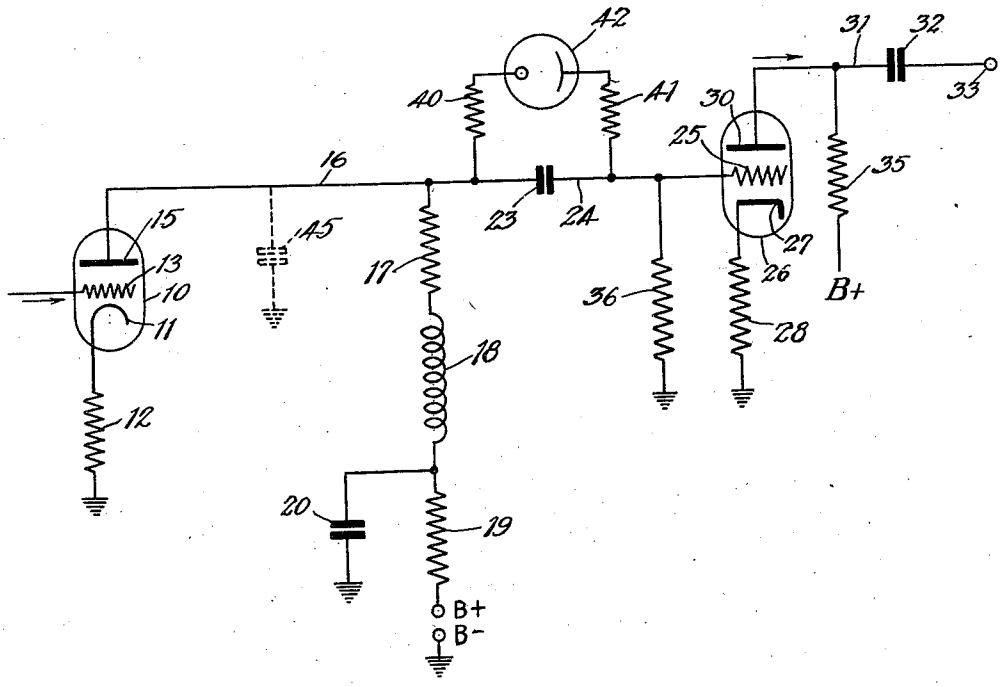
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ELECTRICAL AMPLIFIER

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ELECTRICAL AMPLIFIER

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This invention relates to electrical apparatus and particularly to an amplifier adapted to operate over a range of frequencies, the lower end of which may be extended down to zero frequency. The invention in particular provides a novel coupling between cascaded amplifier stages so that energy from one stage may be effectively and efficiently transferred to the succeeding stage. The invention provides means adapted to cooperate with a coupling capacitor for extending the frequency range thereof as above indicated.

Amplifiers for handling alternating currents over an extended frequency range are well-known. By virtue of the interposition of a coupling condenser, direct current energizing circuits necessary for the proper operation of vacuum tubes may be effectively isolated from each other. Thus the operation of multi-stage amplifier system from a single power supply is easily attained. Where direct current amplification is desired, however, the necessity for a direct coupling between the output circuit of one stage and the input circuit of the succeeding stage complicates the power supply problem and makes efficient and simple energization impossible.

The invention herein provides a simple means whereby both direct and alternating currents may be amplified without complicating the power supply problem.

Of particular importance is the utility of the invention in amplifiers normally operating over extended frequency ranges. Thus as frequency goes up, capacitance to ground of the various circuit elements becomes more and more significant. At frequencies of the order of two or more megacycles per second, this distributed capacitance is of critical importance and generally determines the upper cut-off frequency.

Since distributed capacitance is determined by physical size and disposition of those circuit elements at high radio frequency potentials, it follows that both number and size of circuit components in an amplifier must be maintained at a minimum value if satisfactory high frequency response is to be attained. This requirement conflicts with the requirements for extending the low frequency range of an amplifier. To extend the range of a video amplifier down to zero frequency without impairment of the high frequency response has hitherto been considered impossible with conventional circuits.

The invention herein provides means whereby an amplifier may operate efficiently from zero frequency to the highest frequencies normally handled by conventional video amplifiers. This

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objective is obtained in a simple, efficient and inexpensive manner.

In general, the invention provides a path in shunt to the coupling condenser, which path may efficiently handle zero frequency. The shunt path consists of a constant potential element maintained at substantially ground potential for high frequencies. Thus the inherent distributed capacitance of the entire amplifier system is substantially unchanged, so that no deterioration of high frequency characteristics results.

The shunt path preferably consists of a pair of resistors between which is connected a constant potential device, the three being in series across the coupling condenser. The constant potential device may be a glow discharge tube such as used in voltage regulating devices. The resistors connecting the constant potential device across the coupling condenser preferably have high impedances or resistances compared to the impedance of the coupling condenser for high frequencies. The resistors thus effectively isolate the coupling condenser from the constant potential device as far as high frequencies are concerned. Inasmuch as resistors may be made physically quite small, it follows that the distributed capacitance due to such resistors is negligible and has no substantial effect on the normal distributed capacitance of a well-designed video amplifier.

Referring now to the drawings, Figure 1 is a circuit diagram of a two stage amplifier showing the invention.

Referring to Figure 1, vacuum tube 10 may have cathode 11 connected to ground through suitable bias resistance 12. Vacuum tube 10 has control grid 13 connected to a suitable source of signal voltages to be amplified. Vacuum tube 10 may be of any type desired and, if the upper frequency range is high, it may be of any one of several well-known types particularly adapted for such work. The requirements for vacuum tube amplifiers for high frequency work are well-known and in general involve a low interelectrode capacitance and high transconductance.

While tube 10 is shown as having only three electrodes, it is understood that tubes employing additional electrodes may be used. Inasmuch as the connections for such additional electrodes are well known in the art, no description thereof is deemed necessary.

Anode 15 is connected by line 16 to load resistor 17 and thence to peaking inductance 18. The lower terminal of peaking inductance 18 may

be connected to decoupling resistor 19 and thence to a suitable source of B plus through a radio frequency choke or other means. As is well-known, the function of inductance 18 is to maintain the output voltage of the amplifier stage at the high end of the frequency range. Thus a peaking inductance for use in a video amplifier is illustrated on page 429 of Radio Engineer's Handbook (1943 edition) by Terman. In order to bypass high frequencies across decoupling resistance 19, condenser 20 may be provided.

Line 16 from anode 15 continues on to coupling condenser 23 the other side of which is connected to line 24 going to control grid 25 of succeeding vacuum tube 26. Vacuum tube 26 may have cathode 27 connected through bias resistor 28 to ground while anode 30 may be connected by line 31 through coupling condenser 32 to output terminal 33 for use either in a succeeding amplifier or other device. Anode 30 has load resistor 35 connected in conventional fashion. The input circuit to control grid 25 is completed by grid resistance 36 going from line 24 to ground. It is understood that the output circuit of vacuum tube 26 may be different from that shown and may, if necessary, be the same as the output circuit for vacuum tube 10. The entire circuit so far described is purely conventional and consists of two stages of amplification coupled through condenser 23. In practice, the various elements at high radio frequency potential will be of as small a physical size as possible consistent with proper power rating and will be designed so that distributed capacitance is reduced to a minimum.

In order to transfer direct current from one stage to the next cascaded stage, a shunt path around coupling condenser 23 is provided. This shunt path comprises a pair of resistances 40 and 41 between which is disposed glow discharge tube 42, the three being in series to form the shunt path. Tube 42 may be of any size desired both physically and electrically.

Glow discharge tube 42 has the property of maintaining a constant potential across its electrodes and may conveniently consist of any one of well-known regulator tubes on the market. Such tubes have the property of maintaining a constant drop through wide variation of current so long as the discharge retains its characistics of a glow. Resistance 40 and 41 should preferably have sufficient current carrying capacity so that a small current may be maintained through the tube. In practice, a gaseous discharge device under normal operating conditions may have a resistance of several thousand ohms and be quite small compared to the resistances 40 and 41 which may be as high as fifty thousand or one hundred thousand ohms. The difference in direct current potential across tube 42 will be due to the high anode potential from vacuum tube 10 and the comparatively low bias potential on control grid 25. Resistances 40 and 41 preferably have substantial values and may either be equal or not as desired. The sum of the ohmic impedances of elements 40, 41, and 42 must be small, however, compared to the ohmic impedance of grid leak 36. On the other hand the resistance of elements 40 and 41 must be large enough to isolate the distributed capacity of tube 42 to ground.

During operation, glow discharge tube 42 will serve as a coupling means not only for slow potential variations which may, for all practical purposes, be considered as direct current changes, but will also serve as a coupling means for low frequencies. As the impressed frequency goes higher, the impedance of coupling condenser 23 will decrease and energy will be transferred through this condenser to an increasing degree.

At extremely high frequencies, distributed capacitance of all the circuit elements at high radio frequency becomes of critical importance. This distributed capacitance is indicated in dotted lines as condenser 45 and is shown as going between line 16 and ground. It is evident that, at high frequencies, the equivalent circuit for the amplifier reduces to capacitance 45 and coupling condenser 23. In many instances, inductance 18 is so designed as to resonate with part or all of the distributed capacitance so that maximum voltage output is maintained. In general, however, when the energy bypassed by distributed capacitance 45 equals the energy transmitted through coupling condenser 23, then the frequency at which this occurs may be considered the upper cut-off frequency beyond which amplification falls off very rapidly.

While both sides of coupling condenser 23 are at high radio frequency potential, it is clear that the radio frequency potential along resistances 40 and 41 drops quite rapidly. Tube 42 may for all practical purposes be considered to be at ground radio frequency potential. Because resistances 40 and 41 both have high values compared to the reactance of condenser 23, there will be little radio frequency energy lost through resistances 40 and 41.

With a system such as shown, it is obvious that direct current potential changes may be transferred across coupling condenser 23 so that in effect direct current amplification is obtained. The response of the system to high frequency is unimpaired.

What is claimed is:

1. An amplifier system having a vacuum tube with input and output circuits, a second vacuum tube with input and output circuits, means for supplying the input circuit of said first tube with voltages to be amplified, a coupling condenser between the output circuit of said first tube and the input circuit of said second tube for transferring potential variations, said amplifying system being adapted to operate over an extended frequency range whose upper portion is sufficiently high so that distributed capacitance of the coupling condenser is a substantial factor, a shunt across said coupling condenser, said shunt comprising two resistors and an intervening constant potential device, said resistors having for low frequencies an impedance high compared to that of the device but low compared to the impedance of the coupling condenser.

2. An amplifier system for handling direct and alternating potentials comprising a pair of vacuum tubes, each tube having a cathode, grid and anode, an input circuit connected to each grid, an output circuit connected to each anode, a coupling condenser connecting the output circuit of one tube to the input circuit of the other tube, a shunt across said capacitor comprising two resistors and constant potential device connected therebetween, said coupling condenser having suitable capacitance to present a low impedance at the higher portion of the frequency range covered but a high impedance to the lower frequencies, said resistances having an impedance for the lowest frequencies handled high in comparison to the impedance of said constant potential device but low compared to the impedance of the coupling capacitor.

3. An amplifying system for handling an ex-

tended range of frequencies whose lower limit is zero frequency, said system including a vacuum tube having an input and output circuit, means for supplying signals to be amplified to said input circuit, means for impressing a high potential on said output circuit, a second vacuum tube having input and output circuits, a coupling condenser between the output circuit of said first tube and the input circuit of said second tube, means for impressing a bias potential on the input circuit of said second tube, said potential having a substantially different value than the potential in the first tube output circuit, a shunt across said coupling condenser, said shunt comprising a pair of resistances and intervening gaseous discharge device connected in series, said resistances having a value great in comparison to that of the gaseous discharge tube and having a value low in comparison to the impedance of the coupling condenser for low frequencies, said resistances having sufficient current carrying capacities so that a gaseous discharge in said device may be maintained by virtue of the difference in potential between the output circuit of said first tube and the input circuit of said second tube.

4. The system of claim 3 wherein the output circuit of said first tube has a peaking inductance therein for maintaining the output voltage at high frequencies.

5. A video amplifier system for handling potentials at radio frequencies down to direct potentials, said system comprising a first vacuum tube having an input circuit for receiving signals to be amplified and an output circuit, said output circuit including a load resistor, a second vacuum tube having an input circuit and an output circuit, a coupling condenser connecting the output circuit of said first tube with the input circuit of said second tube, and a shunt path connected across said coupling condenser, said shunt path including two resistances and an intervening constant potential device connected in series, said constant potential device having an impedance for zero and low frequencies which is low, said resistances having a value great in comparison to that of the constant potential device but small in comparison to the impedance of the coupling condenser for frequencies at the lower end of the range whereby potentials developed in the output of said first tube are fed to the input of said second tube predominantly by way of the shunt path for zero and low frequencies and predominantly by way of the coupling condenser for high frequencies.

6. The system of claim 5 wherein said constant potential device is a glow discharge tube.

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