Osram nine·one·two

A modern high quality amplifier & reproducer for the home constructor

9 octaves
12 watts

PRICE 3/6

HOW TO BUILD THE

Osram

912

HIGH QUALITY

GRAMOPHONE AMPLIFIER

•

EASY STAGE-BY-STAGE

WIRING INSTRUCTIONS

FOR THE

HOME CONSTRUCTOR

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ILLUSTRATIONS

Left : The G.E.C. Octagonal Loaded-Port Loudspeaker Cabinet shown fitted with the G.E.C. Metal Cone Loudspeaker. A dimensional drawing of the cabinet appears facing page 38.

Below : The Osram 912 Amplifier in a typical cabinet, complete with the Collaro 3/544 Gramophone Unit. This cabinet allows space for a radio feeder unit beside the turntable.
Cabinets made to the approved published design can be obtained from the suppliers listed on page 33.

FIG. 1.

THE COMPLETE

EQUIPMENT.

THE Osram 912

30-16,000 c/s

INTRODUCTION

The present-day interest in gramophone records and the consequent appreciation of good music and famous artistes is mainly due to the great improvement in the quality of recording and pressing that has taken place in recent years. These technical advances have resulted in records giving long-playing time, if desired, vastly improved quality and the widest range of frequency coverage that the ear can appreciate.

The increasing popularity of listening to gramophone records is also due to a parallel advance in the design of the component parts of the reproducing equipment: the pick-up and motor, the valves and circuitry of the amplifier, and the loudspeaker with its cabinet.

This booklet presents in a practical form the design of the Osram 912—nine octaves response, twelve watts audio output—a completely up-to-date and economical reproducer of gramophone records, whether long-playing at 33⅓ or 45, or the older and perhaps more cherished 78 r.p.m. The following pages describe in detail how the home constructor can build this high quality equipment with little or no radio knowledge except the ability to read a wiring diagram and handle a soldering iron, screwdriver and pliers.

There are many points of outstanding interest in the Osram 912, which comprises a complete amplifier and matched loudspeaker, produced as a result of careful thought backed by the long experience of the valve manufacturer, together with all the accumulated knowledge of the acoustic engineer.

This practical equipment is the sequel to the publication "Art and Science in Sound Reproduction" by F. H. Brittain, published by The General Electric Co. Ltd. The following chapter, by the same author, explains and amplifies some of the essential features of listening to reproduced sound.

GOOD REPRODUCTION

By F. H. Brittain, D.F.H.

There are two distinct stages in the attainment of Good Reproduction. The first stage consists of designing and building apparatus which satisfies all the scientific requirements. The second stage consists of a determination and correction for all those effects which have their being in the difference between the conditions for hearing the original and the reproduced sound. The designs given in this booklet for the Osram 912 amplifier have been chosen to give the highest fidelity obtainable in sound reproduction today ; they will satisfy the most ardent high fidelity enthusiast, but the design of the controls is such that corrections can easily be applied to such things as environment, loudness and even tiredness on the part of the listener. Such controls will enable the maximum pleasure to be obtained by those who want to listen " through the reproduction " to the original.

The Art of Listening

This art is practised by all concertgoers and a large number of people who listen to radio and record programmes. It consists of hearing, or more accurately, taking cognisance of the wanted sounds, and rejecting the irrelevant. An example from a picture will make this clear. Picture to yourself a corner of a cottage with dustbins, a cat and the distant sea. The cottager sees it as an untidy corner, the cat sees it as a possible meal, and the artist sees it as a possible masterpiece. It is clear that different people do not necessarily appreciate any particular occasion in precisely the same manner, and it is because they stop short of the personal reaction that high fidelity enthusiasts frequently produce unpleasant, if not excruciating sounds. It is the purpose of this section of the booklet to show when and why modifications to high fidelity reproduction are necessary ; and how they may be obtained by means of the controls of the Osram 912. It will be assumed that the sound is being reproduced in a normal living room whose length is between 12 and 25 feet and whose breadth is between 8 and 18 feet.

Speech

The first thing to notice is how much variation there is in the quality of the speech from a single individual person on different occasions. This quality will vary with the effort, the " voice effort " which they make. To determine the extent of this change, the following sentence was recorded under three different conditions of voice effort. " Friends, Romans, Countrymen, lend me your ears ; I come to bury Caesar, not to praise him." In the first case a normal conversational level of voice was used, similar to normal speech in a quiet living room. The whole speech was then analysed into its component frequencies, this result was normalised and is represented as a straight line on the graph shown in fig. 2. This graph shows frequency in cycles per second horizontally, and sound pressure upwards ; the unit is the decibel (db.). For the lower curve, the same person was asked to speak very softly, but not actually to whisper. The result of the analysis of this speech is compared with the normal speech in the lower curve of fig. 2. For the third and upper curve, the same person was asked to declaim in a very loud voice. The result of the analysis of this speech is compared with the normal voice in the upper curve of fig. 2. These curves show just how much the human voice changes its quality as it is " raised ". If we make the announcer sound louder by turning up the volume control we shall not have " raised " his voice—only made it sound louder—with the result that it sounds quite unlike the original, it has, in fact, become distorted merely because the volume control was altered. What should be done is to ring up the announcer and ask him to raise his voice, or, of course, if courage fails you, to raise and modify the response of your amplifier in a similar manner.

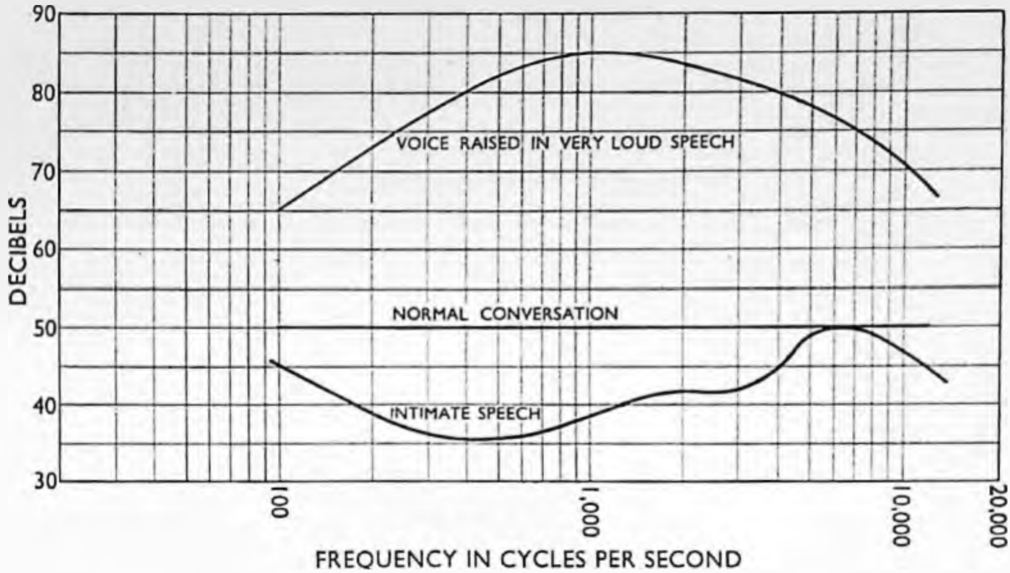


Fig. 2. Change in frequency distribution when voice is raised or lowered.

But there is more to it than this. It may be that you are listening to an after-dinner speech from the Guildhall, which is being broadcast. The speaker is adjusting both his voice and his delivery to suit the people actually present in the hall. He does not deliver his speech as if he were in your own home with you. Your eyes tell you that you are at home, whilst your ears tell you that you are listening to a person speaking in a large hall. Clearly, you must ignore the information provided by either your eyes or ears, or else try to reconcile the anachronism. This last course produces the well-known effect of " listening to the wireless ". If we ignore the information provided by the eyes and concentrate on that from the ears, it is quite possible to imagine that we might in fact hear the speaker like that.

This deliberate attempt to listen to the original by means of the reproduction can be amazingly successful. If you play a record of a symphony over a mediocre reproducer to a flautist he will tell you all about the way in which the flutes were played, but it is very unlikely that he can tell you anything at all about the quality of the reproduction, that not being his concern or interest. It is easy to see how the high fidelity enthusiast may listen too much to quality and too little to music.

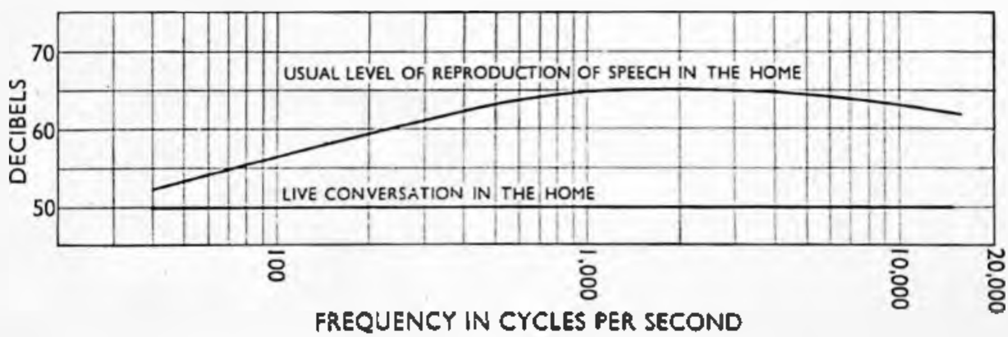


Fig. 3. Corrections to be made to the amplifier frequency response due to the ear hearing the reproduction at increased volume.

Music

In listening to the reproduction of a musical item, a number of new factors are encountered which are quite different from the case of reproduced speech. First of all, the sound pressure at the ear of the listener in his favourite seat in the concert hall is often surprisingly high ; so high, in fact, that a small radio set may distort if an attempt is made to obtain the same sound pressure at the ear of the listener in his favourite armchair in his own home. It is usual to reproduce music in the home in such a way that the reproduced sound pressure at the ear of the listener is considerably less than the original sound pressure at his favourite seat in the concert hall. Now, the unfortunate thing is that the ear changes its behaviour with the loudness of the sounds that it hears. As the loudness is reduced, the low frequencies become less audible and finally disappear completely, while the high frequencies are still quite audible. Fig. 4 shows the extent of this effect when a sound level of 100 db. at the ear of a listener in the concert hall is reproduced at a sound level of 60 db. at the ear of the listener in his own home. Notice that the trouble arises because of the difference in the levels of the two sounds. It may be corrected either by removing the difference in the levels or by altering the frequency response of the reproducing system.

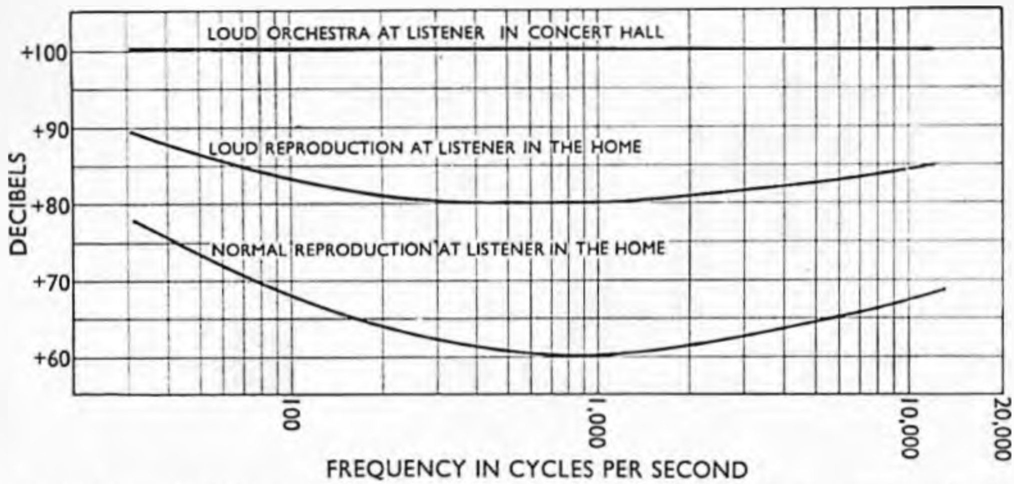


Fig. 4. Corrections to the amplifier frequency response due to the ear hearing the reproduction at reduced volume.

There is another factor which influences the frequency response required for the satisfactory reproduction of music. Different listeners prefer different positions in the concert hall and it is not possible to have different microphone positions to suit each individual listener. The listener at the front of the hall hears the individual instruments clearly separated from each other. The listener at the back of the hall hears the instruments softer, more blended together, and with a greater proportion of the lower frequencies because they are less easily absorbed than the high frequencies ; he also hears a much larger proportion of reverberation than the listener at the front. It has been shown that an increase in the low-frequency response of the reproducer is necessary to compensate for a reduction in loudness of the reproduced sound, and it will be found that a fair approximation to the distance away in a concert hall can be achieved by the use of the high-frequency controls. Just as it is possible to listen through the reproduction to the original sound, so it is possible in the concert hall to listen through the reverberation to the direct sound from the orchestra by the process of mental concentration. This effect is simulated by electrical circuits in the Osram 912 amplifier, and takes the form of a " presence in ", normal, and " presence out " control on the amplifier. The general effect of this presence control is not very violent but will be much appreciated by those with musical taste. It is not readily appreciated that a listener can change his effective position in the concert hall by the amount of concentration which he brings to bear, that is if he is tired, or lets his attention wander, the orchestra will appear to recede, whereas if he is very alert it will appear to be nearer and better defined. Thus the position of the presence control knob may have to be altered if there is a large change in the alertness of the listener.

Music reproduced in the home has usually originated with the B.B.C. or one of the gramophone recording companies. All these different sources have their own ideas of the aesthetic considerations involved in the reproduction of music ; some make the orchestra sound as if it, or at least some of the instruments, were right on top of you. Others give a more harmonious balance to the orchestra as a whole, but at the expense of clarity. Some include a good deal of the effects of the concert hall, whilst others use a microphone technique which very largely cuts out all the effects of the room. The listener in his home may expect to find a certain amount of variation in the presentation of the music he hears and make suitable corrections in his reproducing apparatus.

Listening to a Loudspeaker

Much can be done with a given loudspeaker and its cabinet which will improve the realism of the reproduction. First of all it must be realised that the size, and the furnishings of a living room profoundly alter the performance of any loudspeaker which is played in it, particularly at the lower frequencies. It is therefore necessary to try the speaker in various positions in the room. As a general guide, start with it in the corner of the room and adjust the controls so that the flattest response is obtained when all the factors such as loudness have been taken into consideration. Listen to several pieces of music of different types and if the lowest frequencies are too prominent, or one particular note is unduly loud, move the loudspeaker away from the corner of the room ; either along the wall or straight out from the corner. This will probably reduce the lower frequencies which are most influenced by the room, but there are isolated cases where it has little effect. Ultimately a compromise position must be found which gives reasonable quality and a convenient position for the furniture.

Having got so far, a test should be made on the reproduction of speech. Choose an occasion when the speech is expected to be of the normal kind that you would expect to hear in your own home. The news is read clearly and distinctly and will probably sound rather more precise than normal conversation, and so a talk is often better for this purpose. It should be possible to obtain very realistic quality by setting the amplifier controls in the normal position and taking great care that the volume of sound from the loudspeaker is not greater than it is from a person talking quietly alongside it. Check the naturalness or otherwise of the reproduction by listening from outside the open door. This form of check is necessary because the higher frequencies made by a human come from the lips, but the lower frequencies come more from the chest. In the case of the loudspeaker they all come from the same position and upset our judgment unless we listen in such a way that we are not conscious of the position.

Now let us return to music. It frequently comes from a much larger source than speech and there is all the more reason why we should endeavour to make it appear to be of the correct size. It is quite possible to suggest this apparent size by either of two expedients ; the first is to have two loudspeakers fed from the same reproducer spaced a few feet apart ; use both for music and only one for speech. It will not give you stereophonic sound at all but it will make the source of sound appear to be bigger. A much more satisfactory method, and one which is also much simpler, is to turn the loudspeaker round so that it plays into the wall at such an angle that the sound is " bounced " back at the listener off one or two walls. If you are in any doubt as to where to place the loudspeaker, use a mirror flat against the wall and move it along until it is possible to see the loudspeaker from the usual position of listening. (Two mirrors will be necessary if you are bouncing it round a corner.) The walls of the room will scatter the sound much more than the mirror does light, but an idea can be obtained. Fig. 5 shows the author's living room with the loudspeaker playing off the wall.

Fig. 5. The arrows show how the sound is reflected from wall to wall in order to widen the apparent source. Note that obstructions such as the clock have practically no effect ; it is not necessary for the corner to be absolutely bare.

BASIC FEATURES OF THE OSRAM 912

A high quality gramophone amplifier should not only be capable of reproducing modern long-playing records with complete realism, it should also give the best possible results from older, 78 r.p.m. discs. Indeed, many older records can give a new enjoyment and a new lease of life when played through equipment incorporating the latest developments in amplifier, tone-correction, pick-up, and loudspeaker design. The Osram 912 is a combination which has been specifically designed for home construction of a correctly compensated amplifier and a new high quality loudspeaker primarily arranged for reproducing gramophone records with a very high standard of realism. The equipment will also be found very suitable for use with a wide-band R.F. tuner, particularly for reproduction of the new V.H.F. broadcast service.

The amplifier and loudspeaker units contain certain basic features which are essential for the greatest realism of reproduced sound. The amplifier and record player are contained in one cabinet, and the loudspeaker in another. It should be understood that, whereas the amplifier cabinet shape and size are not critical from the performance point of view, the results claimed for the loudspeaker can only be obtained when using the cabinet specified in this booklet. It is most important, therefore, that the specification given for the loudspeaker cabinet be closely followed.

The loudspeaker and amplifier are often found in one cabinet, but in such cases it is inevitable that certain features required for the highest quality are sacrificed, and so to obtain the full benefit of the quality of both amplifier and loudspeaker, they must be kept separate. Two cabinets need not disturb the amenities of the living room, as the loudspeaker may be conveniently placed in a corner of the room, from where the sound will radiate in a broad beam off the walls, and the amplifier cabinet placed comfortably beside an armchair.

By so arranging the two units, remarkably realistic results can be obtained.

The Amplifier Circuit

The basic design factors for a high-quality amplifier are described in " Art and Science in Sound Reproduction " and need not be repeated. In the Osram 912, all these factors have been borne in mind together with the following essential points :—

(a) Simplicity of assembly by the home constructor.

(b) Availability of components.

(c) Lowest cost compatible with the very high quality of result.

(d) An undistorted power output to suit the average domestic living room.

(e) Versatility, in accommodating a wide range of recordings.

To give the performance required, close adherence to the circuit diagram, component layout, and component specifications is essential and the assembly should present no difficulties.

The first stage of the circuit consists of a low noise input pentode, the Osram Z729, which has been specially designed for this purpose and has extremely low hum and inherent noise levels, coupled with a substantial degree of amplification. The Z729 feeds an Osram B309 double-triode phase-splitter, which in turn, drives a pair of Osram N709 power pentodes capable of producing a maximum power of twelve watts into the output transformer. The H.T. supply is provided by an Osram U709 indirectly heated rectifier. The characteristics of these four valve types are given on pages 39-42.

A newly-developed output circuit, sometimes known as the " ultra-linear ", employs a specially designed output transformer which permits the N709 valves to operate with the efficiency of pentodes and yet with the low distortion characteristics of triodes. Negative feedback is applied so that the twelve watts output is obtained with a very low total harmonic distortion. (Third harmonic distortion is less than 1% at up to 12 watts.)

Controls

In addition to the basic design described above, the Osram 912 Amplifier contains some novel and valuable features, and five controls are provided to suit the requirements of the programme and the listener :—

1. *Volume*

   As explained in " Good Reproduction ", above, the volume control should be used in conjunction with the other controls in order to preserve the degree of realism, particularly at low volume level. It should not be regarded as an independent control for merely altering the level of the sound.

2. *Bass Loudness*

   This employs a novel circuit and is a continuously variable control giving linear response at the centre point, with an attenuation of the bass when turned to the left and an increase when turned to the right. When listening to speech, bass attenuation often increases intelligibility and realism. When listening to music at low volume level, bass accentuation is necessary to preserve the balance. The characteristics of this control are shown in fig. 6.

   As the amplifier has been primarily designed for use with a modern crystal pick-up, no bass compensation for recordings is required.

3. *Treble*

   This provides a linear position, two degrees of attenuation of the higher frequencies, and one degree of accentuation or treble " boost ". It will be found valuable in compensating for the recording techniques of different record manufacturers, and should be adjusted to suit the characteristics of the particular record being played, and the taste of the listener. The characteristics of this control are also shown in fig. 6.

4. *Treble Slope*

   This permits the playing of records which may not be the most modern pressings or which have become worn and normally give a high surface noise or " scratch ". The slope control gives a continuously variable steep cut of the higher frequencies and operates when the treble control is at either of its " cut " positions. As will be seen from fig. 6, the control has the effect of suddenly making sharper the curve of treble cut. The degree of slope of this sharper cut is variable over the portion between each dotted curve and the appropriate solid curve, according to the position of the slope control.

   Apart from removing the scratch from worn records and so making them playable, the control would also be used if the amplifier were coupled to a radio tuner unit to eliminate high-pitched whistles resulting from interference.

5. *Presence*

   The interesting apparent effect of this useful control, when using the G.E.C. metal cone loudspeaker, is described on page 8. It comprises a novel form of circuit which introduces into the feedback path, when turned to " — " or " + ", either an attenuation or a boost of a band of frequencies which correspond to a characteristic rise or fall in the loudspeaker response. The G.E.C. metal cone loudspeaker has a slight dip at about 3,000 cycles per second which the control compensates when set to " + ", adding brilliance and life to the reproduction.

On the other hand, there is usually a slight resonance or rise in output from paper cone loudspeakers at about 3,000 c/s, and the presence control compensates this in the " — " position and so levels the sound output. The characteristics of this control are shown in fig. 7.

Amplifier Rating

The full output of twelve watts is obtained with an input of 100 millivolts r.m.s., with the controls at the level positions and the volume control at maximum. Normally, of course, a programme at this level will be unbearably loud in the average living room, but it should be remembered that an orchestral programme will often contain peaks which approach this level even when being reproduced at a volume setting well below maximum rotation of the control.

General performance curves for the amplifier are given in figs. 8, 9 and 10.

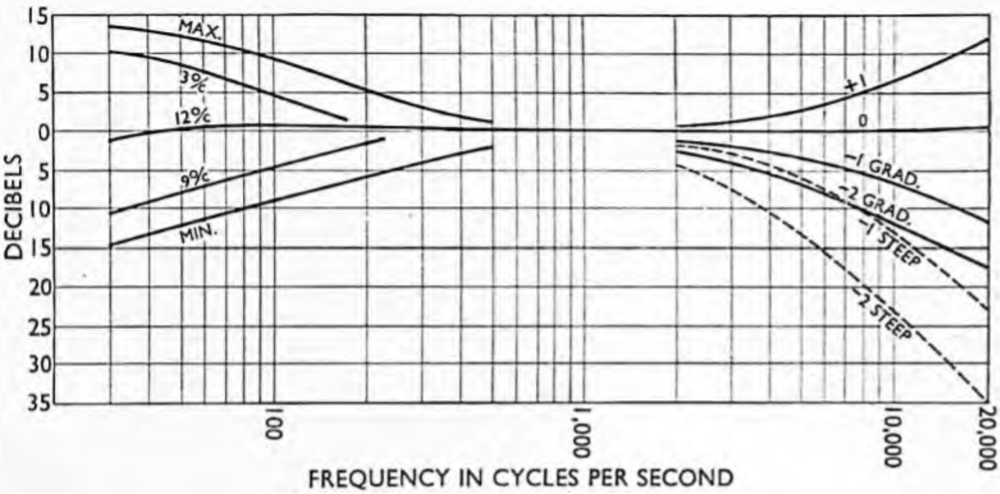


Fig. 6. The left-hand curves show the response at various positions of Bass Loudness. The right-hand solid curves illustrate the four Treble switch positions. The dotted curves show how the two treble cut curves are modified by fully rotating Treble Slope. The position of each dotted curve will alter as Treble Slope is decreased until, when it is fully clockwise, the treble response is that shown by the corresponding solid curve.

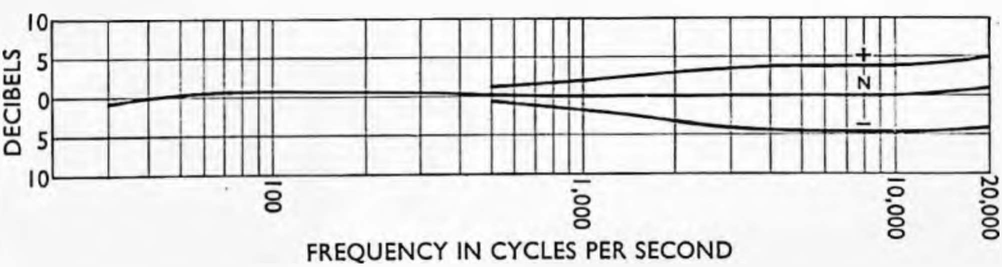


Fig. 7. The effect of the Presence control, with Bass Loudness and Treble controls at the level positions (12 o/c).

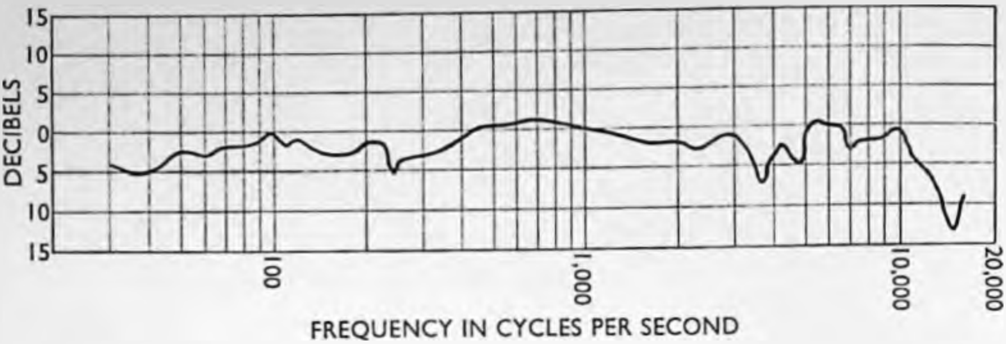


Fig. 8. Overall frequency response of the complete equipment, comprising L.P. record, Collaro Studio Type P pick-up, Osram 912 amplifier and G.E.C. metal cone loudspeaker in Octagonal cabinet.

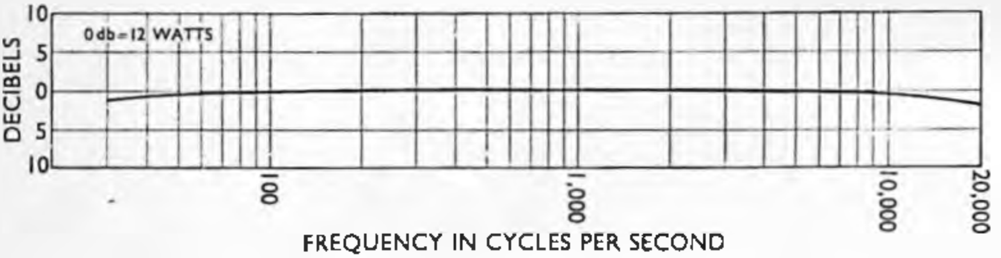


Fig. 9. Peak power output for 1% distortion.

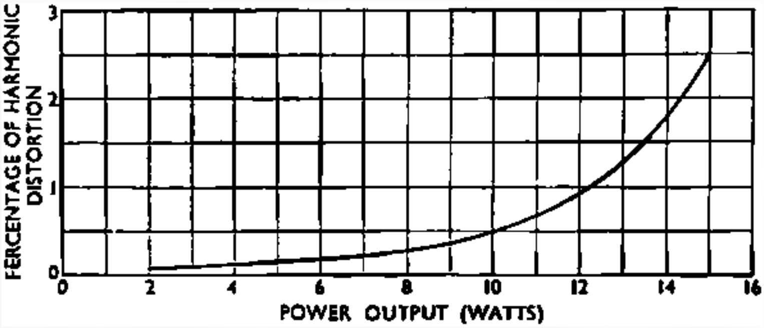


Fig. 10. A push-pull circuit balances out the even harmonics, whilst, of the odd harmonics remaining, the third predominates. This curve shows 3rd harmonic distortion against power output at 400 c/s.

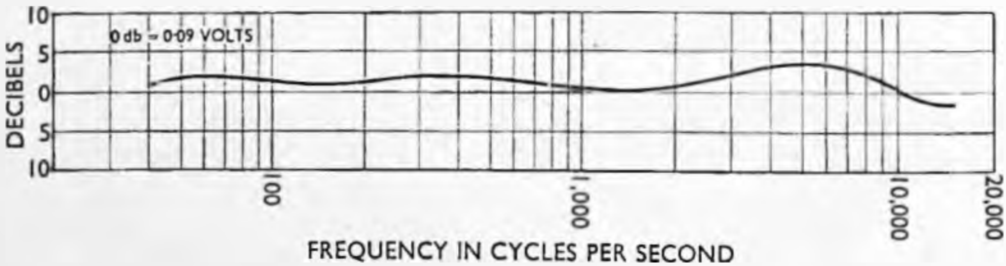


Fig. 11. Frequency response of Collaro Studio Type P pick-up measured across 1MΩ from Decca L.P. test record LXT2695. This shows how the normal falling bass characteristic of the record is compensated in the pick-up itself : no bass compensation is required in the amplifier.

BUILDING THE AMPLIFIER

The following pages contain stage-by-stage instructions for building and wiring the amplifier. No difficulty will be experienced by the home constructor if these instructions are followed precisely and in the order given, provided all components are exactly as specified.

The following general points should be noted, particularly by the newcomer to radio or amplifier construction.

Tools

Apart from a soldering iron, very few tools are required. A screwdriver is necessary, of course, and a small drill for the transformer and choke fixing holes. A small pair of pointed pliers or strong tweezers will be found useful for manipulating and bending wires, as also will a small pair of side-cutters for snipping wire and sleeving.

Although the chassis is available from your retailer, ready-drilled, a detailed drawing of the chassis is given (facing p. 39) for the constructor who has facilities for working sheet metal. Apart from the usual small tools, chassis punches are required for the $\frac{5}{8}$" and $\frac{3}{4}$" holes. The 1 $\frac{1}{16}$" holes may be safely made 1$\frac{1}{8}$" diameter, thus allowing a standard octal punch to be used. A useful accessory for the usual $\frac{1}{4}$" diameter drill is a $\frac{3}{8}$" diameter bit with a $\frac{1}{4}$" diameter shank, obtainable at some tool stores.

The main centre lines should be marked on the chassis, and all dimensions taken from them as shown on the drawing.

Components

The wire ends of resistors and capacitors should be trimmed to the required length by first arranging the component in its approximately correct position, bending the leads as necessary and cutting them at the proper point, allowing sufficient wire to make the joint. Flexible insulated sleeving should be slipped over any wire leads that are in danger of accidentally touching other components, etc., and the wiring diagrams clearly show where this is used.

All components should be placed as nearly as possible in the precise positions shown in the diagrams and their leads bent and cut to suit.

Avoid making a sharp bend in the wire lead of a capacitor or resistor at the point it emerges from the component ; if a tight bend is required, form the wire round a small tube or another capacitor so that it curves out and so avoids possible strain on the component.

Soldering

It is recommended that an electric iron with a small pencil bit be used, otherwise it might be found quite difficult to solder some connections satisfactorily, particularly at the valve sockets. Cored solder of about 18 s.w.g. should be used, and the best method is first to secure the component or wire to the tag so that it will remain in position without having to hold it, and then to lay the point of the solder over the joint and apply the iron on top. The iron should be applied only for as long as is necessary to secure a good joint, otherwise overheating of the component may result. Remove the iron when the solder is flowing easily over the joint. Too much solder should be avoided, as it will run down the tag and possibly form a short-circuit with a neighbouring tag.

Particular care should be taken when soldering to the valve socket tags because of the small spacing between them. It is advisable to check carefully each completed socket for short-circuited connections and to bend the tags if necessary. Rigid connections to socket tags should be avoided because of the possibility of damage to a valve base when forcing it into the socket against a rigidly held tag.

General

Keep a continuous watch on the circuit diagram as the work proceeds. The circuit diagram gives the wiring information in a different form and so serves as a good cross check ; in addition, it gives certain information, such as the wiring of the mains adjustment panel, in a more positive way than can be shown in a physical diagram. The circuit diagram also shows the valve pin numbers and prevents confusion when wiring the closely-spaced valve socket tags.

Two kinds of connecting wire are assumed: bare tinned copper wire of about 22 s.w.g. (covered with 1½ or 2 mm. sleeving, unless otherwise stated), and P.V.C. covered wire, either multi-strand or single 22 s.w.g. Covered wire is used for the longer runs, but it is usually more convenient to use bare wire and sleeving for the shorter connections. Wire and sleeving in a variety of colours enables a colour code to be used which facilitates the tracing of connections and incidentally considerably improves the appearance. Say blue for heater wiring, red for H.T., and so on.

It is assumed throughout the instructions that references to the top, bottom or sides of the chassis, etc., refer to the diagrams as they appear on the pages and not to the actual top or underside of the chassis itself unless this is made clear in the text.

Bare wires and component leads should be covered with sleeving unless otherwise stated.

STAGE 1

(Fig. 12)

Components required :—

Chassis and six grommets	Mains transformer
Output transformer	Smoothing choke
5-Valve sockets	Voltage adjustment panel
Fuseholder and fuse	Gramophone mains socket
Loudspeaker terminals	Input socket and plug

Assemble the above components as shown in fig. 12 and in the various photographs. **The correct orientation of the valve sockets, as shown in fig. 12, is very important for the correct wiring of the amplifier.** The transformers and smoothing choke should be placed according to the photograph appropriate to the make of transformers used (see figs. 31-33), the fixing hole positions marked by scribing through the holes in each component, and 4 B.A. clearance holes drilled (No. 27 drill). The soldering tags shown under certain fixing nuts should not be overlooked.

The heater wiring is carried out first. Starting from the mains transformer (6·3 V, 2·5 A), run twisted wires to V_4, V_3, V_2 and V_1, in that order, as shown in Fig. 12. At V_3 attach a further pair of twisted wires before soldering and run these through the grommet as shown, for later attachment to the pilot lamp holder. Follow the diagram closely as to the layout of the wiring, particularly on the right-hand side, where the wires must run clear of the group board to be fitted later. Remember that V_2, the double-triode, has a parallel connected heater, the connections being to pin 9 and strapped pins 4 and 5. The other valves have their heaters connected to pins 4 and 5. The standard method of pin numbering is used, the socket being viewed from the tag end and the numbering proceeding clockwise as shown on the circuit diagram.

Next, solder four wires, preferably of different colours, to the primary (mains) terminals of the mains transformer. The wire from the " C " or " O " terminal (common) runs through to the right-hand (line) terminal of the gramophone mains socket and the other three are soldered to the appropriately marked sockets of the mains adjustment panel. Note that the fourth socket on this panel, marked " C " (common), is not connected at this stage.

The various photographs on pages 34-35 show how the wiring is arranged above the chassis.

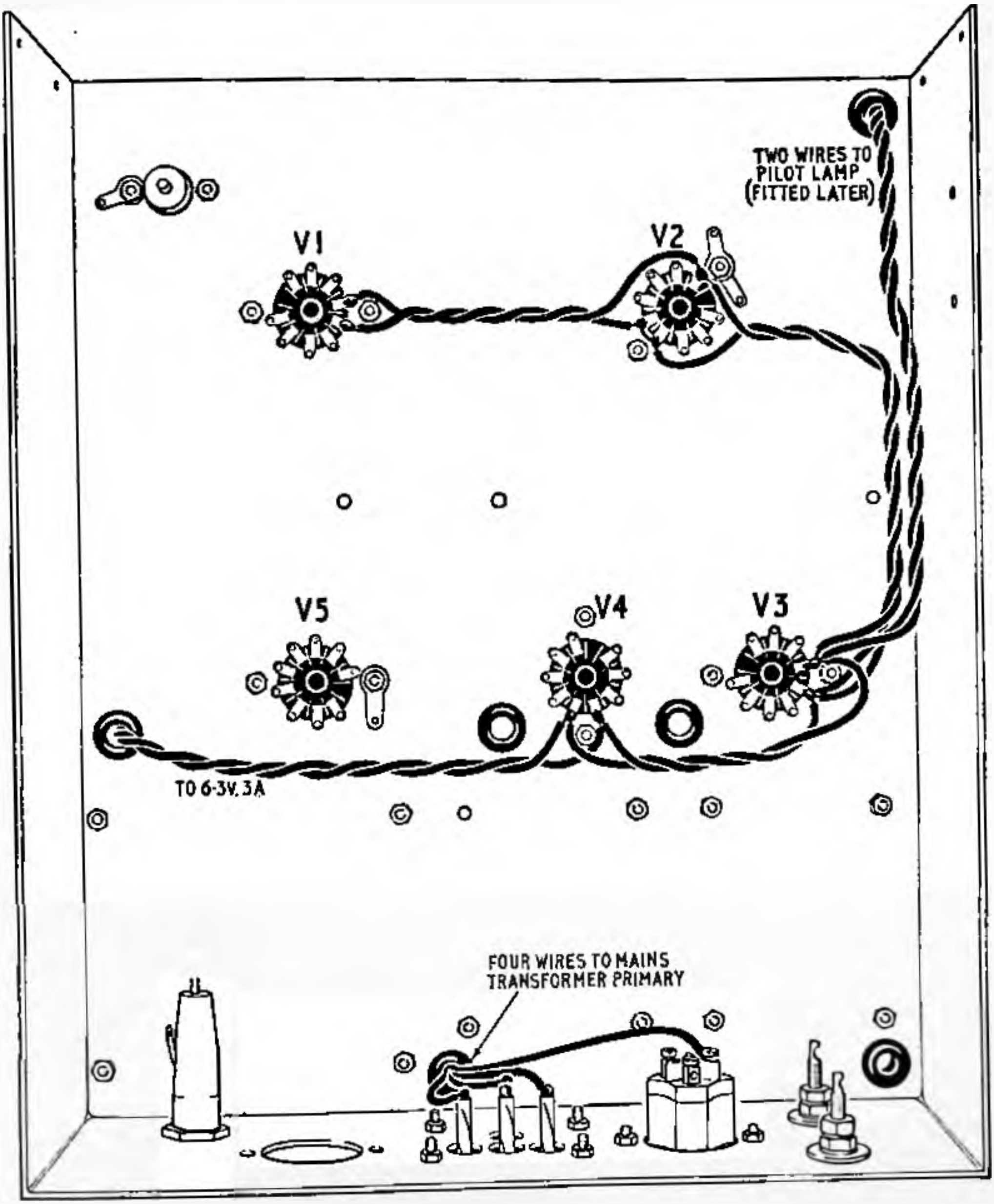


Fig. 12. Stage 1.

STAGE 2

(Fig. 13)

Components required :—

Mains input socket	C_{23} (8 + 16μ F) and clip
C_3 (8 + 16μF) and clip	

The components and wiring of this stage are shown superimposed in black on Stage 1.

Fit the two capacitors as shown, taking care to get the " live " tags at the correct ends and also that these tags are themselves correctly orientated. The yellow and red tags connect to the 8 μF and 16μF sections respectively and the single tag at the other end is the common earth connection. Note that C_{23} is fixed under one of the nuts that secure the smoothing choke or mains transformer and its precise position will be determined by the make of transformers used.

Attach a sufficient length of P.V.C. covered flex or twisted wire to the mains input socket terminals marked " L " (line) and " N " (neutral), feed the wires through the socket hole in the chassis and fix the socket to the chassis with 6 B.A. screws and nuts so that the third terminal, marked " E " (earth) is towards you.

Attach one wire of a further length of flex to one tag of the fuseholder and the other to the left-hand (neutral) terminal of the gramophone mains socket. Run these two flexes, twisted together as shown, through the top right-hand grommet for later connection to the mains switch. For easy identification, each flex should consist of two differently coloured wires—the same colours for each flex. Assuming these colours to be red and blue, (line and neutral), they are labelled accordingly in fig. 13.

Solder a wire to the other tag of the fuseholder and connect this to the right-hand (line) terminal of the gramophone mains socket. Solder a wire to the " C " socket of the mains adjustment panel and connect it to the left-hand (neutral) terminal of the gramophone mains socket.

Solder a pair of twisted wires to the rectifier heater terminals of the mains transformer (6·3 V, 1 A) and run this through to pin 5 and pin 4, to which should be connected pin 3, of the V_5 (rectifier) socket. Run a wire from the strapped pins 3 and 4 of V_5 to the yellow tag of C_{23} (8μF). Solder a pair of twisted wires to the yellow and red tags of C_{23}, run them through the centre grommet and solder them to the terminals of the smoothing choke. (It is immaterial which way round they are connected.)

Solder appropriate lengths of wire to the 300-300 V terminals of the mains transformer, link the centre tap terminal between these terminals, to the centre tap of the 6·3 V, 2·5 A winding and, after soldering a wire to these centre taps, run all three wires through the centre grommet. The two wires from the 300-300 V terminals are soldered to pins 1 and 7 of V_5, and the wire from the centre taps is soldered to the earthing tag at the V_5 socket, together with a wire from the earth tag of C_{23} and a wire from the " E " terminal of the mains input socket. The earth terminal of the gramophone mains socket is connected to that on the mains input socket.

Finally, the earth tag of C_3 is connected to the earthing tag under its own fixing nut. (*Not* to the V_5 earthing tag.)

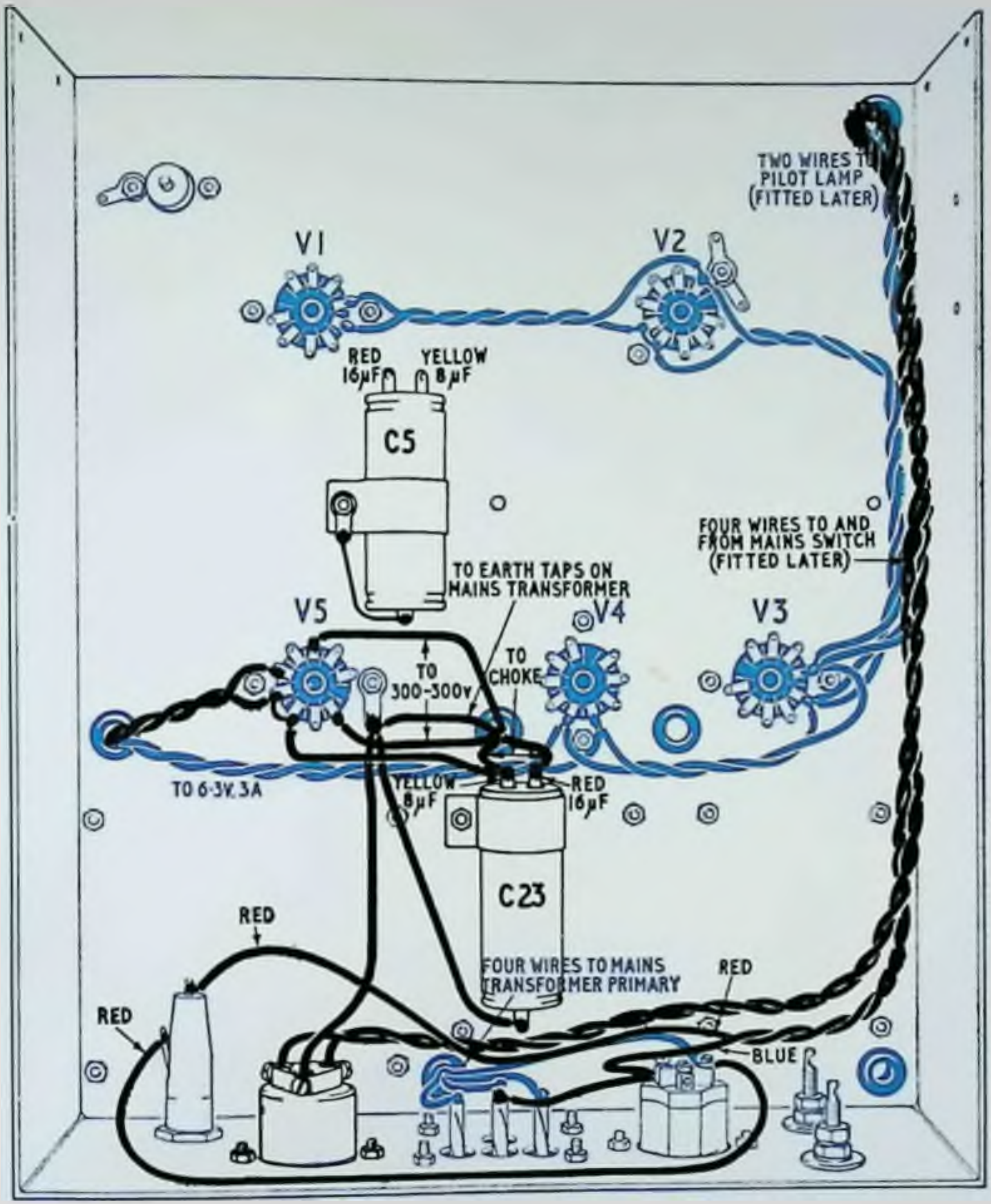


Fig. 13. Stage 2.

STAGE 3

(Fig. 14)

Components required :—

Front panel
2 wafer switches (S_1 and S_2)
C_9 (0·02μF)
C_{12} (470pF)
3 1MΩ potentiometers (R_1, R_8 and R_{10})
C_1 (0·005μF)
C_{11} (220pF)
R_9 (22kΩ, 5%, 0·5 W)

First, the potentiometer shafts must be cut down with a small hacksaw so that $\frac{3}{8}$" of shaft is left projecting from the threaded barrel.

Fix the potentiometers and switches to the panel, with their lock washers on the inside face of the panel to prevent the locating spigots from interfering with the printed front panel added later. The holes for the locating spigots also ensure that the controls are positioned correctly.

Starting at R_1, the volume control, connect two inches or so of wire to the left-hand tag for later connection to the input socket.* Trim one wire lead of C_1 (0·005μF) to $1\frac{1}{2}$" and solder it to the centre tag of R_1. Solder a wire to the right-hand tag of R_1 and run it to the earthing tag on the case of the volume control, solder it there and leave about six inches free for later connection to the chassis.

Next, bend and trim the wire ends of R_9 (22kΩ, 5%—check for gold spot and note that this is the smaller of the two 22kΩ, 5% resistors) to fit between the left-hand tag of R_8 and the earthing tag on its case. Solder R_9 and C_9 (0·02μF) the ends of which should not be trimmed, to the left-hand tag of R_8. Solder the other end of R_9 to the earthing tag on R_8, together with a wire connected to the left-hand tag of R_{10}. This wire is continued to the earthing tag on the case of R_{10} where it is soldered, leaving a further 4" of wire for later connection to the chassis.

Returning to C_9 (0·02μF), the free end is soldered to the centre tag of R_8 together with a further wire, the other end of which is inserted into the middle tag on S_{1b} and left unsoldered until the next stage.

Finally C_{11} and C_{12} (220pF and 470pF) are soldered to the appropriate tags on S_{1b} and their other ends both soldered to the earthing tag on the case of R_{10}.

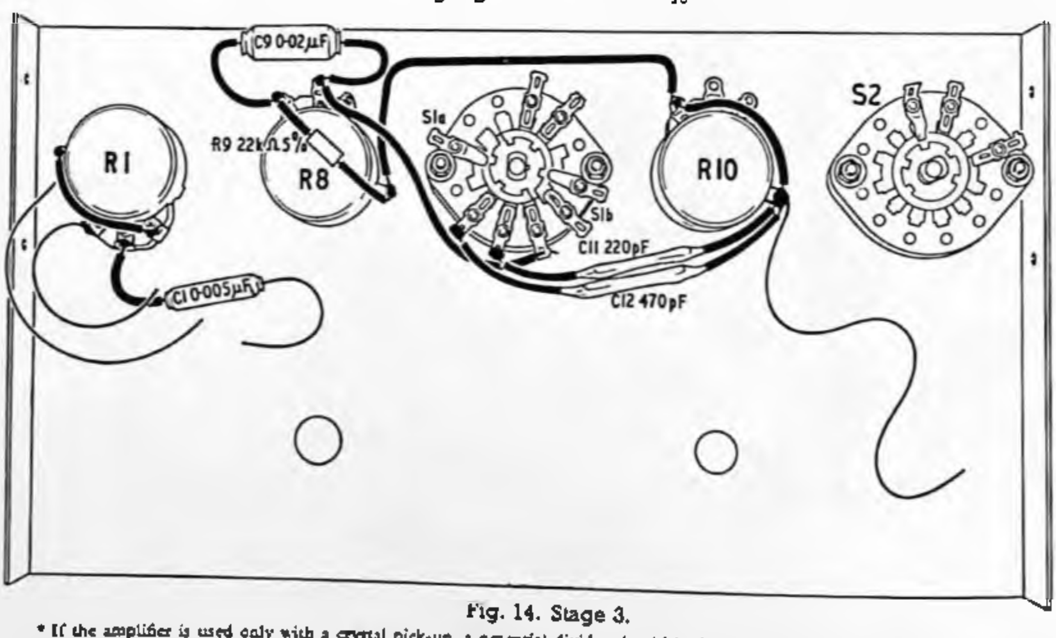


Fig. 14. Stage 3.

* If the amplifier is used only with a crystal pick-up, a potential divider should be inserted at the input as shown in the circuit diagram on page 32. The 680kΩ Type T resistor is connected between the input socket and the left-hand tag of R1. The 330kΩ Type T resistor is soldered between the left- and right-hand tags of R1. These additional resistors are not shown in the list on page 33.

STAGE 4

(Fig. 15)

Components required :—

C_4 (0·05μF)	C_{14} (0·1μF—Type CP36H, 200 V working)
C_6 (470pF)	C_{15} (2μF)
C_7 (1000pF)	R_7 (220kΩ, 5%)
C_8 (2000pF)	R_{11} (150kΩ)
C_{10} (22pF)	R_{12} (100kΩ, 5%)

Bend and trim the wire leads of R_7 (220kΩ, 5%—check for gold spot) and C_8 (2000pF) and solder both to the right-hand tag of R_8. Insert the free end of C_8 into the middle tag of S_{1b}, in which there is already a wire from the centre tag of R_8. Bend and trim the wire ends of R_{12} (100kΩ, 5%—check for gold spot), and solder one end of this, together with the two wires already there, to the middle tag of S_{1b}. Solder the other end of R_{12} to the right-hand tag of S_{1b}, together with about four inches of wire for later connection to V_2.

Solder the free end of R_7 (220kΩ) to the left-hand tag of S_{1a} together with R_{11} (150kΩ) and one wire end, which should be left its full length, of C_4 (0·05μF).

Solder the free end of R_{11} to C_{10} (22pF), the sleeving on these two components being arranged to cover as much of the joint as possible. Solder the other end of C_{10} to S_{1b} (second tag from left).

Solder both C_6 (470pF) and C_7 (1000pF) to the centre tag of R_{10}, their free ends being soldered to the appropriate tags of S_{1a}.

C_{14} (0·1μF) and C_{15} (2μF) should be soldered to S_2—taking care to connect the *positive* end of C_{15} to the switch. Note also that C_{14} is 200 V working and not 350 V, the latter being used elsewhere. It is advisable to bend inwards the extreme right-hand tag of S_2 to prevent any possibility of contact with the chassis.

The front panel may now be fitted to the chassis, using two self-tapping screws in each flange.

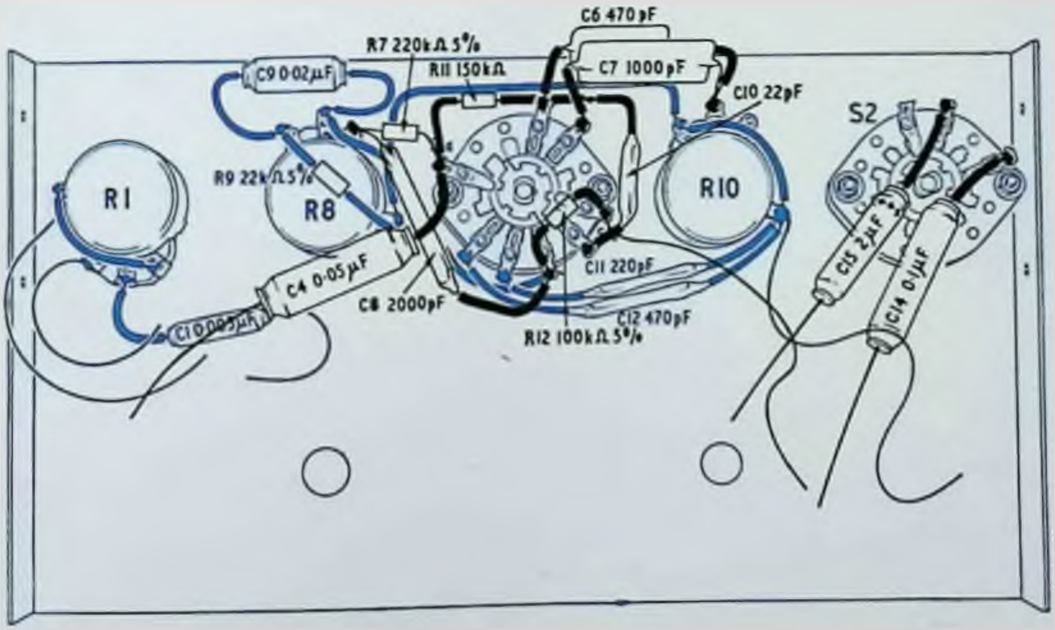


Fig. 15. Stage 4.

STAGE 5

(Fig. 16)

Components required :—

10-way group board	R_{19} (22kΩ, 5%, 1 W)

Fig. 16 shows the first stage in wiring the main group board. The loose wire on the left is for later connection to C_5 (8μF) and the wire at the right is for connection to the chassis at the socket of V_2.

The pieces of sleeving should be cut to fit tightly up to the tags at each end. Note that four of the tags (marked *) are bent outwards to facilitate the soldering of the two grid coupling capacitors fitted in Stage 6.

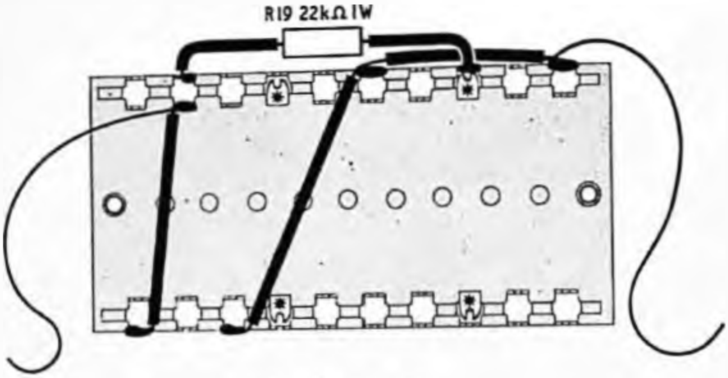


Fig. 16. Stage 5.

STAGE 6

(Fig. 17—opposite page)

Components required :—

C_{17} (0·05μF)	R_{21} (22kΩ, 5%, 1 W)	R_{25} (220kΩ)
C_{18} (0·05μF)	R_{23} (10kΩ, 1 W)	R_{28} (220Ω)
R_8 (22kΩ)	R_{24} (220kΩ)	R_{29} (220Ω)

Fig. 17 shows the group board complete and ready for fixing to the chassis. The wire ends are first bent to shape where necessary, sleeving is then slipped on where shown and, finally, the components are laid into the slots of the tags and soldered, the excess wire being then snipped off.

When soldering C_{17} and C_{18}, the iron should be applied for no longer than is absolutely necessary because of the short leads left on these components.

The group board may now be fitted to the chassis with 6 B.A. screws and nuts, using the holes provided.

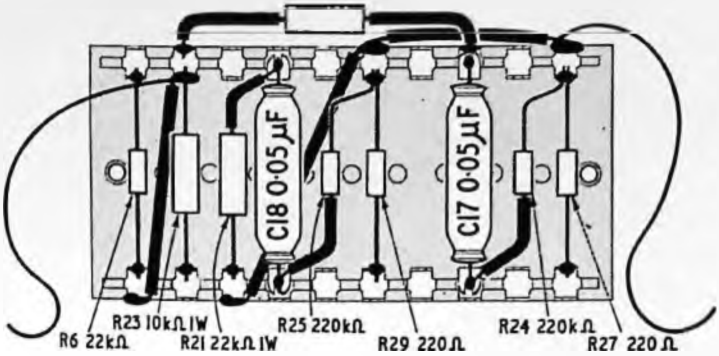


Fig. 17.

Stage 6. See opposite page.

STAGE 7

(Fig. 18)

Components required :—

C_2 (25μF) — R_2 (2·2MΩ)

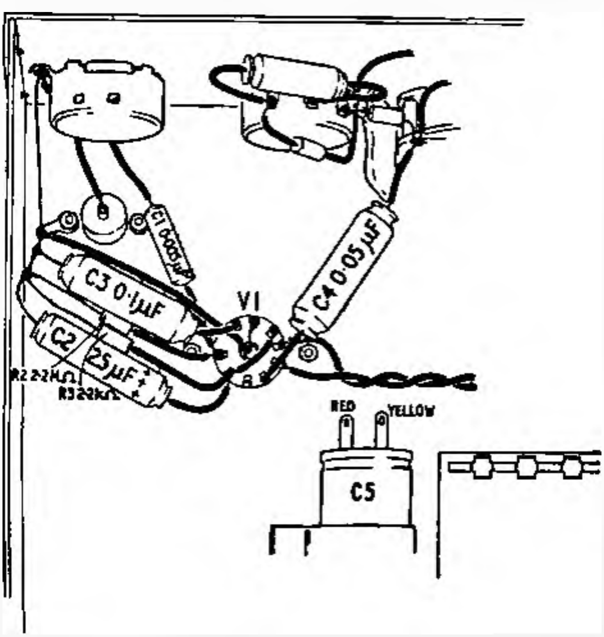
C_3 (0·1μF, 350 V working) — R_3 (2·2kΩ)

This stage and the next deal with the wiring of V_1.

First, solder the wire from the left-hand tag of R_1 to the centre conductor of the input socket. As the input socket insulant will melt under excessive heat, push the input plug into the socket before soldering. This will help to keep the centre conductor correctly positioned if the insulant softens. Apply the iron for as short a time as possible.

Solder the wire from the case of the volume control R_1 to the solder tag at the input socket, together with the *negative* end of C_2 (25μF), continue the wire from R_1 (in sleeving) and solder it to the cylindrical screen on the valve socket ; from here, continue it to pin 2, and solder.

The negative lead of C_2 should be left bare, as shown, so that it can be used for earthing other components.



Next, solder the free end of C_1 to pin 9, together with R_2 (2·2MΩ). The other end of R_2 should be soldered to the earth wire.

Returning to C_2, solder the positive end to pin 8, together with R_3 (2·2kΩ) and a short piece of wire soldered to pin 3. The other end of R_3 should be soldered to the earth wire.

The black end of C_3 (0·1μF, 350 V working) should be soldered to the earth wire and the other end inserted into pin 1 and left unsoldered at this stage.

Fig. 18. Stage 7

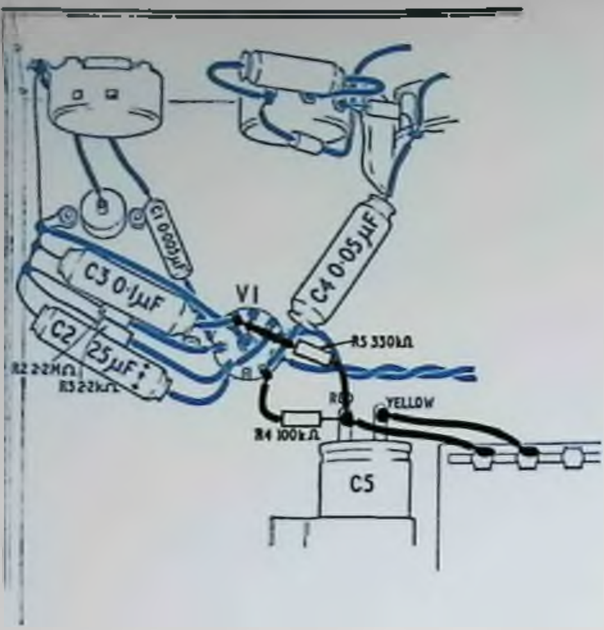


Fig. 19. Stage 8.

STAGE 8

(Fig. 19)

Components required :—

R_4 (100kΩ) R_5 (330kΩ)

Fig. 19 shows the two components and wires added in this stage superimposed in black on Stage 7.

First, solder the existing wire attached to R_{23} (10kΩ) on the group board to the yellow tag on C_5 (8μF). Solder a wire to R_6 (22kΩ) on the group board and twist it round the red tag on C_5 (16μF). Bend to shape the wire ends of R_4 (100kΩ) and solder it together with the free end of C_4 (0·05μF) to pin 6. Shape the wire ends of R_5 (330kΩ) and solder it together with the free end C_3 (0·1μF) to pin 1. Solder the free ends of R_4 and R_5 to the red tag of C_5 (16μF) together with the wire brought previously from the group board.

STAGE 9

(Fig. 20—opposite page)

Components required :—

R_{13} (1·2kΩ)	R_{17} (47Ω)
R_{14} (1kΩ)	C_{13} (25μF)
R_{15} (68Ω)	2—tag strips
R_{16} (1kΩ)	

This stage deals with the wiring of the presence control (S_2) and its associated feedback network.

Fix the two tag strips with 6 B.A. screws and nuts, using the holes provided. Three separate wires are next soldered to the double earthing tag at the socket of V_2 : the wire from the case of R_{10} on the panel ; the wire attached to R_{28} (220Ω) on the group board ; and a wire which should be run up to tag No. 1 on the left-hand tag strip.

C_{14} (0·1μF) and C_{15} (2μF)—already attached to S_2—should be bent to the positions shown and their wire ends inserted in tag 6 and tag 3 respectively.

The resistors attached to the tag strips should be bent to shape and soldered in the following order : R_{15} (68Ω), tag 1 to S_2 (pole) ; R_{17} (47Ω), tag 1 to tag 3 ; R_{16} (1kΩ), tag 4 to tag 6 ; R_{14} (1kΩ), tag 4 to S_2 (pole).

C_{13} (25μF) and R_{13} (1·2kΩ) should next be soldered to the pole tag of S_2, the leads of C_{13} being trimmed to fit between the switch and pin 8 of the V_2 socket. Ensure that the *negative* end of C_{13} is connected to the switch.

Notice that, altogether, there are four components soldered to the pole tag of S_2 : R_{16} (68Ω), R_{14} (1kΩ), R_{13} (1·2kΩ), and C_{13} (25μF).

Finally solder a pair of twisted wires to tags 1 and 4 of the tag strips and secure these wires to the loudspeaker terminals. The earthed tag (tag 1) should be connected to the black terminal.

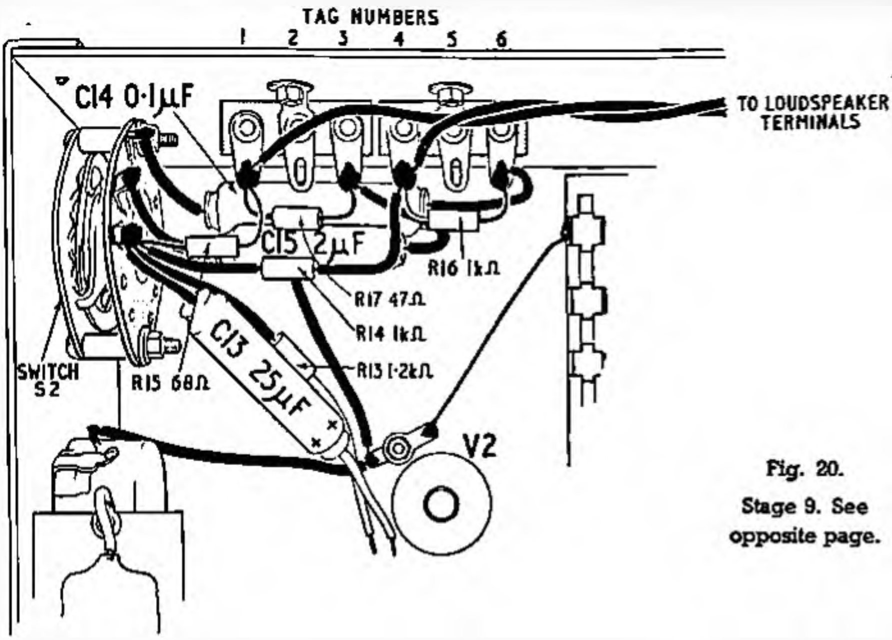


Fig. 20.
Stage 9. See opposite page.

STAGE 10

(Fig. 21—overleaf)

Components required :—

R_{20} (680Ω)	R_{22} (1MΩ)
R_{18} (100kΩ)	C_{16} (0·01μF)

Solder the free ends of R_{13} and C_{13} (*positive* end) to pin 8 of the V_2 socket and solder to pin 7 the wire already attached to S_{1b} on the panel. Solder a wire between C_{17} on the group board and pin 1.

Next, bend to shape and trim the wire ends of the three resistors and solder them in the positions shown, that is : R_{22} (1MΩ) between pin 2 and C_{18} on the group board ; R_{20} (680Ω) between pin 3 and the same tag on the group board ; and R_{18} (100kΩ) between pin 6 and R_{23} on the group board.

Although omitted from fig. 21 for clarity, C_{16} should then be soldered between pins 2 and 6, as illustrated in fig 28 on page 31.

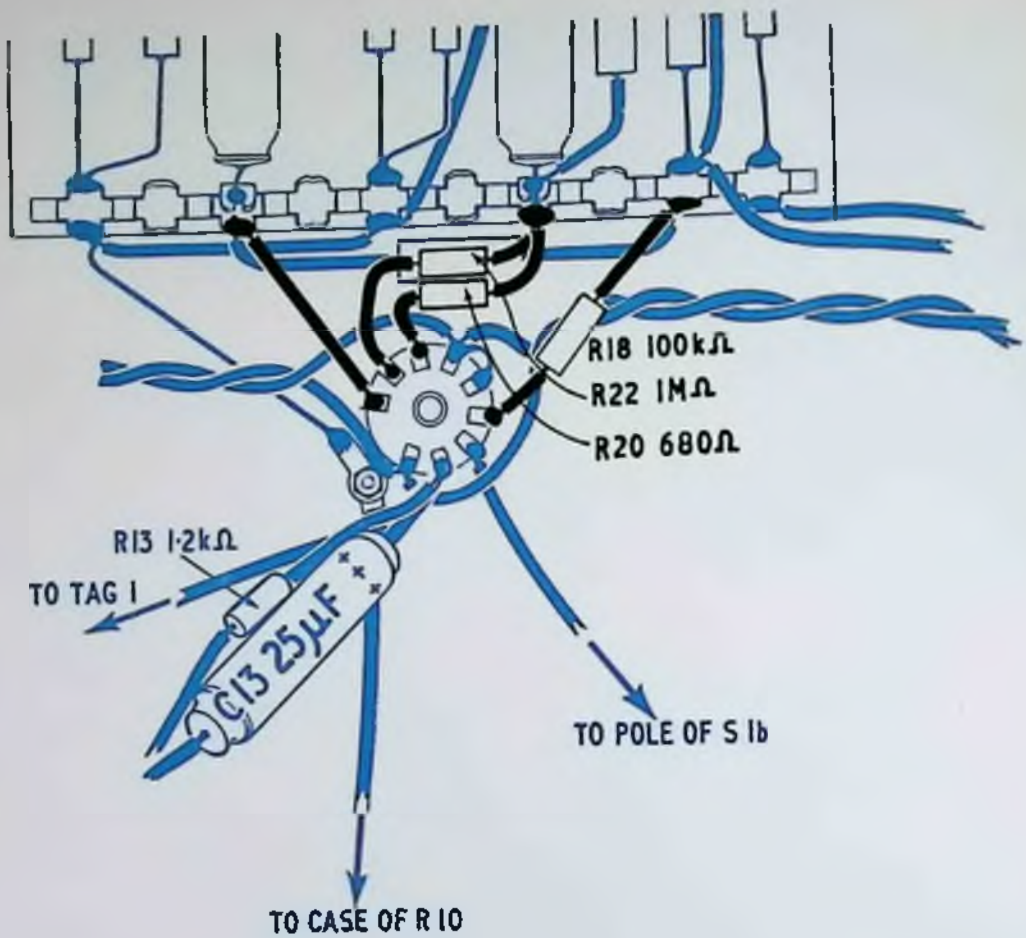


Fig. 21. Stage 10. See previous page.

STAGE 11

(Fig. 22)

Components required :—

R_{26} (10kΩ) R_{27} (10kΩ)

This, the first stage of wiring up the output valves, V_3 and V_4, is shown superimposed in black on the existing wiring.

Bend to shape and solder between C_{17} and C_{18} on the group board and pin 2 on each socket, the two 10kΩ resistors. Note how they are bent to preserve the resilience of the valve socket tags.

The wires between the 220Ω resistors on the group board and pin 3 of each valve socket are next soldered in.

Solder a wire between the red tag of C_{23} (16μF) and R_{23} (10kΩ) on the group board. From the same tag on the group board, run a wire through the grommet between V_3 and V_4 to the centre tap terminal of the output transformer (marked HT or CT).

Solder two wires, of different colours, to one pair of anode and screen terminals on the output transformer and feed them through the grommet. Insert the "anode" wire into tag 7 of V_3 and solder the "screen" wire to the appropriate, and so far unused, tag on the group board. Repeat for the similar connections to V_4.

Ensure that the above "screen" and "anode" wires do not become transposed or connected to the wrong valve.

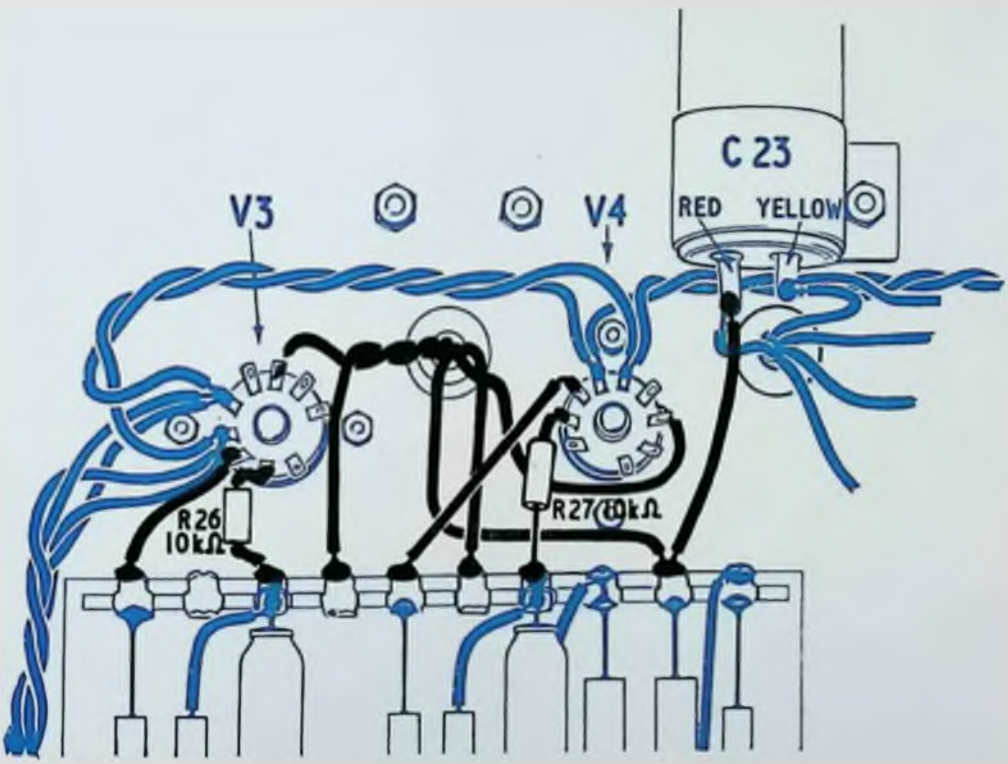


Fig. 22. Stage 11.

STAGE 12

(Fig. 23)

Components required :—

C_{19} and C_{20} (50μF) C_{21} and C_{22} (0·001μF) R_{30} and R_{31} (47Ω)

Bend and trim the wire ends of the two resistors and solder them between pin 9 on each socket and the tags on the group board, to which have already been soldered the " screen " wires from the output transformer.

Next, solder the two capacitors C_{21} and C_{22} (0·001μF) to each pin 7, to which have already been connected the wires from the " anode " terminals of the output transformer, and solder the free ends to the same two group board tags.

Note that the wire ends of the two 47Ω resistors should be kept as short as possible at the valve sockets. Care should then be taken to avoid overheating the resistors when soldering.

Finally solder about 1½" of wire to each end of each 50μF capacitor, slip on an inch of sleeving and solder the capacitors across the two 220Ω resistors on the group board. (See fig. 17 for the positions of these two resistors.)

Important : Be careful to solder the *positive* ends of both capacitors to the tags on the output valve side of the group board, i.e. towards the top of fig. 23. When soldered, arrange the capacitors so that their metal bodies are in no danger of touching other bare parts of the group board. It is preferable to use a stouter gauge wire for their connections to give extra rigidity.

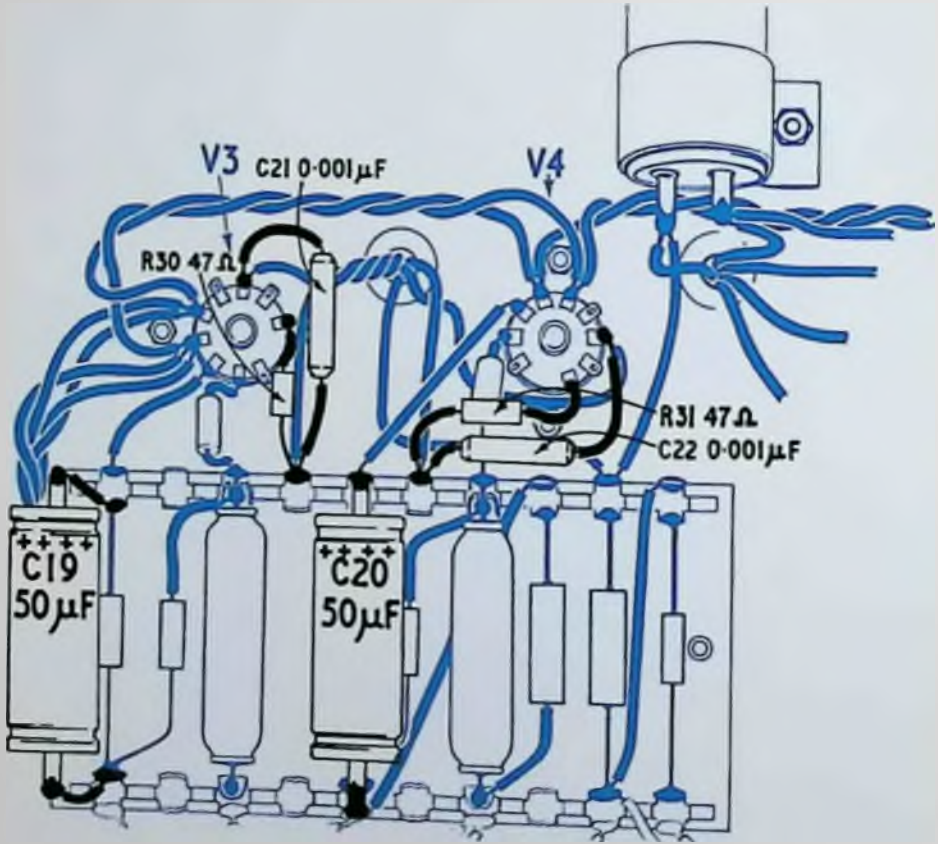


Fig. 23. Stage 12.

STAGE 13

Components required :—

Mains switch (S_3)
Printed control panel
Pilot lampholder and bulb (OS75, 6·5 V, 0·3 A)

The nuts which fix the controls to the front panel must be removed before the printed panel can be fixed. When the printed panel is in position, replace the nuts, at the same time ensuring that the five controls are retained in their correct positions by their locating spigots.

The mains switch is most conveniently wired before fixing to the panel. Fig. 24 shows how to connect the two flexes that were wired in Stage 2 ; the switch should then be fixed to the panel with the tags downward as seen from the rear of the panel. The hexagonal nut should be retained behind the panel and adjusted so that there is just sufficient thread in front to take the round nut.

The pilot lamp may be wired up after fixing and it may be preferred to clamp soldering tags under the terminals and solder the connections. The flex for the lamp was fitted in Stage 1 and runs back under the chassis with the mains wiring until it connects to pins 4 and 5 of V_3.

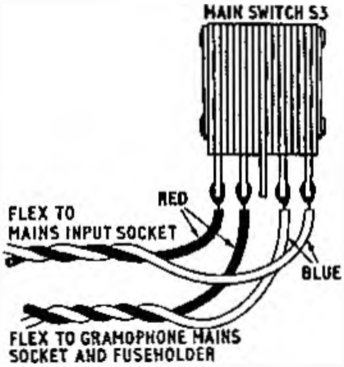


Fig. 24. The mains switch.

The lampholder should be fixed with the terminals upward to prevent any possibility of contact with the chassis and to allow the holder to be adjusted later in order to align the bulb filament with the centre of the lens.

The wiring to the switch and lampholder should be neatly arranged to run above the chassis behind the panel and in the angle formed by panel and chassis.

Figs. 25 and 26 show the wiring of the output transformer secondary terminals. This wiring runs through the grommet in the adjacent corner of the chassis and is attached to the loudspeaker terminals. Either a 3·75Ω loudspeaker or a 15Ω loudspeaker may be connected, depending on the arrangement of the connections at the transformer terminals. The G.E.C. metal cone loudspeaker has an impedance of approximately 3·75Ω.

It should be noted that negative feedback is taken from the output transformer secondary ; therefore, the wires from the loudspeaker terminals to the transformer must be connected a particular way round. If wrongly connected, the feedback will be positive and will cause violent oscillation upon switching on the amplifier. This could damage or even destroy the loudspeaker speech coil, if allowed to build up, especially in the case of the metal cone unit.

The transformer connections should therefore be soldered so that they may be easily transposed if necessary.

Finally, the five knobs are fixed to the control shafts.

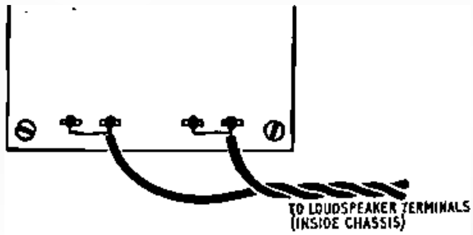


Fig. 25. Output transformer connections for 3·75Ω loudspeaker.

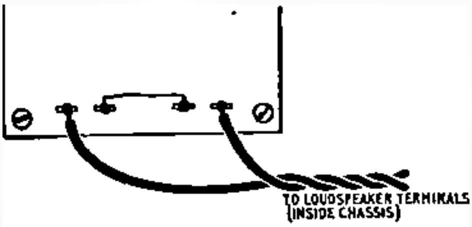


Fig. 26. Output transformer connections for 15Ω loudspeaker.

The amplifier is now complete, but before inserting the valves and connecting up to the mains, all the wiring should be checked against the circuit diagram.

Insert the valves, making quite sure they are in their correct positions, check that the fuse is in the fuseholder and that the dial lamp is in its holder. Set the volume control to minimum and the mains switch off (up). Set the plug in the mains adjustment panel to suit the mains voltage.

The first thing to be determined is whether the output transformer secondary has been connected in the correct phase for the feedback to be negative, and the easiest way to do this is to connect the amplifier to the mains, attach a loudspeaker to the terminals and switch on. **Keep your hand on the mains switch because violent oscillation will be produced as soon as the valves warm up if the output transformer connections are incorrect.** Switch off *immediately* if the loudspeaker starts to howl and reverse the connections to the output transformer. It may be preferred to use an old loudspeaker for this test, if one is available, to prevent any possibility of damage to the loudspeaker to be used with the equipment.

If a D.C. voltmeter is available, the H.T. voltages should be checked against the values shown in the circuit diagram to see that they substantially agree.

Connecting the Gramophone Unit

First attach the coaxial plug to the screened lead from the pick-up as shown below. To prevent any danger of the earthed screening of the pick-up lead touching the terminals on the tops of the transformers, some 3 mm. insulating sleeving should be slipped over this wire as shown.

The mains lead should next be fitted to the gramophone mains plug. If the mains lead from the gramophone unit consists of only two wires, a third wire (insulated) should be attached to some convenient screw on the metal plate of the unit and connected to the earth (E) terminal of the gramophone mains plug. There is a tag provided for this on the Collaro Type 3/544, which is the unit shown in fig. 1.

The equipment is now complete and may be fitted in the cabinet, the amplifier first and the gramophone unit last. The pick-up lead is most conveniently plugged into the amplifier through the hole in the motor board before the gramophone unit is finally screwed into position.

It should be noted that, in this particular application, where the loudspeaker is in a separate cabinet, the various mounting springs for the gramophone unit should not be used ; the unit should be bolted tightly down to the motor board.

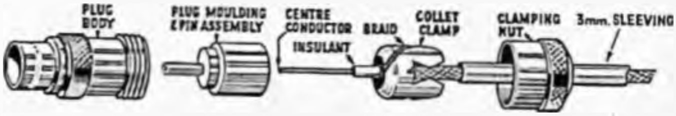


Fig. 27. How to load the "Belling-Lee" Coaxial Plug Type L.734/P.

1. Bare centre wire for ¼".
2. Cover pick-up lead by sliding on 3 mm. sleeving.
3. Slide clamping nut and collet on to lead and twist braid round one tooth of collet as shown.
4. Push centre conductor as far as possible through plug pin and bend sharply for soldering. Solder and trim.
5. Push assembly into plug so that collet enters it. Screw nut on to grip 3 mm. sleeving firmly. The plug pin must be firm.

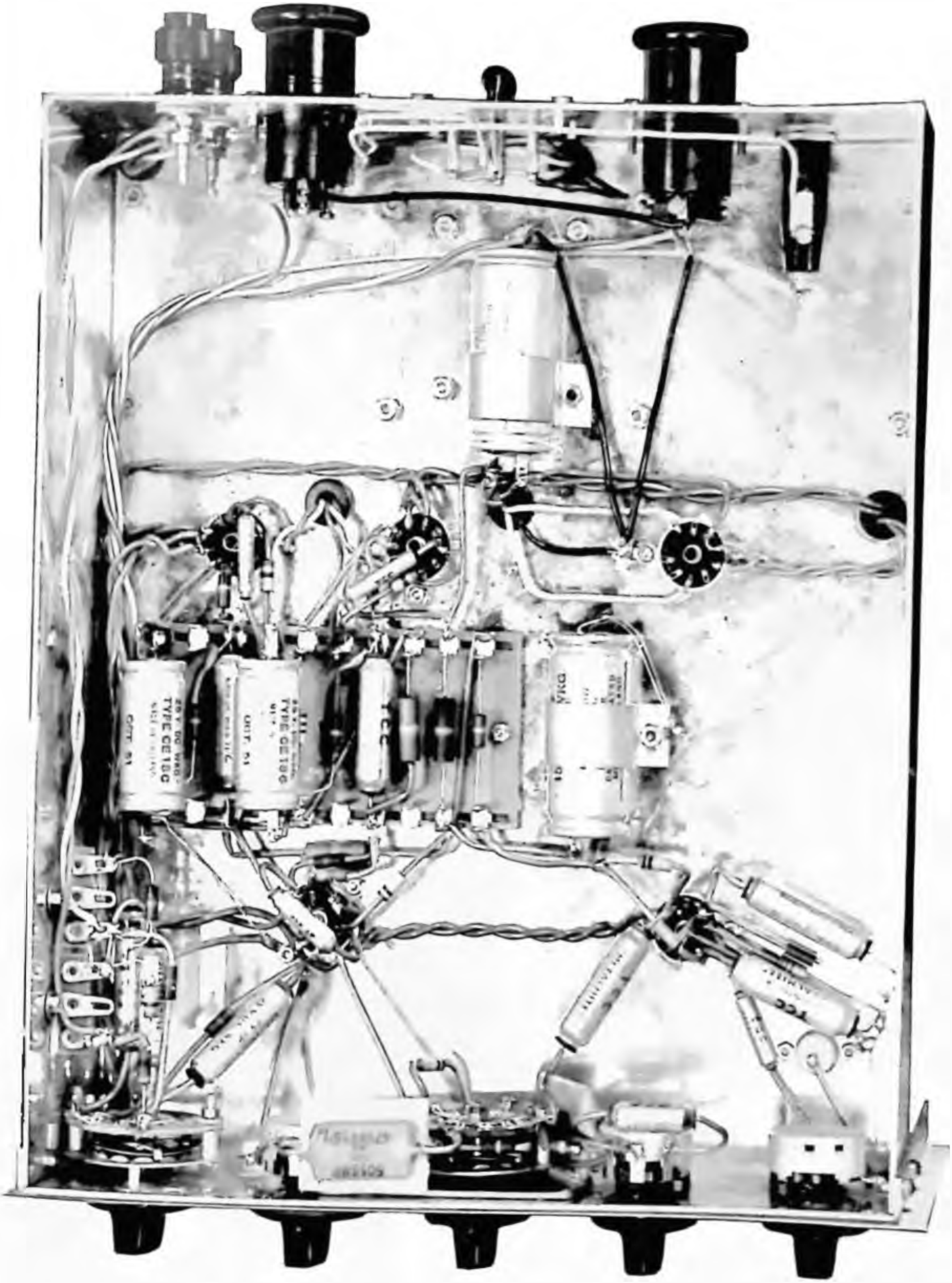


Fig. 20. Under view of the complete chassis.

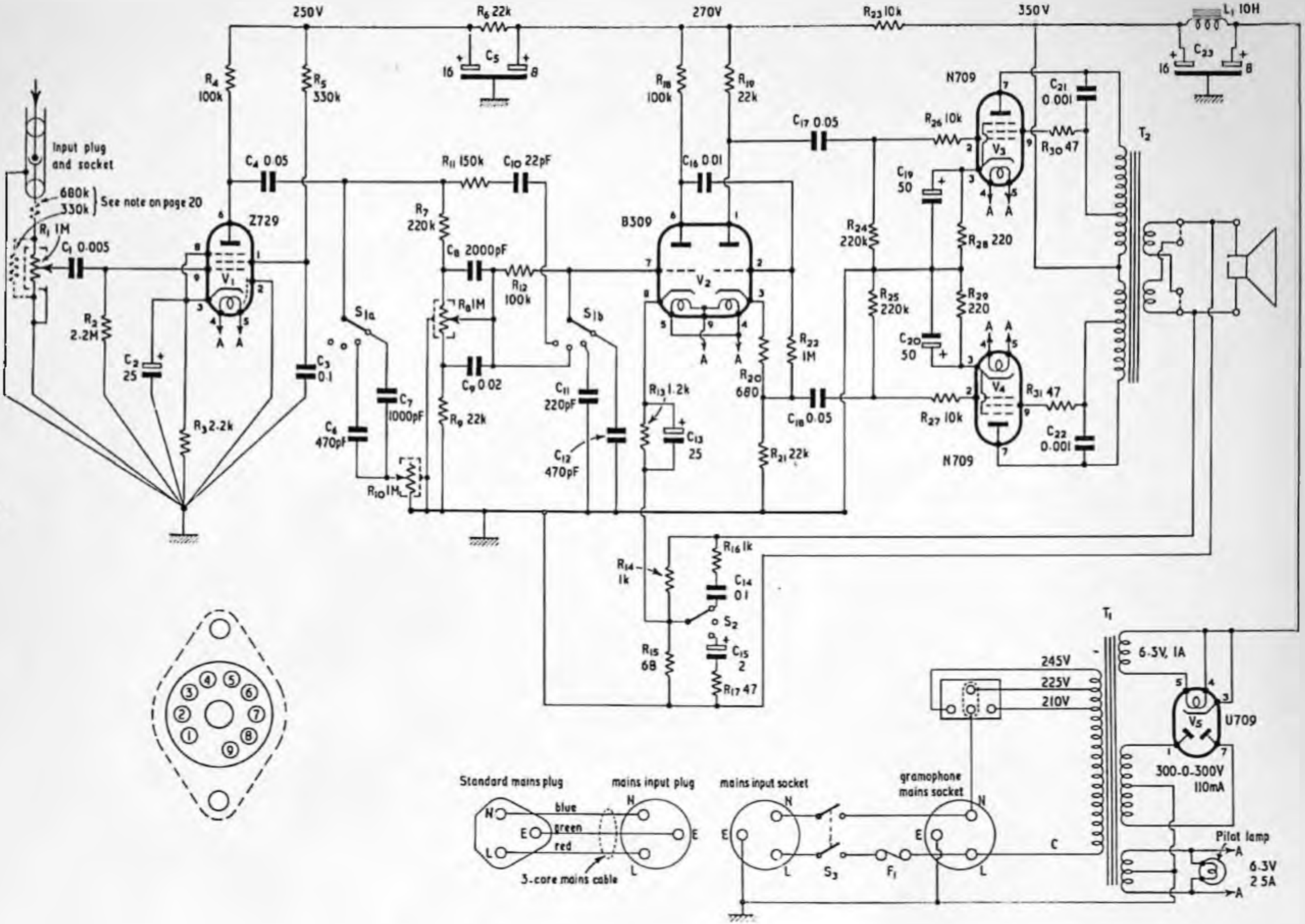


Fig. 29. Circuit diagram. The valve base diagram represents the valve bases or sockets as seen from under the chassis. The various mains plugs and sockets are drawn as though looking at their terminals.

COMPONENT SPECIFICATIONS

"LAB" RESISTORS (RADIO RESISTOR CO. LTD.)

(See also note on page 20)

Reference	Value	Tolerance*	Type†	Colour Code (see below)		
R1	1MΩ	Log. potentiometer Type A				
R2	2·2MΩ	—	T	red	red	green
R3	2·2kΩ	—	T	red	red	red
R4	100kΩ	—	T	brown	black	yellow
R5	330kΩ	—	T	orange	orange	yellow
R6	22kΩ	—	T	red	red	orange
R7	220kΩ	5%	T	red	red	yellow
R8	1MΩ	Log. potentiometer Type A				
R9	22kΩ	5%	T	red	red	orange
R10	1MΩ	Log. potentiometer Type A				
R11	150kΩ	—	T	brown	green	yellow
R12	100kΩ	5%	T	brown	black	yellow
R13	1·2kΩ	—	T	brown	red	red
R14	1kΩ	—	T	brown	black	red
R15	68Ω	—	T	blue	grey	black
R16	1kΩ	—	T	brown	black	red
R17	47Ω	—	T	yellow	purple	black
R18	100kΩ	—	T	brown	black	yellow
R19	22kΩ	5%	R	red	red	orange
R20	680Ω	—	T	blue	grey	brown
R21	22kΩ	5%	R	red	red	orange
R22	1MΩ	—	T	brown	black	green
R23	10kΩ	—	R	brown	black	orange
R24	220kΩ	—	T	red	red	yellow
R25	220kΩ	—	T	red	red	yellow
R26	10kΩ	—	T	brown	black	orange
R27	10kΩ	—	T	brown	black	orange
R28	220Ω	—	T	red	red	brown
R29	220Ω	—	T	red	red	brown
R30	47Ω	—	T	yellow	purple	black
R31	47Ω	—	T	yellow	purple	black

* 20% unless otherwise stated.
† T = 0·5 watt. R = 1 watt.

RESISTOR COLOUR CODE

Resistors are identified by the colour code below. Two methods of marking are used: (a) three rings round the body near one end and read from that end; or (b) coloured body, coloured tip and coloured spot or ring, read in that order.

The first and second colours indicate first and second digits of value; third colour indicates the following number of noughts. Example: Blue body or first ring = 6. Grey tip or second ring = 8. Brown spot (or ring) or third ring = 1 nought. Value = 680Ω.

5% resistors are marked with an additional gold spot or ring.

0 Black	3 Orange	7 Purple
1 Brown	4 Yellow	8 Grey
2 Red	5 Green	9 White
	6 Blue	

N.B.—1kΩ = 1,000 ohms; 1MΩ = 1,000,000 ohms.

T.C.C. CAPACITORS (TELEGRAPH CONDENSER CO. LTD.)

Reference	Value	Tolerance	Rating	Type No.	Style
C1	0·005μF	25%	350 V	CP31N	Metal case tubular
C2	25μF	−20% +50%	25 V	CE77C	Electrolytic
C3	0·1μF	25%	350 V	CP37N	Metal case tubular
C4	0·05μF	25%	500 V	CP37S	Metal case tubular
C5	8+16μF	−20% +50%	450 V	CE34PEA	Electrolytic
C6	470pF	5%	350 V	501SMP	Silvered mica
C7	1000pF	5%	350 V	701SMP	Silvered mica
C8	2000pF	5%	350 V	701SMP	Silvered mica
C9	0·02μF	25%	350 V	CP33N	Metal case tubular
C10	22pF	5%	350 V	101SMP	Silvered mica
C11	220pF	5%	350 V	425SMP	Silvered mica
C12	470pF	5%	350 V	501SMP	Silvered mica
C13	25μF	−20% +50%	25 V	CE77C	Electrolytic
C14	0·1μF	25%	200 V	CP36H	Metal case tubular
C15	2μF	−20% +50%	25 V	CE31C	Electrolytic
C16	0·01μF	25%	350 V	CP32N	Metal case tubular
C17	0·05μF	25%	500 V	CP37S	Metal case tubular
C18	0·05μF	25%	500 V	CP37S	Metal case tubular
C19	50μF	−20% +50%	25 V	CE18C	Electrolytic
C20	50μF	−20% +50%	25 V	CE18C	Electrolytic
C21	0·001μF	25%	500 V	CP30S	Metal case tubular
C22	0·001μF	25%	500 V	CP30S	Metal case tubular
C23	8+16μF	−20% +50%	450 V	CE34PEA	Electrolytic

C5 and C23 require clips, type S6105.

TRANSFORMER SPECIFICATIONS

Output transformer (T2):
Ratio: 21·5 : 1.
Secondary in two halves for 3·75Ω or 15Ω loudspeakers.
Primary taps each spaced at 20% of each half-primary from centre.
7000Ω anode-anode.
12 W rating.
Leakage inductance not more than 0·1H.

Part Nos.: Haddon—AP449.
Partridge—P3591A.
Whiteley—31/450.

Mains transformer (T1):
Primary: 0·210·225·245 V.
Secondaries: 300-0-300 V, 110 mA.
6·3 V, 2·5 A, centre-tapped.
6·3 V, 1 A.

Part Nos.: Haddon—MT482.
Partridge—P3591B.
Whiteley—28/450.

Smoothing Choke (L1): 10 H at 110 mA.

Part Nos.: Haddon—CH458.
Partridge—(10H, 135 mA).
Whiteley—30/450.

Reference	Description	Type No.	Manufacturer
V1	Input pentode	Z729	Osram
V2	Double triode	B309	Osram
V3 & 4	Output pentodes	N709	Osram
V5	Rectifier	U709	Osram
	Pilot lamp	O575	Osram
	Coaxial Input Socket	L734/S	Belling & Lee Ltd.
	Coaxial Input Plug	L734/P	Belling & Lee Ltd.
	Fuseholder	L356	Belling & Lee Ltd.
F1	Fuse (1·5A rating)	L1055	Belling & Lee Ltd.
	Loudspeaker terminals	L1001/1W	Belling & Lee Ltd.
	Group board	C114	A. F. Bulgin & Co. Ltd.
	Tag Strips (two)	T17	A. F. Bulgin & Co. Ltd.
	Control knobs (five)	K370	A. F. Bulgin & Co. Ltd.
S3	Mains switch	S300/PO	A. F. Bulgin & Co. Ltd.
	Signal lamp holder	O170/Red	A. F. Bulgin & Co. Ltd.
	Mains input plug and socket	P73	A. F. Bulgin & Co. Ltd.
	Gramophone mains socket	P437	A. F. Bulgin & Co. Ltd.
S1	Type "H" switch (treble)	14061/B1	A.B. Metal Products Ltd.
S2	Type "H" switch (presence)	14062/B1	A.B. Metal Products Ltd.
	B9A valve sockets (five)	BM9/U	McMurdo Instrument Co. Ltd.
	Mains adjustment panel	VSP393/O	Ediswan-Clix
	Chassis		Tele-Radio (1943) Ltd.
			Whiteley Electrical Radio Co. Ltd
	Printed front panel		Tele-Radio (1943) Ltd.
	Cabinets		Lewis Radio Co.
			Tele-Radio (1943) Ltd.
		BCS1861	G.E.C. (Loudspeaker cabinet only).
	Transformers and choke (see specifications above for Type Nos.)		Haddon Transformers, Ltd.
			Partridge Transformers Ltd.
			Whiteley Electrical Radio Co. Ltd.

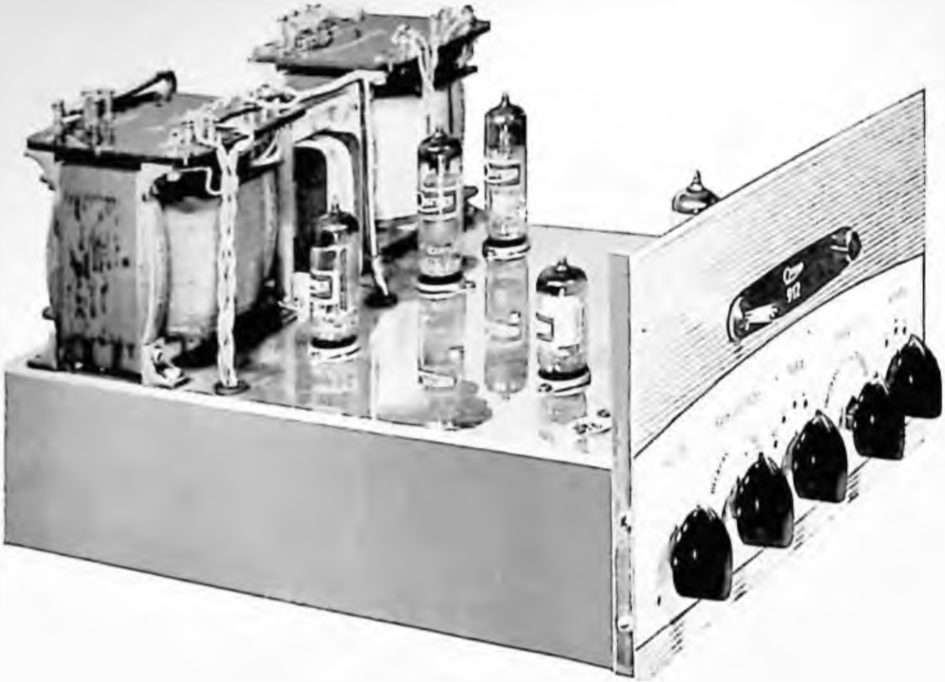


Fig. 30. Top view of the complete chassis.

Fig. 31. Rear view of chassis fitted with Haddon transformers.

Fig. 32. Rear view of chassis fitted with Partridge transformers.

Fig. 33. Rear view of chassis fitted with Whiteley transformers.

THE LOUDSPEAKER

Fig. 34. The G.E.C. BCS 1851 metal cone loudspeaker.

The loudspeaker and its cabinet play a most important part in the attainment of good enjoyable quality in the home. The Osram 912 amplifier has been designed for and tested out on the G.E.C. BCS 1851 Metal Cone Loudspeaker. This loudspeaker is interesting in several respects ; it was designed specifically for laboratory use where low frequencies of great purity have to be generated, the conventional type of large " woofer " loudspeaker, being quite unacceptable because it is not possible to prevent the large paper cone from bending and generating harmonics and intermodulation. The small metal cone on the other hand is so rigid that there is virtually no bending of the cone at low frequencies, resulting in a great reduction in harmonic and intermodulation distortion, if the loudspeaker is operated in a cabinet designed for it.

The high frequency response of the metal cone has been made very attractive by the skilful design of local radial stiffness. The result is a loudspeaker which, alone, covers the entire audio-frequency range, and which is capable of quite outstanding quality when used in its own cabinet, the cabinet contributing to the final sound quality to an even greater extent than usual.

The power which will be required to operate the loudspeaker will depend upon the size of room and the type of reproduction which the listener requires, but it has been found that 12 watts is sufficient to give completely realistic reproduction of a full orchestra in a living room which is rather larger than average. That is to say that the loudness which the listener hears will produce the same impression to him as did the original sound when he heard it from his ideal position.

The power which the loudspeaker can handle is limited by the heat generated in the speech coil and not by the customary increase in distortion which occurs with a conventional paper cone. One result of the lack of distortion is that there is no audible warning to the user that the loudspeaker is being over-run. Damage to the loudspeaker can also result from excessive cone movement caused by slight over-loading of the amplifier, even when the loudspeaker is used in a good cabinet. The first indication of this may well be a slight visible movement of the cone in and out on loud passages, which indicates assymetry of the power amplifier wave form. When the loudspeaker is reproducing loud sounds with an undistorted input, there should be no visible movement of the cone in and out, but it will look slightly blurred in outline. At higher frequencies, distortion in the amplifier may easily give rise to audible distortion which sounds so exactly like a loudspeaker rattle that it is very difficult to believe that it is due to valve overload. It is much more likely to be the amplifier causing the rattle than the loudspeaker.

It is very important that frequencies below 30 cycles per second should be removed as completely as possible in order to prevent very low frequency " rumble " from both the record and turntable giving the loudspeaker an excessive movement, causing it to " dance about " independent of whether a loud or a soft passage is being reproduced.

Technical Data

Frequency range	... 30-17,000 c/s
Maximum instantaneous power rating	... 10-12 watts
Continuous power rating	... 6 watts
Fundamental resonance	... Very small *(less than 2 db at 45/55 c/s)
Speech coil diameter	... 1 in.
Speech coil impedance	... 4 ohms
Field flux density	... 13,500 gauss
Overall diameter	... 8 in.
Overall depth	... 4½ in.
Weight	... 3 lb. 6 oz.

*NOTE.—The apparatus used for the measurement of the fundamental resonance must have a flat frequency response at least to 30 c/s, otherwise a spurious resonance may be detected between 50 and 80 c/s.

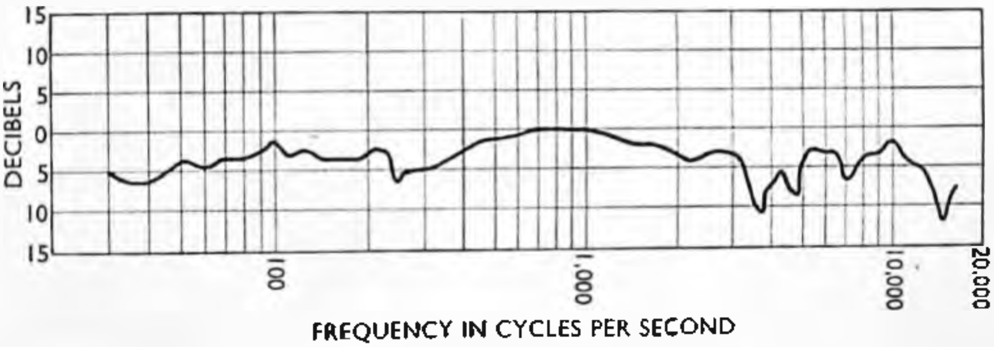


Fig. 35. Frequency response of the metal cone loudspeaker in the G.E.C. octagonal cabinet.

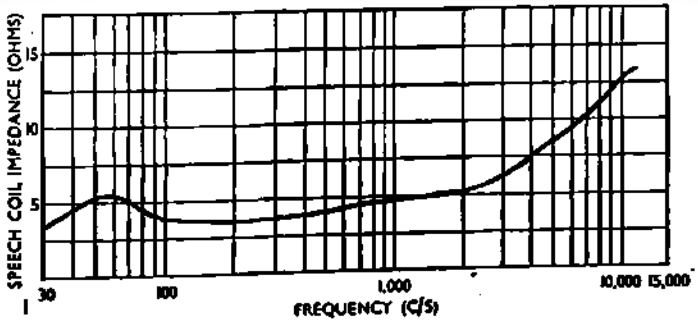


Fig. 36. This curve shows how small is the variation in impedance with frequency.

THE G.E.C. OCTAGONAL LOADED-PORT CABINET

British Registered Design Applied For

British Patent Applied For

As a result of choosing a small rigid cone for the production of the lowest frequencies with great purity, it became imperative to design a cabinet which would effectively couple the small radiating surface to the air, otherwise the improvement gained from the small rigid cone would be squandered in useless cone movement with no radiation. The normal bass reflex cabinet can be made to give satisfactory coupling between the loudspeaker and the air if its resonance is lower than that of the loudspeaker, in this case 40 c/s or even less. Such a low frequency of resonance calls for a large volume of enclosed air, which means that the cabinet itself must be large ; but if the sides of the large cabinet vibrate they will reduce the sound output at the lowest frequencies and increase the harmonic distortion as did the large paper cone of the " woofer " loudspeaker. This trouble caused by the vibration of the sides of the cabinet is so serious that some enthusiasts have constructed cabinets of brick and also double-skinned wood with sand filling. These cabinets are very effective but it is virtually impossible to move them about the room in order to find the optimum position. Just as the small rigid cone was the answer to the loudspeaker, so is the small rigid cabinet the answer to the movable cabinet. For use with the G.E.C. Metal Cone Loudspeaker, the octagonal cabinet is little more than half the size of the conventional bass reflex cabinet, yet it retains an acoustic output down to 30 cycles per second, which is within a few db of the 1000 c/s level depending on the room in which it is used. This low frequency is obtained by means of an external duct formed between the bottom of the cabinet and the floor. Since the height of the bottom of the cabinet from the floor determines the lowest frequency of operation, it is necessary to slightly increase this height if the cabinet sinks into a very soft and deep carpet, but normally the distance shown in the drawing should be maintained.

Until now, the loudspeaker has been rightly considered as the weakest link in a high quality reproducing chain, but with the G.E.C. Metal Cone Loudspeaker in the octagonal cabinet, the total acoustic distortion at 40 c/s per second is as low as 4%, which is comparable with the performance of most amplifiers at this frequency.

The design of the octagonal cabinet is such as to make it as rigid as possible ; a barrel would be even more satisfactory in shape, but might be thought by some to lack artistic merit. The small size and extreme simplicity of the present design permit it to be used in any part of the room, and it will operate very satisfactorily when the loudspeaker is pointing away from the listener into a corner of the room. The inside of the cabinet is hung with two layers of cellulose wadding to absorb high frequencies and to prevent reflection from the back of the cabinet.

Although the octagonal loaded-port cabinet was designed especially for the G.E.C. Metal Cone Loudspeaker, BCS 1851, the outstanding characteristic of which is its bass response, several reputable makes of 8" paper cone speakers have been tested and give acceptable results. Typical of the high-quality loudspeakers tested is the W.B. Stentorian HF810 (Whiteley Electrical Radio Co. Ltd.).

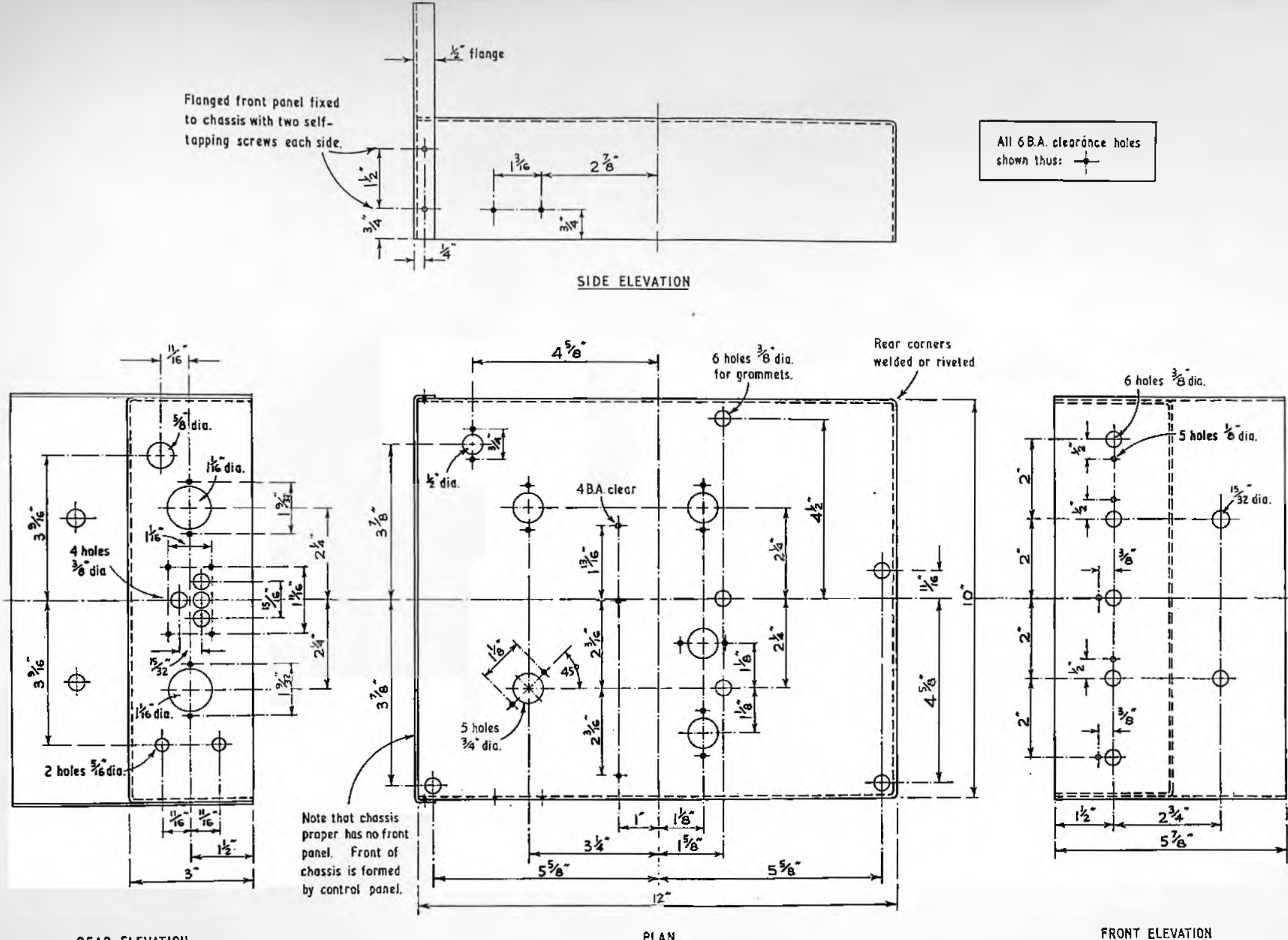


Fig. 37. Working drawing of chassis.
Material : 16 s.w.g. aluminium.

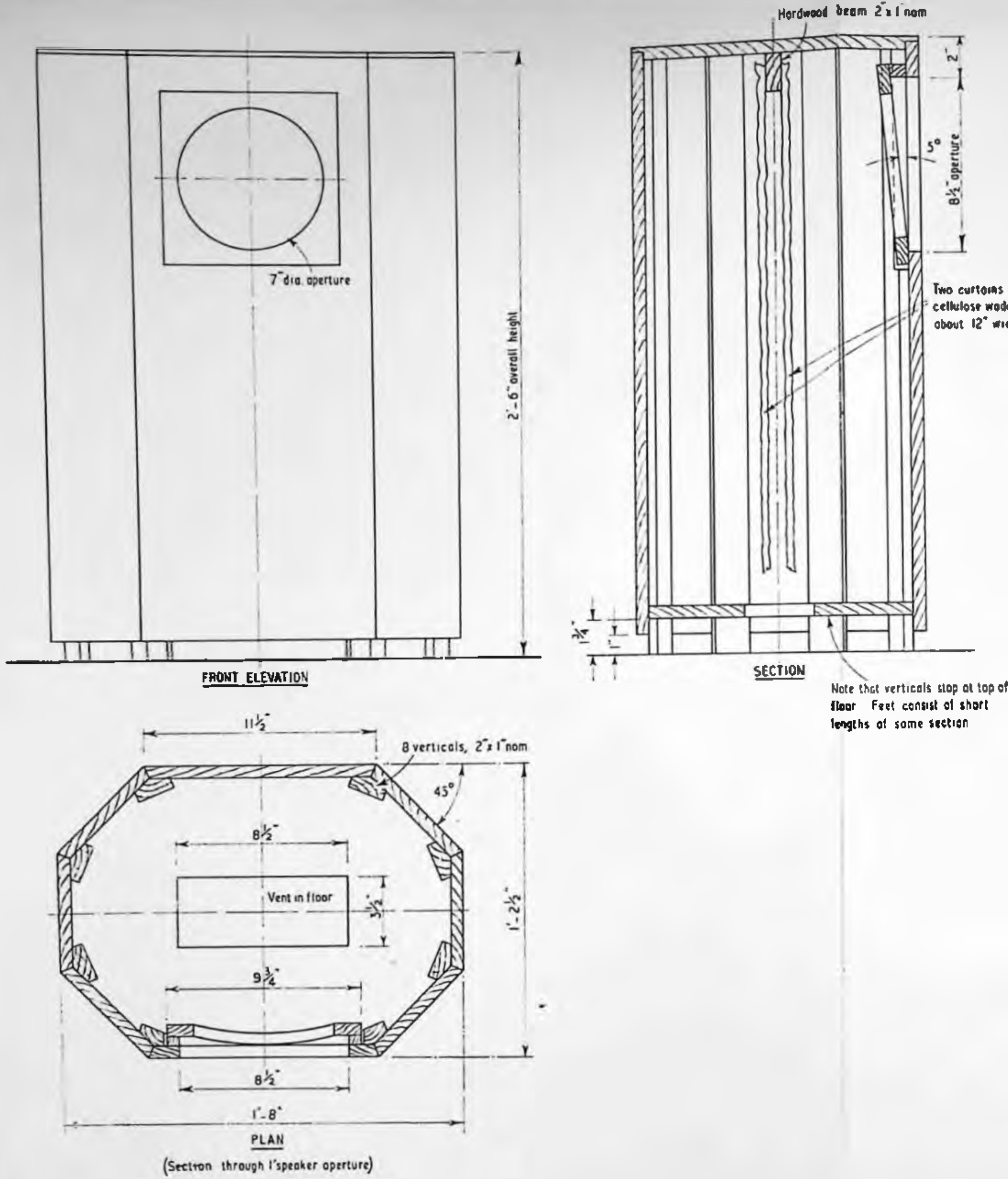
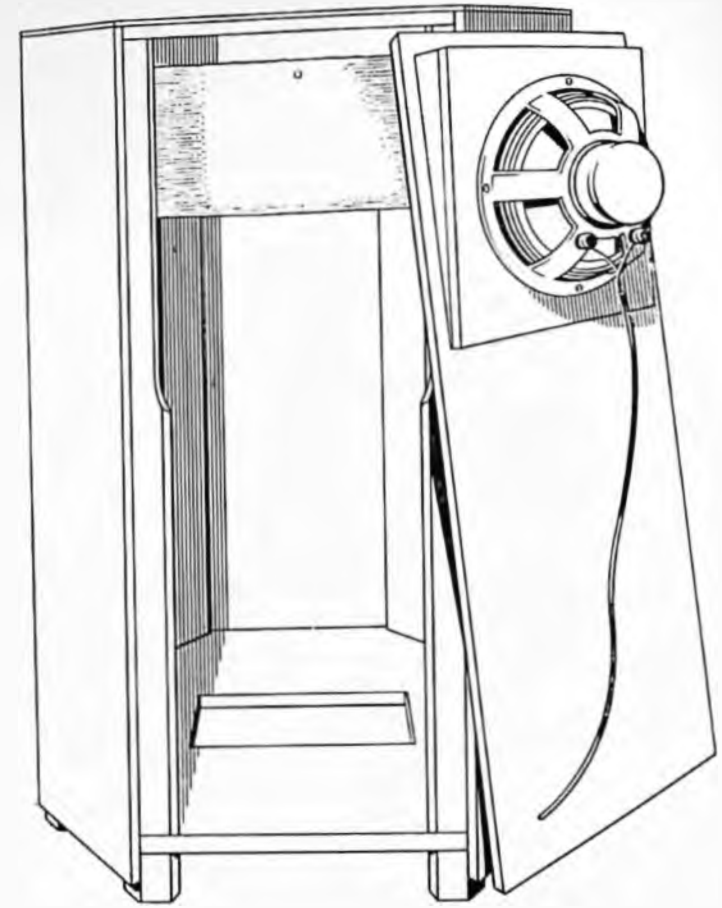
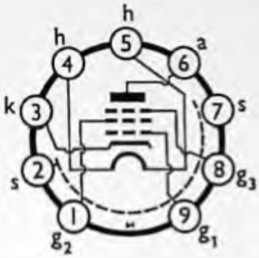


Fig. 38. Working drawing of G.E.C. Octagonal Loaded-Port Loudspeaker Cabinet.
Material : ⅜" ply, finished as desired.



In this view of the cabinet, the curtains of cellulose wadding are rolled up to show the interior. The front is secured with wood screws.



View from underside of base.

Z729

1st STAGE PENTODE

(V_1)

The Z729 pentode has been designed for use in audio frequency circuits demanding the utmost freedom from hum, microphony and other undesirable effects. Special precautions have been taken to reduce to a minimum the capacitance between the control grid and the heater. The highly anti-microphonic construction of the Z729 will normally prevent acoustic feedback ; consequently no precautions are required to overcome microphony in normal applications. Internal screening obviates the necessity for an external screening can.

RATING

Heater voltage	6·3
Heater current	0·2A
Max. anode voltage	300
Max. screen voltage	200
Total cathode current	6 mA
†Anode impedance	2 MΩ
†Mutual conductance	1·85 mA/V

† At anode voltage of 250, screen voltage of 140 and anode current of 3 mA.

TYPICAL OPERATION*

H.T. supply voltage	175	175
Voltage gain	180	110
Approx. cathode current	0·6 mA	1·2 mA
Cathode bias resistor	2·2 kΩ	1 kΩ
Screen series resistor	1MΩ	470kΩ
Anode load resistor	220kΩ	100kΩ

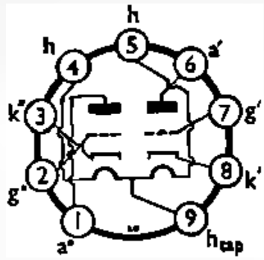
* For general information ; not necessarily as used in the Osram 912 amplifier.

B309

2nd STAGE

DOUBLE TRIODE

(V2)



View from underside of base.

The B309 is a double triode with independent cathodes. In the Osram 912 amplifier, one of these triodes forms the second stage valve, and the other is connected as a phase-splitter which provides a push-pull signal for driving the output stage.

The B309 is of robust design and is free from microphony in normal applications.

RATING

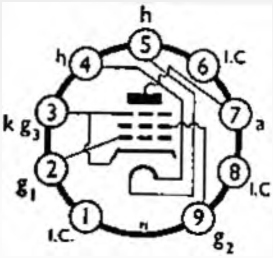
Heater voltage	6·3 or 12·6
Heater current	0·3 A or 0·15 A
Max. anode voltage	300
Max. anode dissipation	2·5 W
†Amplification factor	55
†Anode impedance	10kΩ
†Mutual conductance	5·5 mA/V

† At anode voltage of 250 and grid voltage of —2.

TYPICAL OPERATION (Each Triode)*

H.T. supply voltage	250
Grid bias	—2 V
Voltage gain	37
Anode current	1·4 mA
Cathode bias resistor	1·2kΩ
Anode load resistor	100kΩ

* For general information ; not necessarily as used in the Osram 912 amplifier.



View from underside of base.

N709

OUTPUT STAGE POWER PENTODES

(V_3 and V_4)

The N709 is a high-efficiency power pentode designed for use either singly or in push-pull in the output stage of an audio amplifier. The valve has a high mutual conductance and the resulting sensitivity ensures a considerable output power for a comparatively small input voltage. In the Osram 912, two N709 valves form a push-pull circuit which, in conjunction with a specially designed output transformer, enables lower distortion and output impedance to be obtained than in a normal pentode circuit, yet with a higher power output than that obtainable from triode connection of the valves.

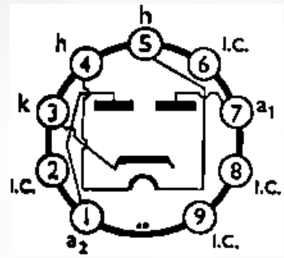
RATING

Heater voltage	6·3
Heater current	0·76 A
Max. anode voltage	300
Max. screen voltage	300
Max. cathode current	65 mA
Max. anode dissipation	12 W
Max. screen dissipation	2 W
†*Mutual conductance*	11·3 mA/V
†Anode impedance	38kΩ

† At anode and screen voltages of 250, anode current of 48 mA and grid bias of —7·3 V.

U 709

BI - PHASE HALF-WAVE RECTIFIER (V5)



View from underside of base.

The Osram U709 is a rectifier of the modern minature type having an indirectly heated 6·3 V cathode and high insulation between heater and cathode. This feature is valuable in certain applications where it is required to operate all valves, including the rectifier, from a common heater supply. In the Osram 912, however, the heater is connected to cathode and supplied by a separate winding on the mains transformer.

RATING

Heater voltage	6·3
Heater current	0.95 A
Max. heater-cathode voltage	450
Max. peak inverse voltage	1000
Max. r.m.s. anode voltage	350
Max. D.C. output current	150 mA

TYPICAL OPERATION (Capacitor Input)*

R.m.s. anode voltage	350 + 350
D.C. output voltage	340
D.C. output current	150 mA
Reservoir capacitor	8μF

* For general information ; not necessarily as used in the Osram 912 amplifier.

COMPONENTS FOR "OSRAM 912"

For the convenience of the constructor the following list is prepared as a guide to the price of the components specified for use in the Osram 912 amplifier. These components can be obtained from any Radio Dealer.

	£ s. d.	£ s. d.
Resistors (" Lab " Resistors)	1 12 4	
Capacitors (TCC)	3 0 6	
Other Components :		
Plugs, Sockets, Fuseholder, Tag Strips, Knobs, Switches, as specified	2 8 4	
Printed Front Panel as illustrated (Tele-Radio) ...	14 6	
Tooled Chassis to " 912 " specification (Whiteley Electrical or Tele-Radio)	**Price on application**	
Set of 5 Osram Valves : Z729, B309, 2/N709, U709 (including P.T.)	4 17 7	
	£12 13 3	
Set of Partridge Transformers and Choke ...	8 6 0	
		TOTAL £20 19 3
Set of Haddon Transformers and Choke	7 19 0	
		TOTAL £20 12 3
Set of Whiteley Transformers and Choke ...	6 8 9	
		TOTAL £19 2 0

Above are approximate alternative total costs of Amplifier parts, less Chassis.

Supplement to Publication No. OV2592

The General Electric Co. Ltd.


G.E.C.
G.E.C.
METAL CONE Loudspeaker
PATENTS APPLIED FOR
G.E.C.

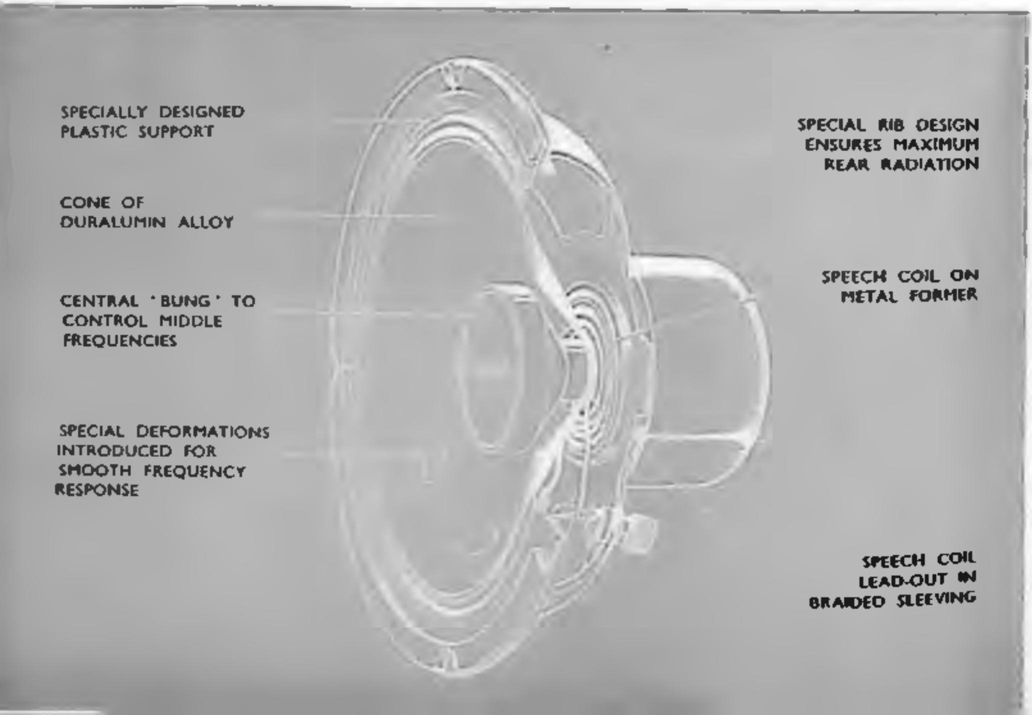
a Unique development in high quality sound reproduction

The G.E.C. Metal Cone Loudspeaker represents an outstanding advance in high quality sound reproduction. It reproduces any type of sound with an unequalled impression of realism. This is because the loudspeaker has an exceptionally wide and smooth frequency response, very low cross-modulation, good transient response and an exceptional performance on the bass frequencies.

The speaker is built round a light but rigid duralumin cone with shaped deformations which contribute to the smooth frequency response. Further smoothing is provided by a central "bung" which eliminates irregularities in the middle frequency response. The plastic material, which is used for the flexible surround, is specially formulated so that it provides the correct mechanical termination for the cone. The magnetic system incorporates a highly efficient Alcomax III ring magnet, which provides a flux density of 13,500 gauss, and the magnetic gap and speech coil have been carefully designed so that a constant driving force is obtained up to the largest cone displacement, driving force distortion being eliminated. The speech coil is wound on a metal former, giving extreme rigidity and reliability and an improved transient and high frequency response.

The working parameters are as follows:—

Maximum instantaneous power rating: 12 watts.
Continuous power rating: 6 watts.
Fundamental resonance: less than 2db at 45/50 c.p.s.
Speech coil impedance: 4 ohms at 400 c.p.s. An auto transformer, BCS 1855A, is available to match 1, 2 or 3 speakers to 15 ohms.



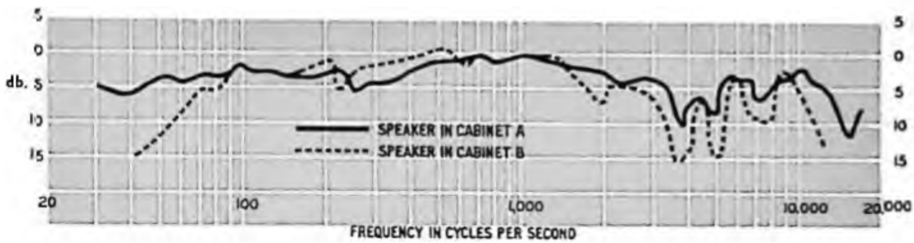
Frequency Response

The effective working frequency range of the speaker is 30 c/s to 20 kc/s.

Typical response curves are shown below and it will be seen that they are remarkably free from resonant peaks.

The average excursion within the range 30 c/s to 17 kc/s is within ± 2½ db with a maximum excursion of ± 6 db.

The wide response makes it unnecessary to use a twin speaker system with change-over frequency separating network.



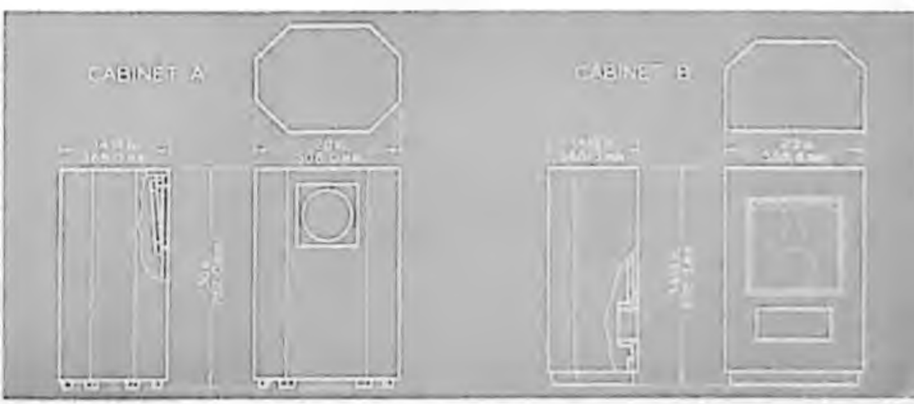
Cabinets

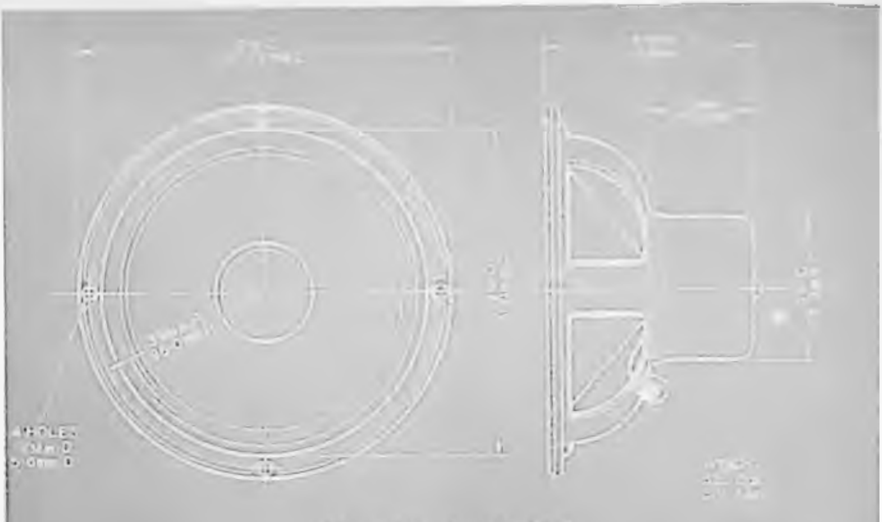
It is essential that a suitably designed acoustic chamber is used with the metal cone loudspeaker in order to obtain correct operation, as the loudspeaker must be correctly loaded at all frequencies.

The design of the chamber will control the effective frequency response of the loudspeaker, also its inter-modulation characteristics. Two typical curves are shown above: in the one the loudspeaker is mounted in a loaded port-octagonal cabinet and in the other it is mounted in a conventional bass-reflex cabinet.

It will be seen that the loaded port produces a much smoother response and enables the full bass frequency performance of the speaker to come into operation. This cabinet, catalogue number BCS 1162, is suitable for one or two loudspeakers.

Full details may be obtained on application.





PRINCIPAL DIMENSIONS

The BCS 1851 Loudspeaker appeals particularly to music lovers and high quality reproduction enthusiasts since it is more than capable of taking full advantage of modern high quality recordings, television sound and broadcast radio. Its balance of performance and clarity give a natural life-like quality to the reproduction.

The simplicity of the unit and its low price, make high quality reproduction an economic and practical proposition.

PRICE

BCS 1851 METAL CONE LOUDSPEAKER UNIT £8 · 15 · 0 tax paid

The right to vary technical details in this publication is reserved by the G.E.C

THE GENERAL ELECTRIC CO. LTD.

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