

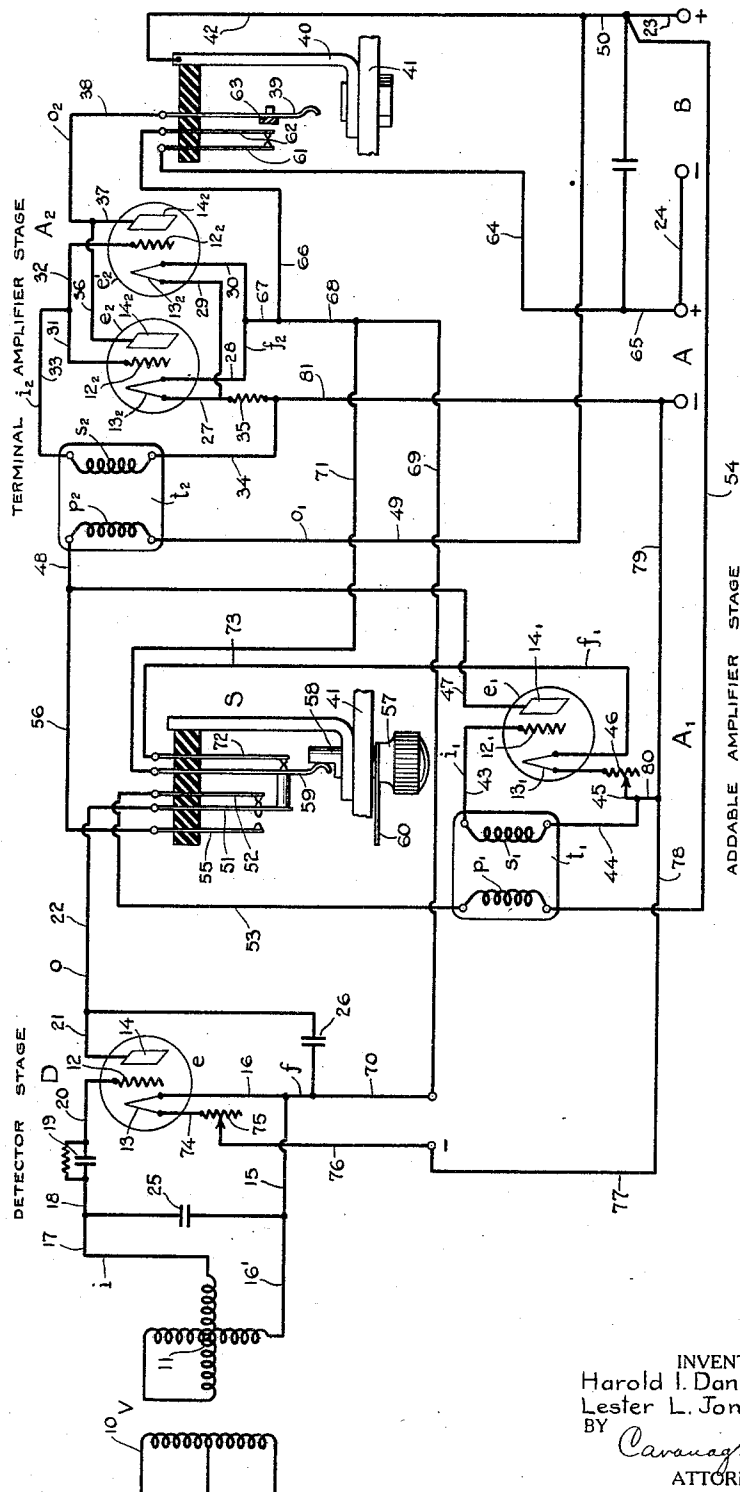
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ELECTRON DISCHARGE TUBE AMPLIFIER SYSTEM

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ELECTRON-DISCHARGE-TUBE AMPLIFIER SYSTEM

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This invention relates to an amplifier system, and more particularly to electron discharge tube amplifier circuits; and has special reference to the provision of an improved switching system for varying the number of steps or stages of amplification in cascade amplifier circuits.

In cascaded electron discharge tube amplifier systems of the type employed, for example, in radio receiving circuits, it is common practice where a stage of amplification is desired to be added for further amplifying the received signals to shift the receiving output circuit such as the phones from one electron discharge tube to the next succeeding tube, and to interpose a transformer between the tubes where transformer coupling is used. In this practice the added step or stage of amplification is added onto a prior stage, with the result that such prior stage is shifted from a terminal or ending position to an intermediate position. This shifting of the terminal stage of amplification presents a number of disadvantages, and it is highly desirable on the contrary to maintain the terminal or last amplifier stage in fixed relation to the receiving output or phone circuit during any and all changes in the number of stages of amplification used.

In a multi-stage audio frequency amplifier, for example, it is always desirable to secure maximum volume with the minimum number of stages of amplification, this because each stage of amplification introduces some distortion; and the maximum volume can be produced best without distortion by using a tube of large power or several tubes of smaller power in parallel, or several tubes in push-pull relation for the last or ending receiving output such as the telephone loud speaker circuit. Where a telephone loud speaker, however, is switched from one electron discharge tube to the next in accordance with this common practice, if the highest efficiency should be desired to be maintained, it would become necessary to provide the large power tube or tubes in push-pull relation for a plurality of stages of amplification, and this would be uneconomical, both as to first cost and maintenance. Where, on the other hand, the tubes in

successive amplification stages have not the same power characteristics, the shifting of the output or phone circuit renders the system inefficient. To provide a system which may be efficient and economical, it is desirable to maintain a fixed relation between the phone circuit and the high power tube stage, keeping such stage always as the ending or terminal stage of the set; and our present invention has for its prime object the provision of an improved switching system in which the last or terminal amplification stage is always maintained in fixed relation to the telephone loud speaker circuit, and in which the added stage is interposed or inserted in position in advance of the phone circuit or the terminal amplification stage.

In a switching system where the added stage is interposed in advance of the ending stage, it is highly important when a step of amplification is added to or removed from the system, to prevent the transferring, changing or switching of high potential input or grid leads, and it is highly advantageous and desirable that the switching be effected only by transferring or changing the output or plate leads. Of the more important advantages residing in the switching of output leads are the simplicity of the switching arrangement this makes possible and the fact that the reactive effects due to the wires leading to the switch gear are much less when these wires are output leads than when they are input leads. This latter consideration is of extreme importance in the application of the system to radio frequency amplifiers. The radio frequency amplification must be exactly balanced as to capacitive reactive effects, and in changing the number of stages by switching the input leads, this balance is disturbed, whereas it is disturbed to a much less degree when switching the output leads. A further consideration of importance in the radio frequency amplification is that the tuning of the radio frequency circuits is substantially unaffected by switching the output leads, whereas it is affected by switching the input leads; and the detuning effect in the radio frequency amplifier assumes very large proportions when the input circuit is an an-

tenna circuit, the switching of the antenna capacity from one input circuit to another input circuit resulting in large changes of tuning. A prime desideratum, therefore, of our present invention, comprehends the provision of a switching system for cascaded electron discharge tubes or devices in which the addible stage is interposed or inserted in position in advance of or prior to a fixed ending stage, and in which the circuit changes are all produced by transferring or shifting the output leads only.

To the accomplishment of the foregoing and such other objects as will hereinafter appear, our invention consists in the elements and their relation one to the other, as hereinafter particularly described and sought to be fined in the claims; reference being had to the accompanying drawing which shows the preferred embodiment of our invention, and in which:

The figure is a wiring diagrammatic view of the improved switching system of our invention, the same being shown applied as a multi-stage audio amplifier for radio receiving circuits.

Referring now more in detail to the drawings, we show the principles of our invention exemplified in a multi-stage audio amplifier system having the detector stage D which is preferably of the electron discharge tube type including the electron discharge device e , to which detector stage is connected a terminal amplifier stage A_2 comprising one or a plurality of electron discharge devices e_2, e'_2 and a transformer t_2 having a primary p_2 and a secondary s_2 for coupling the electron discharge device or tube to a preceding stage, and an addible amplifier stage A_1 which comprises the electron discharge device or tube e_1 and the coupling transformer t_1 having the primary p_1 and the secondary s_1 , the said addible amplifier stage A_1 being insertable or interposable in advance of or in position prior to the terminal amplifier stage A_2 .

Where the system consists in multi-stage audio amplifier circuits, as shown in the drawings, the detector stage D may be connected to any high frequency circuit, as for example to the output of a tuned radio frequency system such as is disclosed in the copending application of Lester L. Jones, Ser. No. 716,124, filed May 27th, 1924, the electron discharge device e of the detector stage being provided with an input circuit i and an output circuit o , the input circuit i being inductively coupled to a radio frequency amplifying stage by means of a variotransformer V having the primary 10 and a variable secondary 11. The input circuit i is connected across the grid 12 and filament 13 of the electron discharge device e , the said input circuit comprising a conductor 15 connected to a conductor 16 forming part of a filament circuit f , conductor 16', secondary

11 of variotransformer V, conductor 17, conductor 18, the integrating device 19, and conductor 20 connected to the grid 12. The output circuit o of the electron discharge device e comprises the conductor 21 connected to the anode or plate 14 of the electron discharge device, the conductor 22 which is selectively connectable to either of the amplifier stages A_1 or A_2 , and more specifically to the primary circuits p or p_2 thereof, by means which will be described more in detail hereinafter, the circuit being completed by the conductor 23 connected to the positive terminal of the battery B, the battery B, conductor 24 which connects the negative terminal of the battery B to the positive terminal of the battery A, the latter battery being the source for energizing the filament circuit f as is well known to those skilled in the art. Preferably both the input circuit i and the output circuit o are shunted by the condensers 25 and 26 respectively.

The ending or terminal amplifier stage A_2 includes, as heretofore stated, the electron discharge devices or tubes e_2 and e'_2 which are arranged in parallel, each being provided with filament 13₂, the grid 12₂, and the plate 14₂, the filaments being both heated to incandescence by means of a filament circuit f_2 , the filaments being connected in multiple to this circuit by means of the conductors 27—28 and 29—30, the grids being connected in multiple by means of the conductors 31 and 32 which are connected in the input circuit i_2 which includes the grids, conductors 31 and 32, conductor 33, secondary, s_2 , conductor 34, filament resistance 35, conductors 27 and 29, and the filament 13₂.

The plates or anodes 14₂ of both electron discharge devices e_2 and e'_2 are also connected in multiple by means of the conductors 36 and 37, and are arranged in the output circuit o_2 which includes the anodes or plates, the conductors 36—37, conductor 38, a receptacle for receiving a telephone connection or jack, which receptacle includes the contact 39 and base contact 40 attachable to the panel 41, the said output circuit being completed by the conductor 42 conductor 23, the battery B, and conductor 24 connected to the battery A and the filament 13₂. When the telephone jack is inserted in the receptacle 39—40, it will be seen that it is a characteristic of the terminal amplifier stage A_2 that the grids and anodes are permanently connected to the input and output circuits of the amplifier stage.

The addible amplifier stage A_1 which includes the electron discharge device e_1 and the transformer t_1 is provided with an input circuit i_1 which includes the grid 12₁, the conductor 43, the secondary s_1 of the transformer t_1 , the conductor 44, conductor 45, the filament rheostat 46, and filament 13₁, and is further provided with an output circuit o_1 which includes the plate 14₁, the conductor 47, con-

ductor 48, primary p_2 of the transformer t_2 , conductor 49, conductors 50 and 23, battery B, conductor 24, positive terminal of battery A, and the filament 13₁. It will be noted that in this addible amplifier stage whether or not the stage is in or out of circuit, the grid 12₁ is permanently connected in the input circuit i_1 and the plate 14₁ is permanently connected in the output circuit o_1 .

As heretofore stated, a prime desideratum of our present invention comprehends the provision of a switching system for cascaded amplifier circuits in which the addible stage is interposed or inserted in position in advance of or prior to an ending stage so as to maintain the ending or terminal stage in fixed relation to the final output or phone circuit, and in which the circuit changes are all produced by transferring or shifting the output leads only so as to inhibit any reactive effects that would be due to transferring or changing input leads. To accomplish the desired ends, the terminal and addible amplifier stages A_2 and A_1 are connected as hereinbefore described, and there is provided a switch mechanism generally designated as S which functions to permit the addible amplifier stage to be inserted or interposed between an initial circuit such as the output circuit o and a second output circuit such as the amplifier output o_1 , the addible amplifier stage being switched in and out of circuit by the breaking and making of circuit connections between the said amplifier output circuit and the said initial output circuit.

The switch mechanism S in the preferred construction comprises a common contact 51 connected to the conductor 22 of the initial output circuit o , a contact 52 connected by means of a conductor 53 to the primary p_1 of the transformer t_1 , the said primary being connected in turn by means of the conductors 54 and 23 to the positive terminal of the battery B, and a third contact 55 connected by means of the conductors 56 and 48 to the primary p_2 of the transformer t_2 . Preferably the contacts 51 and 52 are normally in conductive relation by the closing of the switch points thereof, as clearly shown in the drawings, and the contacts 51 and 55 are in open circuit relation so that when the switch button 57, which is mounted on a part of the panel 41, is in the position shown in the drawings, with the cam element 58 thereof in position to release the resilient contact device 59 connected to the contact 51, both amplifier stages A_1 and A_2 are arranged in series or cascade, and are connected to the detector stage D.

When, however, the button 57, which may be provided with the indicator 60, is given a partial rotation, the spring contact 59 is moved to open the contacts 51 and 52 and to connect the contacts 51 and 55 in circuit closing relation, this operation being effective

for removing the amplifier stage A_1 and for directly connecting the output of the detector D to the output circuit o_1 and more specifically to the primary p_2 of the terminal amplifier stage transformer.

With this described construction, it will be seen that the terminal amplifier stage A_2 is always maintained fixed relatively to the phone circuit, and that during the switching of the addible amplifier stage A_1 in and out of circuit, the input circuits i_1 and i_2 are maintained invariant, the initial circuit being switched between points in the primary transformer circuit of the terminal amplifier stage and the primary transformer circuit of the addible amplifier stage. Thus the grid leads of all stages may be left as short as possible owing to no connection of such leads to the switch gearing, minimizing capacitive feed back reactions due to the capacity between the grid and plate circuits of the tubes, capacitive feed back variations being more pronounced by changes in circuit connections in the grid or input circuits than in the plate or output circuits due to the step-up ratio in the transformers and the relatively high potentials in the grid circuits produced thereby. The permanent connection of the last two output circuits to their tubes and the switching of the high potential output leads also eliminates a considerable number of wires and telephone jacks, thereby lowering the cost of the switching system and making the same more flexible. Where the system is employed for radio frequency amplification, not only are capacitive feed back effects minimized and the balance of the radio frequency amplifier maintained, but the tuning of the radio frequency circuits is substantially unaffected by switch operations. While we have shown this switching system applied to a two-stage audio amplifier and applicable to a two-stage radio amplifier, it will be apparent that the system may be applied to one or multi-stage amplifier systems having any number of tubes with equal advantage.

In the preferred operation of the system, the filament circuits f , f_1 and f_2 of the detector and amplifier stage are all controlled by the telephone receptacle 39—40, and the filament circuit f_1 of the addible amplifier stage is additionally controlled by the operation of the switching gears. To accomplish this, we provide the normally open contacts 61 and 62 which are adapted to be closed by the engagement of the insulating button 63 with the contact 62 when the spring contact 39 is operated upon reception of a telephone jack, the contact 61 being connected to the positive terminal of the battery A by means of the conductors 64 and 65, and the contact 62 being connected to the positive side of all the filament circuits, the connection to the filament circuit f_2 being by means of the con-

ductors 66 and 67, the connection to the filament circuit f being by means of the conductors 66, 68, 69 and 70, and the connection to the filament circuit f_1 being by means of the conductors 66, 68 and 71, contact 59, a complementary contact 72, and conductor 73. The complementary contacts 59 and 72 are controlled by the cam device 58 of the switch button 57 which controls the switching in and out of circuit of the addible amplifier stage A_1 , so that the filament circuit f_1 of such stage may be controlled simultaneously with the control of the addible or intermediate amplifier stage. The negative side of each of the filaments is preferably permanently connected to the negative terminal of the battery A, the connection of the filament 13 being by means of the conductor 74, rheostat 75, and conductors 76, 77, 78 and 79; the connection of the filament 13₁ being by means of the rheostat 46, conductors 45, 80 and 79; and the connection of the filaments 13₂ being by means of the rheostat 35 common thereto and the conductor 81.

The manner of making and using the amplifier switching system of our invention and the many advantages incident thereto will in the main be fully apparent from the above detailed description of the structure and operation thereof. It will be further apparent that while we have shown our invention in the preferred form, many changes and modifications may be made in the structure disclosed without departing from the spirit of the invention, defined in the following claims.

We claim:

1. An electron discharge tube amplifier system comprising an initial circuit, an output circuit connectable to the initial circuit for receiving energy therefrom, a stage of amplification including an electron discharge device having a grid and anode and a transformer having primary and secondary circuits, the grid of the electron discharge device being permanently connected to the said secondary circuit and the anode of the electron discharge device being permanently connected to the output circuit, and mechanism for interposing said stage of amplification between the initial circuit and the output circuit comprising means for switching the said initial circuit from the said output circuit to the primary circuit of the transformer.

2. An electron discharge tube amplifier system comprising an initial circuit, a terminal stage of amplification connectable to the initial circuit and including an electron discharge device having a grid and anode and a transformer having primary and secondary circuits, and an addible stage of amplification also including an electron discharge device having a grid and anode and a transformer having primary and secondary circuits, the secondary circuit of each trans-

former being permanently connected to the grid of the electron discharge device associated therewith, the anode of the addible stage being permanently connected to the primary circuit of the terminal stage, and mechanism for adding or removing the addible stage of amplification comprising means for switching the said initial circuit between points in the primary transformer circuit of the terminal stage of amplification and the primary transformer circuit of the addible stage of amplification.

3. An electron discharge tube amplifier system comprising a terminal electron discharge amplifier having an input circuit and an output circuit, an intermediate electron discharge amplifier having an input circuit and an output circuit, an initial output circuit and mechanism for adding or removing the intermediate amplifier comprising means for changing the circuit connections between the output circuit of the intermediate amplifier and the initial output circuit without interrupting the output circuit of the intermediate amplifier.

4. An electron discharge tube amplifier system comprising a terminal electron discharge amplifier having permanently connected input and output circuits, an intermediate electron discharge amplifier also having permanently connected input and output circuits, the output circuit being coupled to the input circuit of the terminal amplifier, an initial output circuit and mechanism for adding or removing the intermediate amplifier comprising means for changing circuit connections between the output circuit of the intermediate amplifier and the initial output circuit.

5. An electron discharge tube amplifier system comprising an electron discharge amplifier having an input circuit and an output circuit, said amplifier output circuit having a transformer primary permanently connected to the anode of the amplifier, an initial output circuit coupled to the amplifier input circuit, and mechanism for switching the amplifier in and out of circuit comprising means for breaking and making circuit connections between the amplifier output circuit and the initial output circuit without interrupting the amplifier output circuit.

Signed at New York city, in the county of New York and State of New York, this 30th day of July, A. D. 1924.

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