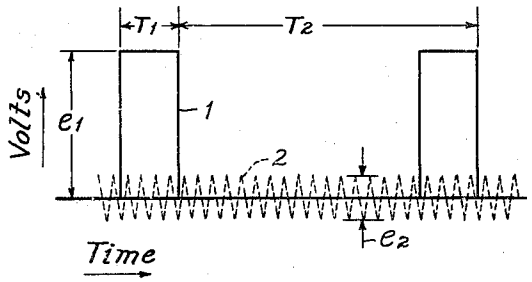
Nov. 15, 1949 R. LEE 2,488,417

PULSE AMPLIFIER

Filed Aug. 26, 1943

Fig. 1.



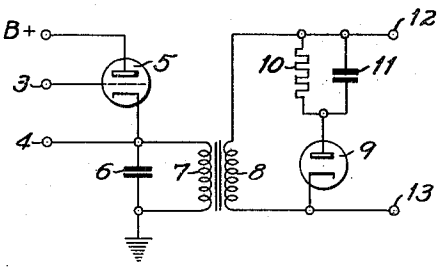


Fig. 2.

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PULSE AMPLIFIER

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1 Claim. (Cl. 179—171)

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My invention relates to amplifiers and, in particular, relates to arrangements for amplifying voltages pulses which are substantially rectangular in wave form.

In earlier radio practice, amplifiers were required to handle periodic waves which were either substantially sinusoidal in wave form or which differed therefrom largely through the imposition of periodic modulations of frequency considerably lower than that of sinusoidal carrier wave. A notable trend of the radio art, particularly in practical use of microwaves and ultra-high-frequency current, has been the employment of waves in the form of rectangular pulses, that is to say, wave forms having nearly vertical leading and following edges connected at the top by a substantially flat crest of nearly constant amplitude. The properties of transformers are such that they are able at the secondary terminals to reproduce quite accurately the wave form of a sinusoidal wave impressed on their primary windings; but it is a different problem to make an arrangement which will cause the accurate reproduction of a rectangular wave at the secondary terminals when a rectangular wave is impressed on the primary terminals of the transformer. Nevertheless, for many purposes such an accurate reproduction of a rectangular wave is extremely important.

One object of my invention is accordingly to provide a circuit arrangement capable of causing a transformer having a rectangular wave impressed upon its primary terminals to reproduce this rectangular wave form to scale at its secondary terminals.

Another object of my invention is to provide a circuit arrangement in which a rectangular wave pulse accompanied by static or other noise voltage impressed upon the primary of a transformer will be reproduced with substantial accuracy of wave form on the secondary terminals of this transformer without the noise or static being exaggerated or amplified to an undesirable degree.

Another object of my invention is to provide a transformer and circuit therefor which will amplify substantially without change of wave form between its primary and secondary terminals high-frequency waves which depart very substantially from a sinusoidal form.

Other objects of my invention will become apparent upon reading the following description taken in connection with the drawings, in which:

Figure 1 is a graph illustrating the wave form of the voltage to be amplified, and

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Fig. 2 is a schematic diagram of a circuit embodying the principles of my invention.

Referring, in particular, to Fig. 1, rectangular wave pulses having substantially vertical sides and flat tops and approximating to sharp right angles at the junction of their sides with their crests and troughs have been shown in recent work to have great utility in the ultra-high-frequency radio art. The heavy line curve 1 in Fig. 1 illustrates a wave form of the type under discussion. However, in many practical radio systems, there is usually present in addition to the waves purposely generated and useful in the circuit an undesired but unavoidable voltage of smaller amplitude and frequency of varying frequency, due to static, tube noises, and the like. The dotted line 2 in Fig. 1 indicates such an undesired voltage. In Fig. 1, the length of the voltage pulse is indicated by the quantity T_1, while the periodic time between successive waves is indicated by the quantity T_2. The amplitude of the rectangular wave is marked e_1, while the amplitude of the undesired noise is marked e_2.

The problem of which I have discovered a solution is the arrangement of a transformer which shall reproduce at its secondary terminals substantially without distortion such a wave form as is shown in Fig. 1 when the latter is impressed upon its primary terminals.

Referring in detail to Fig. 2, a wave form of the character shown in Fig. 1 is impressed across a pair of input terminals 3—4 which are connected, respectively, to the control electrode and to the cathode of an amplifier 5 which may be of any type known to those skilled in the art as suitable for such service. The plate electrode of the tube 5 is connected through a suitable channel to the positive terminal of a direct-current source of which the negative terminal is grounded. Between the cathode of the tube 5 and the ground is connected a capacitor 6 across which is shunted the primary winding 7 of a transformer having a transformation ratio approximately equal to the amplification of magnitude desired for the wave form of Fig. 1. The primary windings 7 is associated with a secondary winding 8 to which it is coupled with as small an amount of leakage reactance as is feasible. For many purposes, it will be found possible to attain this close coupling between the windings 7 and 8 by placing them upon a core containing powdered iron, or very thinly laminated iron. The winding 8 has one terminal connected to the one terminal of the diode or other rectifier

9, the other terminal of this rectifier being connected to the other terminal of the winding 8 through a resistor 10 shunted by a capacitor 11. The polarity of this rectifier is such as to prevent flow of current of opposite magnetic effect to the direct current which flows from tube 5 through winding 7. The terminals of the winding 8 are likewise connected to the output circuit in which it is desired to produce the amplified replica of the wave in Fig. 1 at terminals 12, 13.

I have found that where a secondary winding such as 8 is connected directly to a pair of output terminals like 12, 13 without the addition of any such elements as 9, 10, 11, the impression of a wave of the form shown in Fig. 1 on the input terminals 3, 4 will result in the production at the terminals 12, 13 of a wave form of substantially different type. I have found the presence of the rectifier 9 to be highly effective in eliminating this distortion of the wave form however.

While I have shown the rectifier 9 and its associated elements 10 and 11 as connected to the secondary winding 8, they may be connected in shunt with the primary winding 7.

I have found particularly that where undesired noise voltage such as shown in curve 2 of Fig. 1 is present on the terminals 3, 4, it may be reproduced across the terminals 12, 13 in substantially higher ratio to the amplitude of the rectangular wave unless the resistor 10 and capacitor 11 are connected in series with the rectifier 9 in Fig. 2. In order to limit the amplitude of the noise voltage at the output terminals 12, 13 to a value not greater than the same order as it has at the input terminals 3, 4, the resistor 10, capacitor 11, and recitfier 9 should be selected so that their electrical constants accord with the following formulas:

$$R_2=\frac{e_2R_1}{e_1-e_2}\cdot\frac{T_2}{T_1}$$

$$C=\frac{T_2}{R_2}$$

where

T_1=pulse width (seconds)
e_1=pulse voltage amplitude
e_2=noise voltage amplitude
T_2=time interval between pulses (sec.)
R_1=ohms in rectifier 9
R_2=ohms in resistor 10
C=capacitor 11 in farads.

It will often be found satisfactory that the capacitor 11 be at least as great as the value indicated above, as a surplus above that value will do no harm.

While I have shown a particular embodiment of the principles of my invention in compliance with the patent statutes, those principles are typical of broader applications which will be evident to those skilled in the art.

I claim as my invention:

An amplifier comprising a tube having a control electrode circuit and having an output circuit connected between its anode and its cathode including an impedance connected in the cathode lead of said tube, a transformer primary winding connected in shunt to said impedance, a secondary winding for said transformer having its terminals connected to an output circuit, and a rectifier connected in series with a resistor which is shunted by a capacitor shunting the terminals of one of said windings, said primary and secondary windings being closely coupled, said resistor being equal in value to

$$\frac{e_2R_1}{e_1-e_2}\cdot\frac{T_2}{T_1}$$

where T_2 is the periodic time of an alternating-current voltage impressed on the control electrode circuit of said amplifier, T_1 is the length in seconds of a rectangular wave impressed on said control electrode circuit, R_1 is the resistance of said rectifier in ohms, e_1 is the amplitude of said rectangular waves, and e_2 is the amplitude of noise accompanying said rectangular waves.

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