES OF INTEREST

Colvern Coils—Data Required

CORPORAL D. J. HARVEY, of "Hamilton House," Park House, Bricket Wood, St. Albans, would be grateful to any reader who could send him drawings of the connections for the Colvern Coils K41, K42 and K63.

* * *

Mullard Valves—Wartime Equivalents

THE Mullard Valve Co., Century House, Shaftesbury Avenue, London, W.C.2, have just published a second edition of their booklet giving the recommended alternatives for Mullard Valve types now out of production. The first edition was rapidly absorbed by the trade. They found it useful in enabling them to deal with valve replacements in some of the older types of receiver. This second edition brings the information up to date. Copies will be sent to any trade reader upon request.

* * *

B.I.R.E. Meeting

AT a meeting of the British Institution of Radio Engineers (London Section members), held at 11, Upper Belgrave Street, London, S.W.11, recently, a paper on "Development of Wired Broadcasting" was read by P. Adorjan (member).

* * *

Index for Volume 19

INDEXES for Volume 19 are now ready, and may be obtained for 10d. by post from The Publisher, George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Indexes for all volumes from xi to xix are available at the same price.

* * *

Northern Radio Club

THE object of the above club is to promote and foster the "Ham" spirit and cater for all those whose interests lie in Radio and its allied subjects.

It meets (by permission of Mr. Bourgogne) the first Wednesday of every month in Bourgognes, Newgate Street (opp. St. Andrews Church), Newcastle-on-Tyne, at 7 p.m.

The Northern Radio Club have vacancies for a few more members. Anyone wishing further particulars apply secretary or assistant secretary. A small annual subscription of 3s. 6d. is charged, and 6d. each meeting to cover expenses.

Forces are admitted to membership at a reduced rate of 2s. per annum.

Lectures, morse classes, discussion groups, etc., have been planned for the winter months.

A newsheet of activities is published irregularly.—D. G. LUCAS 9, Dewhurst Terrace, Sunniside, Newcastle-on-Tyne.

What the Forces Think of the G.F.P.

SINCE the start of the G.F.P. in February of this year the B.B.C. has received nearly 24,000 letters from members of the Forces serving in all parts of the world. The Forces, for whom the G.F.P. is designed, praise the material it contains, as their letters show. Here are typical extracts from some of the most recent ones :—

"I have been surprised by the number of complaints about the new G.F.P. I cannot agree with the complaint about too many News Bulletins which I have noticed in the Radio columns of English newspapers sent out to me. Servicemen overseas, who can only listen to the radio spasmodically, appreciate these news bulletins." —A Sergeant in India Command.

"I must say that the Forces Programme in general is greatly appreciated by all members of this mess."—A Sergeant in the R.A.F.

"I am one of the very many who have been made happy by the merging of the Home Forces Programme and the G.O.S."—A Stoker.

"I enjoy the programmes very much and more so now that we are listening to what our folk are hearing at home."—A Radio Officer in the Merchant Navy.

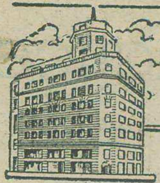
"We are five sergeants of a small unit in Corsica and like most fellows out here, the high spot of the day is listening to 'Forces' Favourites' and other similar programmes."

"When that signature tune of 'Forces' Favourites' is heard on our loudspeaker all the boys sit up and take a bigger interest in life. It may be hard for some people at home to imagine how it is that a few records help injured soldiers along the road to recovery, but I know for a fact that this is so."—A Private of the Eighth Army.

BOOK RECEIVED

RADIO QUESTIONS AND ANSWERS. Vol. 1. By E. M. Squire. Published by Sir Isaac Pitman and Sons, Ltd. 83 pages. Price 5s. net.

VOLUME 1 consists of seven chapters, covering—in a general sense—the D.C. Circuit; Magnets and Electromagnets; Cells and Batteries; The A.C. Circuit; Inductance, Transformers and Condensers; Meters and Thermionic Valves. The subjects are dealt with in the form of questions and answers, and for a student preparing for an examination, self-questioning not only finds out his weak spots, but also helps to strengthen his knowledge and create confidence. A useful book for those undertaking the preliminary part of a radio training.



ON YOUR WAVELENGTH

By THERMION

Training the P.O. Engineer

A STRIKING memorandum on the training of Post Office engineering staff has been presented to the Post Office Training Committee by the Post Office Engineering Union. Its main points are as follow:

"It cannot be too strongly stressed that there are dangers inherent in a system of training of which the sole aim is to provide a sufficiency of highly skilled technicians and which has no function of stimulating interest in wider fields of human activity."

This warning is coupled with a plea for every encouragement to be given to further general education in a memorandum submitted by the Post Office Engineering Union to the Post Office Training Committee. This Trade Union represents over 47,000 workers in the minor non-clerical grades of the Engineering, Stores and Factories Departments of the Post Office.

Rapid revolutionary advances in telecommunications in recent years have created a demand for an entrant with a higher standard of general education than hitherto, and emphasise the need for continued technical education side by side with practical experience. The Union voices a demand that, in addition, regulations should be relaxed to permit young workers in the Post Office to enter in their private capacity into the industrial social and political life of the community.

"The clear aim of a scheme of training should be to provide competent personnel who are, at the same time, no less competent citizens. They should, therefore, be trained for the job they are to do within the context of a wider social concept."

Existing conditions of recruitment and training are criticised. "There appears to be no close adherence to an accepted standard of attainment for prospective entrants into the Service."

"Little regard appears to be paid to the temperamental fitness of a candidate."

"The intake bears no relationship to long-term requirements."

"The training schools are staffed by men who, although capable at their own jobs, have no background of teaching experience."

"The pay and status of instructors are too low to bring out the best men for the job."

Complaint is made that the training is too intensive. Many lads are bewildered by the amount of theory crammed into them in a few weeks' course in the central training schools, while training at evening schools imposes too great a strain on youths who have already worked a 48-hour week. The Union recommends that during the growing period working time should be reduced to about 40 hours a week and evening study should be abolished.

No endeavour is made to provide any training in administration, so that many technically well qualified supervisory officers lack the qualities necessary to evoke the confidence and loyalty of their subordinates.

The Union proposes the establishment of a Departmental Training Committee to operate a new scheme of training under the following categories: Continued General Education; Basic Technical Training; Specialised Technical Training; Training in Administration; Refresher and Correspondence Courses and Further Education.

The Committee should also be charged with the framing of the welfare policy of the Department which should supervise the physical welfare of its staff up to the age of twenty.

A Much Travelled Set

I WAS interested to receive from a captain in the R.A.C. an account of the travels of a Mullard receiver, which he purchased in June, 1941, from an agent in Alexandria. This set went straight to the Western Desert to Mersa Matruh. It travelled in a 15 cwt. truck over the most atrocious ground; it visited Benghazi and Antelat in the 1941 November advance, and it retreated to the East of Tobruk. After being bounced about in the truck for about 6,000 miles, in May, 1942, it travelled from Tobruk to Cairo, Palestine, and then to Baghdad. From there it went to Basra. A further 1,000 miles to Tehran. It returned by road to Baghdad, Palestine, and Cairo. Recently it crossed the Mediterranean and is now in Italy. It has never once failed to operate, and not even a valve has been replaced, although it has been in use every evening. Certainly a receiver which is worth its weight in oranges!

Jitterbugging

BASIL HENRIQUES, chairman, East London Juvenile Court, when addressing a Children's Moral Welfare Committee recently on the subject of the child delinquent, said: "They suffer from the effects of listening, through the microphone, to wild, raucous, jitterbugging noises, called music. Jitterbugging is only a sex exciter for negroes."

Basil Henriques has the same point of view as your scribe. The sooner crooning and jazz bands and the music racket is abolished the better.

Sir Miles Thomas on the Brains Trust

AT a recent Roadfarers' Club luncheon, Sir Miles Thomas referred to the Brains Trust as "... these æsthetic mental acrobats, who inflict their attenuated opinions on us, via the B.B.C. Brains Trust," which seems to epitomise my views of the Brains Trust.

"CLOSED DOWN FOR THE DURATION."

["Thermion" has informed readers, with relief intermingled with regret, that owing to severely depleted staff, due to war conditions, the editor has been compelled to suspend PRACTICAL WIRELESS Advisory Service, and whilst the labour situation remains as it is, queries may not be addressed to it any longer.]

The editor has gone on strike,
  And not without good reason,
Against the folks who worry him
  Both in and out of season
To answer questions.
  What a frightful bore,
When he has answered them
  A thousand times before!

Most readers know we are at war—
  By which his staff's depleted.
One man cannot do six men's work—
  This fact must be repeated.
Refrain from queries,
  You really must and can, sir.
He's through whilst things are as they are,
  He's got no time to answer.

"TORCH."

Our Roll of Merit

Readers on Active Service—Forty-fourth List

H. Johnston (Cpl., A.F.S.).
H. J. Daley (Sgt., R.A.F.).
J. Still (Sigmn., R.C.S.).
S. Green (Gnr., Home Forces).
G. S. Taylor (Tpr., R.G.H.).
J. Thomason (Cpl., R.A.F.).
C. J. Mabbott (Cfn., R.E.M.E.).
W. Harvey (Cpl. R.A.F.)

Aerial Principles and Practice

The First of a Short Series of Articles in which the Most Important Aspects Dealt with in General Terms in Last Month's Article Entitled "Aerial Pointers" will be Explained in Greater Detail

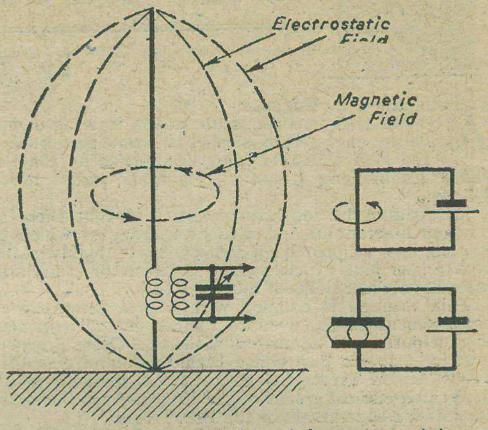


Fig. 1.—Diagram showing the form of the magnetic and electrostatic fields round a vertical aerial. At right are shown the counterparts of the fields in two simple circuits.

AS the article on aerials in last month's issue evoked more interest than was anticipated, it has been decided to treat the subject rather more fully, chiefly for the benefit of those who are concerned with technical aspects and those who propose to set up an amateur transmitting station after the war.

Before dealing with aerials themselves, it is best to obtain a reasonable grasp of the fundamental principles of radiation. We know that so-called wireless waves travel rather in the form of rhythmic surges of electro-magnetic energy. When "thrown off" by the transmitting aerial they are—generally—radiated in all directions. Thus, part of the radiation is upward, part is downward, and part is horizontal. It is easy enough to imagine how the horizontal portion of the radiated energy can actuate, or energise, a receiving aerial at a distance, but what happens to the upward and downward radiation?

Skip Distance

To a large extent, but varying with the frequency and other factors, both are reflected; one by the ionised layers which constitute the stratosphere, and the other by the ground. Because of this, the waves are able to circle the globe. although attenuation naturally occurs due to a certain degree of absorption by the imperfect reflecting surfaces. It is because of the reflection that we have what is known as "skip," which means that there are certain more or less "blind" areas between the points at which the radiated waves strike the ground.

Phase Relationship

This same phenomenon of reflection also accounts, in large degree, for the various forms of fading which are experienced, especially on short waves. It is quite understandable that if the same radiation reaches the receiving aerial after different parts of it have been reflected by different surfaces, one reflection might well travel farther than another. In consequence, the two may be in phase or out of phase, according to the exact distance travelled. When they are in phase they are additive and maximum signal strength is obtained, when they are out of phase the two may well cancel each other, with the result that nothing will be heard from the receiver.

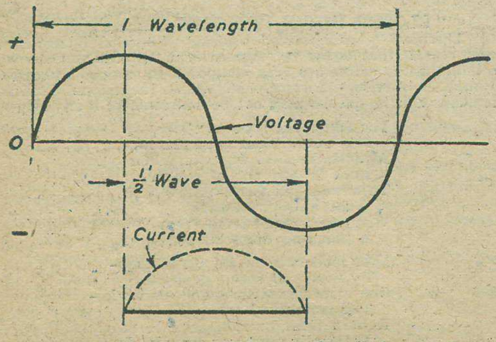


Fig. 2.—Maximum voltage exists between the ends of an aerial when it is one half-wave length (or a multiple of one half-wave) long.

The effect is emphasised by the movement of the surfaces of the upper reflecting layers, and so a variety of "in phase" and "out of phase" reflections may become mixed, giving a complex form of fading.

Magnetic and Electrostatic Fields

Now when radio-frequency energy is applied to an elevated aerial of any type, two principal things happen; there is a fluctuating magnetic field around the aerial wire, and there is a fluctuating electrostatic field between the wire and earth. Fig. 1 will help to explain this. With regard to the magnetic field, this is comparable to that formed around a wire connected across a battery. Most readers will remember from their study of elementary electricity and magnetism that a magnetic field is produced, which can be detected by means of a pocket compass or by passing the wire through a card on which are sprinkled a few iron filings.

The experiment is usually done in school by using D.C., but the same thing applies with A.C., with the exception that the magnetic field builds up and collapses at every half-cycle. An inset to Fig. 1 shows the magnetic field round a wire through which a current is passed from an electric cell.

The electrostatic field between the aerial and earth is comparable with that between the plates of a condenser which is charged. There is a state of electric stress between the two plates, which are at different potential, as also shown inset in Fig. 1. As the aerial is at a different potential from earth, the capacity between aerial and earth is comparable with that between two plates of a condenser. The difference is that, while the field between the plates of a condenser is steady and constant (if we neglect dielectric losses), that between aerial and earth is rising to a maximum and falling to zero at each half cycle; in addition, the polarity of the two is being reversed at every half-cycle.

Effect of Frequency

It is because of the reversal that radiation occurs. It can also be shown that radiation is almost negligible at very low frequencies, and rises rapidly as the frequency is increased from a few hundred to several thousand

(Continued on page 371.)

cycles per second. At frequencies up to about 100 kilocycles per second the radiation consists almost entirely of the ground wave, whilst as the frequency is raised above this figure the effects of reflection are more noticeable. This explains, incidentally, why fading is practically non-existent on wavelengths above 1,000 metres, and why far greater power is required on these long waves to cover any given long distance than is the case on shorter wavelengths.

Polarisation

In Fig. 1 the aerial is shown as being vertical. In that case, the radiation is said to be vertically polarised; that is, the electrostatic lines of force are vertical. If the aerial were horizontal, polarisation would be horizontal. From this it will be seen that the magnetic field is not considered. It is of little value in relation to the total radiated power. In general, it is better to ensure that the receiving aerial is of the same form (horizontal or vertical) as the transmitting aerial, for optimum results, but it has been found that on wavelengths below about 50 metres there is often a rotation of the plane of polarisation and that, irrespective of the polarisation given at the transmitting aerial the wave is polarised vertically by the time that it reaches the receiving aerial.

Free-space and Earthed Aerials

There are two main forms of aerial: Marconi and Hertz. Other names for these types are: grounded and free-space aerials. The free-space or Hertz aerial is normally to be preferred when it can be erected, but the Marconi aerial is a better practical proposition on all excepting short waves. The reason for this is that the optimum length of an aerial in free space (that is, erected at least one half-wavelength above the ground and as far as possible from all earthed objects) is one half-wavelength, or nearly so.

The reason for this can be seen by referring to Fig. 2. It will be seen that the maximum voltage that can be obtained between the ends of the aerial is when one end is at maximum positive potential and the other is at maximum negative potential. It can be seen that this condition is fulfilled when the aerial is one half-wavelength or a multiple of one half-wavelength, long. With the half-wave aerial it will be understood that the points of highest voltage are at the two ends. This, in turn, means that the resistance is greatest at those points. On the same basis, the resistance is lowest, and the current greatest, at the centre of the aerial. These facts will be called upon later in this series.

It is an interesting fact that a quarter-wave grounded or Marconi aerial behaves in practically the same manner as a half-wave free-space aerial. The reason is that the ground acts as a reflector, and we have what is described as an image aerial beneath the ground; this is of the same effective length as the actual aerial which is above ground. Fig. 3 will help to make this point more readily understandable. Imagine radiation from the point marked X on the aerial. Radiation will be upward to the point R (which may be regarded as the receiving aerial) and also downward to the point Y on the ground. This downward radiation is reflected in the same way as light is reflected from the surface of a mirror, so that the downward ray XYR will meet the upward ray XR at the point R. If the line RY is produced it will be found to meet the "image aerial" at a point X_g, which is the same distance below ground level as point X is above that level.

Radiation Resistance

A transmitting aerial possesses what is described as radiation resistance which is measured directly in ohms and may be regarded as D.C. resistance. The radiation resistance may be regarded as the resistance between the transmitter and the ether surrounding the aerial. If this resistance is known, the radiated power can be determined from the formula: $W = I^2R$, the current I being measured by means of a thermo-ammeter in the aerial feeder. The resistance at the centre of a half-wave aerial is between 70 and 75 ohms. A knowledge of this

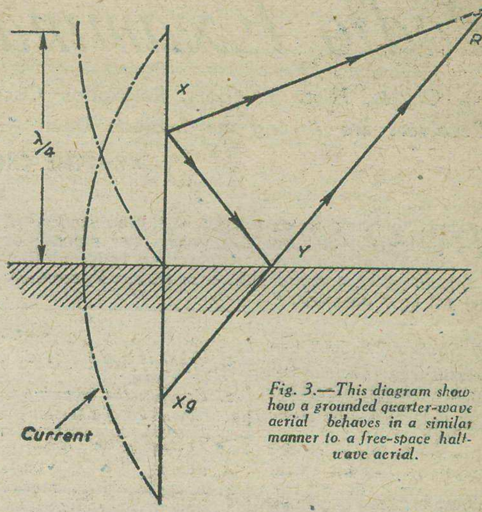


Fig. 3.—This diagram show how a grounded quarter-wave aerial behaves in a similar manner to a free-space half-wave aerial.

is useful when estimating the power output from a transmitter. It is also required when planning the aerial feeder system.

The radiation resistance of a Marconi aerial is comparatively low, and is subject to variation. Because of this, the Hertz aerial is more efficient than the Marconi, where an appreciable amount of power is lost in heating the wire. This calls for further explanation, since there appears to be a contradiction. It was stated that the radiation resistance of a Hertz aerial is about 70 ohms at the centre. But the resistance rises to thousands of ohms toward the ends, and increases from the centre outwards. Thus, the overall current is low, and little heating of the aerial wire takes place.

End Effect

It has been shown that the optimum length of a free-space aerial is one half-wavelength. In practice, a correction has to be made to compensate for what are described as "end effects." These are chiefly concerned with the increased resistance towards the ends of the aerial. Due to the resistance, there is a certain slowing down of the wave-flow in the wire. The correction required is in the region of 5 per cent., but when the very best results are desired it is necessary to determine the critical length by trial.

A convenient formula for ascertaining the approximate correct length of a half-wave aerial is:

$$\text{Length (in feet)} = \frac{492 \times .95}{f \text{ (in mc/s.)}}$$

This is equivalent to: $\text{Length} = \frac{467.4}{f}$

It may seem that the length of a quarter-wave Marconi aerial would be just half of this. In practice, that is not quite correct, because of the lower "end effect" in the Marconi aerial. A suitable and convenient formula is: $\text{Length (in feet)} = \frac{236}{f \text{ (in mc/s.)}}$

You may wish to work out a few examples, and to compare the results with those obtained by dividing the wavelength by 2 and 4 respectively.

(To be continued.)

Radio Examination Papers—33

Wave Guides, Phase Inverters, Relaxation Oscillators and Wiring Details of Mains-operated Receivers are Among the Subjects Dealt with in Question-and-answer Form This Month.

By THE EXPERIMENTERS

1. Wave Guides

WHEN working on extremely high frequencies—in the region of 3,000 megacycles per second, or wavelength of one centimetre—it is found that the normal wire transmission lines or feeder is extremely nefficient. It is also found that these microwaves tend to obey physical rather than electrical laws, with the result that they can be "poured down a tube," in rather the same way that water can.

This is a very crude description, but it will serve as some sort of introduction to the so-called wave guide. It has been found, and can readily be demonstrated, that the radio-frequency output from a microwave transmitter can be fed along a tube of certain cross section (the optimum cross-section is a function of the frequency in use) and may be radiated from the other end. The end of the wave guide remote from the transmitter may be belled out in the form of a horn. The open end may also be passed through a parabolic reflector to obtain increased directional effects.

QUESTIONS

1. *What is a wave guide, and for what purpose can it be used?*
2. *Explain the meaning of phase inversion, and draw the circuit of a simple phase-inverter stage.*
3. *Describe a form of relaxation oscillator or saw-tooth generator. For what purpose may such a device be used?*
4. *List the chief disadvantages of half-wave rectification in connection with the supply of H.T. current for a receiver.*
5. *Draw a diagram to show how you would wire the heaters of four 6-volt valves for operation from a 12-volt supply if three of the valves had a rated heater current of .3 A., while the fourth was rated at .15 A.*
6. *Explain and illustrate three methods of supplying the filament of a dial lamp used in a mains receiver.*

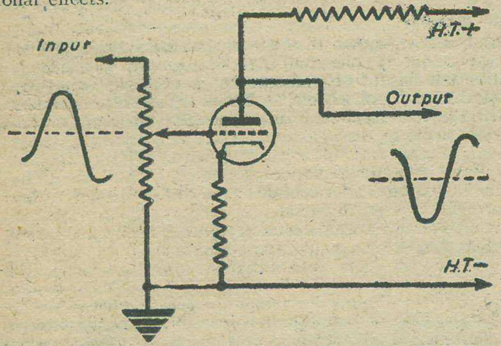


Fig. 1.—A simple phase inverter consisting of an R.C. coupled valve with negative feedback. A potentiometer is connected in the grid circuit to vary the input as necessary in order that input and output shall be of equal amplitude, but opposite phase.

It is found that the tubular wave guide may be curved in the direction of its length without serious loss in efficiency, and also that the guide may consist of various sections of tubing arranged in line, with gaps between them; even then, the radio-frequency output is "guided" along the feeder.

The design of wave guides is somewhat complicated, and presents several mathematical problems. In consequence, it cannot be dealt with here, although it may be mentioned that there are on the market one or two books devoted to this subject.

In general, the wave guide is made of rectangular cross section, and the chief requirement is that one side of the rectangle shall be more than one half-wavelength and less than one wavelength long, while the other shall be less than one half-wave.

2. Phase Inversion

Phase inversion occurs in many circuits used in wireless equipment; sometimes it is a necessary evil, and sometimes the inversion is a matter of design. For example, an ordinary low-frequency transformer acts as a phase inverter since, at any moment when the primary is being fed with a positive-going half-wave the secondary is delivering a negative-going half-wave. In a similar manner, there is a reversal of phase between the grid and anode circuits of a triode, due to the fact that as the grid is being driven more positive, the anode is being made more negative.

The reason for this is that as the grid becomes more positive, the anode current rises. And as the anode current rises, the voltage drop across the anode load increases, with the result that the anode is made less positive—or more negative, according to the viewpoint.

From what has been written so far it will be understood that a resistance-capacity-coupled valve stage produces phase inversion, whilst phase reversal does not occur in a transformer-coupled stage. This principle was employed in some of the earlier television receivers in order to obtain correct phase at the output. Thus, if the phase were incorrect, it could be corrected either by replacing an R.C.C. stage by a transformer stage, or by adding another R.C. amplifier.

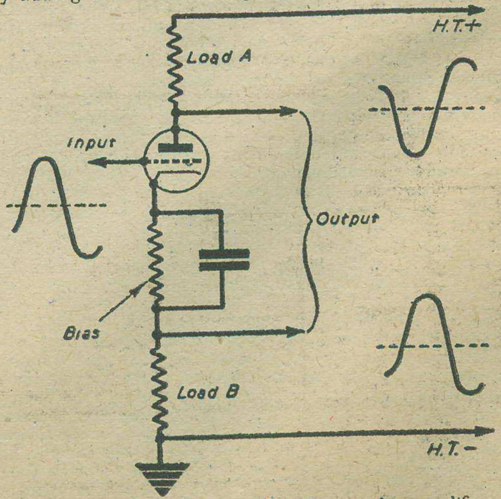


Fig. 2.—A phase splitter or single-valve paraphase amplifier.

A phase inverter, as such, however, is generally regarded as a stage which gives reversal of phase, without producing either amplification or attenuation. For this reason, use may be made of a circuit such as that shown in Fig. 1, which is, in effect, an R.C. stage with negative feedback or degeneration; this is obtained by the omission of a by-pass condenser from the cathode circuit.

A phase-splitter, as used to feed a paraphase amplifier, is similar in principle to a phase inverter, with the exception that two outputs are taken, these being of opposite phase, as indicated in Fig. 2.

3. The Relaxation Oscillator

The usual type of relaxation oscillator is that consisting of a neon lamp in circuit comprising a resistor, condenser and supply of D.C. This is shown in Fig. 3, and the "saw-tooth" output is shown inset. To understand the action of this circuit it is necessary to remember that a neon lamp will "strike"—that is, the neon gas will ionise and act as a conductor between the two electrodes—only after a certain minimum voltage has been reached. When that voltage is reached, the neon glows and acts as an excellent conductor.

It is also necessary to remember that a certain amount of time is required for a condenser to become fully charged when a voltage is applied to it through a resistor. In the circuit shown in Fig. 3 the condenser will begin to charge as soon as the switch is closed. When the condenser is charged to the "striking" voltage of the neon the lamp will glow and the condenser will be discharged almost instantaneously. Charging will recommence, followed by a rapid discharge when the neon conducts. Thus, the circuit acts as a form of oscillator, and the voltage across the condenser can be represented by the saw-tooth waveform illustrated.

A circuit of this kind is useful as a time base for a cathode-ray oscilloscope, where it is desired to move the electron beam across the screen relatively slowly in one direction and very rapidly in the other. For obvious reasons, the "return" is described as the "fly-back."

The simple neon-tube relaxation oscillator described is not widely used in practice, a more usual arrangement being that shown in Fig. 4. where a thyratron or gas-filled triode valve is used. The valve conducts only when a certain minimum anode potential has been reached. Thus, after the condenser between anode and the earth line has been charged to the required anode voltage, the valve conducts and discharges the condenser. At the same time the anode voltage drops due to increased current through the anode resistor. The process is then repeated, in the manner described in respect of the neon-lamp circuit.

4. Half-wave Rectification

In addition to the comparative inefficiency of the half-wave rectifier—due to its rectifying only one half of the total input of A.C.—it has the further disadvantage that the ripple in the D.C. output is of lower frequency than is the case with other types of rectifier. For example, when the rectifier is used with an A.C. supply of 50 cycles per second, the D.C. output contains a 50 cycle ripple. By comparison, the ripple on the output from a full-wave rectifier has a frequency of 100 cycles when used in the same conditions.

The lower frequency of the ripple means that smoothing is more difficult; or, in practical terms, that the inductance of the smoothing choke must be twice as high as that required to give the same degree of smoothing after a full-wave rectifier.

Yet another disadvantage which is often overlooked is that, in addition to the A.C. applied to the secondary of the mains transformer used to feed the half-wave rectifier, there is a D.C. current through the winding. This means that the size of the core must be increased if saturation or marked falling off in efficiency is to be avoided. Because of this, it is customary to use a half-wave rectifier only when little current is required at high voltage. For this purpose the half-wave rectifier shows to advantage over the normal full-wave rectifier, due to the fact that the voltage required across the secondary of the mains transformer is approximately equal to the final D.C. voltage; in the case of a full-wave rectifier the secondary is required to produce twice the D.C. voltage required. For a high-voltage output, this means that the secondary winding must be comparatively bulky.

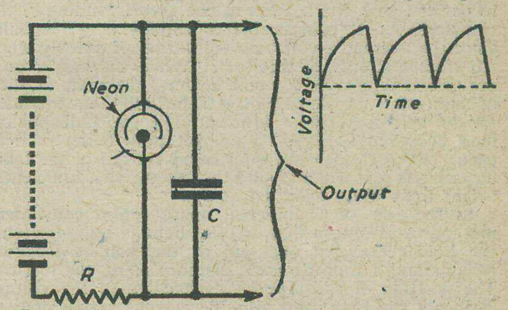


Fig. 3.—A neon-tube relaxation oscillator circuit and (inset) the output waveform.

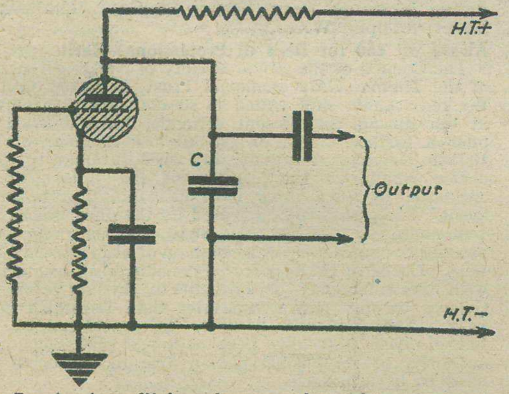


Fig. 4.—A gas-filled or thyratron valve used as a saw-tooth generator. Its operation depends upon the charging of condenser C, and its discharge when the anode voltage rises to such a value that anode current is passed.

5. Valve Heaters in Series

It is customary in certain car-radio and other mobile receivers to wire the heaters in series or in series parallel. Thus, if a four-valve receiver using 6-volt valves were required to be operated from a 12-volt D.C. supply it would be far more economical of current to wire the heaters in series-parallel than to wire them all in parallel and then to employ a voltage-dropping resistor.

In the case of a similar receiver for operation from a 24-volt source, all four heaters could be in series, so that

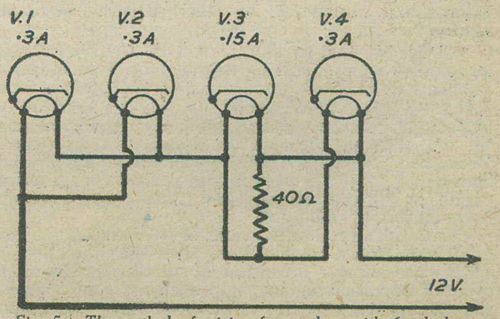


Fig. 5.—The method of wiring four valves with 6-volt heaters in series-parallel so that they may be fed from a 12-volt supply.

the ends of the series circuit could be connected directly to the supply voltage.

Unfortunately, in order to connect heaters in series, it is essential that all should pass the same current ; or, alternatively, that suitable resistors should be wired in parallel with those heaters which take a lower current than that taken by any other.

A circuit which meets the requirement of question 5 is given in Fig. 5. It will be seen that valves V1 and V2 have their heaters in parallel, while the heaters of V3 and V4 are also in parallel. The first pair of heaters is then connected in series with the second. The heater current of valves V1, V2 and V4 is .3 amp., while that of V3 is only .15 amp. It is therefore necessary to connect a shunt resistor across the heater of V3. This should have the same resistance as the heater of V3, so that the current passed by heater and resistor in parallel is .3 amp. As the shunt resistor has to pass .15 amp. at an applied voltage of 6, its value should be 40 ohms. The power rating should be not less than one watt.

6. Pilot-lamp Connections

The simplest method of wiring a pilot lamp is that which is applicable to an A.C. receiver using 4-volt valves. A pilot lamp holder may then be connected in parallel with the heaters to the 4-volt winding of the transformer. It is desirable to employ a 6-volt bulb, since the average 4-volt bulb will burn out quickly when fed from a supply of this sort. When the valves used are of the type with 6.3 volt heaters, the same method of connection may be employed if the bulb is one intended for 6-8 volt operation. Alternatively, two bulb holders may be wired in series, a 4.5-volt bulb being used in each. Even though the total rated voltage of the lamp filaments is 9, it will be found that they give a sufficiently bright light when operated at 6.3.

In the case of a universal mains set, a convenient method of feeding a dial or pilot light is by connecting the holder between one end of the voltage-dropping resistor and a tapping some distance along the resistor. The position of the tapping depends upon the voltage rating of the bulb, and also the current rating of both the bulb and of the set as a whole. The resistance required between the end of the dropping resistor and the tap can easily be found by the application of Ohm's Law, provided that the current passed by both lamp and resistor are known.

A third method which is applicable to universal mains sets is to connect a bulb having a current rating of not less than that of the heaters in series with the heater supply. In practice, it is better that the rating of the bulb should be appreciably higher than that of the heaters. This is because the heaters have a comparatively low resistance when cold, and therefore pass more than their rated current. Thus, a .3 amp. bulb should be used with .15 amp. heaters.

There is a fourth method of feeding the pilot lamp in a universal mains receiver, but this is applicable only when a rectifier having a centre-tapped heater is used ; a representative type is the 35Z5. In this case, the bulb is connected in series with a suitable resistor in parallel with one half of the heater, as shown in Fig. 6. The value of resistor shown is correct when using a lamp rated at about 6 volts .3 amp.

Three methods of connecting a pilot lamp are illustrated in Fig. 6.

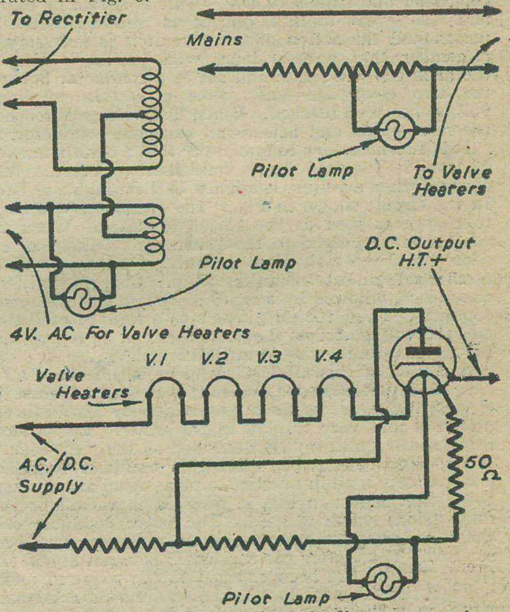


Fig. 6.—Three methods of supplying the filament current for a pilot lamp. They are described in reply to question number 6.

Royal Society of Arts

Thomas Gray Memorial Trust Awards

THE Council of the Royal Society of Arts offer the following Prize under the Thomas Gray Memorial Trust, the objects of which are "The advancement of the Science of Navigation and the Scientific and Educational interests of the British Mercantile Marine":

A Prize of £50 to any person of British or Allied nationality who may bring to their notice an invention, publication, diagram, etc., which in the opinion of the Judges is considered to be an advancement in the Science or Practice of Navigation, proposed or invented by himself in the period January 1st, 1939 to December 31st, 1944. Entries which have already been considered by the Judges in the years 1939–43 are not eligible for further consideration unless they have since been materially modified.

The Council reserve the right of withholding the Prize or of awarding a smaller Prize if in the opinion of the judges no suitable invention is submitted, and in the event of more than one such improvement being approved, the Council reserve the right of dividing the amount into two or more prizes at their discretion.

The Council do not claim any rights in respect of any invention to which a prize may be awarded.

Competitors must forward their proofs of claim between October 1st and December 31st, 1944, to the Acting Secretary, Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

Award of £50 for Deed of Professional Merit

The Council of the Royal Society of Arts, as Trustees of the Thomas Gray Memorial Trust, in recognition of the remarkable skill which is so constantly displayed at sea during the present struggle, have decided to offer a further award of £50 to any member of the British Merchant Navy for any deed brought to their notice which, in the opinion of the judges to be appointed by the Council, is of outstanding professional merit. The period to be covered by the offer will be the year ending September 30th, 1944, and the judges will proceed to consider their decision on or after January 1st, 1945. Deeds of the type to be considered in connection with this offer may be brought to the notice of the Council by any person not later than December 31st, 1944. They will not, however, be considered by the judges unless they have been endorsed by a recognised authority or responsible person able to testify to the deed to be adjudged.

The Council reserve the right to withhold the award or to make a smaller award, or to divide the amount into two or more awards at their discretion.

Sidebands and Reproduction

Why Selectivity can be Achieved Only at the Expense of Quality. By S. A. KNIGHT

THE carrier wave which is radiated by a transmitter when it is in operation, but not actually emitting a programme, is of a constant frequency, its wavelength being that allotted to the transmitter. As soon as a programme is radiated the carrier wave becomes modulated by the audio-frequency components of speech or music in a manner depending upon the system of modulation employed. The most general system of modulation is of the amplitude variety where the audio and high frequency components are combined in such a way that the amplitude of the latter is caused to rise and fall at the frequency of the former. (Fig. 1.) We need not concern ourselves here with frequency modulation, the other system which is not so generally employed at present.

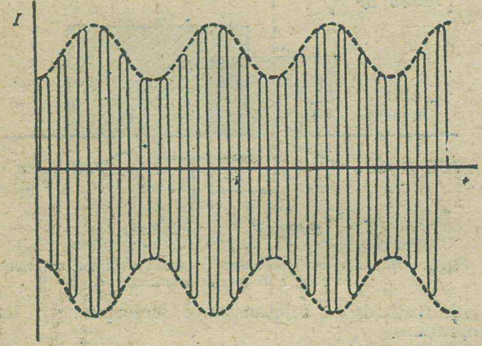


Fig. 1.—The carrier wave of a transmitter modulated by a sinusoidal note.

If the mean amplitude of an unmodulated aerial current is denoted by I, and during modulation it fluctuates above and below this mean value by an amount A, then the ratio of A to I is a measure of the modulation depth of the current flowing in the aerial; obviously the greatest possible modulation is that which causes this ratio to become unity. The percentage modulation is then said to be 100 per cent., and the amplitude of the aerial current then varies between the values of zero and 2I.

Modulated Carrier Wave

The modulated carrier wave, unlike the carrier wave when it is not being modulated, contains additional waves of other frequencies both above and below the frequency of the carrier wave itself. For instance, suppose a single note having a frequency of 2,000 cycles per second is employed for modulation, then beside the carrier itself there are created two additional waves, one with a frequency of 2,000 cycles per second greater than the carrier frequency, and the other with a frequency of 2,000 cycles per second less than the carrier frequency. It might be difficult to picture this state of affairs at first, so consider the position in this way.

Suppose, for simplicity, that a pure note struck on a piano is allowed to impinge on the diaphragm of a microphone connected appropriately to a transmitter emitting a steady carrier wave of frequency f cycles per second. As a result of the electrical fluctuations created by the microphone due to the sound waves of the pure note, the aerial current of the transmitter is modulated at the note frequency which we may suppose to be f_1 cycles per second. This condition will be as illustrated in Fig. 1, where the dotted curve is the modulation envelope, and for a pure note such as we are considering is sinusoidal in nature.

Now we see that the effect of this modulation is to cause the maximum value of the aerial current to vary between $(I+A)$ amperes and $(I-A)$ amperes; therefore the actual aerial current flowing is the same as the three following currents flowing simultaneously:—

(a) A R.F. alternating current (carrier) of maximum amplitude I amperes, and frequency f cycles per second.

(b) A R.F. alternating current of maximum amplitude $\frac{1}{2}$A amperes and frequency $(f+f_1)$ cycles per second.

(c) A R.F. alternating current of maximum amplitude $\frac{1}{2}$A amperes and frequency $(f-f_1)$ per second.

Therefore, the modulated electromagnetic waves radiated from the aerial is equivalent to the three following waves all radiated together:—

(a) The continuous electromagnetic wave of constant intensity proportional to I at a frequency of f cycles per second.

(b) The continuous electromagnetic wave of constant intensity proportional to $\frac{1}{2}$A at a frequency of $(f+f_1)$ cycles per second.

(c) The continuous electromagnetic wave of constant intensity proportional to $\frac{1}{2}$A at a frequency of $(f-f_1)$ cycles per second.

Returning to the actual figures we were using a little while ago we see that if the frequency of the carrier which is modulated by the pure 2,000 cycle note is, say, 100,000 cycles per second (100 kc/s) then the station, in effect, is radiating besides this carrier wave itself, two other sets of electromagnetic waves, one set with a frequency of 102 kc/s and the other set with a frequency of 98 kc/s. The radiation of electromagnetic waves

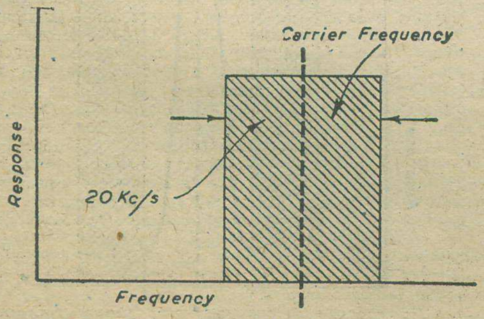


Fig. 2.—The response curve of the ideal receiver considered in the text.

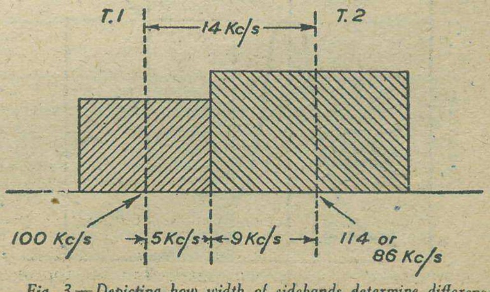


Fig. 3.—Depicting how width of sidebands determine differences of carrier frequency to prevent overlap of signals.

whose frequency is above the frequency of the carrier (in our example the 102 kc/s transmission) is known as the upper sideband radiation, and the radiation of electromagnetic waves whose frequency is below the frequency of the carrier (the 98 kc/s transmission) is known as the lower sideband radiation.

It is because of these sideband radiations that we find ourselves faced by the perpetual war between selectivity and quality, where for a gain in the one we are forced to sacrifice the other.

Carrier Spacing

Musical and other sounds contain frequencies as high as 12,000 cycles per second, some even going further than this, though not many people are able to hear them. It is generally accepted that if all frequencies up to 10,000 cycles per second are faithfully reproduced by a receiver and the loudspeaking device, then there is very little to worry about regarding the quality and realism. From this we see that when a broadcasting station is emitting a programme to fill the needs of the quality fan, the frequencies of the sideband radiations will extend to at least 10,000 cycles per second each side of the frequency of the carrier.

The receiving device, if it is very well designed, will give faithful reproduction by receiving all of these sideband radiations equally well, and there will be no need for it, once a particular carrier wave has been selected, to worry about any other waves whose frequencies extend beyond 10,000 cycles per second either side of the carrier. If it does, then interference will probably be experienced as we shall see in the next section. This wonderful receiver will have a response curve like that of Fig. 2, square or practically so, and it will be quite uninterested in what goes on outside of the requisite bandwidth of 20 kc/s. In practice, however, our wonderful receiver does not exist, and even if it did it would not be of much value. It is evident from the foregoing that if two broadcasting stations are emitting programmes at the same time and there is to be no overlap between them, the carrier frequencies of the two transmitters must be separated by an amount such that the highest sideband frequency of the one exceeds the lowest sideband frequency of the other. This means that the frequency difference of the carriers must consequently be at least equal to the sum of the maximum audio or modulation frequencies transmitted by the two stations. Fig. 3 will make this clear.

A transmitter T_1, operating on a carrier frequency of 100 kc/s is radiating all audio frequencies up to 5,000 cycles per second. Another transmitter, T_2, operating nearby (as regards carrier frequency) is radiating all audio frequencies up to 9,000 cycles per second. If the transmissions of these two stations are never to overlap, their carrier frequencies must iffer by (9,000+5,000)=14,000 cycles per second. Hence, transmitter T_2 must work on a carrier frequency of 114 kc/s or 86 kc/s. This is true for any frequencies of working.

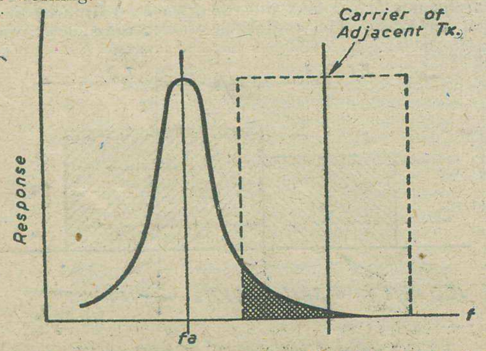


Fig. 5.—Sharp response curve reduces sideband interference, but liable to lead to heterodyne whistles

Interference

Suppose that transmitter T_2 of Fig. 3 decides to transmit on a frequency of 110 kc/s while still radiating all audio frequencies up to 9,000 cycles per second. A receiver tuned to Transmitter T_1 and having a response curve which will just cover the requisite audio bandwidth will now not only receive all the sidebands of tde wanted transmitter, but will also receive all those sidebands from station T_2 which are overlapping into the receivers response curve. (Fig. 4.) The width of overlap, or interference, from T_2 will be equal to 4 kc/s as can be easily seen and calculated from the figure. This is an undesirable state of affairs and the only way to overcome the difficulty will be, of course, for transmitter T_2 to move its carrier frequency up to at least 114 kc/s, or for receiver R to cut its response curve down to a width of only 2 kc/s, 1 kc either side of the wanted station's carrier frequency.

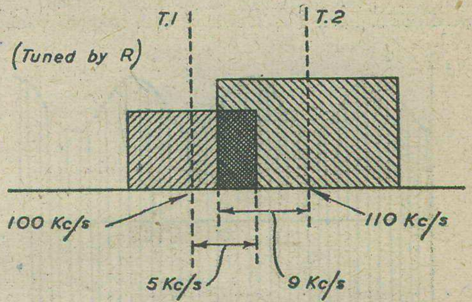


Fig. 4.—How sideband interference is caused when the transmitter T_2 shifts its carrier frequency.

Both methods of solution have, unfortunately, their limitations.

Firstly, spacing the carrier frequencies. This method obviously reduces the number of stations it is possible to accommodate in the broadcasting band.

Secondly, cutting down the receiver's response. This method at once destroys quality reproduction as the outer limits of the sideband radiations, representing the higher audio frequencies, will hardly be received, if at all.

We will discuss the two methods more fully and see how a compromise may be effected.

Accommodation

For quality reproduction and reception free from interference we have seen that the carrier waves of transmitters should be separated by at least 20 kc/s,

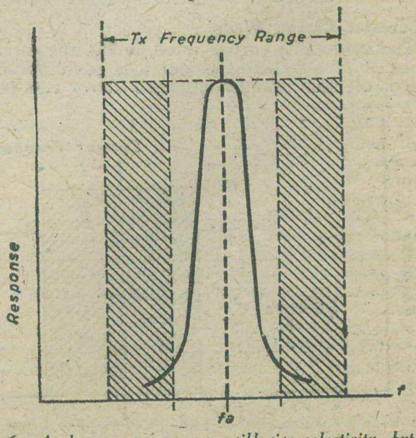


Fig. 6.—A sharp response curve will give selectivity, but the outer sidebands (drawn shaded) are not received, thus resulting in poor reproduction.

each radiating sidebands up to the desired 10 kc/s. This cannot be achieved in practice, as there are many countries each with many transmitters to be crowded in on the frequency range allotted to broadcasting. So a frequency separation of 9 kc/s (approximately) has been chosen by international agreement. There is quite a lot of overlapping due to this necessary evil of reduction from the ideal 20 kc/s separation, though this disadvantage is, in turn, overcome by designing receivers to respond to a much narrower bandwidth than that of the miraculous ideal receiver previously mentioned.

Reducing Receiver Response

Getting down to practical receiver response curves, we find that they are generally of the shape shown in Fig. 5, instead of the square box affair of Fig. 2. The response falls off fairly rapidly on either side of the resonant point f_0 (see Fig. 5), which may be corresponding to the carrier frequency of a wanted transmitter, though there is a tendency for the lower reaches of the curve to stretch an appreciable distance along the frequency scale. Thus, although there may be little or no interference from the sidebands of a nearby transmitter (whose waveband

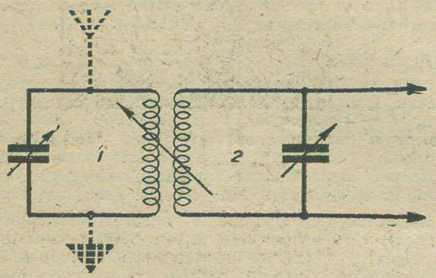


Fig. 7.—A simple band-pass filter.

coverage is shown dotted in the diagram) there may be a tendency for intereference to be experienced from the carrier wave of the adjacent transmitter itself.

This type of interference usually makes itself manifest in the form of a note of constant intensity and having a frequency equal to the difference between the concerned carrier frequencies. The two carriers beat together just as do the oscillations in a super-heterodyne, and produce a third oscillation of frequency equal to the sum or difference of the first two oscillations. The sum of the carrier frequencies does not concern us as far as interference goes; it is in their difference, usually in the order of 8-9 kc/s that an audible, interfering note is produced. This is known as a heterodyne whistle.

In order that this type of interference, as well as sideband overlap, shall be overcome we must make the response curve of our receiver peakier than ever, and this may be fairly readily achieved by the use of several tuned circuits. As soon as this desired selectivity is achieved, however, we find that quality reproduction is impossible, as the receiver will respond only very well to the sideband frequencies which are close to the carrier frequency (Fig. 6), i.e., the lower register. The outer sidebands associated with the upper audio frequencies are only scrappily reproduced, if at all. In speech and musical transmission, especially the latter, there is attenuation and suppression of the high audio frequencies that are components of the speech and musical sounds. The output from the receiver, therefore, lacks crispness and clarity, that is, it becomes boomy.

Sets employing reaction best show this effect of high selectivity upon reproduction. Increasing the reaction has the effect of sharpening the tuning, and a definite falling off in quality can generally be noticed as the regeneration control is advanced towards the point of oscillation.

Thus, for selectivity we must sacrifice quality—and, of course, for quality we must sacrifice selectivity.

Where interfering stations are so far away that reception of their signals is too weak to cause serious interference, or conversely, where the transmitter being received is a strong one at no great distance from the receiver, selectivity becomes of secondary importance, and a fairly flat response curve for the tuned circuits, giving more faithful reproduction of the audio frequencies, can be tolerated.

Advantages of Band-pass Tuning

Our ideal response "box" of Fig. 2, while impossible in practice, gives us a clue of how we may, under the practical conditions outlined above, combine maximum selectivity consistent with quality reproduction. The response curve of a receiver should be as rectangular as

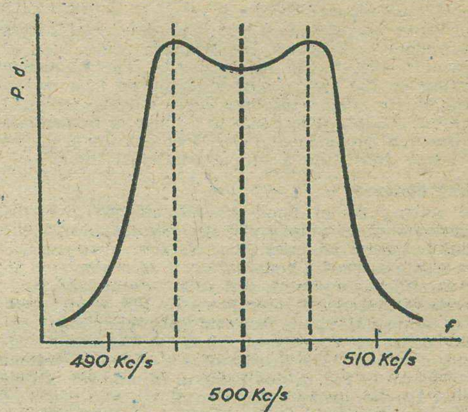


Fig. 8.—General shape of the response curve obtained from a band-pass tuning system.

possible, flat-topped with steep sides. It then covers the frequency band of any desired transmitter, gives even response to all the received frequencies from that transmitter, and does not experience interference from adjacent sidebands or heterodyne whistles.

Band-pass tuning can achieve this result, and give us a nearly flat-topped, steep-sided response curve. Consider Fig. 7, where two tuned circuits are closely coupled together. If before they were coupled in this way each had been tuned to the same frequency, then, after coupling, the tuning frequency of each one will have altered slightly, due to the proximity of the other. Circuit No. 1 is called the primary and circuit No. 2 is called the secondary.

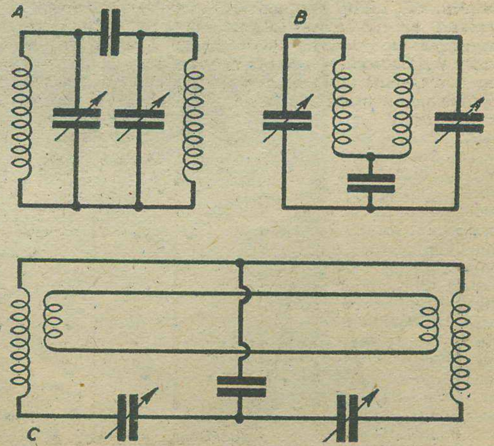


Fig. 9.—Some typical band-pass filter circuits, the last one being a combination of capacitive and inductive coupling.

At frequencies above its resonant point the primary circuit will behave as a pure inductance, and the effective inductance of the secondary will be reduced since the magnetic field produced by the primary will oppose the magnetic field produced by the secondary. At one particular frequency the reactance of this reflected inductance will be equal and opposite to the capacitance of the primary circuit, i.e., the system will be resonant at a point *greater* than that to which its parts were separately tuned. Similarly, at frequencies below its resonant point the primary will behave as a pure capacitance and the effective inductance of the secondary will be increased. In this case the system will be resonant at a frequency *less* than that to which its parts were separately tuned.

If a curve is plotted of the p.d. developed across the secondary coil against frequency, a result such as is shown in Fig. 8 will be obtained. The frequency separation of the two peaks is about 12 kc/s and a receiver having such a response curve may be regarded as giving a good even response to a range of frequencies lying between 495 and 505 kc/s. Two circuits arranged in this way constitute a simple band-pass filter.

Coupling Systems

The setting up of band-pass circuits to give the correct shape of response curve necessitates adjustment of the coupling between the circuits. In practice simple electromagnetic coupling such as is depicted in Fig. 7 is seldom employed, and such systems and combinations of systems as are shown in Fig. 9 are used. In the figure (a) shows top capacity coupling; (b) bottom capacity coupling; (c) a mixed inductive-capacity coupling. The disadvantages of such a system as that shown in Fig. 7, and those of (a) and (b) of Fig. 9 is that the frequency separation of the two peaks of the response curve varies with the tuning of the circuits, the capacitive cases in opposite sense to the inductive cases. Many attempts have been made to obtain a combination circuit which will have a response curve whose hump distance (or bandwidth) does not vary to any noticeable extent with frequency, and Fig. 9 (c) shows such a practical arrangement.

With inductance coupling it will be found that the peak separation increases as the frequency to which the circuits are tuned increases. With capacitive coupling the peak separation decreases as the frequency to which the circuits are tuned increases. Thus, in Fig. 9 (c) when the resonant frequency of these two circuits is increased by reducing their tuning capacities, the capacitive coupling decreases and the peaks of the response curve tend to close up. Because of the inductive coupling, however, the peak separation tends to increase as the frequency is increased. By careful design and critical adjustment of the two forms of coupling, these two tendencies can be made to balance one another, and the peak distance can be kept fairly constant over the entire range of tuning.

The above is a very simple explanation of band-pass tuning; the mathematics of the subject were discussed at some length in the article on A.C. theory, PRACTICAL WIRELESS, November and December, 1943. Readers might like to refer back to these copies in conjunction with the present articles.

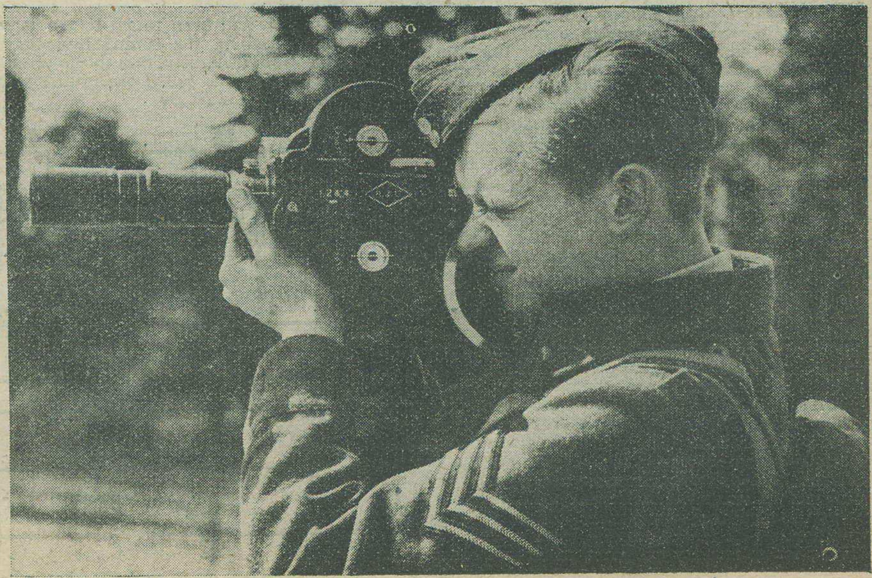
In selective receivers not employing band-pass tuning, compensation is sometimes made for the effect of sideband cutting by arranging the L.F. amplifying stages to give greater amplification to the higher frequencies than to the low. This is the tone correction that is often spoken of in L.F. design.

Wavelength Effect

As soon as the bandwidth to which a receiver is responsive, say, 20 kc/s, becomes comparable with the frequency of the carrier being received, difficulties in getting a flat response curve over the sideband range rapidly increase. It is a well-known thing that "long-wave" stations have a tendency to spread, and fewer can be accommodated in a given range of frequency.

On normal speech and music transmission the difficulty is not very serious, but for the reception of television signals in which the modulation frequencies, and consequently sideband widths, are so very much greater than those encountered for ordinary broadcasting (extending into millions of cycles per second), carrier frequencies of extremely high values are required. That is the reason we find the television wavelengths down in the ultra short regions, generally about 5 to 7 metres.

THE R.A.F. Film Production Unit is responsible for many of the pictures of night bombing and day bombing issued to the Press. Cameramen form part of a 'plane's crew and fly on operational duties. Many, like Flight - Lieutenant Galai Hatchard, D.F.C., who, in peacetime, had been cameraman for the films "Henry VIII" and "Shape of Things to Come," have lost their lives in battle. The Unit is also responsible for making publicity films, and for making up operational films for instructional purposes.



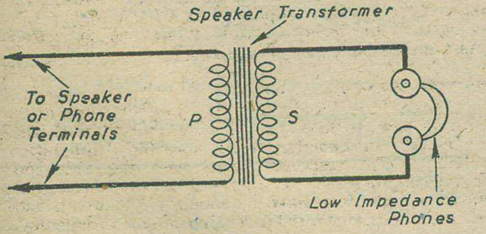
A cameraman of the R.A.F. Film Production Unit focusses his camera.

Practical Hints

Rewinding "Burnt-out" Phones

HAVING an old pair of "burnt-out" high resistance head-phones I decided to rewind them. As it is both difficult and tedious to do this with fine wire by hand, I used 30 S.W.G. enamelled copper wire. In this way they were converted to a low impedance type and were used in conjunction with an ordinary speaker transformer. The results obtained were quite satisfactory with a one-valve set. I have not yet, however, tried them with a crystal set.

The advantages of these phones are: 1. They are simple to wind. 2. As there is only A.F. current flowing through the windings they can be connected either way round. 3. They can (without the transformer) be connected to the extension loudspeaker sockets on any set.



Circuit diagram of low impedance phones and speaker transformer

The gauge of wire used will depend on the size of the bobbins. Each coil should be made to have a resistance of about one half to one and a half ohms. The two coils comprising one phone are wound in opposite directions and the outside of one is connected to the inside of the other. The two remaining ends are connected to the leads. The two phones are wired in series.—H. STERN (Bishops Stortford).

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

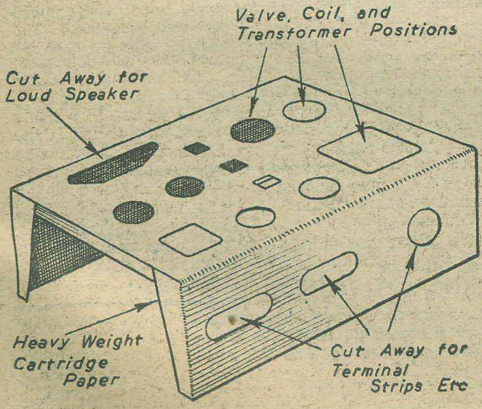
All hints must be accompanied by the coupon cut from page iii of cover.

A Paper Chassis

HAVING to build a mains set of the midget type in which all the components were rather cramped, I made up a full-scale model of the chassis from stiff cartridge paper. Though this naturally would not support the components, it gave me a much better idea of their positioning than a plan would. Holes for the loudspeaker, valve-holders, mains transformer, etc., may be cut out and by supporting them underneath, the components can be arranged in place.

Even though I had used a plan first I found that I had not allowed for the correct speaker cut-out; that one of the valves could not be inserted owing to a component above it, and that the width and depth of the chassis could be reduced. In these days of sheet metal shortage this idea saved a great deal of inconvenience.

When any mistakes in the model have been corrected, it may be used as a jig for cutting out the chassis.—E. S. DENT (Headington).



Paper chassis for facilitating the layout of components.

Multi-range Meter Shunts

WHEN constructing a multi-range meter with several current ranges, if the shunts are arranged as in Fig. 1 with a selector switch, a resistance of a very small order at the contact studs will cause quite a large error in the reading. For example, if the meter is a 1 ma. full-scale deflection one, of 100 ohms resistance, and the shunt (a) is one of 1 ohm resistance, giving F.S.D. for 100 ma., a resistance at the switch contact of 1/10 ohm will cause an error of 10 per cent. Even more error will occur on higher current ranges, for if the shunt (b) is .1 ohm, giving F.S.D. for 1 amp., the same resistance at the switch contacts will give rise to an error as great at 100 per cent.

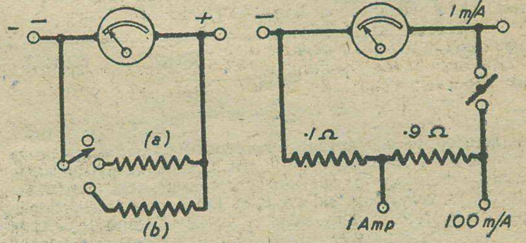


Fig. 1. Fig. 2.

Methods of switching multi-range meter shunts.

When I wanted to construct a multi-range meter, with two extra current ranges, I used the arrangement shown in Fig. 2. Here the ranges are selected by means of plugs and sockets, and the switch shown is closed when the two extra ranges are in use. If, as before, a 1 ma. meter, of 100 ohms resistance is used, a switch resistance of .1 ohm will only introduce an error of 0.1 per cent. in the reading—an amount which will be entirely unnoticed. This method uses fewer shunts, which are simpler to construct, than the Ayrton-Mather method, which has the slight advantage of not needing a switch.—J. T. RUNDELL (Orpington).

Tone Control

Various Forms of Tone Control and Their Application. By S. O. MAWS

THERE are countless occasions in the design of A.F. amplifiers and radio receivers where some form of tone control is desirable, and it is the purpose of this short article to discuss some methods of obtaining desired degrees of "top boost," "top cut," "bass boost" and "bass cut," these four being the chief types of control most usually wanted. The kind of response curve described by these four terms is illustrated in Fig. 1. This article will be entirely confined to circuits giving a fixed degree of control and the only components required in any of the circuits to be described will be resistances and condensers.

Bass Boost Circuit

This form of tone control is very commonly needed, particularly after gramophone pick-ups, of course, where

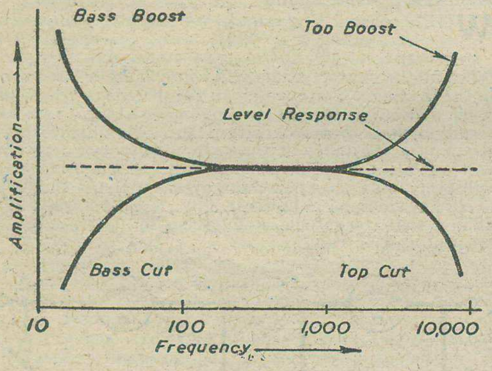


Fig. 1.—Response curves.

it is used to counteract the recording characteristic in which bass is deliberately cut. Some bass boost is often advantageous in normal receivers and amplifiers, for it is very rare indeed that loudspeakers reproduce very low notes of the order of 50 c/s adequately, either because the area of the baffle on which they are mounted is too small or else due to the area of the cone or its elasticity being unsuitable (giving a fundamental resonance at a frequency higher than 50 c/s).

The basic circuit for obtaining bass boost is given in Fig. 2. At high audio frequencies the reactance of the condenser C may be neglected and so the arrangement becomes a simple potential divider and reduces the amplification in the ratio $\frac{R_2}{R_1+R_2}$. At low audio frequencies, however, the effect of C is no longer negligible and so the value of the potential divider tends to equal one. The magnitude of the bass boost is thus given by the expression $\frac{R_1+R_2}{R_2}$ or putting this into the more convenient decibel notation—

$$\text{Number of decibels of bass boost} = 20 \log \frac{R_1+R_2}{R_2}$$

The value of the condenser C decides the frequency at which the bass boost begins. We can say, very approximately, that the rise in bass response will begin at that frequency for which the reactance of C is equal to R_2. In other words the capacity to use, in order that the boost shall begin at a frequency f, is given by—

$$C = \frac{1}{2\pi f R_2}$$

As a numerical example suppose $R_1 = 200{,}000$ ohms and $R_2 = 50{,}000$ ohms. Then $\frac{R_1+R}{R_2} = \frac{250{,}000}{50{,}000} = 5$. This is the voltage step-up at low frequencies. The gain in

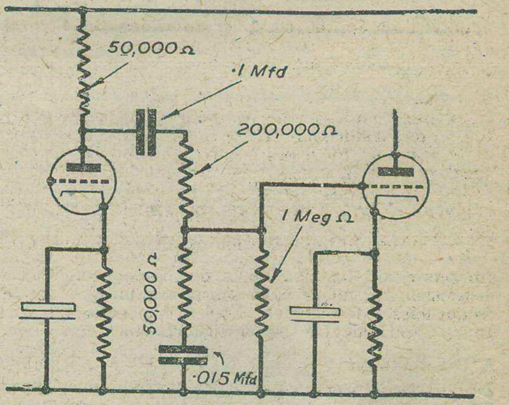


Fig. 3.—Showing application of bass boost circuit.

decibel at low frequencies is thus 20log 5 = 14 decibels. Suppose we decide that the bass boost shall begin at 200 c/s, in which case the circuit will be suitable for use in a gramophone amplifier. Using the formula given above we find—

$$C = \frac{1}{2\pi f R_2} = \frac{1}{2 \times 3.142 \times 200 \times 50{,}000} = .015\ \mu F \text{ approx.}$$

It is convenient to place this bass boost circuit in the

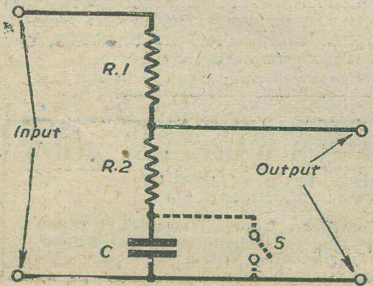
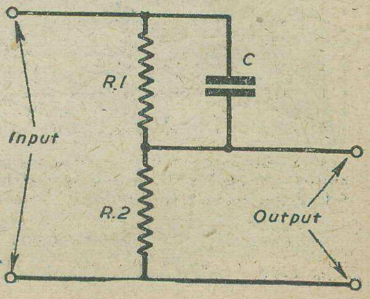


Fig. 2 (left).—The basic circuit for bass boost.

Fig. 4 (right).—The fundamental circuit for top boost.



coupling between A.F. amplifying valves as shown in Fig. 3. Suitable values of all components are given. The 1 megohm resistance indicated is necessary to apply grid bias to the second valve. The boost may be switched off, if so desired, by closing the switch S, which short-circuits C. The circuit is then a plain attenuator of 14 decibels loss.

One important thing should be noticed about this and other boost circuits described in this article, namely, that they give a net loss at all frequencies except the boost frequencies. It is necessary, therefore, to obtain satisfactory results to have an adequate reserve of

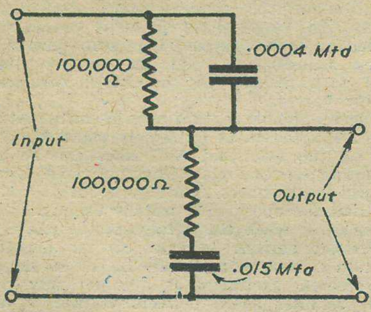


Fig. 5.—A combined circuit for bass and top cut.

amplification in the amplifier to which the control is applied. Otherwise it may be necessary to add another stage of amplification to the amplifier.

Top Boost

A rising high-frequency characteristic is often desirable to counteract sideband cutting in R.F. and I.F. amplifiers, or to make up for losses occurring in moving coil loud-speakers, which, unless they are unusually good, have serious losses above 5,000 c/s. The fundamental circuit is given in Fig. 4. As before, this circuit gives a loss of $\frac{R_1+R_2}{R_2}$ times in amplification at all frequencies except (in this case) the high ones, the reason being that the condenser C effectively short-circuits R_1 at high frequencies. As before, the boost may be said to begin at that frequency for which the reactance of C is equal to R_1 and again we can use the formula $C=\frac{1}{2\pi f R_1}$ in design calculations to find the value of condenser necessary to start the boost at a frequency f. Suppose we want a frequency characteristic rising after 5,000 c/s to about 12 decibels maximum boost. Making

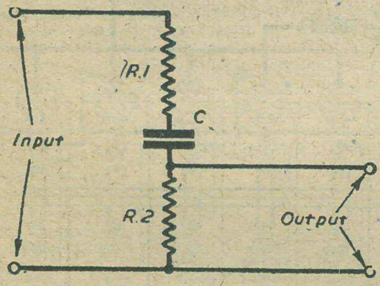


Fig. 6.—Circuit for obtaining a falling off in bass response.

$R_1=150{,}000$ ohms and $R_2=50{,}000$ ohms will give the required 12 decibels rise and using the above formula we find the necessary value of C to be—

$$C=\frac{1}{2\pi f R_2}=\frac{1}{2\times 3.142\times 5{,}000\times 150{,}000}=.0002\mu\text{F approx.}$$

The boost may be switched off by open-circuiting the condenser C.

There is no reason at all why the circuits of Figs. 3 and 4 should not be combined, as shown in Fig. 5, to give a characteristic rising at both high and low frequencies. As most amplifiers and receivers tend to cut bass and top the inclusion of a network such as that of Fig. 5 often brings about an improvement in quality. The values given in Fig. 5 give about 6 decibels boost beginning at about 100 c/s in the bass and at about 5,000 c/s in the top.

Bass Cut and Top Cut

There are certain circumstances in which a falling off in bass response is desirable: in a recording amplifier is an example. To obtain such a response the circuit of Fig. 6 may be used. The circuit given in Fig. 7 does the reverse: it cuts the top. Such a circuit is sometimes useful when reproducing gramophone records which

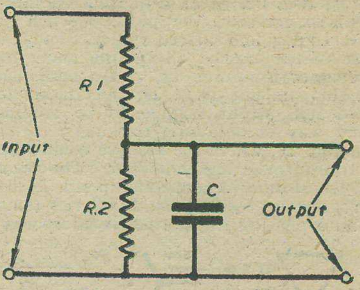


Fig. 7.—Circuit for obtaining top cut.

have an excessive scratch level. The design of suitable tone controls using these circuits should now be clear from the examples of design already given. The same two formulæ apply, namely that the factor by which the response is boosted, or cut, is given by $\frac{R_1+R_2}{R_2}$, and that the capacity wanted to make the boost, or cut, begin at a frequency f is given by—

$$C=\frac{1}{2\pi f R_1} \quad \text{or} \quad \frac{1}{2\pi f R_2}$$

depending whether C is associated with R_1 or R_2 in the circuit. In the case of all the circuits given, except for the bass boost type, R_2 can well be the grid leak of the valve following the circuit. But, as shown in Fig. 3, it is necessary to add an extra resistance to perform this function in the case of the bass boost circuit. The value of grid leak used should be very large compared with R_2, at least 10 times and preferably greater. The author hopes that this article will help readers to make up their own tone control circuits to suit their particular requirements.

PRIZE PROBLEMS

Problem No. 458

LUPIN'S A.C./D.C. receiver gave good results when used in conjunction with an indoor aerial. In an effort to improve reception he fitted an outside aerial, but was surprised to find that the fuse in the main's supply lead blew, as soon as the receiver was switched on. What was the cause, and why did the fuse blow?

Three books will be awarded for the first three correct solutions opened. Address your solutions to the Editor, PRACTICAL WIRELESS, Tower House, Southampton Street, Strand, W.C.2. Envelopes must be marked Problem No. 458 in the top left-hand corner and must be posted to reach us not later than the first post Monday, August 7th, 1944.

Solution to Problem No. 457.

The output voltage from the mains unit was low, and therefore the bias voltage was too high for the 220 H.P.T.

The following three readers correctly solved Problem No. 457 and books are accordingly being forwarded to them: L. Ebbutt, 6, Coillesdene Drive, Joppa, Midlothian, Scotland; G. Samuel, 12, Beaumont Gate, Glasgow, W.2; W. Tozer, 15, Bramble House, Devons Road, Bow, E.3.

Some Applications of Thyratrons

Concluding Instalment of the Paper Read by A. J. MADDOCK, M.Sc., Before the Institution of Electrical Engineers

IT will be realised from Figs. 23 (b) and 23(c) that, in the ideal case, the alternating voltage applied to the transformer leads the flux by 90 deg. so that the positive peakwave with no steady flux, i.e. in the mid-position of control, occurs at the maximum of the applied A.C. voltage. Now the total shift required of the peak wave for all circuits with inductance greater than the critical value, is 90 deg. i.e. $\pm$ 45 deg. from its mid-position. In a 3-phase rectifier, the position when the delay angle $\alpha = 45$ deg. is displaced 15 deg. in advance of the maximum of the applied alternating anode voltage as will be evident from Fig. 21, and a permanent phase shift of this amount must be introduced to permit control to full output voltage to be obtained. One convenient way of obtaining this angle of advance is shown in Fig. 24, where the relative connections to the various transformers are indicated. The secondary of the H.T. transformer is connected in star as also is that of the transformer feeding the auxiliaries (cathode and grids), and a phasing transformer is interposed between the latter and the peak-wave transformer.

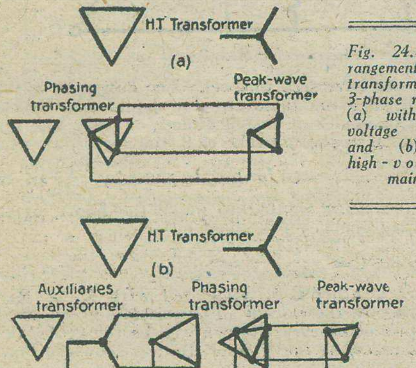


Fig. 24.—Arrangement of transformers in 3-phase rectifier, (a) with low-voltage mains and (b) with high-voltage mains.

The phasing transformer is connected delta-delta but with the supply to the grid transformers taken off as shown at voltage taps 0.21 of the secondary voltage from the ends of the windings, thus giving the 15 deg. advance and a voltage $1/\sqrt{3}$ of that of the phasing transformer primary voltage if the latter is arranged with a step-down ratio of 1 : 0.82. Fig. 24(a) shows the arrangement when the supply mains are at low voltage and the auxiliaries can be fed directly from them, whilst Fig. 24(b) is the case for h.v. supply mains when step-down for the auxiliaries is required. In practice it is often necessary to modify these conditions as regards the phase advance required, especially when large delay angles are required, since the peak waves become broadened and ignition occurs before the maximum voltage of the grid peak wave is reached. Incidentally, Fig. 24(b) also indicates how a 90 deg. phase-shift, relative to the anode-neutral voltage, is obtainable for heating the filaments of directly-heated cathodes as advocated by manufacturer to ensure more even distribution of the space current drawn from the filament; the single-phase filament transformers are connected in delta across the star output of the auxiliary transformer, and the proper phases are selected with respect to the anode voltages of the respective valves.

One very valuable feature of grid-controlled rectifiers is the ease with which extremely rapid overload protection on the D.C. and A.C. sides can be arranged. Quick-acting overload relays interrupt the A.C. excitation to the grid transformers, thus leaving all grids negatively biased, and the overload is usually extinguished in less than one cycle when the voltage of the phase carrying the overload current becomes so far negative that conduction cannot be maintained. When the overload current ceases, excitation is automatically re-applied and the rectifier again delivers voltage at whatever value was set by the position of the grid control.

Compounding of the rectifier may be arranged by feeding a direct current, proportional to the rectified output current, from a shunt in the output lead to a second set of D.C. control windings in the peak-wave transformers. By this means an increase of current, which would normally cause a fall in output voltage, may be made to advance the grid voltage further and thus keep the output voltage constant.

A simplified schematic of a 3-phase full-wave series-type rectifier incorporating the above features is shown in Fig. 25. The several protective and application circuits are omitted for the sake of clarity, but, in addition to the points already mentioned, interlocking is provided so that the high tension cannot be applied until the cathodes have attained operating temperature, and air-blowing equipment is provided on the base of the valves. Also a delay circuit, composed of inductance and capacitance, may be provided in the D.C. control circuit to the grid transformers so that, when first switched on, the rectifier output voltage builds up over a certain period (e.g. 350 millisec) to the value determined by the setting of the grid-control potentiometer.

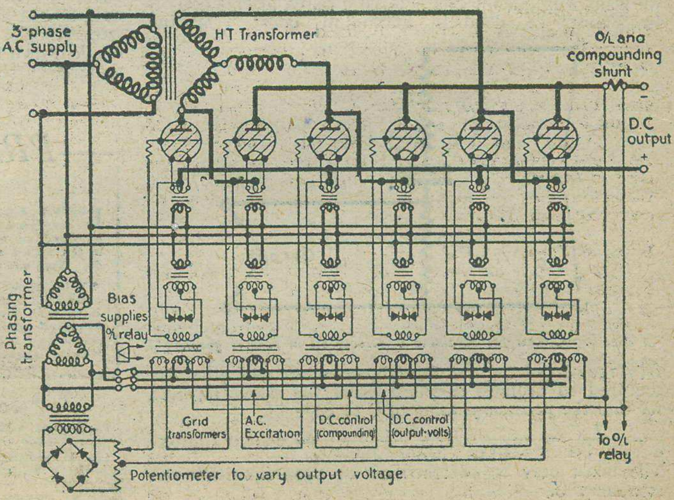


Fig. 25.—Three-phase, full-wave series rectifier circuit.

Mains Transformers—3

Lines of Force and Calculations for Windings. By D. BARBER

(*Continued from page 320, July issue*)

Electromagnetic Induction

GENERALLY speaking, providing certain assumptions are made, transformers are quite easy to design, and if the correct procedure is followed good results are ensured.

It is worth while at this stage to return to the fundamental principles governing electromagnetic induction, and to reconsider them, bearing in mind the practical requirements of the transformer in order that it may function efficiently.

If a coil of wire is linking an alternating magnetic flux, the E.M.F. induced in the coil is directly proportional to:

(1) The number of turns on the coil.
(2) The rate at which the flux is changing or the supply frequency.
(3) The maximum number of lines of force constituting the flux.

It is fairly obvious that the greater the number of turns on the coil and the faster the flux changes, the greater will be the induced voltage. It will also be appreciated that if a large number of lines of force are embraced or linked by the coil a large E.M.F. will result. The term "maximum number of lines of force" may appear a little confusing, but it must be remembered that this flux is following the mains voltage, which, being A.C., is increasing, decreasing and reversing many times a second. Thus, the expression denotes the highest value which the magnetic flux reaches during any one cycle. This will be made clear by glancing at a figure which appeared in an earlier issue, showing an alternating voltage wave.

Expressed in simple arithmetic, the three foregoing rules may be written as a formula, thus:

$$\text{Formula 1}: E = \frac{4.44 \times N \times F \times T}{100{,}000{,}000}$$

where E is the voltage induced in the coil
N is the maximum number of magnetic lines of force
F is the frequency of the supply in cycles per second
T is the number of turns on the coil.

The numbers 4.44 and 100,000,000 are "constants," and so do not vary in any way.

On examining this formula it will be seen that, as the supply frequency is invariably fixed, N and T are the only terms which can be altered to produce a certain voltage, and, furthermore, there is no limit to the number of values which can be given to N and T, and still obtain the same value for E. For instance, N can be made large and T small. The same voltage would also be produced if T were made large and N small. As the size of the coil depends on T and the size of the core is governed by N, it is important to give them suitable values in order that the transformer may be correctly proportioned.

Lines of Force

It is perhaps fortunate in this respect that there is a definite limit to the number of lines of force which a given piece of iron can carry. This value is fixed at about 60,000 lines for every square inch of cross-section. Thus, if the iron section of a transformer were 2 sq. in. it would not be economical to try and force more than 120,000 lines through it. This at once gives a clue as to the value to be assigned to N, which can now be written as 60,000 × A where A is the cross-sectional area in sq. in. of the core limb *on which the coil is wound*. It is important to use the correct value for A, since, in the case of a shell type transformer, the centre limb is always wider than the two outer limbs. Thus, if the coils were wound on the middle leg, the value of A for the middle leg and not the outer legs would be used.

Turns on the Coil

To obtain a given voltage then, the only real variable left is T, the number of turns on the coil, and to obtain a value for this, the formula can be written in this form:

$$\text{Formula 2}: T = \frac{E \times 100{,}000{,}000}{4.44 \times F \times 60{,}000 \times A}$$

For example, suppose that it is desired to find how many turns to put on the primary coil of a shell type transformer for operating on, say, 200 volt mains at 50 cycles frequency. Assume that the coil is to fit on the centre leg, which has a cross-sectional area of 2 sq. in. Substituting all the values in the formula:

$$T = \frac{200 \times 100{,}000{,}000}{4.44 \times 50 \times 60{,}000 \times 2}$$

which works out at 750, so that this transformer would require 750 turns on its primary coil. It is perhaps advisable at this point to correct a false impression, which often exists, that the size of the wire or the *resistance* of the coil has something to do with the ability of the transformer to work off a certain mains voltage. This is certainly not the case, since, in the example quoted above, as long as the number of turns was 750, it would be immaterial whether the wire was small or large in diameter.

Primary Calculations

The factor which does affect the size of the primary wire, however, is the output which it is desired to obtain from the secondary coil. Assume that in the transformer above a secondary output of 100 volts 4 amps. is required. Transformers are always rated in "volt-amperes," that is, volts × amps., so that in this case the secondary output would be 100 × 4, i.e. 400 volt-amperes (abbreviated 400 v.a.). Small transformers of this type usually require about 15 per cent. more input to the primary than is taken from the secondary, so that in this particular case the primary input would be:

$$\frac{115 \times 400}{100} = 460 \text{ volt-amps.}$$

The difference (60 volt-amps.) is wasted and appears in the form of heat in the coils and core.

Since the primary input will be 460 volt-amps. and the primary voltage is 200, the primary current at full load will be 460 divided by 200 = 2.3 amps., consequently the wire used for this winding must be able to carry this current without over-heating. The table below shows the current that can be safely passed through different sizes of wire. On looking at this table it is seen that

S.W.G.	Bare Diam. in inches	Permissible Working Current in amps.	S.W.G.	Bare Diam. in inches	Permissible Working Current in amps.
14	.080	10.05	26	.018	.508
15	.072	8.15	27	.0164	.422
16	.064	6.45	28	.0148	.344
17	.056	4.93	29	.0136	.286
18	.048	3.26	30	.0124	.241
19	.040	2.51	31	.0116	.210
20	.036	2.04	32	.0108	.183
21	.032	1.61	33	.0100	.156
22	.028	1.23	34	.0092	.133
23	.024	.904	35	.0084	.110
24	.022	.760	36	.0076	.090
25	.020	.628			

No. 19 s.w.g. with a bare diameter of .040in. is the nearest size and could be safely used for this primary coil.

The Secondary

Turning now to the design of the secondary coil, the voltage required is 100, and the current is 4 amps. Using the same formula for the number of turns as was used for the primary, the secondary coil will have:

$$\frac{100 \times 100{,}000{,}000}{4.44 \times 50 \times 60{,}000 \times 2} = 375 \text{ turns}$$

assuming that the secondary coil is also wound on the centre limb as is usually the case.

The nearest wire size is obtained from Fig. 1, and is seen to be No. 18 s.w.g. If this secondary were wound with 375 turns, it would be found that although when giving no current the voltage would be correct, i.e. 100, when supplying 4 amps. the voltage would be, perhaps, 5 per cent. low, due to a voltage drop in the coil itself. To compensate for this it is necessary to add 5 per cent. of extra turns to the value obtained from the formula, giving a figure of:

$$\frac{105 \times 375}{100} = 394 \text{ turns.}$$

This figure of 5 per cent. should always be added in the case of any transformer secondary winding.

The Core

It is important that there is sufficient winding space on the core to enable all the primary and secondary turns to be wound on. Usually in the case of amateur transformer work, the constructor starts off with a core of definite size and weight, and wishes to know what is the maximum output he can obtain from it. To help in this matter the following formula may prove useful:

$$\text{Formula 3: V.A.} = \frac{W \times F}{2.5}$$

where VA is the maximum output obtainable from the secondary

W is the weight of the complete core in *pounds*

F is the supply frequency.

2.5 is a constant.

If this formula is used, no difficulty should be experienced in finding room for all the turns required. Sometimes space may be somewhat restricted if, for instance, several secondary coils are to be wound on one core; in a case like this, wire having a thinner insulating covering should be used. Four types of covering are possible, viz., enamel, double silk, single cotton, and double cotton. The latter is usually used where space is not too limited, since it is cheap and fairly easy to handle. The double cotton covering increased the diameter of the wire by .01in. Single cotton is sometimes used, although not very often, having rather poor insulating quality; this covering increases the wire diameter by about .006in. Silk covering is rarely used, since in addition to being expensive, it is not easily obtained under present conditions. Enamelled wire is very useful where space is very restricted, as it normally increases the bare diameter of the wire by only .003in. to .005in. The chief drawback is, however, the ease with which the enamel covering is cracked if handled at all roughly, so that shorted turns are much more common with enamelled wire than with any other type of covering. Because of this, it should not be used unless circumstances compel its application, or until the amateur has had a little experience in its manipulation.

All the main aspects of design have now been covered, and it only remains to show the correct procedure to be adopted when working out from a given core. This is as follows:

(1) Weigh the core and from this estimate the maximum possible output, using formula 3.

(2) Measure up the cross-sectional area of the core limb on which it is proposed to assemble the coils, and from this figure work out the number of turns on the primary coil, using formula 2.

(3) Work out the primary current value, and, using the table in Fig. 1, select a suitable size of conductor.

(4) Work out the nominal secondary turns, using formula 2, and add 5 per cent. for voltage drop on load.

(5) Select a suitable wire size for the secondary from the table below.

If these rules are observed, a sound design should result and if the transformer is then carefully constructed satisfaction will be assured.

Grid Bias Voltage

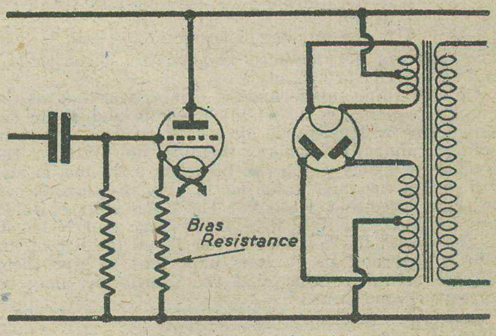
THIS note has been written in the belief that it will be of some help to those beginners who may find it difficult to understand how grid bias voltages are obtained in mains-driven sets.

Most textbooks state that by inserting a resistance in the cathode lead the cathode is made positive with respect to earth, and by connecting the grid to earth it is therefore negative with respect to cathode. Here the subject is left, and while the above explanation may suffice for some people to grasp the underlying principles, it is the writer's opinion that there are many who find it all too brief.

The accompanying diagram shows, in the conventional manner, a triode valve supplied with power from the mains unit on the right; BR, the bias resistance in the cathode lead, results in the grid being negative wih respect to cathode.

Now, for the sake of simplifying the explanation, let's think of the electron flow as that of water, and of the mains unit as a pump, drawing water from the anode and passing it back to cathode through the connecting "pipes."

If, in place of BR, we apply pressure with one foot, what happens? Yes! the pressure on the lower side increases, while that on the upper is reduced. Now, the grid being connected to the lower side will also have an increased pressure, even though the water has to



Circuit diagram showing how a triode valve is supplied with power from a mains unit.

pass through a high resistance. The reason for this being that there is no water escaping from the grid, so that the pressure there will build up until it is the same as that on the lower side of our foot.

If we now go back and think of electrons in place of water we should be able to understand what is meant by saying that the grid is negative with respect to cathode. The point to bear in mind is that there will be more electrons per atom on the grid than on the cathode, or, in other words, the grid has a negative potential with respect to cathode.—W. H. M.

Valve Data Sheets

EVER-READY

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EQUIVALENT TYPES— 2-VOLT VALVES

EVER READY	COSSOR	DARIO	FERRANTI	HIVAC	MAZDA	MULLARD	MARCONI OSRAM	STANDARD	SIX-SIXTY	TUNGSRAM	TRIOTRON
K.80.A.	210 P.G.	—	V.H.T.2.A./V.H.T.2	—	—	F.C.2	X.21	—	—	—	—
K.80.B.	—	—	—	—	—	F.C.2.A.	X.22	—	—	V.O.2	—
K.50.N.	—	—	—	—	—	V.P.2.B.	—	—	—	—	—
K.50.M.	210 V.P.T.	—	—	V.P.215	V.P.215	V.P.2	—	—	218 V.P.	H.P.211/H.P.221	—
K.40.B.	220 S.G.	—	—	S.G.220	215 B.	P.M.12.A.	S.22, S.24	5.B.1	218 S.G.	S.220, S.S.210	S.215
K.40.N.	220 V.S.	T.B.452	V.S.2	—	S.215.V.M.	P.M.12.M.	V.S.24	—	218 V.S.G.	S.V.220	S.208
K.23.A.	—	—	—	—	L.21.D.D./L..2/D.D.	T.D.D.2	H.D.22	—	—	—	—
K.23.B.	210.D.D.T.	—	H.2.D	—	H.L.21.D.D.	T.D.D.2.A.	H.D.22	—	S.S.210.D.D.T.	D.D.T.2	—
K.30.K.	210 H.L.	T.B.282	—	H.210	H.L.210/H.L.2	P.M.1.H.L.	H.L.2	1.H.L.B.1	210 H.L.	H.R.210	H.D.2
K.30.D.	210 Det.	T.B.172	—	D.210	L.210.L.2	P.M.2.D.X.	L.2/B.L.21	—	210 D.	L.D.210	S.D.2
K.30.E.	210 Det.	T.B.172	—	D.210	L.210.L.2	P.M.2.D.L.	L.2/B.L.21	—	210 D.	L.D.210	S.D.2
K.70.B.	220 H.P.T.	T.C.432	—	V.220	Pen.220	P.M.22.A.	K.T.2./P.T.2	Pen.B.1	220 Pen.	P.P.220	P.225
K.70.D.	—	—	—	—	Pen.231	P.M.22.D.	—	—	—	—	—
K.33.A.	220 B, 240 B.	T.B.402	H.P.2	B.230	P.D.220	P.M.2.B.	—	—	220 B.	C.B.215	E.220.B.
K.33.B.	—	—	—	—	P.D.220.A.	P.M.2.B.A.	B.21	—	—	C.B.220	—
K.77.A.	—	—	—	—	Q.P. 240	Q.P.22.A.	Q.P.21	—	—	—	—

A.C. MAINS VALVES

EVER READY	COSSOR	DARIO	FERRANTI	HIVAC	MAZDA	MULLARD	MARCONI OSRAM	STANDARD	SIX-SIXTY	TUNGSRAM	TRIOTRON
A.36.A.	41.S.T.H.	—	—	—	—	T.H.4	X.41, X.42	—	—	—	—
A.36.B.	—	—	—	—	A.C./T.H.I.	T.H.4.A.	X.41	—	—	T.X.4	—
A.80.A	41.M.P.G.	—	V.H.T.4	—	—	F.C.4	M.X.40	15.A.2	—	M.H.4105	0407
A.50.M.	M.V.S./Pen.	—	{V.P.T.4 V.P.T.4.A.}	A.C.V.P.	—	V.P.4	V.M.P.4	9.A.1	H.P.2.A.C.	{H.P.4105 H.P.4106}	S.434.N.
A.50.N.	—	—	V.P.T.4.A.	—	—	V.P.4.A.	—	—	—	—	—
A.50.A.	M.S. Pen. A.	T.E.464	S.P.T.4	A.C./H.P.	A.C./S.2 Pen	S.P.4	M.S.P.4	8.A.1	H.P.1.A.C.	H.P.4100	S.435.N.
A.50.B.	—	—	—	—	—	S.P.4.B.	—	—	—	S.P.4.B.	—
A.50.P.	—	—	—	—	A.C./V.P.2	V.P.4.B.	—	—	—	V.P.4.B.	—

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A.C. AND A.C./D.C. VALVES—*(Continued)*

EVER READY	COSSOR	DARIO	FERRANTI	HIVAC	MAZDA	MULLARD	MARCONI OSRAM	STANDARD	SIX-SIXTY	TUNGSRAM	TRIOTRON
A.20.B.	D.D.4/D.D.L.4	—	—	—	A.C./D.D./V.G.14	2.D.4.A.	D.41	D.D.A.1	—	D.D.465	D.401
A.23.A.	D.D.T.	—	H.4.D.	A.C./D.D.T.	A.C./H.L.D.D.	T.D.D.4	M.H.D.4/D.H.42	11.A.1/11.A.2	4.D.D.T.A.C.	D.D.T.4160	—
A.27.D.	—	—	—	—	—	Pen.4.D.D.1	—	—	—	—	—
A.30.B.	41MTB./41MTA.	—	—	—	A.C.2/H.L.	904.V.	M.H.41	—	4.D.X.A.C.	A.R.495	A.440.N.
A.30.D.	41MHF./41MTL.	T.E./384	D.4	A.C./H.L.	A.C./H.L.	354.V.	M.H.4	H.L.A.2	4.G.P.A.C.	A.R.4101	A.430.N.
A.70.B.	M.P./Pen.A.	—	—	A.C.Y.	A.C./Pen.	Pen.4.V.A.	KT42/N40/N42	7.A.2	4.Pen.A.A.C.	{APP4A/APP4100 APP4120}	{P.440.N. P.441.N.}
A.70.C.	42.M.P./Pen.	—	P.T.4.	—	A.C.2/Pen.	Pen.4.V.B.	N.41	7.A.3	—	APP4C	—
A.70.D.	—	—	—	—	—	Pen.A.4	—	—	—	—	—
A.70.E.	—	—	—	—	A.C.4/Pen.	Pen.B.4	—	—	—	A.P.P.4.D.	—
A.11.A.	{408.B.U. 506.B.U.}	—	—	—	—	D.W.2	U.10	—	—	P.V.495	G.431, G.470
S.30.C.	4.X.P.	—	L.P.4	—	P.P.3/250	A.C./044	P.X.4	—	H.V./4/2	P.460/015/400	K.435/10
A.11.B.	—	—	—	U.U.120/350	U.U.3/U.U.4	1.W.3	M.U.12	1.A.7. R.2	1.H.120/350	A.P.V.4200	—
S.11.D.	442.B.U.	F.W.2	R.4	—	U.U.120/350	D.W.4/350	U.12	—	W.120/350	P.V.495	G.4110
A.11.C.	—	—	—	U.U.120/500	U.U.5	I.W 4	M.U.14	R.3	—	—	G.4120.N.
A.11.D.	—	—	—	—	—	I.W.4/350	—	—	—	—	—
A.40.M.	M.V./S.G	—	—	{A.C.V.S. A.C.V.H.}	A.C./S.G.V.M.	M.M.4.V.	V.M.S.4	V.S.G.A.1.	4.M.M.A.C.	{S.4105 A.S.4125}	{S.415.N. S.431.N.}
C.20.C.	—	—	—	—	D.D.620	2.D.13.C.	—	10.D.1	—	—	—
C.30.B.	—	—	D.A.	—	H.L.1320	H.L.13.C.	—	—	—	—	—
C.23.B.	13.D.H.A./220.D.D.	T. T.B.C.113	H.A.D.	—	H.L./D.D.1320	T.D.D.13.C.	—	11.D.3	—	D.D.T.13	D.T.1336
C.36.A.	202.S.T.H.	—	—	—	—	T.H.21.C.	—	—	—	T.X.21	—
C.80.B.	13.P.G.A	—	V.H.T.A.	—	—	F.C.13.C.	X.30, X.32	15.D.1	—	V.O.13.B.	01307
C.50.B	—	—	—	—	—	S.P.13.C.	—	—	—	S.P.13.B.	S.1328
C.70.D.	—	—	—	—	Pen.3520	Pen.36.C.	—	7.D.6	—	—	—
C.10.B.	40.S.U.A.	—	R.Z.	—	U.4020	U.R.1.C.	—	1.D.5	—	—	—

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).

Tuning Coils

SIR,—Some months ago an article appeared in PRACTICAL WIRELESS dealing with the design and construction of tuning coils. In this article, the following formula was given:

$$L = \frac{2A^2 N^2}{3A + 9B}$$

where A = Mean diameter of coil in inches.
B = Length of winding in inches.
N = Total number of turns on coil.
L = Resultant inductance in microhenries.

As, however, the problem usually confronting the home constructor is that of finding the number of turns required to give a certain inductance, the formula can be modified to

$$N = \frac{45L + \sqrt{15L\ (135L + 4A^3K^2)}}{2A^2K}$$

where L, A, and N have the same significance as before and

K = Number of turns per inch for the wire size chosen taking into account the type of covering.

This factor K can be found by reference to standard wire tables.

The choice of wire gauge is not critical, for long waves 32-40 S.W.G., for medium waves 24-34 S.W.G., and for short waves 18-28 S.W.G.—the deciding factor usually being the space available. Broadly speaking, however, the thicker the wire the better the coil.

I hope that this modified formula will be of some use to home constructors in these times of acute component shortage.—G. D. BRITTAIN (Hendon).

Station Identification

SIR,—I would like to add a little to A. J. Newman's letter. AFHQ may be heard most of the time between 14.30 and 16.00 hours on the 18 m. band.

Radio France transmits from Algiers.

Can anyone tell me the call sign of the new Leopoldville station on 16.88 and 25.7 m. described in a recent edition of PRACTICAL WIRELESS? It comes on the air at 12.15 hours. I first heard it on April 15th on 16.88 m., but I suppose it was only testing then. Another Leopoldville station, OPL, which announces itself as Radio Congo-Belge, operates on 14.97 m. and comes on the air at 12.55 hours. All times are D.B.S.T. —S. HUDSON (Cambridge).

Reception in Ireland

SIR,—I know that we here do not call the B.B.C.'s tune, but reception over here is sometimes so variable that the set is switched off. It certainly is anti-directional—to Britain.

There has been interesting discussion in PRACTICAL WIRELESS on the merits of H.F. on short waves, and evidently a difference of opinion among amateurs.

When first I listened on the higher frequencies, some ten years back, I used one stage of tuned H.F., with the usual Det. and L.F. amp., with *then* gratifying results, but now I find a Det./L.F. arrangement the most efficient (with accumulator and mains H.T.). Perhaps this is due to components and/or valves, and as we know, one faulty component may upset a whole period of experimenting. Practically, many seem to have resorted to the simple Det./L.F. I have no experience of a Communications Rx.

I wonder if the proposed United Nations League has considered the issue of an International Receiving Licence, and the charge for this.—M. K. H. (Blackrock).

Faulty B.B.C. Transmissions?

SIR,—I have been interested by the number of letters you have received from listeners since my original, concerning faulty transmissions by the B.B.C.

What has amazed me most is the diverse areas which are affected thus, and not able to receive the service for which they contribute.

One notes that according to the B.B.C.'s idea, that body is doing a very excellent job of war work, but I wonder if the majority of home listeners think so, when they tune in hoping to hear a speech by the King or Prime Minister and get only a horrible jumble of noises, to say nothing of the times they try to hear the usual programmes after a hard day's work, and find it unendurable.

No, sir! The B.B.C. has fallen down on the job and badly, too, either because they have not the "know how" to provide a reliable signal under wartime conditions, or because they just don't care.

In conclusion, is there any evidence that the present system of broadcasting has ever prevented a single enemy machine from dropping its bombs? I guess not, and it is quite time that it was scrapped.—C. FIELD (St. Asaph).

Post-war Radio

SIR,—Referring to the article on Post-war Radio in June's PRACTICAL WIRELESS, I would like to point out to the writer that "12 words per minute" was always required to obtain a Post Office transmitting licence, also, amongst British amateurs, it has long been considered that holding a transmitting licence was for experimental purposes, and not a hobby.

Regarding "hamfeasts," this should read "hamfest," and is an Americanism.

I cannot agree that the amateur will be pushed lower down the wavelength scale, as the amateur has already found practically all the answers here, which for practical purposes are optical, it is now for the manufacturers to make suitable equipment.

Prior to the war, with perhaps one exception, there was no one in this country making a receiver with crystal filter. We have band-pass crystal filters now!—FRANK J. WADMAN (G2GK).

Short and Medium Wave Midget Receiver

SIR,—This small receiver gives good 'phone reception of a number of stations on the medium wave, and good results on the short wave. The writer had good reception of the United Nations Radio, Algiers. All reception was carried out with 5yds. of throw-out aerial. The coil is wound with 22 c.c. for grid windings, and 32 enamelled wire for both reaction windings. Valve types giving best results are L.F. or Power. Det. valves will work, but if a valve of this type is used, a 10 ohm resistor must be used in series with L.T.+lead. A 10,000 ohm resistance can be used instead of H.F.C., but choke gives best results. Both tuning condensers (tuning .0005 mfd., reaction .0003 mfd.) are of the small solid type.—E. H. PERCY (2FSC).

Licensed Radio Repair Depots?

SIR,—I would be pleased if you would draw the attention of your readers to a potential restriction of their liberties proposed by the Radio and Television Retailers' Association (R.T.R.A.) as reported in a current trade paper. This august body are requesting the Board of Trade to license radio repair depots in a similar fashion to the licensing of radio retailers.

This is proposed in view of the "unfavourable report of many of the new radio repair depots."

Thus it is proposed that further shackles be imposed on the technically minded radio serviceman.

If this move really would eliminate the dabbler who is a menace to the public because of his insufficient knowledge, all would be well, but the actual effect will surely be to prevent the efficient serviceman who may be doing good work for the public, in his spare time, from undertaking work, or opening a repair depot, without a licence.

If the retail licensing is a true example, such a serviceman will find that existing dealers will oppose him in his application and he will find it almost impossible to open up.

This proposed move is the more impertinent when it is remembered that many dealers nowadays rely on the spare time serviceman, not having the necessary ability to do their own repairs.

If your readers act in union in opposing this proposal through your journal, they may avert this imposition.

The way to eliminate the dabbler is an examination in theory and practice *by an independent body*. The irony of this would be that a large percentage of dealers would be unable to pass the exam.

Personally, I think that the present state of affairs, for all its abuses, is preferable to any form of licensing —SERVICEMAN (Barrow).

A Beginner's Activity

SIR,—Reading the letter of B. K. Holder (Birmingham) in the July issue of PRACTICAL WIRELESS inspired me to write to you and tell you of "another beginner's activity."

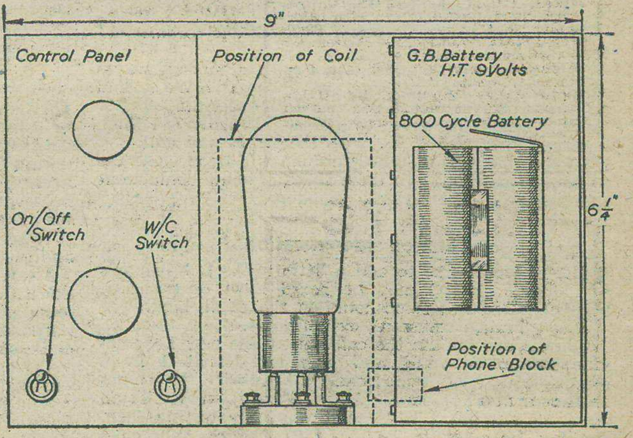
My radio career is very similar to his, although I have only been doing radio work for two years.

The first set I built was an o-v-2 battery model, the design of which I found in your book *Practical Wireless Circuits*. This worked quite well and I still use it with a new coil and in conjunction with an A.C. mains eliminator. I then tackled several S.W. Rx's of the o-v-o type, but none gave any satisfactory results—some gave none at all! Then I built F. G. Rayer's o-v-1 Rx described in PRACTICAL WIRELESS March, 1943, and at last I had a S.W. Rx that worked well. I added to this an H.F. section which gave me a receiver similar to the "Economy Three." I am afraid I don't get much time for listening in and accurate logging, etc., for I am studying physics, chemistry, pure and applied mathematics, which takes up most of my spare time in the evenings.

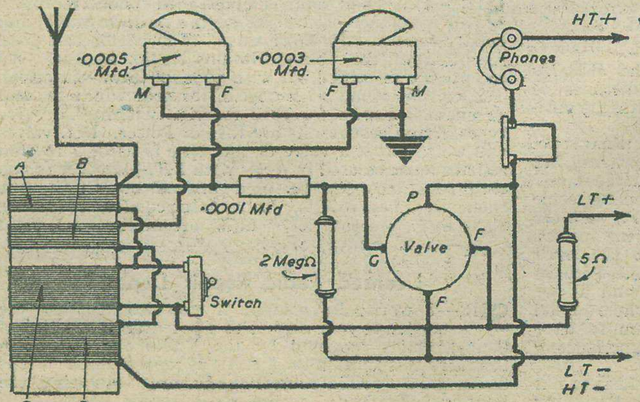
In the way of ordinary T.R.F. receivers for medium wave work, the latest set I have built is a midget A.C./D.C. I am having some trouble in the H.F. section, but I hope to overcome this by careful re-wiring.

I have enclosed my address and if B. K. Holder (or anyone else about 17-18 years of age) is interested I would be pleased to correspond with him, or them, for since we are both studying the same subjects and both are interested in radio work, we might be of great assistance to each other.

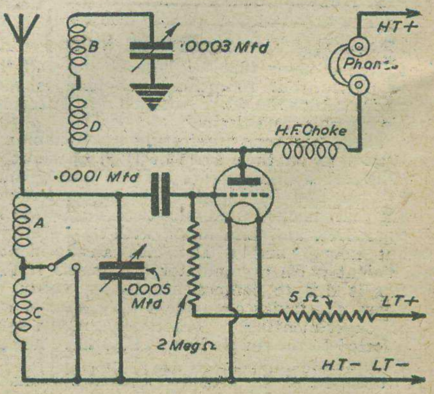
To close, I can only add that PRACTICAL WIRELESS is a really first-class radio periodical which helps me considerably in my studying and in my practical radio work. An example of this is shown by S. A. Knight's article on Kirchoff's laws about which I have read and re-read in text books, but at last I can understand them perfectly.—W. HOBEIN (Leicester).



General arrangement. Depth of cigar box is 2¾in., and 'phones are mounted on a small block inside box.



Layout of the short and medium wave receiver. See letter from E. H. Percy.



Coil fitted over valve. Reaction split for short and medium waves.

Practical Wireless
BLUEPRINT SERVICE

PRACTICAL WIRELESS

CRYSTAL SETS

	No. of Blueprint.
Blueprints, 6d. each.	
1927 Crystal Receiver .. .. —	PW71*
The "Junior" Crystal Set .. —	PW94*

STRAIGHT SETS. Battery Operated

One-valve : Blueprints, 1s. each.	
All-Wave Unipen (Pentode) .. —	PW31A
Beginners' One-valver .. .. —	PW85*
The "Pyramid" One-valver (HF Pen) .. .. —	PW93*
Two-valve : Blueprint, 1s.	
The Signet Two (D & I F) .. —	PW76*
Three-valve : Blueprints, 1s. each	
Selectone Battery Three (D, 2LF (Trans)) .. .. —	PW10
Summit Three (HF Pen, D, Pen) —	PW37*
All Pentode Three (HF Pen, D (Pen), Pen) .. .. .. —	PW39*
Hall Mark Cadet (D, LF, Pen (RC)) —	PW48
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*
The Monitor (HF Pen, D, Pen) .. —	PW61
The Tutor Three (HF Pen, D, Pen) —	PW62
The Centaur Three (SG, D, P) .. —	PW64
The "Colt" All-Wave Three (D, 2 LF (RC & Trans)) .. .. —	PW72*
The "Rapide" Straight 3 (D, 2 LF (RC & Trans)) .. —	PW82*
F. J. Camm's Oracle All-Wave Three (HF, Det, Pen) .. —	PW78
1938 "Triband" All-Wave Three (HF, Pen, D, Pen) .. .. —	PW84
F. J. Camm's "Sprite" Three (HF Pen, D, Tet) .. .. —	PW87*
The "Hurricane" All-Wave Three (SGD, (Pen), Pen) .. .. —	PW89
F. J. Camm's "Push-Button" Three (HF Pen, D (Pen), Tet) —	PW92*
Four-valve : Blueprints, 1s. each.	
Beta Universal Four (SG, D, LF, Cl. B) .. .. —	PW17
Nucleon Class B Four (SG, D (SG), LF, Cl. B) .. .. —	PW34B
Fury Four Super (SG, SG, D, Pen) —	PW34C
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*
F. J. Camm's "Limit" All-Wave Four (HF Pen, D, LF, P) .. —	PW67*

Mains Operated

Two-valve : Blueprints, 1s. each.	
A.C. Twin (D (Pen), Pen) .. —	PW18*
Selectone A.C. Radiogram Two D, Pow) .. .. —	PW19*
Three-valve : Blueprints, 1s. each.	
Double-Diode-Triode Three (HF Pen, DDT, Pen) .. .. —	PW23*
D.C. Ace (SG, D, Pen) .. .. —	PW25*
A.C. Three (SG, D, Pen) .. —	PW29
A.C. Leader (HF Pen, D, Pow) .. —	PW35C*
D.C. Premier (HF Pen, D, Pen) .. —	PW35B*
Unique (HF Pen, D Pen), Pen) .. —	PW36A
F. J. Camm's A.C. All-Wave Silver Souvenir Three (HF Pen, D, Pen) —	PW50*
"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*
Four-valve : Blueprints 1s. each.	
A.C. Fury Four (SG, SG, D, Pen) —	PW20*
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A.C. Hall-Mark (HF Pen, D, Push-Pull) .. .. .. —	PW45*
Universal Hall-Mark (HF Pen, D, Push-Pull) .. .. .. —	PW47*

SUPERHETS

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F. J. Camm's 2-valve Superhet .. —	PW52*
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A.C. £5 Superhet (Three-valve) .. —	PW43*
D.C. £5 Superhet (Three-valve) .. —	PW42
F. J. Camm's A.C. Superhet 4 .. —	PW59*
F. J. Camm's Universal £4 Superhet 4 .. .. —	PW60
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Experimenter's Short-wave Three (SG, D, Pow) .. .. .. —	PW30A*
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The Band-Spread S.W. Three (HF Pen, D (Pen), Pen) .. —	PW68*

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MISCELLANEOUS

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Simple-Tune Three (SG, D, Pen) —	WM327
Economy Pentode Three (SG, D, Pen) .. .. —	WM337
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Economy A.C. Two (D, Trans) A.C. —	WM286
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THESE blueprints are drawn full size. The issues containing descriptions of these sets are now out of print, but an asterisk beside the blueprint number denotes that constructional details are available, free with the blueprint.

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

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PORTABLES

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MISCELLANEOUS

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