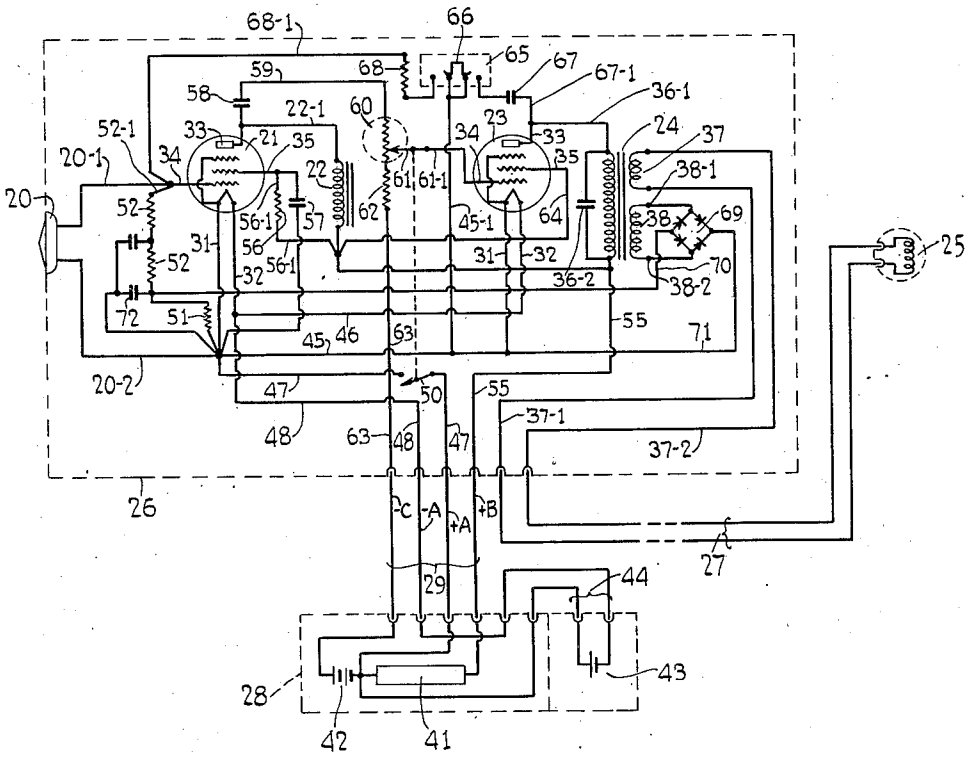
Aug. 17, 1943. H. B. SHAPIRO 2,327,321

HEARING AID AMPLIFIER

Filed Nov. 12, 1941 4 Sheets-Sheet 1

Fig. 1.



INVENTOR

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BY Pinckles & Gelmo

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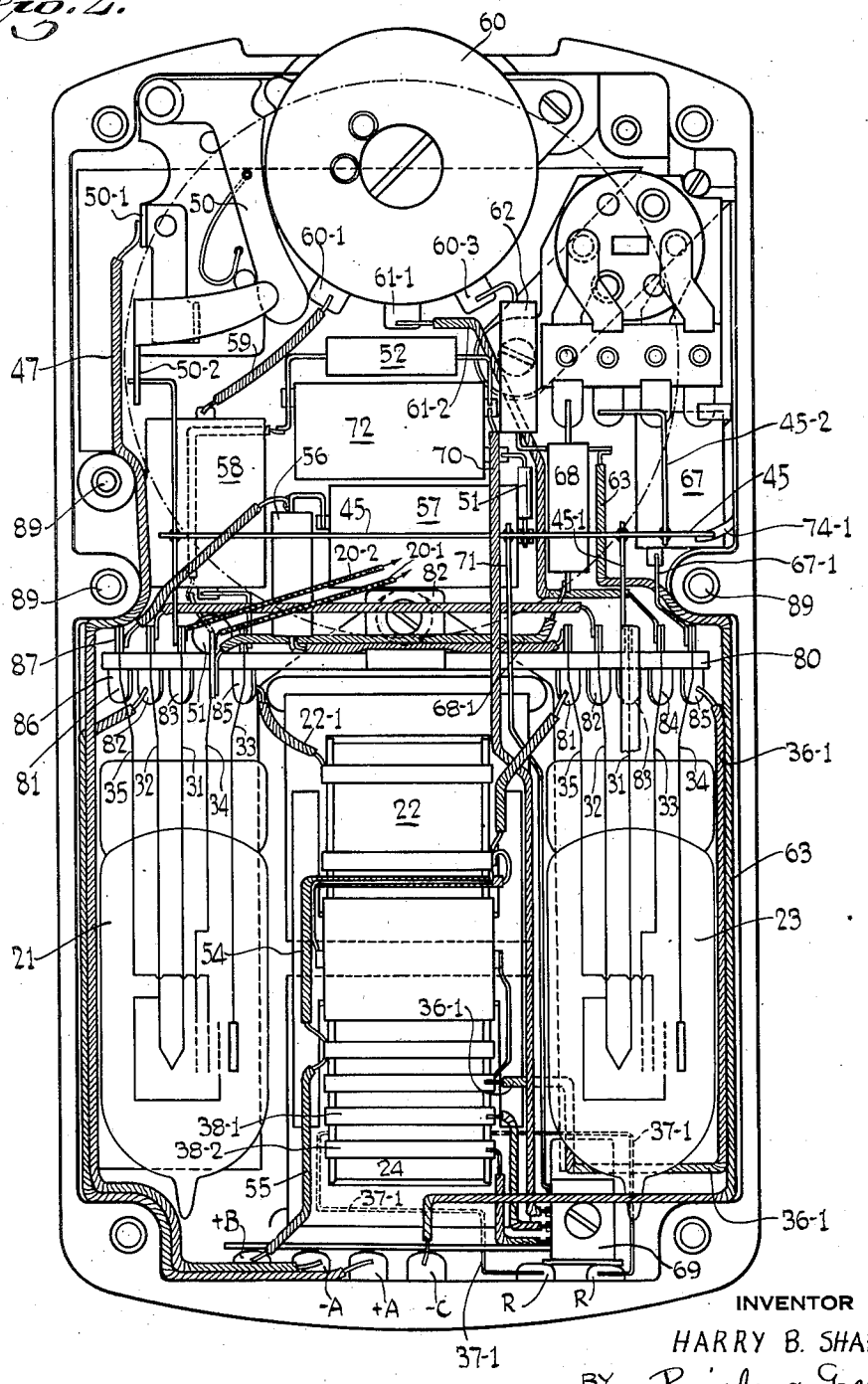
Aug. 17, 1943. H. B. SHAPIRO 2,327,321

HEARING AID AMPLIFIER

Filed Nov. 12, 1941 4 Sheets-Sheet 2

Fig. 2.



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Aug. 17, 1943. H. B. SHAPIRO 2,327,321

HEARING AID AMPLIFIER

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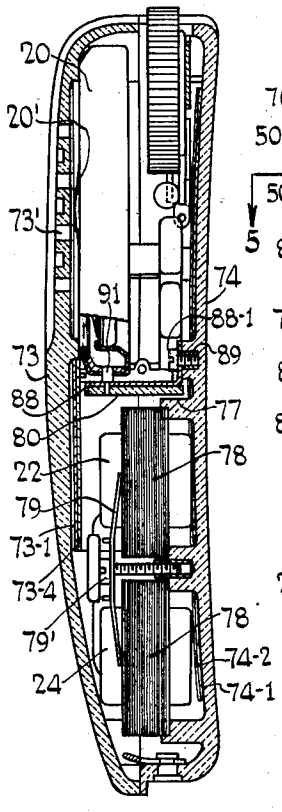

Fig. 3.

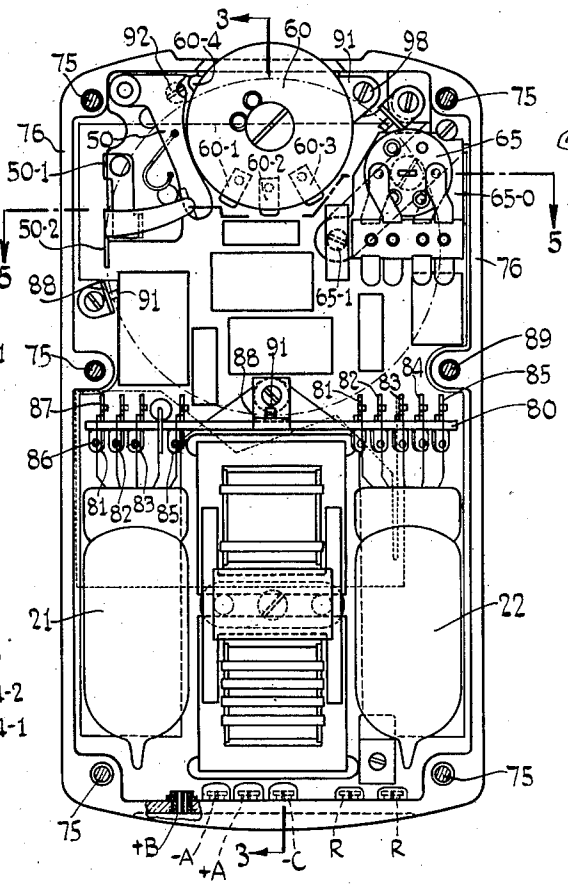

Fig. 4.

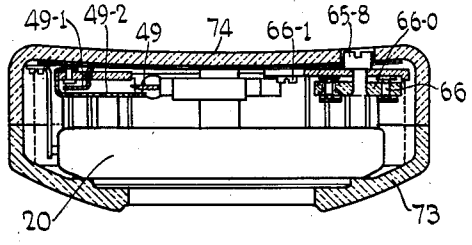

Fig. 5.

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HEARING AID AMPLIFIER

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Fig. 6.

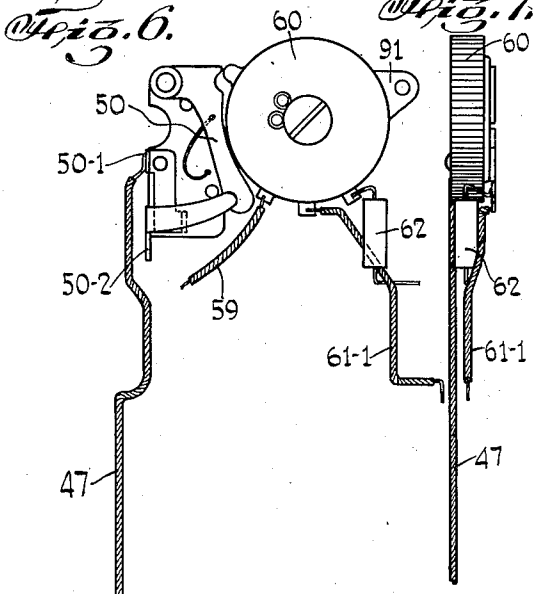


Fig. 7.

Fig. 8.

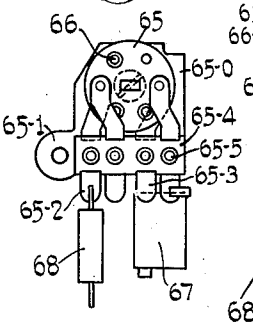


Fig. 9.

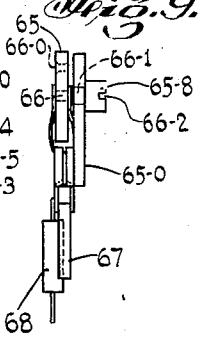


Fig. 10.

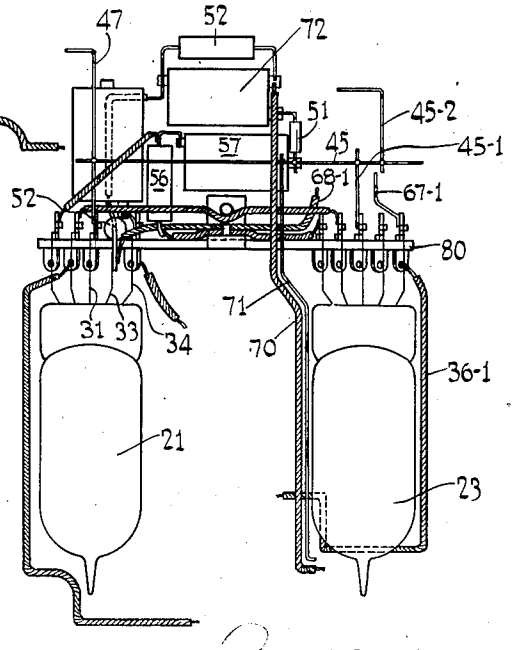
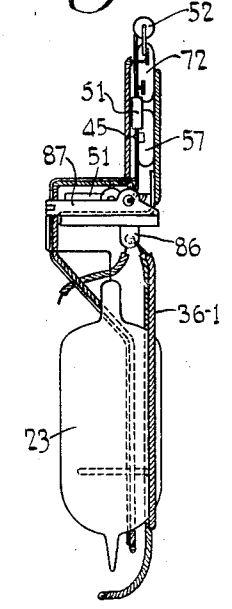


Fig. 11.



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Patented Aug. 17, 1943

2,327,321

UNITED STATES PATENT OFFICE

2,327,321

HEARING AID AMPLIFIER

Harry B. Shapiro, Willoughby, Ohio, assignor to Sonotone Corporation, Elmsford, N. Y., a corporation of New York

Application November 12, 1941, Serial No. 418,858

9 Claims. (Cl. 179—107)

This invention relates to hearing aid amplifiers, and particularly to electron tube hearing aid amplifiers.

Among the objects of the invention are arragements and methods for mounting and assembling the structural elements of a compact electron tube hearing aid amplifier that must be small and light enough for inconspicuous and comfortable wear on the body of the user and must house all the elements of the amplifier so that they are readily accessible for replacement or for reconditioning, while assuring that when in use, the amplifier operates in a foolproof manner.

The foregoing and other objects of the invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawings wherein

Fig. 1 is a circuit diagram of an electron amplifier hearing aid in connection with which one exemplification of the invention will be described;

Fig. 2 is a view of the amplifier unit of the hearing aid with the front casing and the microphone removed illustrating the various structural elements of the amplifier unit mounted in their positions on the rear wall of the casing together with their interconnections, representing one exemplification of the invention;

Fig. 3 is a vertical sectional view through the amplifier casing illustrating the mounting of the principal structural elements of the amplifier;

Fig. 4 is a view similar to Fig. 2 omitting, for the sake of better showing, the interconnections between the structural elements of the amplifier;

Fig. 5 is a horizontal sectional view along line 5—5 of Fig. 4;

Fig. 6 is an elevational view of one element of the sub-assembly of the amplifier shown in Fig. 2;

Fig. 7 is a side view of the sub-assembly shown in Fig. 6;

Fig. 8 is an elevational view of another sub-assembly of the amplifier shown in Fig. 2;

Fig. 9 is a side view of the sub-assembly of Fig. 7;

Fig. 10 is an elevational view of another sub-assembly of the amplifier shown in Fig. 2; and

Fig. 11 is a side elevational view of the sub-assembly of Fig. 10.

The principles underlying the invention will be explained by their application to one form of an electronic amplifier hearing aid shown diagrammatically in Fig. 1, Figs. 2 to 11 illustrating the novel mounting and assembly arrangement of the elements of such amplifier exemplifying one form of the invention, features of which are disclosed in the copending application of Harry B. Shapiro, Serial No. 418,857, filed Nov. 12, 1941, as a continuation-in-part of his application Serial No. 294,649, filed September 13, 1939.

As shown in Figs. 1 to 5, the electronic amplifier hearing aid has a high-impedance microphone 20 which drives a voltage amplifier stage including the amplifier tube 21, the output of which is impressed across a magnetic-core coupling inductance 22 on a power amplifier stage, including the power amplifier tube 23, the output of which is shown impressed through a magnetic-core transformer 24 on a receiver. The microphone with all the elements of the amplifier are housed in a flat small compact casing 26 and the receiver is connected to the amplifier unit through a detachable flexible cord 27. Operating energy for the amplifier is shown supplied from a compact electrical battery cell assembly 28 which is connected to the circuits of a tube through a detachable flexible multi-lead cord 29.

Pentodes are shown used as the voltage amplifier tube 21 and the power amplifier tube 23, each comprising a filamentary cathode having two terminal leads 31, 32, an anode having a terminal lead 33, a control grid having a terminal lead 34, a screen grid having a terminal lead 35. The transformer 24 has a primary winding 36, a secondary winding 37 through which the output is impressed on the receiver 25, an additional secondary winding 38 connected to an automatic limiting circuit referred to later.

The battery assembly 28 which supplies the operating energy to the amplifier has a plate supply battery 41, grid bias cells 42 and a cathode heating cell 43 which is interconnected to the battery assembly through a flexible cord 44. The battery assembly has a set of socket terminals, through which the leads +B, —A, +A, —C of the battery cord 29 are detachably interconnected with the proper battery cells.

The cathode leads 31, 32 of the two amplifier tubes 21, 23 are connected in parallel to leads 45, 46 which are connected through cathode supply leads 47, 48 to the battery cord leads +A, —A from the cathode heating cell 43, the cathode lead 45 being indicated as the ground. A switch

50 in the supply lead 47 serves to close or open the cathode heating circuit.

The grid leak resistance of the voltage amplification tube 21 is formed by a resistance element 51 connected in series with two additional resistance elements 52 between the grounded cathode lead 45 and the control grid lead 34 of tube 21. The plate or anode lead 33 of tube 21 is connected through the coupling inductance winding 22 to the plate supply lead 55 from the battery cord lead +B. The lead 54 extending from the positive supply lead 55 impresses through a resistor element 56 the required positive potential on screen grid lead 35 of tube 21, a by-pass condenser 57 shunting the resistor element 56.

The output of the voltage amplification stage is impressed through a blocking condenser 58 and a lead 59 on the input circuit to the power amplification stage of tube 23 which is formed of a rheostat unit 60 having an adustable tap with a lead 61 connected to the control grid 34 of the power tube 23, the resistance of the rheostat element 60 forming with a series connected resistor element 62 a grid leak resistance connected through a grid bias supply lead 63 to the battery cord supply lead —C.

The plate supply lead 33 and the screen grid lead 35 of the power tube 23 are connected to the positive plate supply lead 55 through the transformer winding 26 and through the serially connected leads 64, 54, respectively. There is also shown provided a multi-position switch unit 65 having a movable contact member 66 which connects in one position a condenser 67 in parallel to the primary winding 36 of the output transformer for boosting the response in a selected part of the lower frequency range. In the other position, the sliding contact 66 of switch 65 connects a resistance 68 parallel to the microphone 20 for cutting off a selected part of the low frequency response.

The amplifier is further shown provided with an automatic peak cutoff circuit provided with four copper oxide rectifier elements arranged to form a rectifier bridge 69 having two diametrically opposite terminals connected to the secondary transformer winding 38, the other two diagonally opposite terminals of the rectifier bridge 69 being connected through leads 70, 71 to impress a rectified component of the output voltage derived from the output transformer 24 on the control grid 34 of the voltage amplification stage. The two resistance elements 52 connected in series, and the two condenser elements 72 connected in shunt with the leads from the rectifier bridge 21 to the grid input circuit 69—1 serve to filter and smooth out the rectified voltage.

The novel operating features and the various advantages of the amplifier arrangement described above are fully explained in the copending application of Harry B. Shapiro, Serial No. 418,857, filed Nov. 12, 1941, as a continuation-in-part of the application Serial No. 294,649, filed September 13, 1939, and are claimed therein.

Most of the hard of hearing or deafened persons are very sensitive and seek to conceal their hearing impairment. Accordingly, to be practically useful, a hearing aid must be light, small and compact so that it may be worn comfortably and inconspicuously on the body of the user. In addition, it must be simple and foolproof in operation, and it should require little attention and a minimum of parts that may get out of order or require replacement so as to free the user from mental and physical strain as well as annoyances to which he is subjected when the instrument has to be repaired or checked up.

To meet the foregoing requirements, it is important that the electron tube hearing aid amplifier unit, to which the present invention is directed, be not only compact and small, but that all the elements of the amplifier unit shall be readily accessible for repair or exchange and reconditioning without loss of time and without introducing complications when one or another circuit element of the amplifier unit has to be removed or replaced.

In an effort to meet the foregoing requirements, prior hearing aid amplifier units had the principal circuit elements of the amplifier mounted on a mounting plate which was placed in the flat compact casing of the amplifier unit and was readily removable therefrom so as to enable checking or replacement of a defective element. Such mounting plate had, of course, to have a certain rigidity, and in order to keep the circuit elements held in position by the mounting plate insulated from each other, the mounting plate had to be of resistance material, thus taking up a part of the space in the interior of the amplifier and making it necessary to use a larger amplifier casing than would be otherwise required.

According to the principles of the present invention, the structural elements of the amplifier are arranged in the form of sub-assemblies built around the relatively rigid structural elements of the amplifier so that each sub-assembly is self-supporting in its required relationship. This arrangement eliminates the need for a bulky mounting plate and makes possible a very effective reduction in the overall bulk of the amplifier while assuring ready replacement or dismantling of the amplifier elements without disturbing their general relationship.

The principles underlying the invention will now be explained in connection with a hearing aid amplifier unit exemplifying one form of the invention.

Referring to Figs. 2 to 5, all the elements of the amplifier unit are housed in a small flat compact casing, indicated in Fig. 1 by the dash lines 26, only about 4 x 2¼ x ¾ of an inch in volume, the casing being formed of a front wall or cover 73 and a rear wall 74 molded of synthetic resin insulating material, the two casing halves being held clamped together by screws 75. The rear wall 74 of the amplifier unit is designed so as to form the mounting wall which supports all the elements of the amplifier unit in their operative position so that upon removing the cover 73 they are available not only for ready inspection, but also for ready replacement. This eliminates the necessity for mounting the structural elements which have to be connected into the amplifier circuit on a mounting plate extending through the entire length of the casing space.

As shown in Figs. 3 to 5, the rear wall is reinforced by a flange 76 extending along its edges so as to form a rigid structure and its central lower portion is provided with inwardly projecting short-post extensions 77 shaped so as to retain in position the core 78 of the coupling inductance 22 and transformer 24 of the amplifier, the two core structures with the windings mounted thereon being held in position by a clamping plate 79 and a screw 79' engaging an internally threaded bushing molded and embedded in the central post 77. The shoulder portion of the

mounting wall extending along the lower edge thereof is provided with holes in which are mounted four terminal bushings, marked +B, —A, +A, —C, arranged for detachable engagement with the cord plugs of the battery cord 28 and two bushings R, R for establishing detachable engagement with the leads of the receiver cord 44. The bushing and plug connectors, shown, are of the type described in the pending application of Carlisle et al, Serial No. 346,112, filed July 18, 1940.

A narrow insulating strip 80, of fibrous insulating synthetic resin material, for instance, projects inwardly from the rear wall 74 in the middle region thereof and has mounted thereon two sets of terminal lug strips 81, 82, 83, 84, 85 of sheet metal. Each terminal lug strip is firmly anchored in the insulating strip 80, for instance, by twisting the downwardly extending ear portion 86 thereof relatively to the forked portion 87 extending upwardly on the upper side of the insulating strip 80. The electrode leads of the voltage amplifier tube 21 are secured, as by soldering, to the upwardly projecting forked ends 87 of the set of terminal lugs 81 to 85 on the left end of the terminal strip, and the leads of the power tube 23 are connected to the forked ends of the other set of terminal strips 81 to 85, the control grid lead 33 of the voltage amplifier tube 21 being free so as to assure that it remains highly insulated.

The strip 80 is detachably held in its position on the mounting wall by an angular bracket 88 having its inner end clamped by a screw 88—1 to a bushing 89 embedded in a reinforced portion of the mounting wall 74. As shown in Figs. 3 and 4, two additional similar brackets 88 are secured to similar peripherally displaced bushings embedded in the mounting wall 74, each of the brackets being provided with a centrally projecting pin 91 holding in position the microphone unit 20 so that its diaphragm 20' faces the portion of the cover wall provided with the openings 73' through which sound waves reach the diaphragm. The microphone shown is so held within the casing as to prevent propagation of sound from the space between the microphone diaphragm and the facing acoustically pervious wall portion 73' to the space of the casing enclosure extending behind the microphone, in the manner explained in my copending application Serial No. 394,527, filed May 21, 1941 as a continuation-in-part of my application Serial No. 350,595, filed August 3, 1940. In the region of an opening slit provided in the upper portion of the flange 76 of the mounting wall is located the rheostat unit 60 forming a flat structure having a bottom wall provided with a mounting strip 91 secured by two screws 92 to bushings, such as the bushings 89 embedded in the mounting wall. The mounting strip 91 serves also as a unitary support for a pivotally mounted blade of the switch unit 49 provided with two switch terminals 49—1, 49—2 which, together with the switch blade 49, are insulatingly held on the mounting strip 91. The rheostat unit 60 is provided with three terminals 60—1, 60—2, 60—3 through which it is interconnected to the other elements of the amplifier circuit in the way shown in Fig. 1.

The combination rheostat and switch unit shown is of the type disclosed in the copending application of Harry B. Shapiro, Serial No. 418,856, filed Nov. 12, 1941, as a continuation-in-part of his application Serial No. 303,563, filed November 9, 1939, and is provided with a circular grip wall, a portion of which is exposed through the slit in the flange wall of the casing enabling the user to adjust the rheostat and the volume by a slight turn of the circular grip member. The nose 60—4 of the rheostat is arranged to cooperate with portions of the switch blade 49 so as to abruptly actuate it to the closed position when the rheostat is moved initially from its low volume position and to abruptly snap the switch blade 49 to its open position shown in Fig. 4 when the rheostat grip disc is returned to its low volume position.

The other switch unit 65 has its contacts supported on a substantially rigid base plate 65—0 of insulating material having a portion 65—1 held clamped against the mounting wall 73 by a screw engaging a bushing embedded in a reinforced portion of the wall 73. The switch base plate 65—0 has secured thereto two pairs of contact strips 65—2, 65—3 held in place by insulating strips 65—4 which are secured to the base plate by rivets 65—5. One or more movable contact members 66 are formed by pins embedded in a circular disc 66—0, secured, as by riveting, to the end of a pin 66—1 provided at the other end with a head 65—3 having a slit 66—2, so that the contact carrying disc 66—0 may be rotated on the base plate 65—0. Each pair of stationary contact strips 65—2, 65—3 has rearwardly projecting overlapping portions extending on opposite sides of the rotary disc 66—0 which carries the transversely extending metallic switch pins 66 arranged so that by selectively rotating the disc 66—0 to different positions, a switch pin 66 establishes connections between one of the pairs of contacts 65—2, 65—3 or keeps both pairs of contacts open.

Fig. 2 shows how the various elements of the amplifier are interconnected by the various connector leads into the amplifier circuit shown diagrammatically in Fig. 1, corresponding leads and parts in Figs. 1 to 11 being indicated by the same reference numerals.

Figs. 10 and 11 show the sub-assembly formed of the terminal strip 80 with its two sets of terminal strips 81 to 85 and the various other elements—including the tubes 21, 23 and all resistor and condenser elements with their leads—mechanically interconnected and joined by their wire leads into a self-supporting structure which may be detachably secured and removed from its position against the inward face of the mounting wall 73 of the casing. The sub-assembly is held in its position by clamping its central mounting bracket 88 to the central bushing 89 of the mounting wall with a screw 88—1, as shown in Fig. 3.

The connecting leads through which the different resistor elements, condenser elements and terminal members of the contact strip 80 are joined, are made from insulated and non-insulated wire elements, which are chosen to be sufficiently stiff so that all the elements retain their proper relationship with regard to the relatively rigid mounting strip 80, thereby permitting easy mounting and removal of the sub-assembly from its position on the mounting wall 74 of the casing, without disturbing the elements of the sub-assembly.

All the principal resistor and condenser elements required for completing the amplifier circuit of the type indicated in Fig. 1 may be thus joined and assembled into a sub-assembly having as its principal junction member the narrow rel-

atively rigid contact strip 80 extending transversely between the facing walls 73, 74 of the casing confining the narrow space of the amplifier unit. However, some of the resistor and condenser elements may be joined to the other relatively rigid structural elements which form a part of the amplifier circuit, such as the resistor unit 60, the switch unit 50 or the switch unit 65.

Thus, as shown in Figs. 6 and 7, the rheostat unit 60 which forms in conjunction with the switch 50 a substantially self-supporting unitary structure may have secured thereto the wire leads 47, 59, 61—1, as well as the resistor element 62, the wiring elements and the connector elements of the resistor unit 62 being sufficiently stiff so that once shaped they will maintain their relation shown, enabling the completion of the sub-assembly and mounting the sub-assembly as a unit in its position on the casing wall by fastening the mounting plate 91 of the rheostat unit by screws 92 to the wall 74 in the way shown in Fig. 4 and explained above. In a similar manner, the tone control switch unit 65 may have connected thereto the condenser and resistor elements 67, 68 together with any other associated elements into a unitary self-supporting sub-assembly, with interconnecting wiring portions sufficiently stiff so as to maintain all the elements of the sub-assembly in their proper relationship after they have been once joined in the sub-assembly, permitting mounting of the sub-assembly in its position on the wall by fastening it with a screw 65—1, in the way shown in Fig. 4 and explained above.

In making the sub-assemblies it is convenient to use colored leads so as to facilitate the interconnection of the elements of the sub-assembly. The following procedure may be adopted in making the sub-assembly shown in Figs. 10 and 11: The various leads shown in Fig. 10, except leads 45, 45—1, 47, after having been first cut to the required length and bent, are soldered to the terminal strips 81 to 85 of the mounting strip 80. Thereupon, the wire leads 45—1, 47 are soldered to the upwardly facing ears of the two contact strips 83, and the transverse interconnecting wire 45 is then soldered to the two wires 45—1, 47, the several wires having been cut and bent to their required shape before soldering. The various condensers and resistors have their terminal leads then trimmed to size and soldered in their proper positions, whereupon the wire elements forming their interconnections are soldered in place after having first been cut and bent to shape.

In a similar manner, the sub-assembly of Figs. 6 and 7 and the sub-assembly of Figs. 8 and 9 are separately made. In order to shield the amplifier elements, the main area of the inwardly facing surface of the mounting wall is coated with a layer 74—1 of conducting material, for instance, by spraying, and a sheet of insulating material 74—2 is placed thereover so as to assure that no short occurs between elements of the amplifier circuits and the shielding layer 74—1.

Alternatively, a sheet of insulating material 74—2 cut to shape so as to fit against the inwardly facing surface of the mounting wall 74 has cemented to the side facing the wall a foil 74—1 of a suitable metallic conducting material, such shielding arrangement having been found highly satisfactory in practical use. In a similar manner, the metallic shielding layer 73—1 enclosed by an inwardly facing layer of insulating material 73—4 is interposed between the inwardly facing surface of the cover 73 of the casing and the elements of the amplifier enclosed thereby.

The following procedure is followed in mounting the sub-assemblies in their positions on the mounting rear wall 74 of the casing: The shield foil 74—1 with its overlying foil 74—2 are cemented in position and the lead 63 is soldered in position to the terminal bushing —C, the lead 63 having been first cut and bent to shape. Thereupon, the sub-assembly shown in Figs. 10 and 11 is fastened by its bracket 86 in position, the ground interconnecting lead 46 of the cathodes being connected by soldering to a foil strip 74—1 extending from the metallic foil shield extending over the inner face of the rear casing wall 74. The combined rheostat 60 and switch unit 49 is then affixed in position and the ends of its leads 47, 59, 61 are connected to the points of interconnection in the manner shown in Fig. 2, lead 42 of the terminal strip sub-assembly being joined by soldering to the terminal tip 48—2 of the switch unit. The tone control switch unit 65 is then mounted in position on the casing wall 74 whereupon the terminal ends of the resistor element 68 and condenser 67 are soldered to the leads 60—1 and 67—1 of the previously affixed sub-assembly held together by the terminal strip 80.

Since the operating features of the amplifier are fully disclosed in the copending application of Harry B. Shapiro, Serial No. 418,857, referred to above, no further explanation is required and it is desired that the disclosure of the aforesaid Shapiro application be considered as a part hereof.

By providing the terminal strip 80 with an additional set of terminal strips 81 to 85 located between the two sets of terminal strips shown in Figs. 2 and 4, a third tube and additional elements for completing a three-tube hearing aid amplifier circuit, for instance, of the type described in connection with Fig. 22 of the aforesaid Shapiro application Serial No. 418,857, may be housed, mounted and arranged in accordance with the principles of the present invention in a housing of the same character as that required for housing the amplifier described above in connection with Fig. 1.

Various other modifications of the invention will suggest themselves to those skilled in the art. It is accordingly desired that in construing the breadth of the appended claims they shall not be limited to the specific details shown and described in connection with the exemplifications thereof.

I claim:

1. In an electron tube amplifier member forming part of an inconspicuous wearable hearing aid and designed to be energized from a direct-current energy source for supplying amplified output of a microphone to a receiver: a flat casing small enough for substantially hidden wear on the body of a user and having two walls detachably joined along their edges so as to form a casing enclosure confining a relatively shallow interior space having narrow sides; one of said walls having an inwardly facing mounting surface, and reinforcing elements forming part of said wall and rendering it substantially rigid; a substantially firm mounting member extending along said mounting surface between opposite narrow sides of said enclosure and dividing the enclosure into two enclosure sections; a plurality of metallic terminal members insulatingly secured to and held in position by said mounting

member so as to expose terminal portions of said terminal members to said interior space; interconnected elements of an amplifier housed in said casing including at least two multi-electrode amplifier tubes; each tube having a plurality of electrode leads extending from the tube and joined to exposed terminal portions of said mounting member so that said tubes are held thereby in predetermined positions in one of said enclosure sections; a plurality of external connector elements insulatingly secured to a wall portion of said enclosure for completing the operative circuit interconnections from said amplifier to external hearing-aid circuit portions and having inwardly facing exposed terminal portions; a predetermined set of circuit elements of said amplifier being interconnected to the terminal members secured to said mounting member so as to constitute with said tubes an interconnected structural unit forming part of at least two amplifier stages one of which constitutes an input stage and the other of which constitutes an output stage; said set of circuit elements including at least two self-supporting impedance elements each having at least one terminal wire interconnected to terminal portions of said mounting member so as to be held thereby in predetermined positions in the other of said space sections; said structural unit forming said mounting member, said tubes and said set of circuit elements constituting a self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface.

2. In an electron tube amplifier member forming part of an inconspicuous wearable hearing aid and designed to be energized from a direct-current energy source for supplying amplified output of a microphone to a receiver: a flat casing small enough for substantially hidden wear on the body of a user and having two walls detachably joined along their edges so as to form a casing enclosure confining a relatively shallow interior space having narrow sides; one of said walls having an inwardly facing mounting surface, and reinforcing elements forming part of said wall and rendering it substantially rigid; a substantially firm mounting member extending along said mounting surface between opposite narrow sides of said enclosure and dividing the enclosure into two enclosure sections; a plurality of metallic terminal members insulatingly secured to and held in position by said mounting member so as to expose terminal portions of said terminal members to said interior space; interconnected elements of an amplifier housed in said casing including at least two multi-electrode amplifier tubes; each tube having a plurality of electrode leads extending from the tube and joined to exposed terminal portions of said mounting member so that said tubes are held thereby in predetermined positions in one enclosure section; a casing wall portion bordering the other enclosure section being acoustically pervious; a plurality of external connector elements insulatingly secured to a wall portion of said enclosure for completing the operative circuit interconnections from said amplifier to external hearing-aid circuit portions and having inwardly facing exposed terminal portions; a predetermined set of circuit elements of said amplifier being interconnected to the terminal members secured to said mounting member so as to constitute with said tubes an interconnected structural unit forming part of at least two amplifier stages one of which constitutes an input stage and the other of which constitutes an output stage; said set of circuit elements including at least two self-supporting impedance elements each having at least one terminal wire interconnected to terminal portions of said mounting member so as to be held thereby in predetermined positions in said other space section; said structural unit formed of said mounting member, said tubes and said set of circuit elements constituting a self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface; and a high-impedance microphone in said other enclosure section having a diaphragm exposed to the acoustically pervious wall portion and being connected to the input stage of said amplifier.

3. In an electron tube amplifier member forming part of an inconspicuous wearable hearing aid and designed to be energized from a direct-current energy source for supplying amplified output of a microphone to a receiver: a flat casing small enough for substantially hidden wear on the body of a user and having two walls detachably joined along their edges so as to form a casing enclosure confining a relatively shallow interior space having narrow sides; one of said walls having an inwardly facing mounting surface, and reinforcing elements forming part of said wall and rendering it substantially rigid; a substantially firm mounting member extending along said mounting surface between opposite narrow sides of said enclosure and dividing the enclosure into two enclosure sections; a plurality of metallic terminal members insulatingly secured to and held in position by said mounting member so as to expose terminal portions of said terminal members to said interior space; interconnected elements of an amplifier housed in said casing including at least two multi-electrode amplifier tubes; each tube having a plurality of electrode leads extending from the tube and joined to exposed terminal portions of said mounting member so that said tubes are held thereby in predetermined positions in one enclosure section; a plurality of external connector elements insulatingly secured to a wall portion of said enclosure for completing the operative circuit interconnections from said amplifier to external hearing-aid circuit portions and having inwardly facing exposed terminal portions; a predetermined set of circuit elements of said amplifier being interconnected to the terminal members secured to said mounting member so as to constitute with said tubes an interconnected structural unit forming part of at least two amplifier stages one of which constitutes an input stage and the other of which constitutes an output stage connected to said external connector elements; said set of circuit elements including at least two self-supporting impedance elements each having at least one terminal wire interconnected to terminal portions of said mounting member so as to be held thereby in predetermined positions in the other enclosure section; said structural unit formed of said mounting member, said tubes and said set of circuit elements constituting a self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is

not disturbed when it is mounted on or removed from its position on said mounting surface; a casing wall portion bordering the other enclosure section being acoustically pervious; the impedance elements of said one unitary structure extending within said other enclosure section in the space between said microphone and said mounting surface.

4. In an electron tube amplifier member forming part of an inconspicuous wearable hearing aid and designed to be energized from a direct-current energy source for supply amplified output of a microphone to a receiver: a flat casing small enough for substantially hidden wear on the body of a user and having two walls detachably joined along their edges so as to form a casing enclosure confining a relatively shallow interior space having narrow sides; one of said walls having an inwardly facing mounting surface, and reinforcing elements forming part of said wall and rendering it substantially rigid; a substantially firm mounting member extending along said mounting surface between opposite narrow sides of said enclosure and dividing the enclosure into two enclosure sections; a plurality of metallic terminal members insulatingly secured to and held in position by said mounting member so as to expose terminal portions of said terminal members to said interior space; interconnected elements of an amplifier housed in said casing including at least two multi-electrode amplifier tubes; each tube having a plurality of electrode leads extending from the tube and joined to exposed terminal portions of said mounting member so that said tubes are held thereby in predetermined positions in one of said enclosure sections; a plurality of external connector elements insulatingly secured to a wall portion of said enclosure for completing the operative circuit interconnections from said amplifier to external hearing-aid circuit portions and having inwardly facing exposed terminal portions; a predetermined set of circuit elements of said amplifier being interconnected to the terminal members secured to said mounting member so as to constitute with said tubes an interconnected structural unit forming part of at least two amplifier stages one of which constitutes an input stage and the other of which constitutes an output stage; said set of circuit elements including at least two self-supporting impedance elements each having at least one terminal wire interconnected to terminal portions of said mounting member so as to be held thereby in predetermined positions in the other of said space sections; said structural unit forming said mounting member, said tubes and said set of circuit elements constituting a self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface; said amplifier including at least one additional self-supporting circuit control element and at least one additional self-supporting impedance element having a terminal wire connected to said control element and constituting therewith an additional self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface.

5. In an electron tube amplifier member forming part of an inconspicuous wearable hearing aid and designed to be energized from a direct-current energy source for supplying amplified output of a microphone to a receiver: a flat casing small enough for substantially hidden wear on the body of a user and having two walls detachably joined along their edges so as to form a casing enclosure confining a relatively shallow interior space having narrow sides; one of said walls having an inwardly facing mounting surface, and reinforcing elements forming part of said wall and rendering it substantially rigid; a substantially firm mounting member extending along said mounting surface between opposite narrow sides of said enclosure and dividing the enclosure into two enclosure sections; a plurality of metallic terminal members insulating secured to and held in position by said mounting member so as to expose terminal portions of said terminal members to said interior space; interconnected elements of an amplifier housed in said casing including at least two multi-electrode amplifier tubes; each tube having a plurality of electrode leads extending from the tube and joined to exposed terminal portions of said mounting member so that said tubes are held thereby in predetermined positions in one enclosure section; a casing wall portion bordering the other enclosure section being acoustically pervious; a plurality of external connector elements insulatingly secured to a wall portion of said enclosure for completing the operative circuit interconnections from said amplifier to external hearing-aid circuit portions and having inwardly facing exposed terminal portions; a predetermined set of circuit elements of said amplifier being interconnected to the terminal members secured to said mounting member so as to constitute with said tubes an interconnected structural unit forming part of at least two amplifier stages one of which constitutes an input stage and the other of which constitutes an output stage; said set of circuit elements including at least two self-supporting impedance elements each having at least one terminal wire interconnected to terminal portions of said mounting member so as to be held thereby in predetermined positions in said other space section; said structural unit formed of said mounting member, said tubes and said set of circuit elements constituting a self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface; and a high-impedance microphone in said other enclosure section having a diaphragm exposed to the acoustically pervious wall portion and being connected to the input stage of said amplifier; said amplifier including a least one additional self-supporting circuit control element and at least one additional self-supporting impedance element having a terminal wire connected to said control element and constituting therewith an additional self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface.

6. In an electron tube amplifier member forming part of an inconspicuous wearable hearing aid and designed to be energized from a direct-current energy source for supplying amplified output of a microphone to a receiver: a flat casing small enough for substantially hidden wear on

the body of a user and having two walls detachably joined along their edges so as to form a casing enclosure confining a relatively shallow interior space having narrow sides; one of said walls having an inwardly facing mounting surface, and reinforcing elements forming part of said wall and rendering it substantially rigid; a substantially firm mounting member extending along said mounting surface between opposite narrow sides of said enclosure and dividing the enclosure into two enclosure sections; a plurality of metallic terminal members insulatingly secured to and held in position by said mounting member so as to expose terminal portions of said terminal members to said interior space; interconnected elements of an amplifier housed in said casing including at least two multi-electrode amplifier tubes; each tube having a plurality of electrode leads extending from the tube and joined to exposed terminal portions of said mounting member so that said tubes are held thereby in predetermined positions in one enclosure section; a plurality of external connector elements insulatingly secured to a wall portion of said enclosure for completing the operative circuit interconnections from said amplifier to external hearing-aid circuit portions and having inwardly facing exposed terminal portions; a predetermined set of circuit elements of said amplifier being interconnected to the terminal members secured to said mounting member so as to constitute with said tubes an interconnected structural unit forming part of at least two amplifier stages one of which constitutes an input stage and the other of which constitutes an output stage connected to said external connector elements; said set of circuit elements including at least two self-supporting impedance elements each having at least one terminal wire interconnected to terminal portions of said mounting member so as to be held thereby in predetermined positions in the other enclosure section; said structural unit formed of said mounting member, said tubes and said set of circuit elements constituting a self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface; a casing wall portion bordering the other enclosure section being acoustically pervious; the impedance elements of said one unitary structure extending within said other enclosure section in the space between said microphone and said mounting surface; said amplifier including at least one additional self-supporting circuit control element and at least one additional self-supporting impedance element having a terminal wire connected to said control element and constituting therewith an additional self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface.

7. In an electron tube amplifier member forming part of an inconspicuous wearable hearing aid and designed to be energized from a direct-current energy source for supplying amplified output of a microphone to a receiver: a flat casing small enough for substantially hidden wear on the body of a user and having two walls detachably joined along their edges so as to form a casing enclosure confining a relatively shallow interior space having narrow sides; one of said walls having an inwardly facing mounting surface, and reinforcing elements forming part of said wall and rendering it substantially rigid; a substantially firm mounting member extending along said mounting surface between opposite narrow sides of said enclosure and dividing the enclosure into two enclosure sections; a plurality of metallic terminal members insulatingly secured to and held in position by said mounting member so as to expose terminal portions of said terminal members to said interior space; interconnected elements of an amplifier housed in said casing including at least two multi-electrode amplifier tubes; each tube having a plurality of electrode leads extending from the tube and joined to exposed terminal portions of said mounting member so that said tubes are held thereby in predetermined positions in one of said enclosure sections; a plurality of external connector elements insulating secured to a wall portion of said enclosure for completing the operative circuit interconnections from said amplifier to external hearing-aid circuit portions and having inwardly facing exposed terminal portions; a predetermined set of circuit elements of said amplifier being interconnected to the terminal members secured to said mounting member so as to constitute with said tubes an interconnected structural unit forming part of at least two amplifier stages one of which constitutes an input stage and the other of which constitutes an output stage; said set of circuit elements including at least two self-supporting impedance elements each having at least one terminal wire interconnected to terminal portions of said mounting member so as to be held thereby in predetermined positions in the other of said space sections; said structural unit forming said mounting member, said tubes and said set of circuit elements constituting a self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface; said amplifier including at least one additional self-supporting circuit control element and at least one additional self-supporting impedance element having a terminal wire connected to said control element and constituting therewith an additional self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface; the casing wall having said inwardly facing mounting surface embodying at least two reinforcing elements of material stronger than the material of said wall; said two reinforcing elements having an opening for detachably clamping therein said two unitary structures in their operative positions on said mounting surface.

8. In an electron tube amplifier member forming part of an inconspicuous wearable hearing aid and designed to be energized from a direct-current energy source for supplying amplified output of a microphone to a receiver; a flat casing small enough for substantially hidden wear on the body of a user and having two walls detachably joined along their edges so as to form a casing enclosure confining a relatively shallow interior space having narrow sides; one of said walls having an inwardly facing mounting sur-

face, and reinforcing elements forming part of said wall and rendering it substantially rigid; a substantially firm mounting member extending along said mounting surface between opposite narrow sides of said enclosure and dividing the enclosure into two enclosure sections; a plurality of metallic terminal members insulatingly secured to and held in position by said mounting member so as to expose terminal portions of said terminal members to said interior space; interconnected elements of an amplifier housed in said casing including at least two multi-electrode amplifier tubes; each tube having a plurality of electrode leads extending from the tube and joined to exposed terminal portions of said mounting member so that said tubes are held thereby in predetermined positions in one enclosure section; a casing wall portion bordering the other enclosure section being acoustically pervious; a plurality of external connector elements insulatingly secured to a wall portion of said enclosure for completing the operative circuit interconnections from said amplifier to external hearing-aid circuit portions and having inwardly facing exposed terminal portions; a predetermined set of circuit elements of said amplifier being interconnected to the terminal members secured to said mounting member so as to constitute with said tubes an interconnected structural unit forming part of at least two amplifier stages one of which constitutes an input stage and the other of which constitutes an output stage; said set of circuit elements including at least two self-supporting impedance elements each having at least one terminal wire interconnected to terminal portions of said mounting member so as to be held thereby in predetermined positions in said other space section; said structural unit formed of said mounting member, said tubes and said set of circuit elements constituting a self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface; and a high-impedance microphone in said other enclosure section having a diaphragm exposed to the acoustically pervious wall portion and being connected to the input stage of said amplifier; said amplifier including at least one additional self-supporting circuit control element and at least one additional self-supporting impedance element having a terminal wire connected to said control element and constituting therewith an additional self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface; the casing wall having said inwardly facing mounting surface embodying at least two reinforcing elements of material stronger than the material of said wall; said two reinforcing elements having an opening for detachably clamping therein said two unitary structures in their operative positions on said mounting surface.

9. In an electron tube amplifier member forming part of an inconspicuous wearable hearing aid and designed to be energized from a direct-current energy source for supplying amplified output of a microphone to a receiver: a flat casing small enough for substantially hidden wear on the body of a user and having two walls detachably joined along their edges so as to form a casing enclosure confining a relatively shallow interior space having narrow sides; one of said walls having an inwardly facing mounting surface, and reinforcing elements forming part of said wall and rendering it substantially rigid; a substantially firm mounting member extending along said mounting surface between opposite narrow sides of said enclosure and dividing the enclosure into two enclosure sections; a plurality of metallic terminal members insulatingly secured to and held in position by said mounting member so as to expose terminal portions of said terminal members to said interior space; interconnected elements of an amplifier housed in said casing including at least two multi-electrode amplifier tubes; each tube having a plurality of electrode leads extending from the tube and joined to exposed terminal portions of said mounting member so that said tubes are held thereby in predetermined positions in one enclosure section; a plurality of external connector elements insulatingly secured to a wall portion of said enclosure for completing the operative circuit interconnections from said amplifier to external hearing-aid circuit portions and having inwardly facing exposed terminal portions; a predetermined set of circuit elements of said amplifier being interconnected to the terminal members secured to said mounting member so as to constitute with said tubes an interconnected structural unit forming part of at least two amplifier stages one of which constitutes an input stage and the other of which constitutes an output stage connected to said external connector elements; said set of circuit elements including at least two self-supporting impedance elements each having at least one terminal wire interconnected to terminal portions of said mounting member so as to be held thereby in predetermined positions in the other enclosure section; said structural unit formed of said mounting member, said tubes and said set of circuit elements constituting a self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface; a casing wall portion bordering the other enclosure section being acoustically pervious; the impedance elements of said one unitary structure extending within said other enclosure section in the space between said microphone and said mounting surface; said amplifier including at least one additional self-supporting circuit control element and at least one additional self-supporting impedance element having a terminal wire connected to said control element and constituting therewith an additional self-supporting unitary structure, the interconnecting circuit portions of which are sufficiently stiff and so arranged that the relationship of its elements is not disturbed when it is mounted on or removed from its position on said mounting surface; the casing wall having said inwardly facing mounting surface embodying at least two reinforcing elements of material stronger than the material of said wall; said two reinforcing elements having an opening for detachably clamping therein said two unitary structures in their operative positions on said mounting surface.

HARRY B. SHAPIRO.