Feb. 1, 1927. 1,616,200

W. J. SHACKELTON

TRANSFORMER

Filed Oct. 23, 1922

Fig. 1.

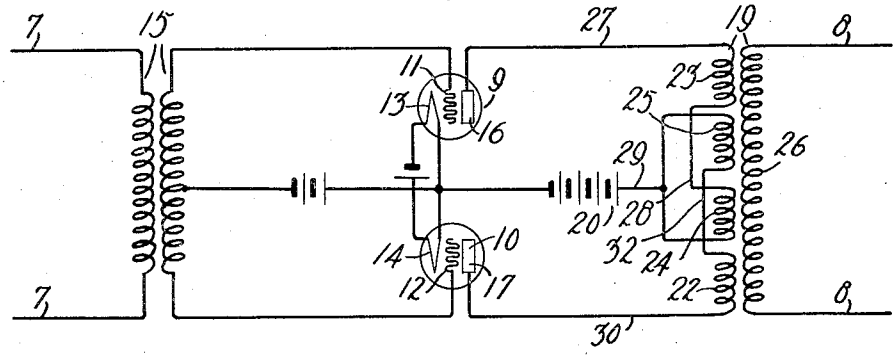
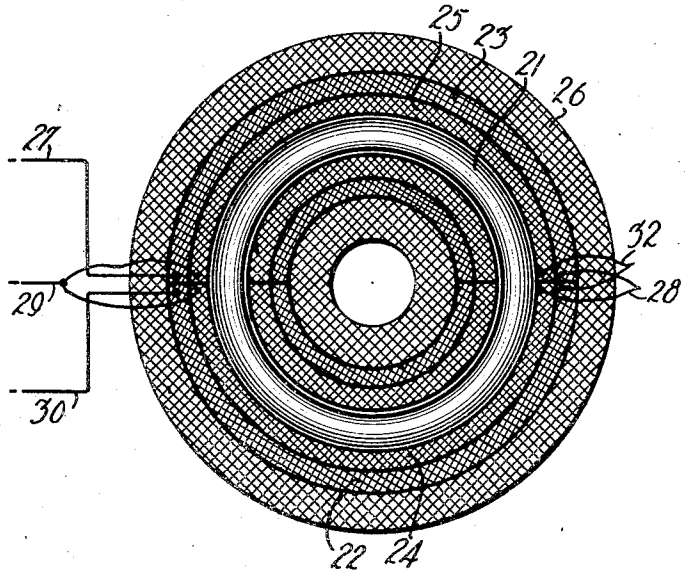


Fig. 2.



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UNITED STATES PATENT OFFICE.

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TRANSFORMER.

Application filed October 23, 1922. Serial No. 596,205.

This invention relates to transformers and balanced amplifier circuits employing them.

An object of this invention is to reduce transient voltage effects in signaling circuits employing transformers, particularly, electric discharge device output transformer circuits.

Another object of this invention is to prevent a sudden current change in a transformer winding from building up a transient voltage effect of a magnitude appreciably greater than the normal operating voltage impressed thereon.

Another object of this invention is to reduce the tendency of a push pull amplifier to sing.

In accordance with the form of this invention hereinafter described in detail, these objects are accomplished by an embodiment of this invention applied as an output transformer for a push-pull repeater circuit. In such a type of circuit it is customary to connect the negative terminal of the output circuit battery to the two cathodes of the tubes arranged in push-pull relation, the positive terminal of the source being connected to the mid-point of the primary winding of the output transformer, the two outside terminals of the primary winding being connected respectively to the two anodes of the tubes. Certain types of output transformers hitherto employed in push-pull circuits have in the normal operation of the circuit been subjected to high transient voltages, due in part at least, to leakage reactance between different parts of the transformer primary winding. This leakage reactance acts as a separate inductance element so that dangerous transient voltages may be produced at its terminals by a sudden change in the current therethrough. In addition this leakage reactance tends to produce parasitic oscillations. Leakage inductance introduced in the input circuit has a similar effect in producing oscillations.

In accordance with one form of this invention, these high transient voltages are substantially reduced, by eliminating the leakage reactance of the transformer. This may be accomplished in the case of an output transformer of a push-pull repeater by dividing the primary winding into four sections, two sections being wound on one half of a closed magnetic core and the other two sections being wound on the other half. The output circuit of one of the push-pull tubes should include the outer section on one half of the core and the inner section on the other half, while the other push pull tube should contain in its output circuit the remaining outer section and inner section. These winding sections should be so connected that they are all aiding for the signaling currents which flow from one anode to the other anode. Any leakage lines of force which tend to be created by one section of the primary winding due to a change in the strength of the space current flowing from the battery to each individual anode will be neutralized by the primary winding section associated therewith through which the space current flows in the opposite direction. This arrangement prevents the formation of any appreciable leakage reactance and consequently prevents the production of large transient voltages which would otherwise be produced.

Referring to the drawings Fig. 1 is a schematic representation of this invention embodied in a transformer for a push-pull repeater.

Fig. 2 illustrates the manner in which the various windings of the output transformer of Fig. 1 may be placed upon a magnetic core.

Fig. 1 discloses a portion of a signaling system comprising two line sections 7, 8, interconnected by a push-pull repeater or amplifier comprising two vacuum tubes 9 and 10. Control electrodes 11 and 12 and cathodes 13 and 14 are connected to the line section 7 by a suitable input transformer 15, while the anodes 16 and 17 and the cathodes are connected to line section 8 by an output transformer 19. A source of voltage 20 is connected between the mid point of primary winding transformer 19 and the cathodes for supplying space current to both tubes. In order to prevent large transient voltages being produced across the primary winding of the transformer 19 due, for example, to a sudden blocking of the space current in the tubes 9 and 10 caused, for example, by the grids 11 and 12 becoming positive

with respect to their cathodes, it has been found desirable to arrange the primary winding in a plurality of sections in a particular manner as shown more in detail in Fig. 2. As shown in Fig. 2, output transformer 19 comprises a closed magnetic circuit 21 which has two primary winding sections 22 and 24 wound on one half of the core and two other primary winding sections 23 and 25 wound on the other half. The secondary winding 26 is wound around the entire core. The preferable method of connecting the four primary winding sections 22 to 25 in the output circuit of tubes 9 and 10 is to connect lead 27 from anode 16 to one terminal of section 23, the other terminal of section 23 by a wire 28 being connected to one terminal of section 24, which is the inner section on the other half of the core. The other terminal of winding section 24 by a lead 29 is connected to the positive terminal of battery 20. Similarly lead 30 from anode 17 is connected to one terminal of the outer section 22, while the other terminal of section 22 by wire 32 is connected to one terminal of the inner section 25, the other terminal of which by wire 29 is connected to the positive terminal of battery 20. The individual portion of the output circuit of the tubes 9 and 10 therefore includes one inner section and one outer section, wound on different parts of the core structure 21. Since the magnetization in winding 23, for example, is exactly neutralized by the magnetization of winding 25 through which the current from battery 20 is flowing in the opposite direction it is evident that no leakage flux and hence no leakage reactance will result. Similarly the magnetization of winding 22 is neutralized by the magnetization of the winding 24. In order that this neutralization may be substantially complete it is preferable that the four sections of the primary winding should all be composed of an equal number of turns.

In one instance where the value of the source of voltage 20 was 750 volts the primary winding of an output transformer having appreciable leakage reactance frequently had developed across its terminals transient voltages as high as three or four thousand volts, which in several instances was sufficient to break down the transformer insulation. These transient voltages of such a magnitude however are absent when as above described the transformer is arranged to have substantially no leakage reactance.

The purpose of having one outer section and one inner section on each side of the midpoint of the primary winding is to keep the transformer balanced with respect to natural capacity effects existing between the two windings,—and the core and casing. This arrangement also gives a balanced d. c. resistance.

It is obvious that this invention is not limited to the particular embodiment described above but that various modifications thereof may be made without departing otherwise from the spirit of this invention as defined in the appended claims.

The invention claimed is:

1. A transformer comprising a magnetic core, primary and secondary windings, said primary winding being composed of four sections of equal number of turns, two of said sections being wound on one part of said core, said two other sections being wound on another part of said core, said primary winding between its external terminals comprising a series aiding circuit, being said four sections connected in the following order: the outer section on one part of said core, the inner section on the second part of said core, the remaining inner section and the remaining outer section.

2. A repeater transformer comprising a closed magnetic core, primary and secondary windings, a connection to the mid point of said primary winding, the portion of said primary winding located on one side of said mid point being divided into two equal portions, wound on different parts of said core, the part of said winding on the other side of said mid point being wound in two equal portions on different parts of said core.

3. In combination, a push-pull repeater, a line and a transformer for coupling said repeater to said line said transformer having one winding connected to said line and another winding divided into two portions each individual to one of the elements of said repeater and connected thereto, each portion of said winding being divided into a plurality of winding sections, all of the sections being disposed relative to one another such that the leakage reactance is reduced substantially to zero between the two portions of said winding that are respectively individual to said repeater elements.

4. A transformer comprising a magnetic core, a primary winding, a secondary winding, a tap to the mid point of said primary winding, each part of said primary winding between said tap and one side terminal being divided into an even number of sections wound on different parts of said core.

5. In combination, a push pull repeater having electron emitting means and a plurality of anodes, an output transformer therefor comprising a magnetic core, a primary winding, a secondary winding, a connection from said electron means to the mid point of said primary winding, a connection from each of said anodes to an outside terminal of said primary winding, the portion of said primary winding located between each outside terminal and said mid point connection being divided into two equal sections wound on different parts of said core and respectively overlaid whereby

the leakage reactance between said two portions of the primary winding is minimized.

6. In combination, a repeater comprising a plurality of space discharge paths having spacial electrodes arranged in push-pull relation, an incoming line, an outgoing line and circuits for associating said paths with one of said lines comprising a circuit branch individual to each of said discharge paths and a transformer having a closed core and having a winding connected to the respective line and a second winding divided into two portions each of which is connected in one of said individual circuit branches, each of said portions being divided into a plurality of winding sections, certain sections of each winding portion being disposed symmetrically on each side of certain sections of the other winding portion and in close proximity thereto whereby the leakage between said winding portions is reduced substantially to zero.

7. A transformer comprising a magnetic core, a plurality of windings, one of said windings being composed of four sections of equal number of turns, two of said sections being wound on one part of said core, said two other sections being wound on another part of said core, said winding between its external terminals comprising a series aiding circuit, said four sections being connected in the following order: the outer section on one part of said core, the inner section on the second part of said core, the remaining inner section and the remaining outer section.

In witness whereof, I hereunto subscribe my name this 20th day of October, A. D., 1922.

WILLIAM J. SHACKELTON.