Feb. 16, 1937. P. O. FARNHAM 2,070,971

AUDIO FREQUENCY TRANSMISSION CIRCUIT

Filed May 18, 1933

Fig. 1.

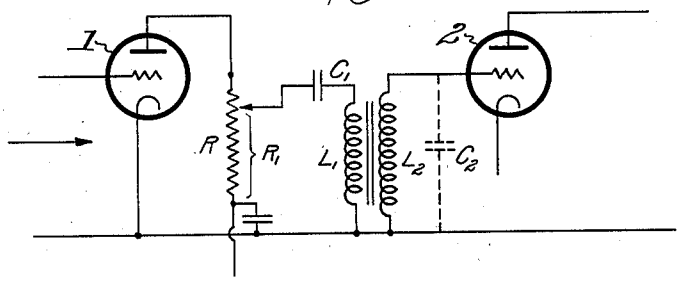
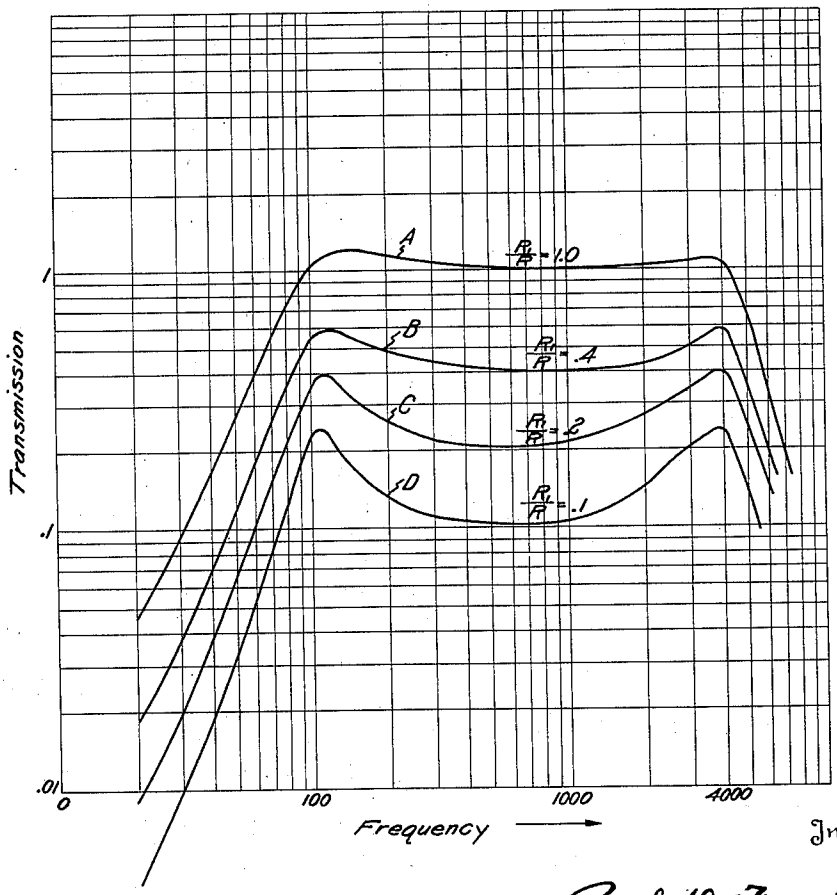


Fig. 2.



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AUDIO FREQUENCY TRANSMISSION CIRCUIT

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13 Claims. (Cl. 179—1)

This invention relates to audio frequency transmission circuits and more particularly to circuits including adjustable elements for controlling the transmission efficiency.

The recent trend in radio receiver design has been towards a higher quality of audio reproduction and this extension of the audio frequency band has resulted, when some of the known volume control systems are employed, in a variation of tone quality with changes in the audio level. An audio transmission system which has a substantially equal transmission efficiency over a wide frequency band, for all adjustments of the output level, has the apparent effect of suppressing the higher and lower frequencies at low output levels since the ear is not equally sensitive over the entire band when the output or room level of reproduction is reduced.

An object of the invention is to provide an audio frequency transmission system in which changes in output level are automatically accompanied by an adjustment of the frequency-transmission efficiency of the system. An object is to provide an audio frequency amplifier circuit including circuit elements adjustable to vary the output level by a frequency-selective control of the transmission efficiency. More particularly, an object of the invention is to provide an audio frequency transmission system of the type in which the primary of a transformer is coupled through a condenser to an adjustable tap on an input resistance, and in which the transformer circuit has resonance peaks at the ends of the audio frequency band which is to be reproduced.

These and other objects and advantages of the invention will be apparent from the following specification when taken with the accompanying drawing, in which:

Fig. 1 is a fragmentary circuit diagram of an audio frequency transmission system embodying the invention; and

Fig. 2 is a curve sheet showing the relation between frequency and transmission efficiency at different adjustments of the output level of the system.

In the drawing, the reference numeral 1 identifies a vacuum tube which may be an audio amplifier of a radio receiver or other transmission system, or the detector of a radio receiver. The plate circuit of tube 1 includes a voltage divider or resistance R having an adjustable tap for impressing any desired portion of the available output voltage across the primary winding L_1 of the transformer which couples the tube 1 to the following load circuit. A blocking condenser C_1 is included in the lead from winding L_1 to the tap on resistance R to permit the grounding of the other terminal of the winding. An amplifier tube 2 is illustrated as the audio load connected across the secondary winding L_2, but it will be apparent that the transformer may work into other types of load circuits. In any event, a capacity C_2 is effectively in shunt with the secondary and, as indicated by the dotted line illustration, the capacity may be provided solely by the distributed capacity of the secondary and the input capacity of the load circuit.

As the tap is adjusted towards the low potential terminal of resistance R, the reduction in the magnitude of the section R_1 of the resistance brings the capacities C_1, C_2 into play to alter the transmission characteristics of the circuit. By appropriate design of the transformer, this effect is not detrimental but results in a desirable regulation of fidelity with changes in output level. Since the ear has approximately the same sensitivity for all audio frequencies at high output levels but is less sensitive to the lower and higher frequencies at low levels, an effective tone compensation for changing output levels requires a uniform transmission for all frequencies at high levels and a greater reduction of the medium than of end frequencies when the output level is lowered.

The invention provides means for automatically effecting this tone compensation by the use of a transformer having such primary and leakage reactances that the transformer resonates with capacity C_1 at the lower end of the transmitted frequency band and with capacity C_1 in series with capacity C_2 at the higher end of the band. At high output levels, the resonance effects are negligible since resistance R_1 is included in the resonant circuits and, for high output levels, is of substantial magnitude. As the value of resistance R_1 is reduced to lower the output level, the resonance effects become increasingly important and thus prevent the transmission efficiency at the ends of the audio band from falling as rapidly as the transmission efficiency for frequencies at the central section of the band.

The invention presents the further advantage that a transformer of appropriate design requires a primary winding of relatively low impedance, and therefore permits a substantial voltage step-up in the transformer. The turns ratio of windings L_1, L_2 may be of the order of 1 to 6.

The following data is given as an example of

appropriate values which may be used to obtain resonance effects at about 100 to 4000 cycles.

L_1=about 60 henries, with an audio frequency resistance at 100 cycles of about 8000 ohms
L_2=about 960 henries
C_1=.07 microfarads
C_2=50 micromicrofarads
R=20,000 ohms
Total leakage inductance of the transformer, referred to the secondary side=30 henries.

The tone compensation which is obtainable with such a system is represented graphically in Fig. 2, in which curve A shows the relation between transmission and frequency when the tap is moved to the high potential terminal of resistance R. In obtaining the values for plotting curve A, voltages of different frequencies but of a constant magnitude were impressed across resistance R through a series resistance of 10,000 ohms equal to the output or plate resistance of tube 1, and the resulting output voltages across winding L_2 were measured, the output voltage for 1000 cycles being arbitrarily taken as unity of the scale of transmission values. For this maximum output level, there was an approximately equal transmission of all audio frequencies between 100 and 4000 cycles.

Curves B, C and D are similar curves representing the transmission-frequency characteristic of the network when the tap was adjusted to make R_1 equal to 0.4, 0.2 and 0.1, respectively, of R. It will be noted that a frequency selective adjustment of the transmission efficiency was obtained, and that the characteristic curve became more sharply peaked at the ends as the output level was lowered.

The degree to which the end frequencies are emphasized as the general output level is lowered may be varied by appropriate changes in the relative values of the transformer inductances and the capacities or by the size of resistance R relative to the plate resistance of tube 1. Although the series of curves show that the fidelity of transmission varies with the output level, the variation is in such sense as to compensate for the frequency selective response of the human ear, and the net result is that approximately the same fidelity of reproduction is maintained for all output levels.

It will be apparent that the invention is not limited to the particular values of circuit elements or to the particular frequency range recited in the above example.

I claim:

1. An audio frequency transmission system including an input resistance across which an audio frequency voltage may be impressed, an adjustable tap on said resistance, an audio frequency load circuit connected between said tap and one terminal of said resistance, and means serially connected between said tap and said load circuit and including the portion of the resistance between the adjustable tap and said terminal for reducing the efficiency of transmission of low frequencies at a less rapid rate than that of the reduction in the efficiency of transmission of higher frequencies when said tap is adjusted to lower the transmission efficiency.

2. An audio frequency transmission system including an input resistance across which an audio frequency voltage may be impressed, an adjustable tap on said resistance, an audio frequency load circuit connected between said tap and one terminal of said resistance, and means serially connected between said tap and said load circuit and including the portion of the resistance between the adjustable tap and said terminal for reducing the efficiency of transmission of high frequencies at a less rapid rate than that of the reduction in the efficiency of transmission of lower frequencies when said tap is adjusted to lower the transmission efficiency.

3. An audio frequency transmission system including an input resistance across which an audio frequency voltage may be impressed, an adjustable tap on said resistance, an audio frequency load circuit connected between said tap and one terminal of said resistance, and means serially connected between said tap and said load circuit and including the portion of said resistance between the tap and the terminal for reducing the efficiency of transmission of frequencies at the respective ends of the transmitted audio frequency band at a less rapid rate than that of the reduction in efficiency of transmission of frequencies at the central part of the band when the tap is adjusted to lower the transmission efficiency.

4. An audio frequency transmission system comprising an input resistance having a tap adjustable along the same, a coupling transformer, means connecting the low potential terminal of the transformer winding to the low potential terminal of said resistance to maintain the same at the same audio frequency potential, a capacity connected between the other terminal of said primary and the adjustable tap, and an audio frequency load circuit connected across the secondary of said transformer, the transformer resonating with said capacity at a frequency at the lower end of the band of frequencies to be transmitted, the portion of said resistance connected across the transformer winding acting to control the resistance effects of the transformer and capacity said resistance effects becoming increasingly greater as the value of said portion of the resistance is decreased.

5. An audio frequency transmission system as claimed in claim 4, in combination with capacitive means resonating with said transformer at a frequency at the upper end of the band of frequencies to be transmitted.

6. A transmission system adapted to pass a band of audio frequencies, said system including an input resistance across which audio frequency voltages may be impressed, an adjustable tap on said resistance, a coupling network comprising reactive elements and resonant at two frequencies between which said band is included, and a load circuit, said coupling network having output terminals across which said load circuit is connected and having input terminals connected, respectively, to said tap and to one end of said input resistance, and said reactive elements being effectively in series with the portion of the said resistance included between said tap and that end of said input resistance to which an input terminal is connected, whereby the adjustment of said tap to transfer less audio voltage to said coupling network reduces the resistance in series with said reactive elements to effect a lesser change in the transmission of frequency in the middle of said band than in the transmission of frequencies at the ends thereof.

7. In an audio frequency transmission system, the combination with a voltage divider comprising a resistance across which an audio frequency voltage may be impressed, and a tap adjustable

along said resistance to cooperate with one terminal thereof as the output terminals of said voltage divider, of an audio frequency load circuit, and a reactive network serially connected between said output terminals and said load circuit means including the portion of the resistance between the tap and said output terminal for acting upon the reactive network for reducing the efficiency of transmission of low frequencies at a less rapid rate than that of the reduction in the efficiency of transmission of higher frequencies when said tap is adjusted to transmit a lesser fraction of the total available audio frequency voltage to said load circuit.

8. In an audio frequency transmission system, the combination with a voltage divider comprising a resistance across which an audio frequency voltage may be impressed, and a tap adjustable along said resistance to cooperate with one terminal thereof as the output terminals of said voltage divider, of an audio frequency load circuit, and a reactive network serially connected between said output terminals and said load circuit means including the portion of the resistance between the tap and said output terminal for acting upon the reactive network for reducing the efficiency of transmission of high frequencies at a less rapid rate than that of the reduction in the efficiency of transmission of lower frequencies when said tap is adjusted to transmit a lesser fraction of the total available audio frequency voltage to said load circuit.

9. In an audio frequency transmission system, the combination with a voltage divider comprising a resistance across which an audio frequency voltage may be impressed, and a tap adjustable along said resistance to cooperate with one terminal thereof as the output terminals of said voltage divider, of an audio frequency load circuit, and a reactive network serially connected between said output terminals and said load circuit, means including the resistance element for affecting the reactive network for reducing the efficiency of transmission of frequencies at the respective ends of the transmitted audio frequency band at a less rapid rate than that of the reduction in efficiency of transmission of frequencies at the central part of the band when said tap is adjusted to transmit a lesser fraction of the total available audio frequency voltage to said load circuit.

10. An audio frequency transmission system including an input impedance device across which an audio frequency voltage may be impressed, an adjustable tap on said impedance device, an audio frequency load circuit connected between the tap and one terminal of the impedance device and means comprising a circuit having resonance effects at low audio frequencies connected between the tap and the load circuit for reducing the efficiency of transmission of the low audio frequencies at a less rapid rate than that of the reduction in the efficiency of transmission of higher frequencies when the tap is adjusted to lower the transmission efficiency, the degree of the resonance effects being controlled in accordance with the resistance value of the impedance between the tap and the terminal of the impedance.

11. An audio frequency transmission system including an input resistance across which an audio frequency voltage may be impressed, an adjustable tap on the resistance, an audio frequency load circuit connected between the tap and one terminal of the resistance whereby substantially any part of the voltage drop across said resistance may be impressed upon the load circuit in accordance with the position of the tap on the resistance and means connected between the tap and the load circuit and including said resistance for reducing the efficiency of transmission of low frequencies at a less rapid rate than that of the reduction in the efficiency of transmission of higher frequencies when the tap is adjusted to reduce the amount of energy transferred to the load circuit the amount of resistance between the tap point and said terminal acting to determine the differences in the rates of reduction.

12. An audio frequency transmission system including an input resistance across which an audio frequency voltage may be impressed, an adjustable tap on the resistance, an audio frequency load circuit connected between the tap and one terminal of the resistance whereby substantially any part of the voltage drop across said resistance may be impressed upon the load circuit in accordance with the position of the tap on the resistance and means connected between the tap and the load circuit and including said resistance for reducing the efficiency of transmission of frequencies at the respective ends of the transmitted audio frequency band at a less rapid rate than that of the reduction in the efficiency of transmission of frequencies at the central part of the band when the tap is adjusted to reduce the amount of energy transferred to the load circuit the amount of resistance between the tap point and said terminal acting to determine the differences in the rates of reduction.

13. An audio frequency transmission system including an input resistance across which an audio frequency voltage may be impressed, an adjustable tap on the resistance, an audio frequency load circuit connected between the tap and one terminal of the resistance whereby substantially any portion of the voltage drop across the resistance may be impressed upon the load circuit in accordance with the portion of the tap on the resistance, a coupling network between the resistance end and load circuit comprising reactive elements, said coupling network being resonant at two frequencies between which the band of audio frequencies is included, said reactive elements being effectively in series with the portion of the said resistance included between the tap and said terminal of the resistance, the resistance value of said last named portion of the resistance acting to determine the effect of the coupling network upon the band of frequencies transmitted in such a way that the adjustment of said tap to transfer less audio voltage to the coupling network effects a different change in the transmission of frequencies in the middle of the band of frequencies and in the transmission of frequencies at the ends of said band of frequencies.

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