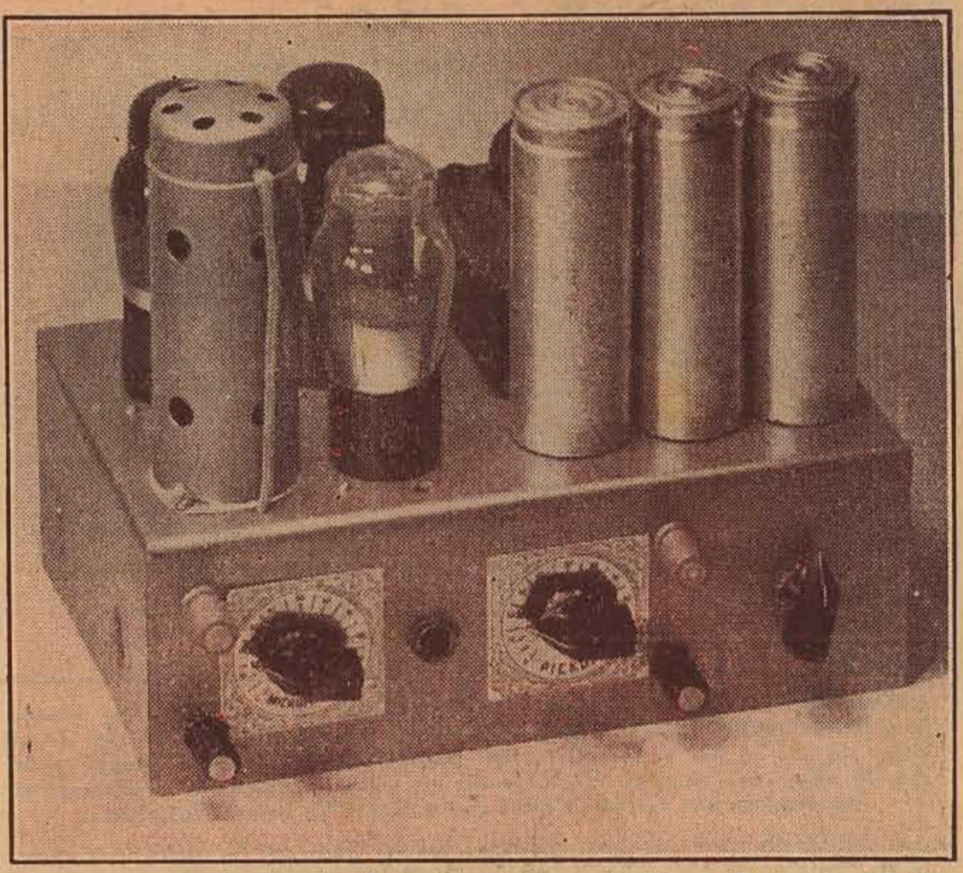
NOVEL TEN WATT AMPLIFIER FOR P.A.

Radio & Hobbies Circuit PA-3

In the first of the present series of Public Address articles, we described in detail the construction of two five watt amplifiers suitable for use at parties or at other small functions. Last month we presented a theoretical article dealing with loudspeaker networks and output transformers. Here is the third article. This time we describe a rather novel push-pull amplifier, which can be built economically and on a small chassis.



Here is the completed push-pull amplifier, built up on the small chassis originally used for the amplifiers PA-1 and PA-2. The microphone input terminals and volume control are on the extreme left of the chassis. Next comes the changeover switch, the pick-up terminals and volume control and finally the tone control.

YOU will remember that, when we described the previous amplifiers PA-1 and PA-2, we used a chassis having one more than the necessary number of valve holes. Although one does not like to see vacant holes in a chassis, we had in mind to describe other amplifiers using the same chassis and making good use of the extra valve socket hole.

One scheme which suggested itself was to use the extra hole for a pre-amplifier stage. No doubt many of our readers have already done this. When space permits, we intend to describe a five-watt amplifier complete with a preamplifier stage and a rather novel mixing arrangement, which we have in mind.

PUSH-PULL AMPLIFIERS

However, we did not consider it wise to describe another five-watt amplifier so soon and attention was accordingly directed to the possibility of constructing, on the particular chassis, a push-pull amplifier, which would naturally have a higher power output

As it turned out, the idea proved quite practicable.

In the design of the amplifier the fact was borne in mind that many of our readers may have built up the amplifier PA-2, described in the February issue, and may desire to rebuild it to the push-pull circuit.

Accordingly, we sought to arrange matters so that the new amplifier would use a 100 milliamp power transformer, a 5Y3-G rectifier valve, and a loud speaker with a 1000 ohm field winding.

Owing to the fact that there was only room on the chassis for four valves in all, it was not possible to utilise the usual push-pull circuit, which requires five valves in all. If we were to have push-pull output, a totally different circuit would have to be evolved.

TECHNICAL ASPECTS

However, we have said quite enough by way of introduction and it remains to consider the technical aspects of the matter.

In any push-pull amplifier the two output valves have to be fed with signal voltages equal in amplitude, but opposite in phase.

In practise, it is seldom convenient to have the amplifier push-pull throughout, and it is preferable for the amplifier to be capable of operating from a "single-sided" input source. This obviously necessitates a special circuit arrangement in the amplifier itself to develop push-pull signal voltages for the output valves.

One of the earliest methods of achieving this was to use a push-pull audio transformer in the plate circuit of the penultimate amplifier stage. The plate of this amplifier is fed through the primary winding of the transformer in the usual manner, and equal and out-of-phase voltages are developed across the split or centre-tapped secondary winding.

When resistance coupling became popular, special resistance coupled circuits were evolved. Chief among these were the phase-inverter and the phase-splitter circuits.

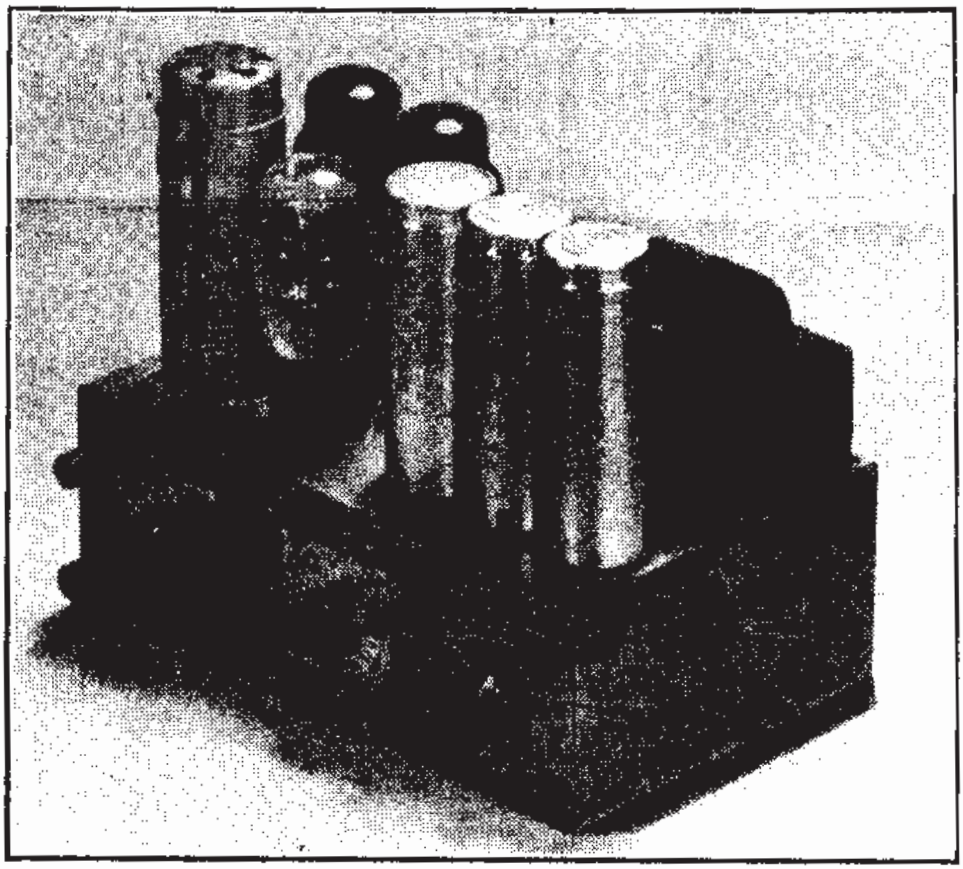
PHASE-INVERTER AND PHASE-SPLITTER

The phase-inverter is simply a special additional stage, which is included for the express purpose of developing an out-of-phase signal voltage for one of the push-pull valves.

In the case of a phase-splitter, on the other hand, a triode valve is operated with equal loads in the plate and cathode circuits. Across these two loads equal but out-of-phase signal voltages are developed. This particular circuit has been used a number of times in amplifiers described in "Radio and Hobbies."

Under ordinary circumstances the

by W. N. Williams



Another view of the chassis. The 6J7-G voltage amplifier is located as far as possible from the power transformer. Alongside it is the 5Y3-G rectifier. The two output valves are side by side at the rear of the chassis. We were fortunate enough to be able to obtain can type electrolytic condensers, which improved the appearance of the amplifier and helped to avoid undue congestion beneath the chassis.

phase-splitter does not contribute materially to the overall gain and it has to be preceded by a high gain audio voltage amplifier stage.

If you want to refresh your memory on the details of this circuit, have a look at the 13 watt amplifier on page 39 of the Christmas issue. Note that the second 6J7-G is connected as a triode and has a high resistance load both in the plate and the cathode circuits. The first 6J7-G operates as a high gain pentode audio voltage amplifier.

A DISADVANTAGE

The disadvantage of all the schemes mentioned is that they necessitate the use of an additional major component —either a bulky and expensive audio transformer or an extra stage.

On the small chassis in question, it is not a proposition to use either an audio transformer or an additional stage.

Actually, there is more to it than simply trying to use a certain small chassis. At the moment, radio parts are becoming more and more scarce, and there is a real point in economising in parts, and particularly valves. Furthermore, there is always a call for an amplifier with a fairly high output and capable of being built up on a small chassis.

ANOTHER CIRCUIT

With this thought in mind, we set about to evolve a reliable push-pull circuit using the minimum number of valves. The idea of using multiple valves had to be discarded, because such valves are not made in Australia and are therefore difficult to procure. However, to continue: It is a well-known fact that, in an ordinary amplifier stage, the plate voltage is approximately 180 degrees out-of-phase with the grid voltage. The word "approximately" is used advisedly, since the effect of any capacitance or inductance in circuit may be to cause a certain amount of phase rotation.

It follows, therefore, that, if the grid of one of a pair of push-pull output valves is fed in the normal manner, the signal voltage for the second could be obtained from the anode circuit of the first. All that would be necessary would be to use a suitable network to isolate the d-c component and to pass on the correct signal voltage.

Readers will remember that this scheme was actually used in one of our receivers some time ago, and many readers sent in enthusiastic reports about the results they obtained with it.

LOAD CRITICAL

However, the scheme has certain disadvantages which do not make it entirely suitable for a general purpose amplifier. Most serious of these is the fact that the signal voltage for the second valve is dependent on the output load impedance and variations of the latter, accidental or otherwise, cause variations in the signal voltage to the lower output valve, and consequently upset the balance of the amplifier.

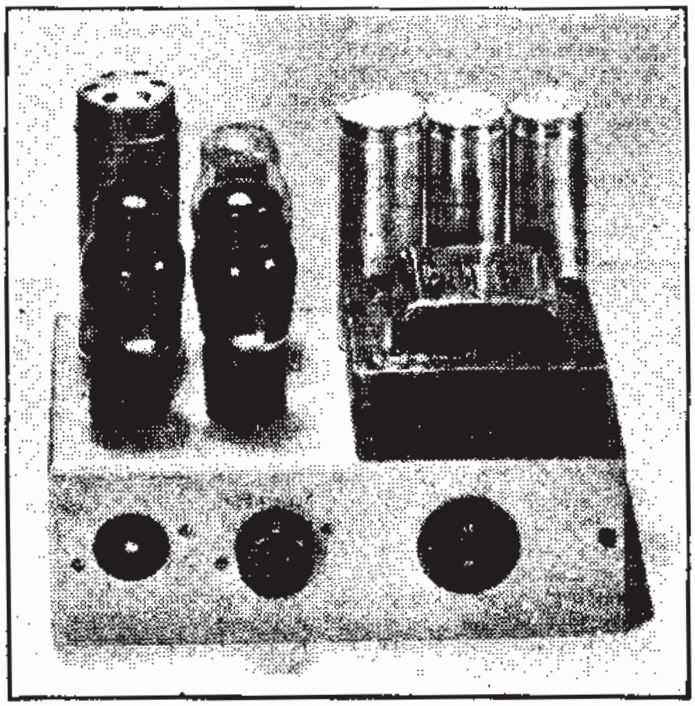
For example, if the load impedance is ever made higher than it should be, the second or lower output valve will receive more signal voltage than the first, and will overload before it. If the load resistance is made too low, the effect is just the opposite.

Certainly negative feedback helps in this respect, since it tends to keep the output voltage constant, irrespective of variations in the load impedance. However, it is by no means a cure-all for the trouble.

PHASE ROTATION

Another point, about which we were suspicious, was the matter of phase rotation, which might cause trouble when tone compensation was applied.

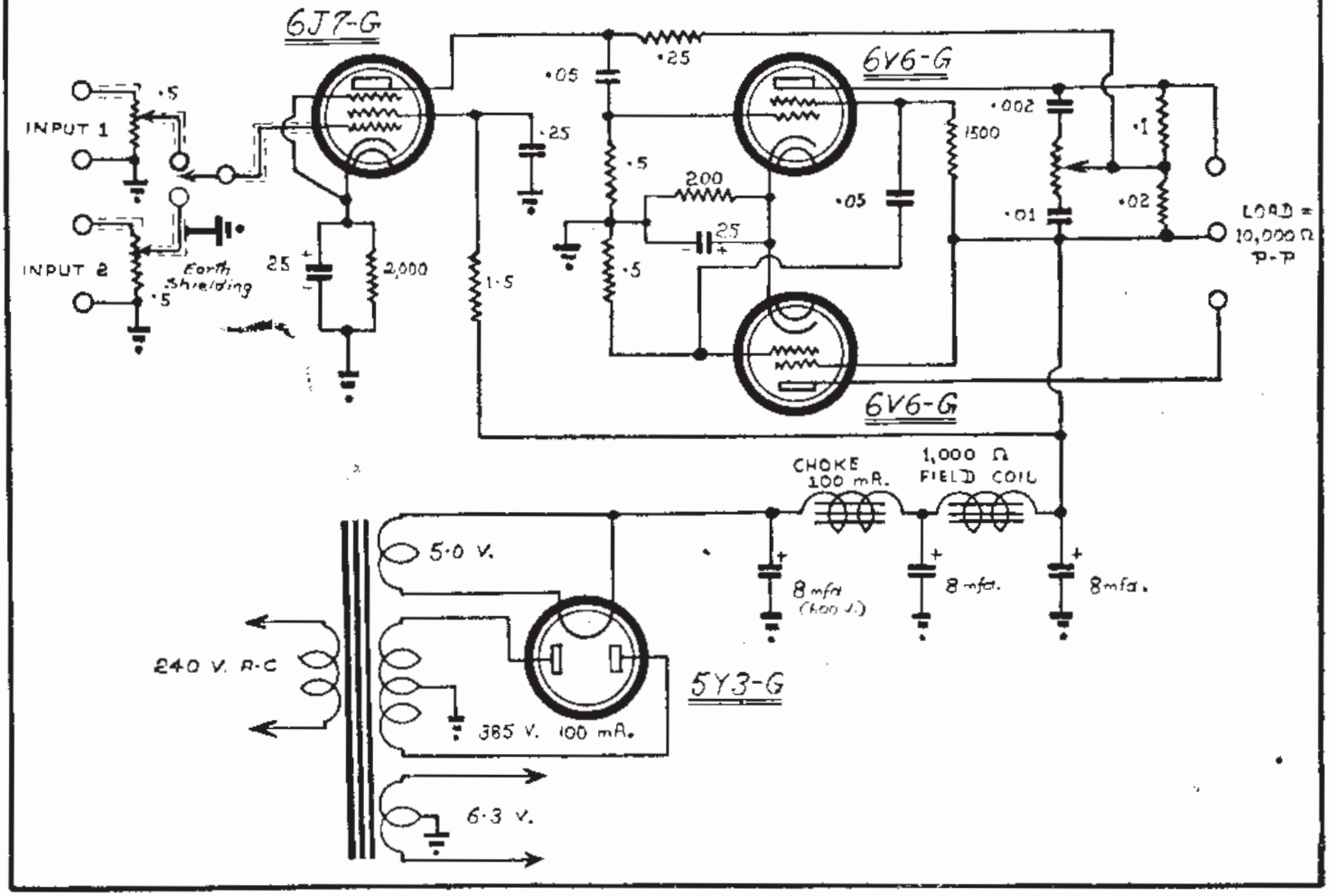
These matters were duly checked in a practical set-up and the troubles anticipated were actually experienced. It was found that the circuit worked well under proper conditions, but, with incorrect values of output load resistance or with tone compensation applied, the amplifier was inclined to be unstable.



At the rear of the chassis there is the five-pin loudspeaker socket, the power outlet socket and the mains plug. The power transformer shown is a 100 mA. type. A heavier transformer could be used if one is on hand. Even an 80 milliamp transformer would probably serve, although it would be operating under full load.

COMPLETE SCHEMATIC CIRCUIT DIAGRAM

RADIO & HOBBIES AMPLIFIER PA-3



The complete schematic circuit diagram. The unusual features are the method of feeding the lower output valve and the system of tone control utilising negative feedback. As the circuit stands the output is about ten watts but higher power output could be obtained by increasing the voltage on the output valves. The tone control potentiometer is .25 meg.

This should not be construed to mean that the circuit is not capable of giving good results. It simply means that it is not an ideal circuit to use in a general-purpose amplifier, which may occasionally have to operate under makeshift conditions.

Accordingly, some other scheme was sought, which would not be subject to these troubles. The best solution appears to be to derive the necessary out-of-phase voltage from the screen circuit of the upper valve instead of from the plate circuit.

LOAD RESISTANCE IN SCREEN CIRCUIT

When the potential on the grid of an ordinary output valve is varied, the plate current and the screen current vary in the same direction. Thus, when the grid voltage is swung in a positive direction, the plate current rises and the screen current also rises.

If a load resistor is connected in series with the screen circuit, the variations in screen current set up variations in voltage across it. These are in phase with the simultaneous variations in plate voltage and consequently out of phase with the signal voltage on the control grid.

The relationship between the screen current and/or voltage and the grid voltage is reasonably linear and the audio voltages developed across the load resistance in the screen circuit are a replica of the signal voltages fed to the control grid.

If the value of the screen load resistor is suitably adjusted, the audio voltages developed across it can be made exactly equal to the signal voltages on the grid but, of course, 180 degrees out of phase. These voltages may then be fed to the grid of the lower output valve through a suitable coupling network.

This scheme is by no means original

AMPLIFIER PARTS LIST

- 1 Chassis, 9½ x 6 x 3½.
- 1 Power transformer 385v CT., 385v HT. at 100 mA., 6.3v at 3 amp., 5v at 3 amp.
- 1 Filter choke, 100 mA.
- 3 8 mfd. electrolytic condensers.
- 2 25 mfd. electrolytic condensers.
- 1 .25 mfd. tubular condenser.
- 2 .05 mfd. tubular condensers.
- 1 .01 mfd. mica condenser.
- 1 .002 mfd mica condenser.
- 1 1.5 meg. resistor, 1 watt.
- 2 .5 meg. resistors, ½ watt.
- 1 .25 meg. resistor, 1 watt.
- 1 .1 meg. resistor, 1 watt.
- 1 .02 meg. resistor, 1 watt.
- 1 2000 ohm resistor, 1 watt.
- 1 1500 ohm resistor, W.W.
- 1 200 ohm resistor, 3 watt.
- 2 .5 meg. potentiometers.
- 1 .25 meg. potentiometer.
- 1 2-way switch.

SOCKETS: 1 5-pin, 1 6-pin, 4 octal.

VALVES: 1 6J7-G, 2 6V6-G, 1 5Y3-G.

SPEAKER: Electro-dynamic, with 1000 ohms field coil and plate to plate impedance of 10,000 ohms.

SUNDRIES: 4 terminals, 1 valve can, three pointer knobs, 2 indicator plates, braided wire, hook-up wire, nuts and bolts, 1 grid clip, &c.

and we have seen it used on other occasions. Some may be inclined to look upon it as a technical "wangle," but there is no need to apologise for it.

The finished amplifier performed in grand style and there was not the slightest suggestion of instability or of parasitic oscillation on peaks of signal. On an oscillograph the output wave appeared to be perfectly clean at all audio frequencies.

In our amplifier the output valves used were type 6V6-G. It was found that, under the particular operation conditions, a resistor of 1,500 ohms in the screen of the upper valve gave just the right signal voltage for the lower valve. The d-c voltage drop across the resistor was very small and we venture to say that its effect on the normal operation of the valve would be negligible.

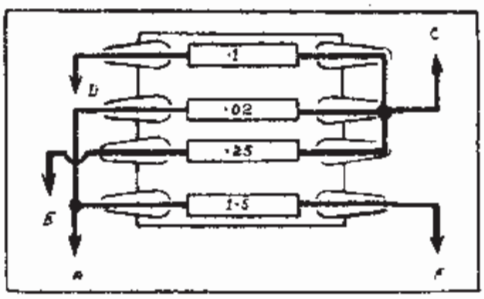
VALUE OF SCREEN LOAD RESISTOR

It must be pointed out that the value of the screen load resistor specified is only correct for type 6V6-G valves under particular operating conditions. For other operating conditions an entirely different value may be necessary, although we cannot say, at the moment, how great the variation might be.

Similarly, for other types of output valves, different values of screen load resistance would probably be necessary.

There does not seem to be any easy way of calculating the value without an intimate knowledge of the more obscure characteristics of the particular valve. In our case the exact value was determined experimentally, the indication being obtained by means of a cathode ray oscillograph.

RESISTOR PANEL



There are only four resistors in all on the resistor panel. The resistors should be interconnected as shown and then wired into the amplifier according to the letter code.

The d-c screen current of type 6V6-G valves, in common with all other beam tetrodes, varies somewhat from valve to valve and we were rather apprehensive lest this should result in considerable variation in the audio output voltage from the screen circuit of different valves.

This point was carefully checked on the oscillograph with all the valves on our shelves, but it was found that the variation from valve to valve was negligibly small.

You will note that the connection of the second output valve does not interfere, to any extent worth mentioning, with the normal operation of the voltage amplifier and the upper output valve. The overall gain is not materially affected, and it simply means that we get twice as much power output for the same power input.

If you are fussy about detail, you may connect another 1500 ohm load resistor in the screen circuit of the lower valve so that the two output valve circuits will be exactly balanced. However, we did not consider that such a resistor was necessary.

NEGATIVE FEEDBACK AND TONE CONTROL

It was considered desirable to provide negative feedback, and this was ultimately applied to the plate circuit of the voltage amplifier from a divider network across the upper portion of the loudspeaker transformer. In fact, the circuit is exactly the same as for a single sided amplifier.

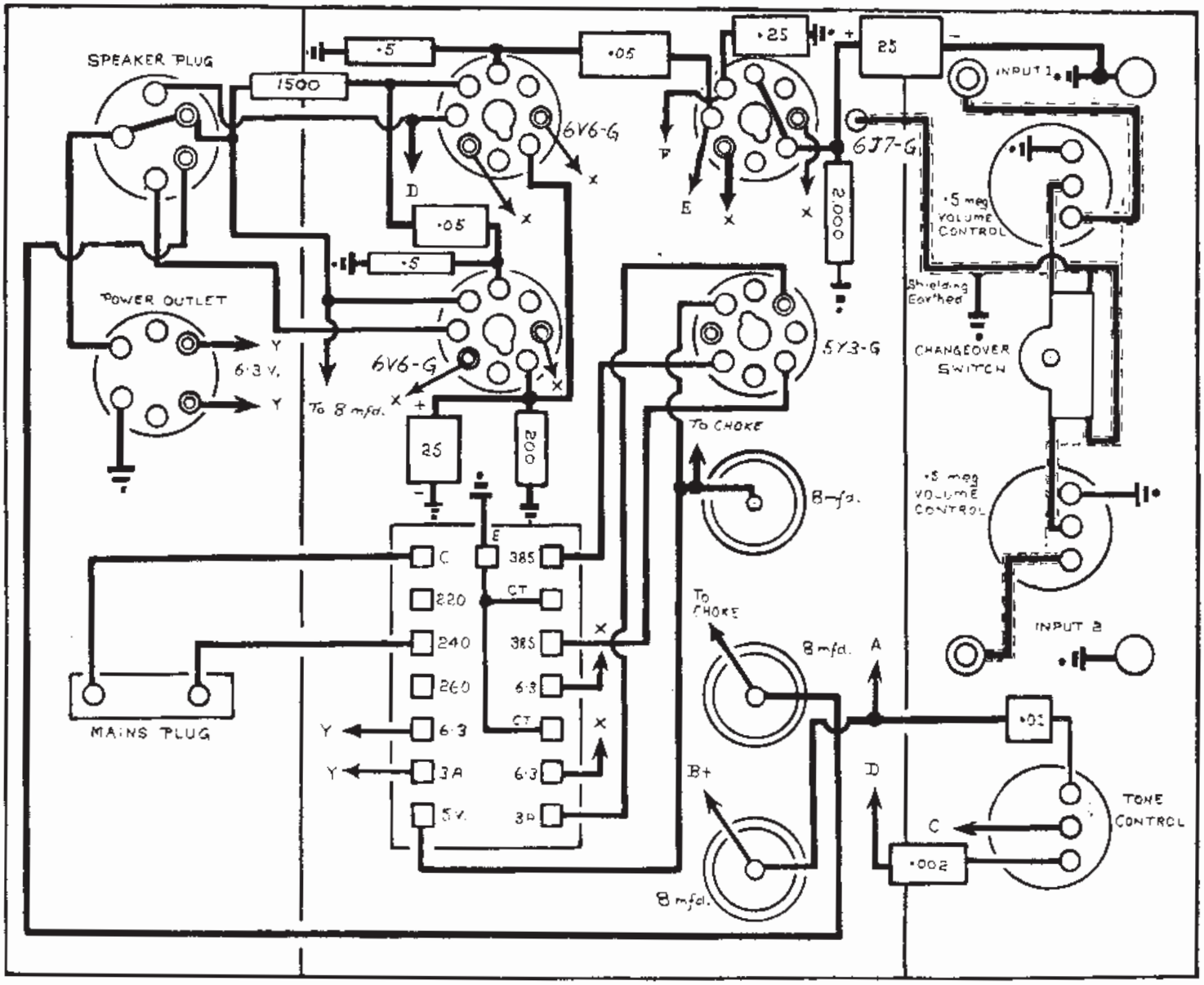
Due to the coupling between the two halves of the output transformer primary winding, the feedback is effective for both output valves. This point is not difficult to check.

The next matter considered was that of fitting a tone control. In the amplifiers PA-1 and PA-2, and in the 1942 Pentagrid Four receiver, the tone control system permitted the treble response to be either accentuated or attenuated, as desired.

In view of this, we were not contented at the thought of fitting an ordinary "top-cut" control.

Accordingly, we tried out the same tone control switch arrangements as used in the previous amplifiers PA-1

UNDERNEATH WIRING DIAGRAM



Here is the underneath wiring diagram for the amplifier. Everything is fairly clear and you should not have any difficulty in following it. The resistor panel has not been drawn in but the various connections to it are letter-coded. The diagram of the panel itself appears on the opposite page.

and PA-2. In practice, the scheme worked very well.

It follows that, if the feedback network is upset, so that the output of the upper valve at high frequencies is accentuated or attenuated, the input to the lower valve at these frequencies is changed, and its output must likewise be greater or less, as the case may be.

AVOIDING A SWITCH

Unfortunately, a few of our readers seem to have had unexpected difficulty in obtaining a suitable tone control switch. This is rather surprising, since a single-bank five-position switch is all that is required. In fact, any ordinary tapping switch could be pressed into service, provided the arm was suitably insulated.

However, to avoid further difficulties on this score, we set about to evolve a circuit which would yield the same results but without the necessity of using a switch. A few minutes' work with a pencil and a scrap of paper provided the solution. Have a look at the tone control system shown in the circuit diagram.

Across the negative feedback divider network is connected another network comprising a .002 mfd. condenser in series with a .25 megohm potentiometer in series with a .01 mfd. condenser. The moving arm of the potentiometer is returned to the junction of the two resistors comprising the feedback divider network.

RESISTOR COLOR CODE

VALUE	BODY	END	DOT
1.5 meg.	Brown	Green	Green
.5 meg.	Green	Black	Yellow
.25 meg.	Red	Green	Yellow
.1 meg.	Brown	Black	Yellow
.02 meg.	Red	Black	Orange
2000	Red	Black	Red

When the arm of the potentiometer is rotated to one extreme position, the .01 mfd. condenser is rendered ineffective, and the .002 mfd. condenser is shunted across the upper portion of the feedback divider network. This has the effect of increasing the feedback at high frequencies and naturally results in high frequency attenuation.

TREBLE CUT AND BOOST

When the control is rotated to the other extreme, the .002 mfd. condenser is rendered ineffective and the .01 mfd. condenser is connected in parallel with the lower portion of the divider network. This decreases the feedback at the higher frequencies and results in treble boost.

At intermediate settings of the control it is possible to obtain more moderate degrees of treble boost or cut, or to obtain a level response.

The capacitance of the respective condensers determines the frequency

range over which the tone control is operative, and values can be chosen to suit individual requirements. However, the values specified should be found suitable for most purposes.

To obtain smooth control, advantage must be taken of the "taper" of the resistance element. With ordinary potentiometers, the control has to be wired so that rotation in a clockwise direction results in treble attenuation. If you find that the control is not smooth, try the effect of reversing the outer connections.

WIDER APPLICATION

This type of control can quite readily be applied to conventional single-sided amplifiers, such as the amplifiers PA-1 and PA-2. With the latter amplifiers, it is simply a matter of substituting the network shown for the tone control switch and the associated condensers.

If the tone control potentiometer is fitted with an off-on switch, this can be wired so as to open circuit the connection between the entire feedback network and the plate circuit of the output valve. However, it is recommended that the feedback be left in circuit where possible.

The remainder of the circuit is more or less conventional. Two sets of input terminals are provided, the desired input channel being selected by a change-over switch.

OVERALL GAIN

Mixing circuits could be incorporated, if desired. As yet we have not been able to cover this subject in the present series of articles. For general information on mixing circuits, we suggest you refer to the article in the December issue under the heading "PRE-AMPLIFIER PROS. AND PROBLEMS."

The overall gain of the amplifier is ample to allow full output to be obtained with almost any type of gramophone pickup or with a high output carbon microphone. The gain is also sufficient to allow the amplifier to be used with a high output crystal microphone under close talking conditions.

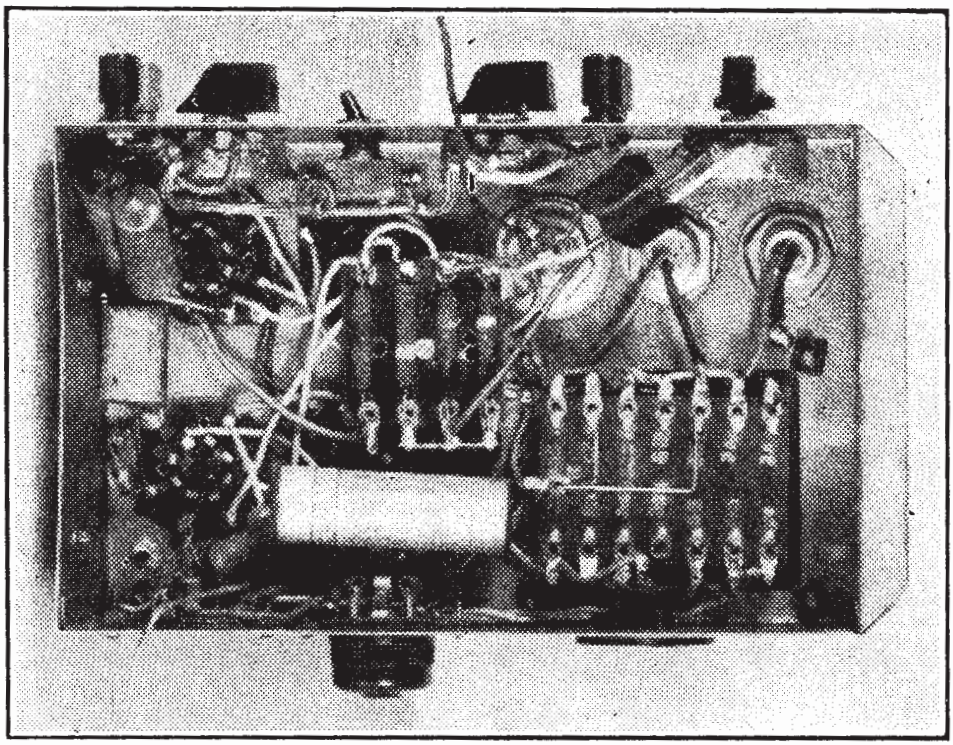
Under conditions of distant speaking or with low output microphones, a separate preamplifier stage would be necessary.

The voltage amplifier is a 6J7-G, operating as a high gain pentode and feeding into the upper output valve in the usual manner. The method of feeding the lower output valve has already been discussed in some detail.

OUTPUT VALVES

As the circuit stands, the output valves are operating under very easy conditions, and should, therefore, last quite a long time. These days, there is quite a point in making one's valves last as long as they will. Replacement valves are becoming more and more difficult to obtain, and the position may become steadily worse as the war progresses.

For all that, you will find that the amplifier will give 10 watts of output, free from any obvious distortion. We had no opportunity of taking precise measurements of the performance, but



Here is the underneath photograph, showing where all the parts fit in. The resistor panel is mounted in its correct position but the power choke has been removed for the sake of clarity. The latter mounts underneath the chassis and below one of the 6V6-G sockets. Care has to be taken to keep the parts clear of the space occupied by the choke.

the output appeared to be quite "clean" of an oscillograph.

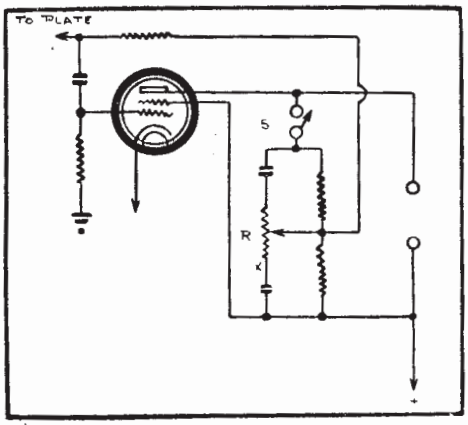
If higher output is desired, the voltages on the output valves can be pushed up, and there should be no difficulty in obtaining the 13 watts output claimed for previous amplifiers using type 6V6-G output valves.

If the operating conditions are changed considerably, it would be advisable to check the value of the screen load resistor, if facilities are available. Once set, the value should not need to be changed for individual valves of the same type.

The optimum plate-to-plate load for the output valves is 10,000 ohms, and it is advisable to adhere to this value. Slight mis-matching might not be noticeable, but excessive mis-matching would result in poor performance.

VOLTAGE and CURRENT MEASUREMENT

Total high tension voltage	270 volts
6V6-G screen to cathode	254 volts
6V6-G cathode to earth	16 volts
Voltage drop across field	77 volts
Total high tension current	77 mA.



If the volume control potentiometer R is equipped with a built-in off-on switch, the latter can be wired as shown to cut out the feedback when the control is advanced to the extreme treble boost position.

POWER SUPPLY

The power supply circuit is quite conventional. A standard 100 milliamp power transformer is specified, but a heavier transformer could be used if one is on hand. At a pinch, an 80 milliamp transformer might even be used, but it would be operating without any margin of safety.

A two-section filter is specified, comprising a 100 milliamp power choke and a 1000 ohm field coil. With this arrangement, the hum was imperceptible under ordinary circumstances. In some cases it may be found possible to do without the choke.

Ideally, the first two electrolytic condensers should be 600-volt wet types. Unfortunately, there are few, if any, available nowadays and it will probably be found necessary to use semi-dry types.

Can type condensers make things easier from the point of view of space, since they mount on top of the chassis. If semi-dry condensers have to be used, try and obtain 600-volt types, at least for the two condensers nearest the rectifier.

TORCH LAMP FUSE

As we suggested in another article, it is often a good plan to wire a torch lamp as a fuse in series with the centre-tap connection to the high tension secondary winding of the transformer. In the event of one of the condensers becoming a short circuit, this will protect the rectifier from complete disaster. Naturally, it is necessary to use a globe having a sufficiently low fusing current.

The power supply shown would be quite capable of supplying the small additional current drain necessary to operate a preamplifier stage. However, the current drain of a tuner would be rather high and would cause undue reduction of the high tension voltage. Under these circumstances it would be desirable to use a 5V4-G rectifier valve, which would offset the additional voltage drop across the speaker field.

ASSEMBLING THE COMPONENTS

The various photographs of the chassis show clearly where all the parts fit in. The only component which will call for careful manipulation is the power choke, which fits underneath the chassis, immediately below one 6V6-G socket.

It is advisable to obtain a compact choke, as otherwise some difficulty may be experienced in getting it to fit in. There are no holes in the chassis for the choke and you will have to drill two holes to suit your particular choke.

When assembling the components on the chassis make sure to mount everything firmly and tighten the transformer bolts properly to prevent the laminations humming when the amplifier is in operation. Solder lugs should be placed here and there under mounting bolts to act as earth points.

WIRING

The entire input circuit to the first valve should be shielded to guard against electrostatic hum pick-up. The various pieces of braiding should be bonded together and definitely earthed. Make sure also to earth one of each pair of input terminals.

The earthing system for the input circuit should be kept quite separate from the earthing system to do with transformer. The screen and cathode bypass condensers and the cathode resistor of the 6J7-G should be returned to the "input" earth system and kept well away from the power transformer.

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IT'S WORTH MILLIONS — IF IT WORKS!

(Continued from Page 7)

internal-combustion engine, the motion picture, radio, the aeroplane, the linotype, the induction motor for alternating current, electric welding, and the audion or electron tube which gave wireless a voice.

It is upon inventions of this kind that great industries are based. They have earned millions on millions, not only for their inventors, but for the investors who bought or leased the patent rights, and for the thousands of inventors who have patented improvements on the basic inventions, to say nothing of the millions of uninventive folk for whom they have created comforts and jobs at better wages.

Maybe your invention will rock the world and change the face of civilisation, too. You never can tell. George Westinghouse didn't think his air-brake amounted to much, but it made a large fortune for him and revolutionised railways.

VARIOUS MOTIVES

The ideas for inventions don't always spring from the altruistic motive of benefiting the human race, or even from a desire to make money. The dial telephone exchange owes its existence to a suspicious American undertaker who thought a business rival had bribed the telephone operators to bungle his calls. This set him to working out what he called the "girlless exchange."

Sheer timidity led Dr. Rene Laennec, a French physician, to invent the stethoscope. The doctor was bashful about putting his head to the bosoms of his lady patients. One day, while on his way to visit a lady whose bosom filled him with trepidation, he noticed a couple of children sending signals through a board. One would scratch his end of the board, the other would listen at the other end.

The thought flashed upon the doctor that he might use the same principle to listen to the chest of his patient. So he shaped a piece of hardwood for his special needs, applied the far end to his patient's chest, the near end to his ear. From this crude beginning has developed the amazingly sensitive instrument now used by physicians.

LAZY INVENTOR

The desire of Humphrey Potter to play won for him undying fame as an inventor. In the early Watt steam engine, the steam was alternately admitted to the opposite ends of the cylinder through cocks turned by hand. It was Potter's job to turn the cocks. By tying strings to the cocks so that the engine would itself turn them, he freed himself so that he could play.

There were accidents all along the line in the discovery of ethyl as an anti-knock ingredient in petrol. After a great deal of research, Charles F. Kettering, chief of research for General Motors, and Thomas Midgeley, Jun., came to the conclusion that the knock must be due to the color of the gasoline.

An assistant was sent to the chemical storerooms for a coloring matter which would completely dissolve in petrol. The storekeeper did not know off-hand any such chemical, but his eye fell upon a bottle of iodine, and he handed it out in the hope that iodine would dissolve in petrol and certainly would give it color. The knocking disappeared instantly.

COINCIDENCE

Now, out of over ten thousand bottles of chemicals in the storeroom, it happened that just one bottle contained material that would eliminate knock! While their earlier theory was found to be wrong, iodine furnished Messrs. Kettering and Midgeley with the knowledge that materials of the bromide family would prevent knocking. This clue ultimately led to the invention of tetra-ethyl lead.

Kettering figured indirectly in the discovery of one of the more important of the recent improvements in motor engines, the so-called "tin-plated piston." Engineers in the General Motors laboratory were supervising an endurance test run on a transmission unit. Just as word came that Kettering was coming to inspect the test, the pistons of the motor began to slap under wear and heavy load.

One of the engineers proposed, as a temporary measure and in order that the "Boss" might see the test in operation, that they build up the worn pistons by coating them with tin. The coated pistons ware replaced. The engine ran along for months, so long, in fact, that the curiosity of the engineers finally became aroused, and it was only then that the surprising wearing qualities of the tin coating became appreciated.

SO IT GOES ON

The untiring effort of hundreds of inventors have finally given the lie to the old adage that "Necessity is the mother of invention." In the modern world, necessity is more nearly the child of invention, than its mother. Most of the inventions that once were regarded as luxuries are now regarded as constituting the bare necessities of life.

NOVEL TEN WATT AMPLIFIER FOR P.A.

(Continued from Page 43)

In our amplifier you will see that we stood some of these components on end and connected the earthed end directly to one of the earth terminals. The components associated with the output valve are not so important and can be earthed at the most convenient point.

When wiring the electrolytic condensers watch the polarity of the connections. The polarity of each of the electrolytic condensers is clearly marked on the circuit diagram and you will have no difficulty in getting things right. The main point is not to forget.

For the rest, there is little to worry about and it is merely necessary to follow the usual rules of assembly and wiring.

A FEW HINTS

If you are not used to building radio gear, do not be in too great a hurry. Make sure that every soldered joint is secure before you pass on to the next. Resin colored solder is probably the best solder to use. If the solder does not flow evenly over the joint, use a smearing of good flux.

Never use more flux than is absolutely necessary. If you do, you will find that it will run under the lugs, when heated, and form a sticky mess, which looks bad, and is bad.

Do not make the connecting leads longer than necessary, but run them where they will "stay put."

Mount the condensers and resistors as firmly as possible and in such positions that they will not come adrift when the chassis is subjected to vibration and bumping. If you cannot manage it otherwise, a loop of stout thread around the condenser and under some fixture will often keep it in place.

If the leads to any of the condensers or resistors have to be extended, use a small piece of fine busbar and slip a piece of spaghetti tubing over the extended lead. This method is preferable to tacking a small piece of hook-up wire to the end of the lead. The result is seldom rigid and increases the possibility of short-circuiting the other leads.

If in doubt as to where a lead goes, do not guess at it, but study the underneath wiring diagram and the circuit carefully and endeavor to make quite sure.

There is little more than can be said and it remains to do the actual building.

When the amplifier is first switched on, watch the rectifier carefully in case there happens to be short-circuit anywhere. If the rectifier shows any signs of a blue glow between filament and plate, switch off immediately and search for a short between B plus and earth.

If you cannot locate anything wrong, it may be that one of the electrolytic condensers is faulty. If no means are available for testing the condensers, try the effect of disconnecting them one by one and see if the amplifier then heats up normally.

OSCILLATION

If the amplifier should break into uncontrollable oscillation, when switched on, the chances are that you have the output valve circuit mixed up somewhere. Switch the amplifier off again and see that you have the feedback connected to the correct output valve.

Another possible cause of oscillation is the failure to earth the input circuit or the associated shielding. However, these points are just mentioned in case you strike trouble.

In actual practice you should have no such difficulties and the amplifier should operate satisfactorily "from the word go."