

April 1, 1941.

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2,236,690

NEGATIVE IMPEDANCE CIRCUIT

Filed March 5, 1938

FIG. 1

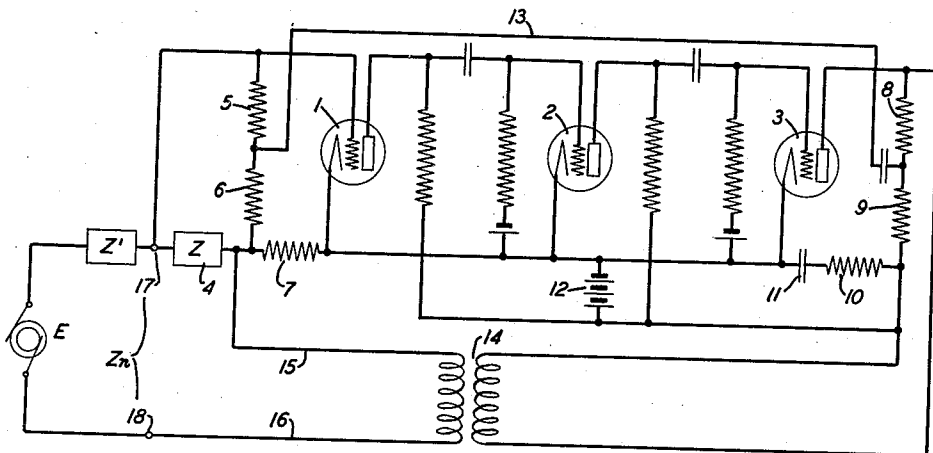
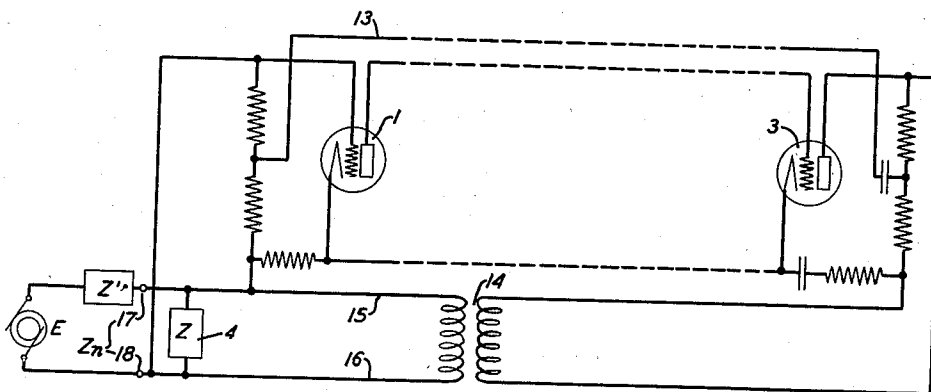


FIG. 2



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2,236,690

NEGATIVE IMPEDANCE CIRCUIT

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Application March 5, 1938, Serial No. 194,036

2 Claims. (Cl. 178-44)

The present invention relates to circuits for producing negative impedance effects.

An object of the invention is to stabilize negative impedance circuits so as to obtain more highly stable negative impedances.

A difficulty in the use of negative resistances or negative impedances is that any normal instabilities and any normal variations of magnitude with frequency are multiplied in their effects. Thus, in a single negative resistance circuit of a positive resistance R and negative resistance $-r$ in series,

$$I = \frac{E}{R-r}$$

where I is the current flowing as a result of application of a driving voltage E . If r is about 10 per cent different from R in absolute magnitude, a 1 per cent variation in r or in R becomes about a 10 per cent variation in I .

Negative impedance elements are inherently less stable than positive resistance and impedance elements. It becomes important, therefore, to be able to improve the stability of negative impedances where possible.

One method of producing negative impedance is by positive regeneration of amplifier circuits. This may be done with series, shunt or with hybrid coil connection of input and output circuits. One example of such method of producing negative impedance is found in my prior Patent 1,779,382, October 21, 1930.

In negative impedance circuits involving amplification with positive regeneration, the stability is improved in accordance with this invention by applying a stabilizing negative feedback to a suitable portion of the system including the amplifier, thereby improving the stability of the negative impedance that is being produced.

In the drawing to which reference will now be made for a full disclosure of preferred embodiments of the invention—

Fig. 1 is a schematic circuit diagram of a negative impedance system with series positive regeneration and with a stabilizing negative feedback; and

Fig. 2 is a similar diagram of a negative impedance system using parallel positive regeneration.

In Fig. 1 a three-stage amplifier comprises tubes 1, 2 and 3 with suitable interstage circuits shown as the conventional resistance-capacity type. This amplifier is provided with a negative feedback connection 13 from its output to its input side, the connections being made by

means of an output bridge and an input bridge. The input bridge includes resistances 5, 6 and 7, the feedback connection being made at the junction of 5 and 6 as shown. In this way the feedback is kept independent of variations in resistance across the input diagonal extending from the grid to the junction of resistances 6 and 7. Similarly, the output bridge consists of resistances 8, 9 and 10, the feedback connection being made at the junction of resistances 8 and 9. The feedback path is thus conjugate to the output circuit across the diagonal between the plate of tube 3 and the junction of resistances 9 and 10. Space current for all three tubes is supplied from a suitable source such as battery 12. Condenser 11 is a blocking condenser.

The feedback action and the manner in which it is attained including the input and output bridges and their design are in accordance with the teachings of H. S. Black Patent 2,102,671, issued December 21, 1937, to which reference may be made for a fuller disclosure.

Positive feedback is used by way of transformer 14 and circuit 15, 16, in connection with a positive impedance Z at 4 and a source of driving voltage E to develop a negative impedance Z_n looking into the circuit at terminals 17 and 18 in the general manner disclosed in my prior Patent 1,779,382 referred to above. The impedance Z' is a positive external impedance to be neutralized in part by the negative impedance of the circuit. The voltage drop across Z is applied to the grid of the first tube 1, is amplified in stages 1, 2 and 3 and is fed back in amplified form through transformer 14 in aiding phase with the voltage E , whereby, with proper adjustment and proportioning, a negative impedance Z_n is developed between the terminals 17, 18, having a component which is the negative of the positive impedance Z . Transformer 14 aids in producing the required phase relation between the fed back voltage and the voltage E .

As developed in the mathematical discussion in my prior patent supra, the negative impedance Z_n is produced as the difference between relatively large quantities one of which involves as a factor the voltage amplification factor of the amplifier. The other quantities may in any given system be simply positive resistances or reactances which may be constructed or controlled to be electrically very stable. As noted above, however, a relatively small instability in one of the relatively large quantities whose difference determines the negative impedance represents a large percentage instability in the

negative impedance. Consequently, in accordance with this invention the stability of the negative impedance is improved by stabilizing the amplifier, which is likely to be the greatest source of instability because it includes such elements as tubes and voltage sources. The improvement in stability is substantially proportional to the gain reduction due to the negative feedback. By providing large excess gain in the amplifier and reducing the gain by feedback to the required value, great improvement in stability is secured.

In Fig. 2 the parts corresponding to the elements in Fig. 1 are correspondingly designated and it will be seen that Fig. 2 shows the shunt type of negative impedance circuit in that the circuit 15, 16 from feedback transformer 14 is connected in parallel across positive impedance 4 and the series combination of source of voltage E and positive impedance Z'. Otherwise the construction and operation of this circuit are the same as in the case of Fig. 1.

The invention is not to be construed as limited to the particular circuits that have been disclosed since the details may be varied widely in actual practice. The scope of the invention is defined by the claims.

What is claimed is:

1. In combination, a pair of terminals between which the negative of a given positive impedance is to be produced, a source of voltage and said positive impedance connected in circuit with said

terminals, an amplifier connected to amplify the voltage developed in said positive impedance and to apply the amplified voltage to said circuit in phase with the voltage from said source, whereby the negative of said positive impedance is developed across said terminals, means to stabilize said negative impedance comprising a gain stabilizing negative feedback circuit for said amplifier and means rendering said feedback circuit conjugate with respect to the terminals of said positive impedance.

2. In a negative impedance circuit, a circuit having two terminals across which a negative impedance effect is to be produced, a positive impedance in circuit with said terminals, means developing a drop of potential across said positive impedance, an amplifier having input and output terminals, means to apply said drop of potential to the input of said amplifier, said amplifier having a positive feedback circuit and a negative feedback circuit, said positive feedback circuit feeding back a portion of the amplified voltage from the output to the input side in phase with said drop of potential whereby the negative impedance effect is produced and said negative feedback circuit applying a portion of the amplified voltage from the output to the input side of said amplifier in sufficient amount to reduce the gain of the circuit and stabilize said negative impedance effect.

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