Dec. 17, 1929. H. WHITTLE 1,739,699

ELECTRICAL TRANSMISSION CIRCUITS

Filed Aug. 30, 1926

Fig.1

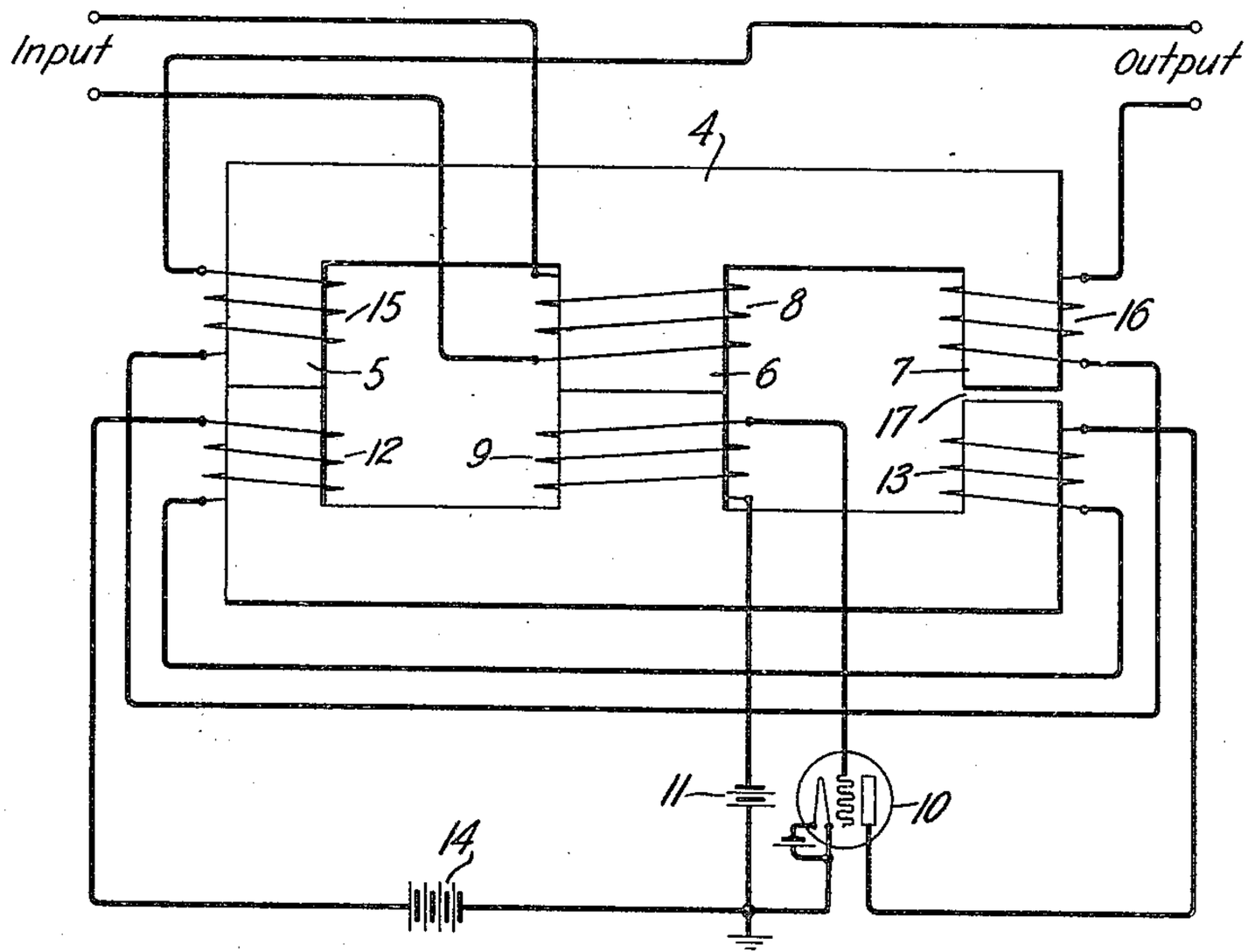
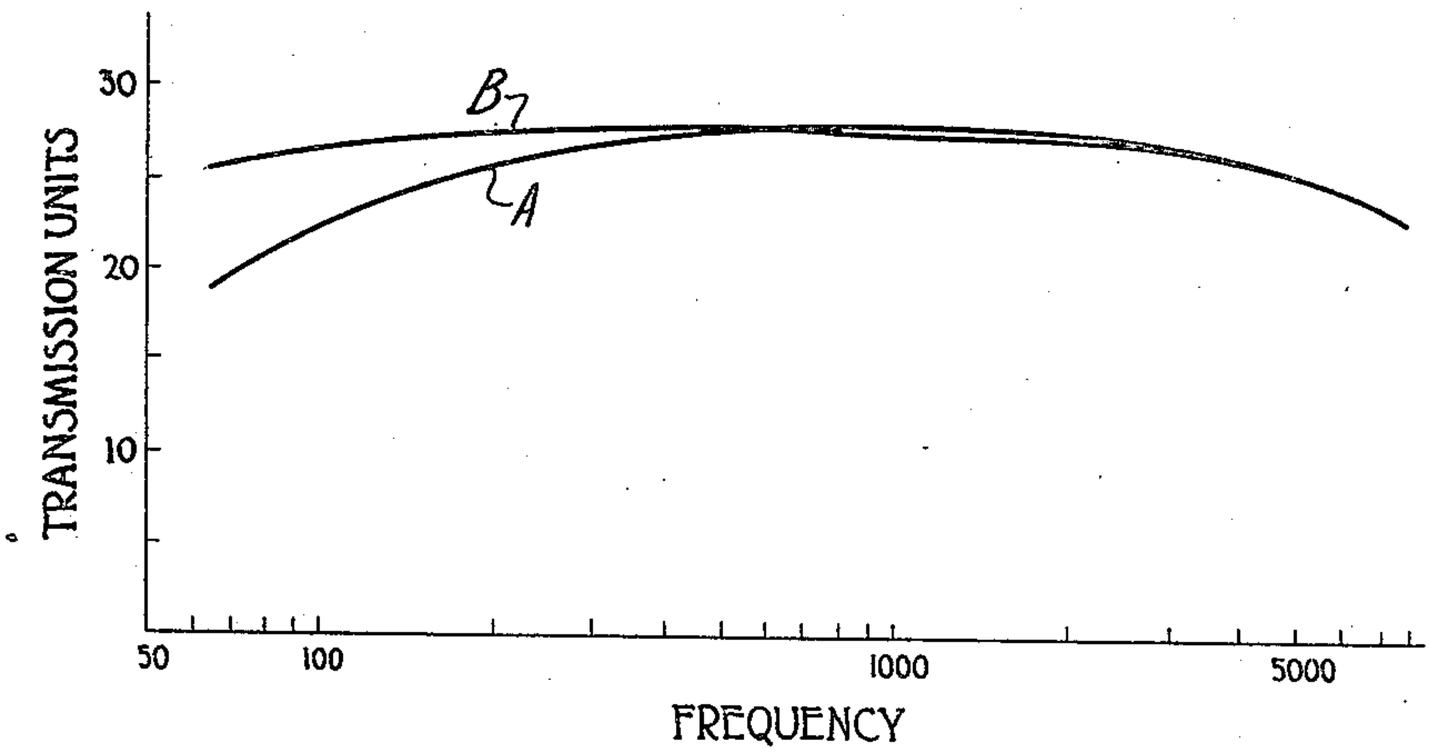


Fig.2



Inventor:
Horace Whittle

by E.S. Suggs Att'y.

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UNITED STATES PATENT OFFICE

HORACE WHITTLE, OF MAPLEWOOD, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

ELECTRICAL TRANSMISSION CIRCUITS

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This invention relates to electrical transmission circuits, and particularly to amplifier circuits.

An object of the invention is to control the transmission characteristic of amplifier circuits.

A specific object of the invention is to obtain uniform amplification over a wide range of frequencies.

Heretofore, branched core structures have been used for mounting transformer windings associated with two or more circuits, but in all cases the branches of the structures and the windings mounted thereon have been balanced to prevent coupling between the circuits.

According to this invention, a branched core structure is employed in an amplification circuit for mounting both the input and output transformers and by unbalancing the arrangement of the core structure or windings, coupling is provided between the two sets of windings. The transmission characteristic of the amplifier can be controlled by means of this coupling effect. Specifically, the coupling may be adjusted to give uniform transmission throughout a wide band of frequencies by increasing the amplification of the lower frequencies where the gain is usually low due to the shunting effect of the mutual impedance of both the input and output transformers.

In one embodiment this invention comprises a core structure having three legs with one set of windings mounted on one leg and the other set divided between the other two which are unbalanced, for example, by providing one with an air gap.

This invention not only provides a simple way of controlling the characteristic of an amplifier but the use of a single core structure for both transformers will in many instances result in a considerable saving in cost and space requirements.

This invention can be more readily understood by reference to the following detailed description in connection with the drawing in which: Fig. 1 shows diagrammatically one embodiment of the invention in a vacuum tube amplifier circuit, and Fig. 2 shows graphically the amplification frequency characteristic of the circuit of Fig. 1.

Referring to the drawing, there is shown a core structure 4 having three legs 5, 6 and 7 and formed of two stacks of E shaped laminations. Mounted on the middle leg 6 are two transformer windings 8 and 9 which serve as the input transformer for a vacuum tube amplifier 10. The secondary winding 9 is connected to the input electrode of the tube 10 through a grid biasing battery 11, in the usual manner.

Two windings 12 and 13 are mounted on the outer legs 5 and 7, respectively. These windings are connected in series to form the primary winding of the output transformer for the tube 10 and are connected to its output electrodes through a plate battery 14, in the usual manner. Two other windings 15 and 16 are also mounted on the outer legs 5 and 7, respectively, and are connected together in series to form the secondary winding of the output transformer. For the sake of clearness, the windings on each leg are shown in the diagram side by side. Obviously in a physical embodiment it is preferable to wind one over the other.

Magnetic flux in the leg 6 produced by current flowing in the winding 8 will divide and take paths in opposite directions through the legs 5 and 7 so that, when the outer legs and the windings thereon are balanced, the inductive effects in windings 12 and 15, for example, due to the flux produced by the windings 8 and 9, are neutralized by the corresponding flux in windings 13 and 16.

Similarly, when the outer legs and windings thereon are balanced, the magnetic flux produced in legs 5 and 7 by current in either coils 12 and 13 or 15 and 16 does not pass through the leg 6 which then connects points of equal magnetic potential.

However, by unbalancing the structure, it is possible to produce an inductive coupling between the input and output transformer windings. In the embodiment shown in the drawing, an unbalance is obtained by the use of an air-gap 17 in the leg 7, which gives a higher reluctance than the butt joints of the other legs. The coupling produced by this

unbalance causes a feed back from the output transformer to the input transformer which gives an increased amplification at the lower frequencies for the following reasons. When the fluxes in the input and output transformers are in phase, the feedback is a maximum. This occurs at the low frequency end of the characteristic. As the frequency increases, there is a difference in phase between the fluxes of the input and output transformers, due to the phase shift in the input transformer, which in turn is due to the effect of its leakage and distributed capacity. The result of this is to reduce the effect of the feedback at higher frequencies. By regulating the length of the air gap, i. e., the difference in the length of the gap 17 and the gaps in the other legs, it is possible to control coupling between the input and output windings to give a desired amount of feed back.

Obviously, the unbalance may be accomplished by other means, for example, by reducing the cross-section of one of the outer legs or by winding a larger portion of the windings on one leg than on the other. Also, of course, the output transformer may be mounted on the inner leg and the input transformer on the outer legs, if desired.

Fig. 2 shows graphically the amplification characteristic obtained experimentally on the amplifier of Fig. 1. The abscissæ represent frequencies in cycles per second and the ordinates amplification in transmission units. Curve A shows the amplification characteristic when the outer legs and windings thereon are balanced, that is, with no feed back. Curve B shows the characteristic when an air-gap is inserted in one leg to give an unbalance which will produce substantially uniform amplification throughout the frequency range from 60 to 5,000 cycles per second.

The constants of the circuit, of course, may be adjusted to give other types of characteristics, for example to give a high amplification at the lower frequencies to compensate for distortion in other parts of the circuit in which the amplifier is employed.

While this invention has been described in connection with a vacuum tube amplifier, obviously it may be used with any non-passive transmission element.

What is claimed is:

1. In combination, a transmission element having input and output terminals, and a combined input and output transformer therefor comprising a branched core structure, input transformer windings mounted on one branch and output transformer windings mounted on another branch, and means for controlling the wave transmission characteristics of the combination comprising means for unbalancing said transformer to provide coupling between said input and output windings.

2. In combination, a transmission element having input and output terminals, a combined input and output transformer therefor comprising a magnetic core having three branches and input and output windings, one of said windings being mounted on one branch of said core and the other of said windings being divided between the other branches of said core, and means for controlling the transmission characteristic of the combination comprising means for unbalancing said transformer to provide inductive coupling between said input windings and said output windings.

3. A combination according to the next preceding claim in which the branches of the core between which the said other of said windings is divided have such different magnetic reluctance as to give the desired unbalance of said transformer.

4. In combination, an amplifier for uniformly transmitting a wide band of frequencies, and a combined input and output transformer therefor comprising a branched core structure and input and output windings mounted on separate branches, said transformer being unbalanced to provide coupling between said windings to increase the amplification of frequencies in the lower portion of said band.

5. In combination, an electric discharge device having input and output terminals, a combined input and output transformer therefor comprising a magnetic core having three branches, input transformer windings mounted on one branch and output transformer windings divided between the other two branches, and means to control the transmission characteristic of said combination comprising means for producing a different magnetic reluctance in one of said two branches of said core than in the other of said two branches.

In witness whereof, I hereunto subscribe my name this 26th day of August A. D., 1926.

HORACE WHITTLE.