

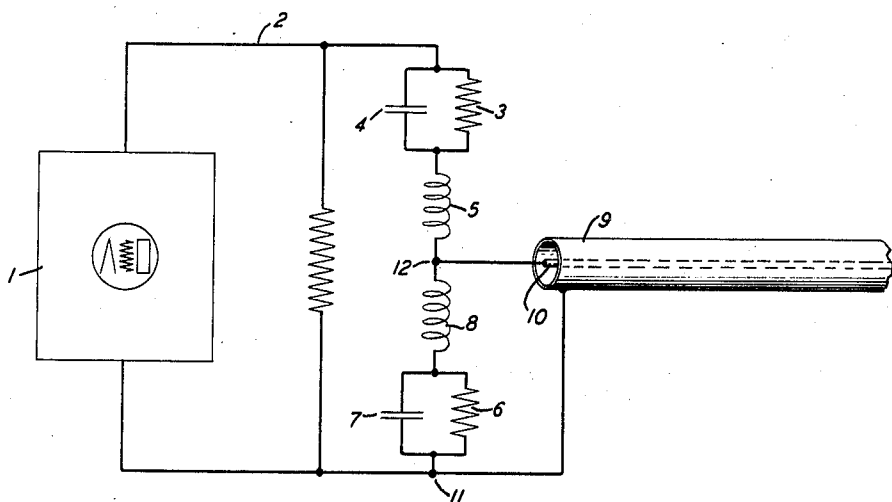
Dec. 3, 1940.

P. MERTZ

2,223,736

TRANSMISSION CIRCUIT

Filed March 24, 1938



INVENTOR
P. MERTZ
BY *J. P. Neville*

ATTORNEY

UNITED STATES PATENT OFFICE

2,223,736

TRANSMISSION CIRCUIT

Pierre Mertz, Bellerose, N. Y., assignor to Bell
Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application March 24, 1938, Serial No. 197,772

4 Claims. (Cl. 178-44)

The present invention relates to transmission circuits and more particularly to means for coupling circuits having different characteristic impedances.

5 In general, a signal supply circuit may be coupled to a line or receiving circuit of radically different impedance value in two ways, first, by the use of a resistance pad, and second, by the use of a transformer.

10 While the resistance pad is effective for a signal band including current variations of zero frequency and extending to an upper limiting frequency of a million or more cycles per second, if the elements are properly constructed, it introduces a transmission loss which is large, for example, of the order of 30 decibels when match-
15 ing an output or supply circuit of several thousand ohms with a line or receiving circuit having an impedance of the order of 100 ohms or when matching a 100-ohm supply circuit with a receiving circuit having an impedance of several thousand ohms. On the other hand, a transformer introduces very little transmission loss in the frequency range over which it is effective. How-
20 ever, no transformers have so far been designed which can effectively transfer a signal including current variations extending over the extremely wide frequency range mentioned above.

25 It has heretofore been proposed to provide a coupling for two lines, the ratio of the impedances of which varies with frequency, by means of a unit which is adapted to provide an impedance transformation having a variable ratio over a wide band of frequencies. The purpose of the
30 unit is to substantially eliminate all reflections throughout the band, and the coupling is effected in such manner that the circuit acts at low frequencies as if the line were directly connected without any shunting devices.

35 Nyquist Patent 1,959,494, issued May 22, 1934, discloses means for coupling input and output circuits, comprising a network including a plurality of transformers which supplement each other, each serving for a part of the current in a wide frequency range, the network operating as
40 a whole to transform, with uniform attenuation, signal current variations extending over a wider range of frequency than would be possible for any one of the component transformers.

45 When terminal apparatus is coupled to a line, the characteristic impedance of which varies rather widely throughout the frequency band to be transferred, the question arises whether the terminating impedance viewed by the line should
50 be its own characteristic impedance or whether

it should be a pure resistance. It is found that in general the latter is advantageous, if the resistance is made equal to the asymptotic characteristic impedance of the line, i. e., the resistance approached by the characteristic impedance of the line for the higher frequencies. The advantages are, first, the greater simplicity of the termination, and secondly, the fact that the impedance mismatch in this case produces a measure of equalization in both the attenuation and delay, particularly the latter, of the over-all connection.

This invention is directed to a coupling unit of the type disclosed in the Nyquist patent, but which operates to effect the transfer, from one circuit to another, of a signal comprising a band of current variations which may extend down to approximately a zero frequency component or may include direct current.

5 An object of the present invention is to provide for transforming currents of wide frequency range, extending down to and including direct current, from one voltage to another with an attenuation which, though not uniform, permits actual transfer of useful signal throughout the whole range, and with a constant ratio of transformation, so that a pure resistance of suitable value on the high impedance side is transformed into a pure resistance of lower value on the low impedance side.

A feature of the invention relates to a unit, which has a substantially constant impedance transformation ratio for current variations extending over a wide frequency range including direct current, for coupling two circuits having
35 respectively different impedance characteristics.

By way of example, the invention will be hereinafter described as applied to a system in which the terminal amplifier of a television equipment, adapted to produce a television signal having
40 current variations extending from one or more million cycles down to substantially, and even including, zero frequency, is coupled to a coaxial conductor by a network, which comprises an autotransformer having its two windings and two resistances, each shunted by a by-pass condenser, connected in series with each other, and with the series circuit connected to the output terminals of the amplifier, and the input terminals of the coaxial conductor connected to the network at
45 points such that one winding of the transformer and one of the resistances, with its associated by-pass condenser, are connected in series with each other across the conductor terminals.

A detail description of the invention follows

and is illustrated in the attached drawing, in which the single figure shows a coupling circuit embodying the invention.

Referring to the drawing, an image current, 5 having an upper limiting frequency of a million or more cycles and direct current as a low limiting frequency, after being amplified by a thermionic discharge device 1, or other suitable amplifier, is supplied to a series circuit 2 comprising 10 a resistance 3 shunted by a condenser 4, an inductance 5, a resistance 6 shunted by a condenser 7, and an inductance 8, which is mutually coupled to the inductance 5 to constitute an autotransformer.

15 A coaxial conductor, comprising an outer tubular conductor 9 enclosing a conductive wire 10, is connected at points 11 and 12, respectively, i. e., across the portion of the series circuit 2, which includes the resistance-condenser combination 6—7 and the inductance 8.

By selecting the values of the resistances 3 and 6, the capacities of the condensers 4 and 7, respectively in shunt thereto, and providing an autotransformer of the proper design, a coupling 25 network is provided which terminates the cable in approximately a pure resistance at all frequencies within the signal band, the value of such resistance being substantially equal to the asymptotic characteristic impedance of the line, i. e., the resistance approached by the characteristic impedance of the line at the high frequency end of the signal band to be transmitted.

The values of the condensers 4 and 7 should be so chosen that they provide low impedance 35 paths in shunt to the resistances 3 and 6, respectively, for current variations in the upper portion of the frequency range of the signal band, whereby these high frequency variations are bypassed about these resistances and are applied 40 to the autotransformer, which operates to transfer them from the amplifier to the line.

Since the condensers are ineffective as coupling units and the transformers are ineffective at zero and low frequencies, current variations 45 in the lower portion of the frequency range of the signal band are transferred by means of the resistance pad comprising the resistances 3 and 6. This resistance unit causes more loss than the transformer and, in fact, serves to introduce a 50 transmission loss which is high at the low frequency end of the range. However, this occurs in a portion of the frequency range where such loss is of relatively minor importance and may even be beneficial in that the resistance unit acts 55 in part as an equalizer to compensate for the low attenuation of the cable.

A network of the type described above may be designed so that the autotransformer operates alone to transfer current variations having frequencies lying in a range extending from a relatively low frequency to a million, or even several million, cycles per second, from an output or supply circuit having a substantially constant impedance of several thousand ohms, to a coaxial conductor circuit having an impedance of the order of 100 ohms, while for current variations lying in a frequency range extending from approximately the lower limiting frequency transferred by the transformer, down to and including zero frequency, or direct current, the resistance unit alone serves to effect the transfer. In a limited frequency range, intermediate that transferred by the transformer and that transmitted by the resistance, both of these coupling 75 units will cooperate to effect energy transfer.

As described above, the network comprises a transducer having the complete series circuit included between its input terminals and a portion only of the series circuit connected to its output terminals. However, the invention contemplates 5 the use of the transducer in the reverse manner, i. e., it may be used to couple a low impedance input or supply circuit to a high impedance output or receiving circuit. In this case, the supply circuit is connected to the intermediate terminals, 10 i. e., those having the resistance-condenser combination 6—7 in series with the winding 8 connected between them, while the receiving circuit is connected to the outer terminals, i. e., those having the complete series circuit connected between them. 15

According to this invention, a unit which may be used to couple an input, or signal supply circuit, having an impedance of the order of 10,000 ohms to a receiving circuit having an impedance 20 of the order of 100 ohms, or in the reverse manner, may, for example, comprise a resistance 3 of 10,000 ohms shunted by a condenser 4 of 655 mmf., a winding 5 and a winding 8, the combined self-inductance of these two windings being of 25 the order of 50 millihenries and that of winding 8 being approximately .5 of a millihenry, a resistance 6 of 100 ohms shunted by a condenser 7 of .0655 of a microfarad, and mutual inductance of 5 millihenries between the windings 5 and 8. 30

Such a network will operate to transmit a current band including zero frequency and extending to an upper limiting frequency of one or more million cycles per second, the exact value of the upper limiting frequency will depend largely upon 35 the construction of the autotransformer and may be extended to several million cycles.

The transition from resistive to inductive coupling occurs at approximately 16 kilocycles, i. e., at this frequency both couplings operate to effect the transfer of approximately equal amounts 40 of the signal energy from one circuit to the other.

For a limited region in the neighborhood of 16 kilocycles, signal energy is transferred in varying amount by the respective couplings, depending upon whether the energy to be transferred 45 lies between 16 kilocycles and the lower limiting frequency of this region or in the range above 16 kilocycles, and, outside this region, energy transfer is effected solely by one coupling or the other. 50

While the invention has been described herein as applied to television transmission, and specific details have been given for a particular case, it is to be understood that the coupling unit herein disclosed may be used in other types of signal 55 systems, in which signals, extending over a wide frequency band that includes direct current, are to be transferred with constant transformation ratio between circuits having radically different impedance values in the frequency range of the 60 signals to be transmitted.

What is claimed is:

1. A transducer having input and output terminals for coupling a source of signals having a wide frequency range including a zero frequency or an approximately zero frequency component to a load to obtain a low loss at high frequencies and to maintain a constant resistance termination to the load, comprising a first resistor and a second resistor, a first condenser 70 connected in shunt with the first resistor, a second condenser connected in shunt with said second resistor, and a transformer having a first winding and a second winding, one terminal of said first resistor and one terminal of said sec- 75

ond resistor being connected by a single current path comprising said second winding, said first winding and said first resistor being connected in series with each other between one set of terminals, and said second winding and said first and second resistors being connected in series with each other across the other set of terminals.

2. A transducer having input and output terminals for coupling a source of signals having a wide frequency range including zero frequency or an approximately zero frequency component to a load to obtain a low loss at high frequencies and to maintain a constant resistance termination to the load, comprising a first resistor and a second resistor, a first condenser connected in shunt with the first resistor, a second condenser connected in shunt with said second resistor, a transformer having a first winding and a second winding, one terminal of said first resistor and one terminal of said second resistor being connected by a single current path comprising said second winding, said first winding and said first resistor being connected in series with each other between one set of terminals, and said second winding and said first and second resistors being connected in series with each other across the other set of terminals, and a third resistor connected across said other set of terminals.

3. A transducer having input and output terminals for coupling a source of signals having a wide frequency range including zero frequency or an approximately zero frequency component to a load to obtain a low loss at high frequencies and to maintain a constant resistance termination to the load, comprising a first resistor and a second resistor, a first condenser connected in shunt with the first resistor, a second condenser connected in shunt with said second resistor, a transformer having a first winding and a second winding, one terminal of said first resistor and one terminal of said second resistor being connected by a single current path comprising said first and second windings in series,

said first winding and said first resistor being connected in series with each other between one set of terminals, and said first and second windings and said first and second resistors being connected in series with each other across the other set of terminals, and a third resistor connected across said other set of terminals, the resistance of said first resistor being less than that of said second resistor, the self-inductance of said first winding being less than that of said second winding and the capacitance of said first condenser being greater than that of said second condenser.

4. A coupling arrangement for connecting a source of high and substantially constant impedance over a range of frequencies extending upward from substantially zero to a load having a characteristic impedance which varies widely for frequencies within said range, which comprises a series circuit including in series said source and an element made up of a resistance and a capacity in parallel with each other and a second element consisting of a transformer coil carrying all of the current of said series circuit at the lower frequencies of said range and a third element in said series circuit made up of a resistance and a capacity in parallel with each other, said transformer being between said two parallel arrangements, and a load having its terminals connected respectively to a mid-tap of said coil and to a terminal of one of said parallel arrangements remote from the terminal thereof connected to said transformer, whereby said condensers are ineffective as coupling elements and said transformer is effective as a coupling element at high frequencies but is ineffective as a coupling element at zero and low frequencies and current variations for zero and low frequencies are transferred by means of said resistances which introduce relatively high transmission loss at the lower end of said frequency range.

PIERRE MERTZ.