

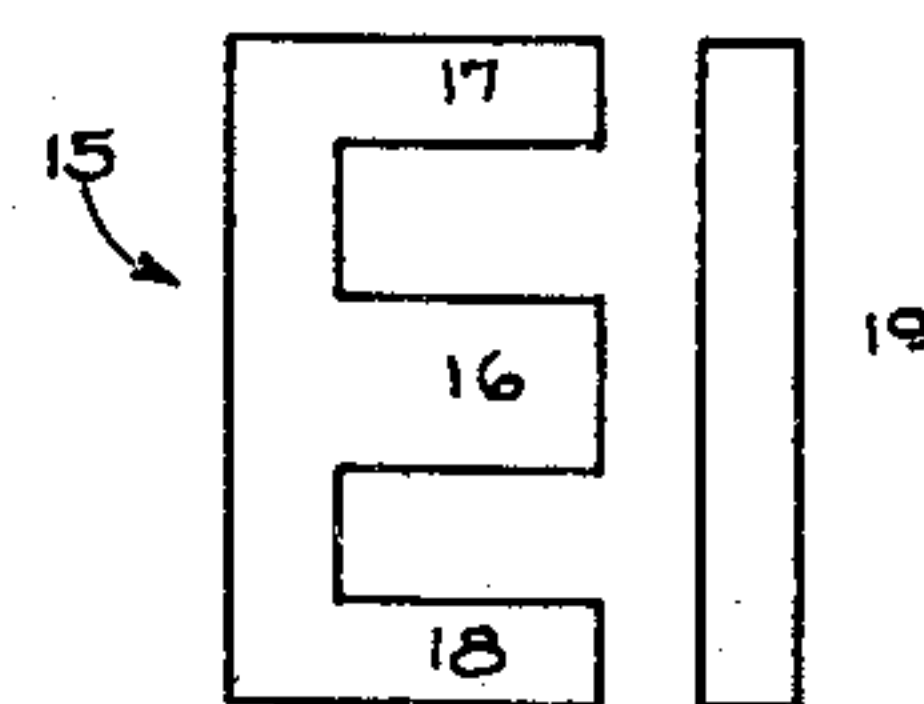
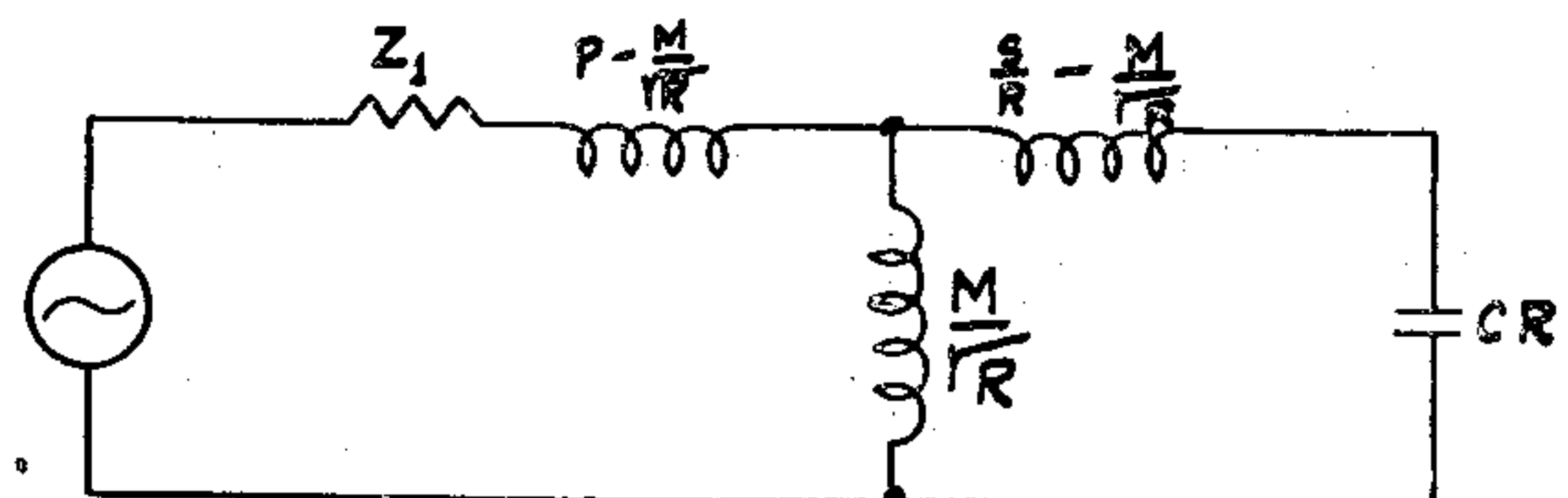
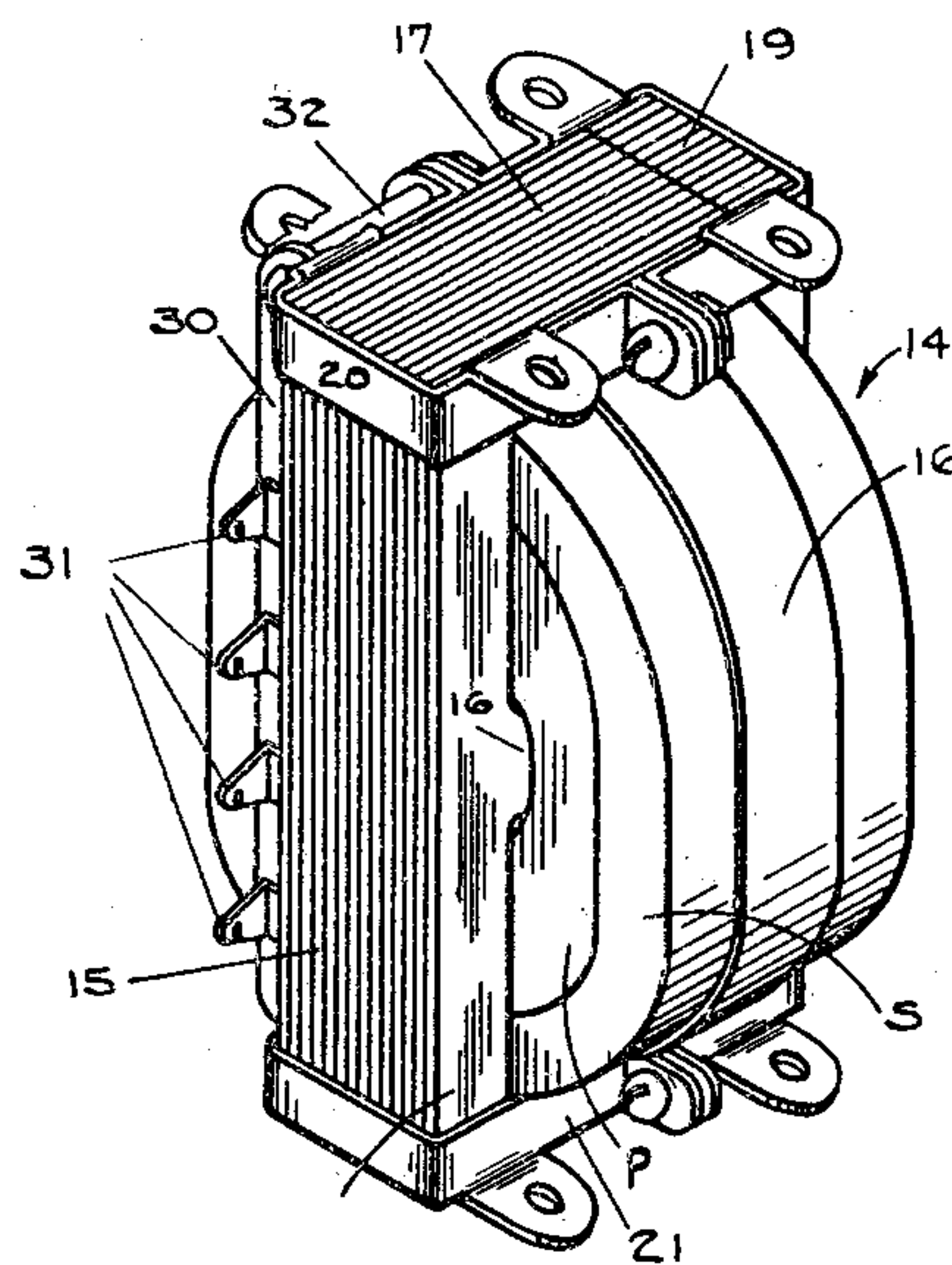
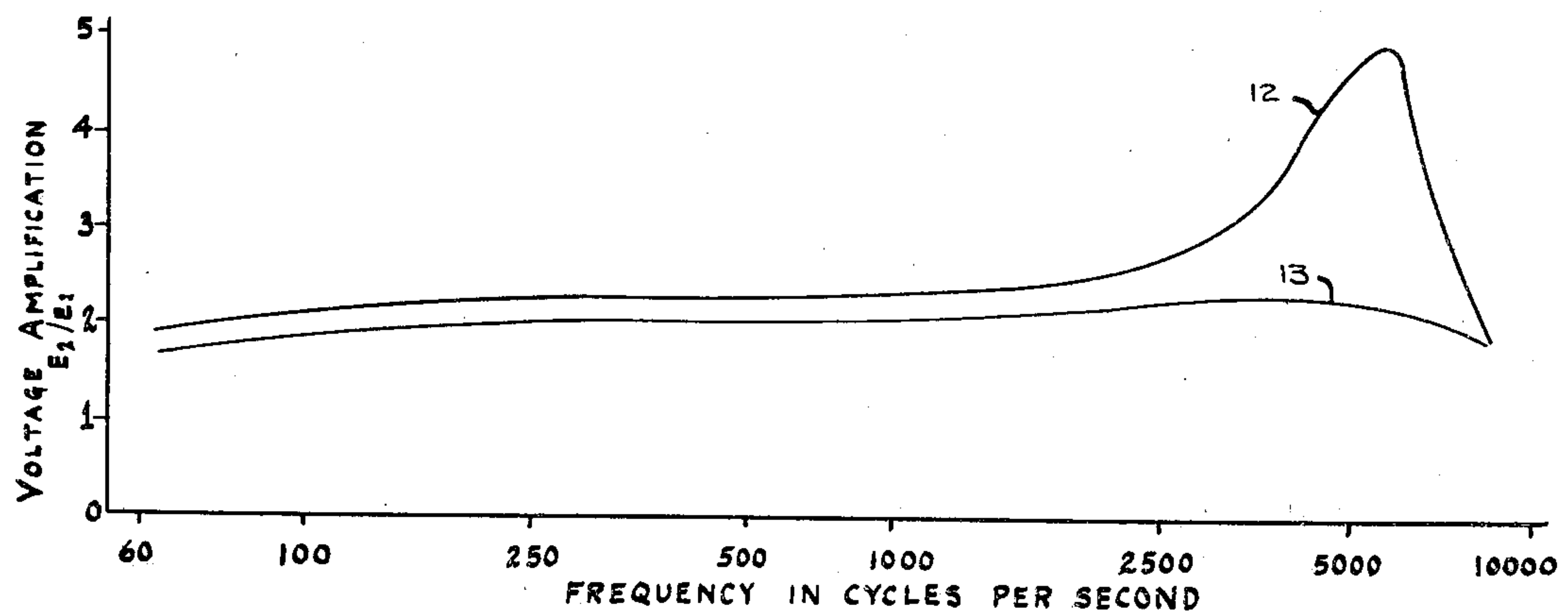
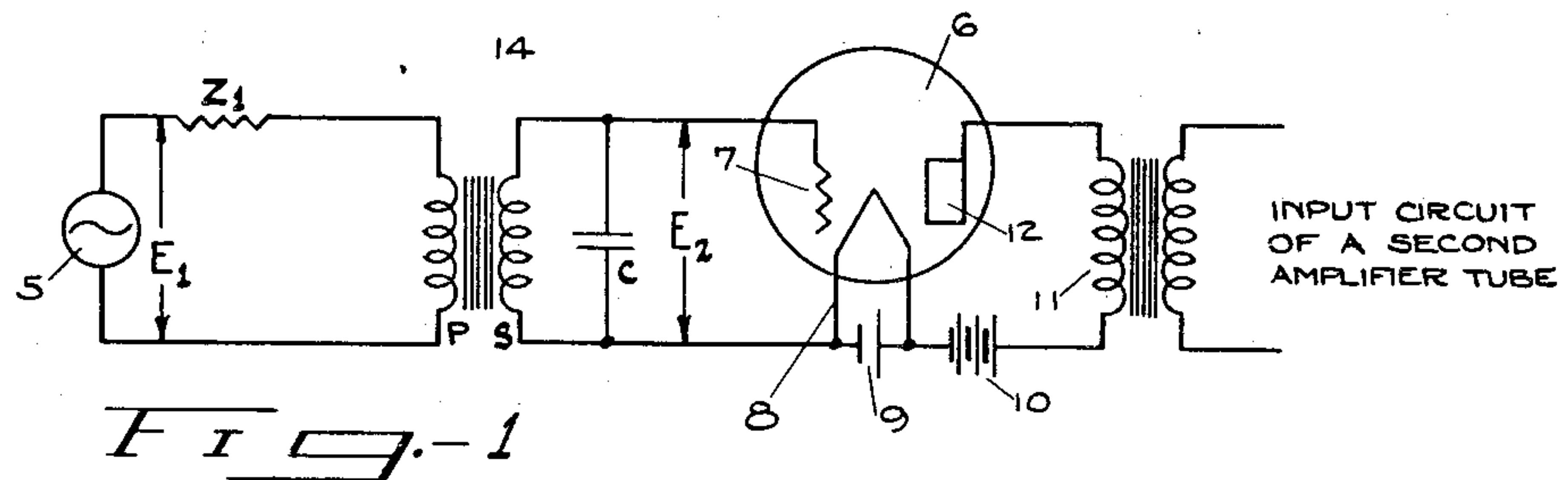
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AMPLIFYING SYSTEM

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AMPLIFYING SYSTEM.

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This invention relates to system for amplifying electrical variations comprising a band of frequencies and more particularly to circuits including vacuum tubes and modified transformers for use in amplifying electrical signals.

It has been recognized in amplifying systems using vacuum tubes coupled by means of transformers, that certain inherent capacities and leakage inductances in these devices cause an unequal amplification of the various incoming signals, which results in an effect commonly known as distortion. In order to obtain substantially distortionless amplification it is necessary that all frequencies within a predetermined range of reception be amplified an equal amount by the amplifying device. Graphically, this is represented by the condition in which the relation between voltage amplification and frequency is represented by a flat curve.

The main feature of the present invention is the structure and arrangement of parts, which when incorporated in vacuum tube circuits, effect substantially distortionless amplification.

Another feature of the invention resides in the introduction in transformer coupled vacuum tube circuits of an effective resistance in the resonant circuit of such an arrangement to neutralize the tendency of certain frequencies to be amplified more than others.

Another feature of the invention resides in the provision of a transformer for coupling an incoming source of signals to a vacuum tube amplifier, said transformer being of such structure that all frequencies of the incoming signal shall be amplified a substantially equal amount.

For a more complete understanding of the invention, reference is made to Fig. 1, in which there is represented diagrammatically an alternating source of electromotive force, which may be an incoming signal, voltage in the plate-filament circuit of a vacuum tube coupled to the input circuit of a vacuum tube amplifier by means of an audio transformer.

Fig. 2 shows curves, one of which indicates the variations of amplification with frequency in the circuit of Fig. 1 without the present invention and a second curve showing the sub-

stantially uniform amplification of signals throughout the range of audible frequency, when the present invention is employed.

Fig. 3 is a schematic circuit of Fig. 1, in which the transformer and associated circuits have been represented by an equivalent unity ratio T-net-work.

Fig. 4 is a perspective view of a transformer for use in circuits such as is shown in Fig. 1.

Fig. 5 is a view showing the form of laminations, which form the core of the transformer.

Referring to Fig. 1, there is indicated an alternator 5, which impresses an alternating electromotive force across the circuit of which the primary winding P of the transformer is a part. It will be understood, however, that the alternator is merely symbolic of a source of alternating current, which in practice would be developed in the plate filament circuit of a vacuum tube upon whose grid filament circuit is applied an alternating voltage. In the mentioned circuit there is indicated an impedance Z_1 , which may be the plate filament resistance of the mentioned vacuum tube, in which case the impedance is in the form of a non-inductive resistance. The transformer just referred to is preferably of the type indicated in Fig. 4 and which will presently be described, although the invention is not limited to this particular structure.

The secondary winding S of this transformer is included in series with the input circuit of the thermionic or vacuum tube 6, terminating at one end in the grid 7 and at its other end in the filament 8. As is well known the filament is provided with a heating source, which may be the battery 9 and an output circuit including a source of space current 10, extending from one side of the filament 8 through the primary winding 11 of a second transformer to the plate 12 of the vacuum tube. The transformer just referred to is preferably of the step up type and the secondary voltage induced in the secondary winding S of the transformer, is thus impressed across the input circuit of the vacuum tube just described wherein it is amplified and impressed upon the primary winding 11 of the transformer included in the output circuit of the vacuum tube 6. The circuit arrangement just de-

scribed is that of the conventional transformer coupled vacuum tube amplifier in which it has been recognized that uniform amplification throughout the desired range of frequencies has not been obtained. In other words, when the effective voltage amplification indicated by the voltage ratio $\frac{E^2}{E^1}$, where E^2 represents the voltage across the secondary winding of the transformer and E^1 the voltage across the input circuit, is plotted against frequency, a peak appears as is shown by the curve 12 in Fig. 2. In the lower-ratio transformers such peaks usually occur at the higher frequencies, such as frequencies around five thousand; whereas in the higher ratio transformers, these peaks may be present at frequencies as low as one thousand, although it will be understood that the position of such peaks along the frequency axis is dependent upon the design of the transformer.

In order to understand how the amplifying system of Fig. 1 is modified to eliminate the peak in its amplification curve, so that substantially uniform amplification at all frequencies may be obtained as indicated graphically by curve 13, it is necessary to analyze the various impedances present in the net-work of Fig. 1. This may be done by representing the elements of Fig. 1 by the equivalent simplified diagram, shown in Fig. 3, in which the transformer is replaced by an equivalent unity ratio T-network. In this diagram P, S and M are respectively the primary, secondary and mutual impedances of the transformer 14, while R is the impedance ratio $\frac{S}{P}$ of the transformer and C is the sum of the internal capacity of the transformer windings and capacity of the grid-filament circuit of the vacuum tube 6. It will be understood that at a certain frequency, dependent upon the various values of these impedances, series resonance may take place in the circuit Z^1 , $P - \frac{M}{\sqrt{R}}, S - \frac{M}{\sqrt{R}}, CR$. Of these components of this last mentioned circuit, the first is a non-inductive resistance, the second and third are the inductances of the leakage impedances of the transformer and the fourth is the sum of the transformer winding and vacuum tube capacities. The inductance of the branch $\frac{M}{\sqrt{R}}$ is so high as compared with the leakage inductances, that it has very little effect upon the condition of series resonance as above described. Due to the well known phenomenon of the magnification of voltage in resonant circuits, the voltage E^2 applied across the grid-filament or input circuit of the vacuum tube 6 may become greater than the voltage E^1 multiplied by the turns ratio of the transformer, the normal maximum

amplification in the absence of series resonance, which results in an exaggerated amplification, graphically indicated by the peak in the curve 12 of Fig. 2.

In accordance with the present invention, it has been found possible to suppress for the most part, the undesirable exaggerated amplification referred to, by means of the transformer 14 of Fig. 4. This transformer has a laminated core generally referred to as 15, which is formed of two sets of punchings, one being E-shaped with arms 16, 17 and 18 and the other being I-shaped as is shown at 19 of Fig. 5. As is well known these punchings are of magnetic material riveted together and are held with the I-shaped members engaging the ends of the branches 16, 17, and 18 by means of clamps 20 and 21, which also serve as brackets for supporting the transformer. A terminal strip 30 of insulating material serves as a support for the terminals 31 to which the ends of primary and secondary windings or coils are attached. This strip is mounted on one of the pairs of bolts which tighten the clamps 20 and 21 and is held in spaced relation from the lugs on these clamps by spacer 32. The middle branch 16 of the core is encircled by a primary winding P, in turn encompassed by the secondary winding S and these windings are in turn surrounded by the side members 17, 18 and 19 of the core. These primary and secondary windings are formed preferably of small gauge enamelled wire, although this wire may be insulated by silk or cotton. A band 16 of conducting material entirely encircles the secondary winding on the median line thereof, and has its ends electrically joined together, so that it frictionally engages the outer surface of this winding. This band constitutes a closed tertiary winding consisting of a single turn, which is more closely coupled to the secondary winding than to the primary winding. Although but a single band conductor is shown, it will be understood that this tertiary winding may consist of a plurality of turns of wire or other electrical conductor.

This band or tertiary winding has for one of its purposes the introduction of sufficient effective resistance into the mentioned resonant circuit of which the capacity C of Figs. 1 and 3 is a part, to lower the crest of and to broaden the resonant peak in the amplification curve, as shown in curve 13 of Fig. 2.

While it is true that the amplification at all frequencies is somewhat reduced, the proportional reduction in amplitude is much greater in the region of the resonant peak than at the frequencies below this region, so that if desired, the transformer may be designed to overcome this slight reduction in amplification, by correspondingly increasing the turns ratio of the transformer.

For convenience in description, but a single thermionic tube is shown, but the invention is not so limited, for it is directed to a multi-stage amplifier system in which each stage has a thermionic tube coupled to the thermionic tube of an adjacent stage by a transformer.

In such multi-stage amplifier systems of the audio frequency type, having a plurality of vacuum tubes and employing ordinary transformers to couple these vacuum tubes, operating difficulties are often encountered due to feed-back through stray capacities in the system, from the output circuit of the amplifier to the input circuit of the detector or succeeding tubes. On account of the exaggeration in amplification at the peak, before referred to, the amplification may become sufficient at this point to produce oscillation or regeneration. The effective resistance induced in the system from the closed tertiary winding 16, substantially annuls this tendency by reducing the amplification to nearly normal value at the point where the peak previously occurred. This greatly adds to the stability of the amplifier and also limits distortion, which might otherwise be caused by regeneration, oscillation and consequent over-loading of the amplifier.

It will be understood that the foregoing disclosure is merely typical of applicant's invention and that it includes any means whereby exaggerated portions in the amplifying range are suppressed.

What I claim is:

1. A transformer comprising a core, primary and secondary windings encircling a portion of said core, and a flat band of con-

ducting material surrounding said secondary winding.

2. A transformer having a core, primary and secondary windings encircling a portion of said core and a band of conducting material surrounding said secondary winding on its median line.

3. A transformer having a core, of low reluctance, primary and secondary windings encircling a portion of said core, and a band of conducting material surrounding said secondary winding, so that the median line of said band and of said secondary winding are superimposed, said core having a portion completely encircling said band and said primary and secondary windings.

4. A transformer having a core formed of E-shaped and I-shaped laminations placed with the branches of the E-shaped laminations engaging the I-shaped laminations, primary and secondary windings about the central branch of said E-shaped laminations, and a band of conducting material surrounding said windings, the outer branches of the E-shaped laminations extending outside of said windings and said band.

5. A transformer having a core of laminated magnetic material, primary and secondary windings of fine wire encircling a portion of said core, a band of conducting material surrounding said secondary winding, a clamp for each end of said core, a strip of insulating material supported on said clamps, and terminals for said windings mounted on said insulating strip.

In witness whereof, I hereunto subscribe my name this 1st day of August A. D. 1925.

BENJAMIN OLNEY.