Mainly about Construction

BY "MEGOHM"

Push-Pull Amplification

THE SYSTEM EXPLAINED

The advent of super-power valves and high-grade audio transformers has for a time rather caused the push-pull amplifier to be neglected, but in the continual search after volume combined with quality, this system is quite likely to once more spring into favour.

The feature of this amplifier is that, following an ordinary transformer-coupled stage, two transformers with centre-tapped secondary windings are suitably coupled to two similar power-valves, so that the whole forms one stage of amplification, giving full-wave rectification of signals, instead of the usual half-wave rectification in ordinary stages. This is a non-technical idea of the general principle.

Now an attempt will be made to set forth the action of the push-pull amplifier in as simple a manner as possible. It may be stated here that the object of the amplifier is, not so much amplification as the elimination of distortion, but as this elimination allows greater volume to be taken advantage of, the greater amplification is thus obtained, even if in an indirect way.

Referring to the diagram, the input transformer, T1, is seen on the left. Both transformers are similar to the usual audio transformer, with the exception that the secondary winding of one and the primary of the other is provided with a centre tap. Needless to say, quality in these transformers is a highly essential feature, otherwise quality might be lost rather than gained. The transformers are retailed in pairs, one alone being of no use. The output of the previous valve is fed into the primary of T1. Each end of the secondary winding is connected to the grid of its respective amplifier valve, and the centre-tap to both valve filaments, a grid-bias battery, D, being inserted in this lead as shown. The output of these two valves is then passed through the centre-tapped primary of T2. The secondary of this transformer is then connected to the loudspeaker, acting in the same way as an ordinary output transformer, so that no direct current passes through the speaker windings.

It is in the output circuit that the so-called "push-pull" action takes place. The special input transformer is required merely for the purpose of dividing the input between the two valves.

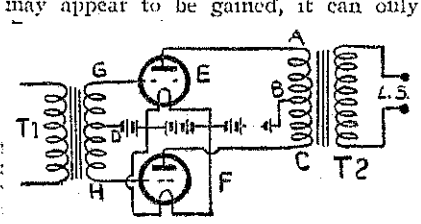
Suppose the current flowing from the tapping-point B to the point A is slightly decreased, this causes a slight decrease in the magnetic field produced by the plate-current flowing into the valve E, so that less opposition will be offered to the flux produced by the current flowing from B to C. In other words, a slight decrease of current from B to A will give a slight increase from B to C, so that a decrease on one side of the primary adds to the effect of the current on the other side.

Put in another way, when the terminal of coil G is positive, its valve grid is positive, but the grid end of coil H and its valve grid are at the same instant negative. So while the grid of valve E is positive, this valve is delivering heavy current through coil A, and while the grid of valve F is negative, it cannot deliver any current through its plate coil C. The current in A then induces a proportional current in the secondary winding.

When there is no voltage induced in coils G and H, the plate currents neutralise each other, and no output current is induced in the secondary of T2. With the opposite direction of the return half of the oscillation, the reverse action takes place, the grid and coil of valve E now become negative, and the grid and coil of valve F positive, inducing by means of coil C a current in the secondary of T2.

GRID SWING DOUBLED.

In the case of connecting two valves in parallel, and a.c. resistance is halved, but the amplification factor remains the same, and although extra amplification may appear to be gained, it can only



be very slight, as the grid swing is not increased.

The effect of push-pull is to double the grid swing which would be obtainable with the use of one valve alone in the ordinary manner.

Take separately, the oscillations in the coils A and C would produce characteristic curves showing distortion, but when the two oscillations are added together as they are in the secondary of the output transformer, the resulting curve is symmetrical and free from distortion, the elements contributing to distortion acting in opposite directions, cancelling one another.

Although ordinary small power valves may be used in the push-pull amplifier, it is now being constructed with two power valves of the 171 type, and with 180 volts on the plates, these will deliver to the speaker as much energy as one 210 type valve with 350 volts on the plate. Whether 120 type dryseil or other tubes are used, the amplifier will always give good and proportional results.

For efficiency, of course, all parts should be as low-loss as possible, and the wiring be well spaced. It is difficult to conceive how any cramped, high-capacity short-wave receiver can compete with one neatly laid out, all parts given the proper spacing, and the amplifier portion kept to itself. Soldered joints well made will help efficiency a lot.

A.C. VALVE OPERATION

A RESUME OF THE POSITION

The principle that allows of alternating current being used for filament heating is that of "thermal inertia." The degree of temperature variation depends upon the heat-storing capacity of the filament in relation to its heat-dissipating ability, so that in operating ordinary valve filaments with unrectified and unsmoothed a.c. the most efficient will be those filaments that have sufficient "thermal inertia" or bulk, which is almost its equivalent, to retain full emission heat between one cycle and the next. It has been shown that the amount of temperature hum is greatest from thin, low heat capacity filaments such as the 199 type, and smallest in the heaviest filaments such as those in the 112 type of tube. For this reason the heating of the filament of the last power valve with raw a.c. is a simple proposition, the chief precaution being to twist the leads together to prevent the hum reaching other parts of the circuit by radiation or induction.

It has also been shown that the amount of temperature variation depends not alone upon the ratio of surface or radiating area to the mass of the filament, but also upon the actual operating temperature of the filament itself. As radiation losses are the chief factor in lowering temperature during the periods of small or no current, it is seen that very low temperatures, that is dull emission valves, greatly facilitate temperature stability. It has also been found that a V-shaped filament conduces to hum more than a straight one.

CONCERNING THE FILAMENTS.

Coming now to actual a.c. operation of a whole set, there are two outstanding types, first those in which the a.c. is rectified and smoothed and then used to heat filaments of ordinary valves, and second those using special valves either of rugged filament or heater element type, either of which operates with raw alternating current. In either type, however, the voltage is usually reduced by a step-down transformer, and this enables the filaments to be wired in parallel in the ordinary way. When ordinary valves are used, some systems necessitate the filaments being wired in series, which is usually a more economical scheme, as the amperage required by the filaments is thereby much reduced, although the voltage required increases for each valve used according to the filament requirement, which must be the same for each.

As ordinary power-valve filaments may be run quite well on raw a.c., one of these may be used in the last stage instead of a special a.c. valve.

A number of firms make filament heating transformers, including Amestran, Dongan, Modern, National, Silver-Marshall, Thordasson, and General Radio. The voltage taps on all these except the last are 1.5, 2.5, and 5.0 volts. The General Radio transformer taps are 2, 3.5, 5.0, and 7.5 volts. In some cases the voltages of two taps are connected in series, so that they add together to suit certain valves.

The filament type of a.c. valve costs less, and has a longer life than, the heater type, but the latter has a lower inter-electrode capacity, which is desirable in a neutralised circuit. Grid bias is essential on the R.F. valves, when the filament type is used, and should be a little more negative than on the A.F. side, but if a slightly lower plate voltage is employed on the R.F., then the same bias can be used as on the A.F. Any type of audio amplification can be employed with excellent results.

THE DETECTOR.

Either heater or filament type may be used as a detector, but the UY227 type of heater has several advantages over the filament type, from which there is a slight but not objectionable hum. The heater tube may be used with either grid-leak condenser arrangement or with C bias, and although the filament type will function quite well with the same arrangement, is better suited for plate rectification. Plate rectification, however, is not as sensitive as grid-leak condenser, and leads to other complications. The Kellogg a.c. tube is an excellent detector for circuits such as the Browning-Drake. A bias up to 10 volts must be available for a heater type detector.

LEADING MAKES OF VALVES.

The following are the leading makes of a.c. valves at the present time:—

HEATER TYPE.

	Filament Volts.	Amps.	Amplification.
C327	2.5	1.75	7.8
UY227	2.5	1.65	8.7
McCullough ..	3.0	1.0	8.6
Sovereign ...	3.0	1.5	8.5
Marathon ..	5.5	1.0	7.3
Arcturus	15.0	0.35	10.5
Magnatron ...	2.5	1.50	9.3
FILAMENT TYPE.			
CX326	1.5	1.05	8.5
UX226	1.5	1.05	8.7
Armor	1.0	2.4	7.8
Van Horne ...	1.0	2.0	9.0
Ce Co	1.5	1.05	9.2
Magnatron ..	1.5	1.05	8.8

The plate voltage on all the above is 90 volts for both types and the grid bias minus 4.5.

In adapting a.c. operation to the Browning-Drake a different method of neutralisation has to be adopted by which the plate voltage is fed to the R.F. valve through a cored choke coil instead of through the primary of the R.F. transformer. For the audio stages is recommended an impedance incorporating an R.F. choke, second stage resistance coupling, and last stage a special arrangement of resistance and impedance to eliminate any tendency to "motor-boat" when used with a B power unit.

The UY227 and CY327 are listed at six dollars in America, and the CX326 at nine dollars.

The above brief particulars have been compiled by "Megohm" with the idea of giving readers an outline of the system employed and the valves used for a.c. operation. The first complete a.c. operated receiver in New Zealand arrived in Wellington a few weeks ago. It is probable that in a short time some of the makes of valves mentioned above will be on the market here.

It is not advisable to attempt to increase output of certain factory-made reflex sets by substituting a power-valve for the last audio. Such a change, with the appropriate grid bias and plate potential may render the radio-frequency amplifier quite unstable.

The Selective Crystal Set

CONSTRUCTING AS A WAVE-TRAP

The R.R. selective crystal set described last week answers quite well as a wave-trap for valve sets, rendering them just as selective as the crystal set itself at the most selective setting, which used as a trap on the four-valve Browning-Drake at two miles from 2YA, cuts out that station with a movement of the dial of two degrees either way.

Many constructors near a main station will prefer to construct the set complete with crystal as shown. This can then be used as a wave-trap, and in case of trouble with the set or during alterations is always available as a stand-by receiver. For use as a wave-trap the 'phones are not required, the aerial is connected to its usual terminal at the right, and the earth terminal is connected to the aerial terminal of the valve receiver. The crystal need not be plugged in, and earth is plugged into socket 6, and aerial usually into socket 5. Then tune in the unwanted station on the valve set, and with the trap condenser tune the unwanted station to minimum strength possible. The trap is then left permanently set if only one interfering station has to be dealt with. Any wanted station can then be tuned in on the valve set without interference, except upon wave-lengths very close to that of the unwanted station.

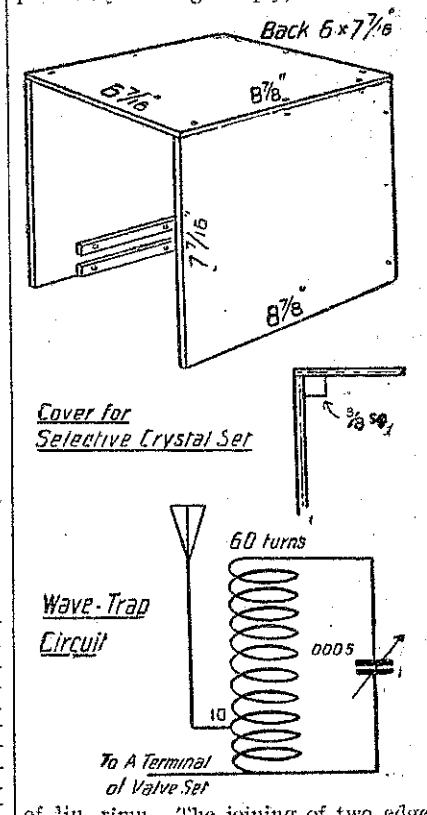
CONSTRUCTING AS A WAVE-TRAP ONLY.

Construction as a wave-trap only dispenses with the telephone and crystal connections, and for most situations a permanent aerial tap at the 10th turn of the coil will be all that is required. It would be a good plan when installing the trap to test the aerial connection to the 18th turn also, as although rather less selective at this setting, it might be more suitable for certain conditions. Once this has been decided, the connection can be permanently soldered to either position. The 10th turn will be the best where the distance from a main station is not great. Tested on a very unselective one-valver that brought in 2YA all over the dial at two miles, this trap gave it selectivity that cut 2YA out at four degrees either way.

Constructors will please themselves in the method of fitting up the wave-trap, but a neat accessory will be the result if it is housed in the cover as shown, with panel minus sockets and 'phone clips. The aerial terminal would then be permanently connected behind the panel to the coil tap and the "earth" terminal to the bottom of coil. This terminal then connects to the aerial terminal of valve set.

MAKING THE COVER.

For the assistance of constructors making the cover, the description of a simple method is given here, with sizes that will serve as a good guide, though care must be taken to allow for any deviation from size in panel or base-board. The cover sizes will fit a 6in. by 7in. panel, and 6in. by 8½in. baseboard. The top and sides are made preferably of Oregon 3-ply, and the back



of ⅜in. rimu. The joining of two edges of 3-ply at the top corners is effected by screwing each piece to a strip of wood ⅜in. square, placed inside the corners and short enough to allow for the thickness of the panel. Two strips ⅜in. by ¼in. shortened to allow the width of the front batten of baseboard, are screwed to the inside of each side as shown, and into these the receiver slides. A coat of shellac gives a suitable finish. If a strut is placed at the side of the panel it is to be set in sufficiently far to clear the running strips inside the cover.

This is quite a useful wave-trap for New Zealand conditions, and will be found a tremendous improvement on an unselective receiver.

Three dozen ⅜in. No. 4 brass screws will be required.