Dec. 19, 1939. J. P. SMITH, JR 2,184,104

ATTENUATION NETWORK

Original Filed Aug. 28, 1937 2 Sheets-Sheet 1

Fig. 1.

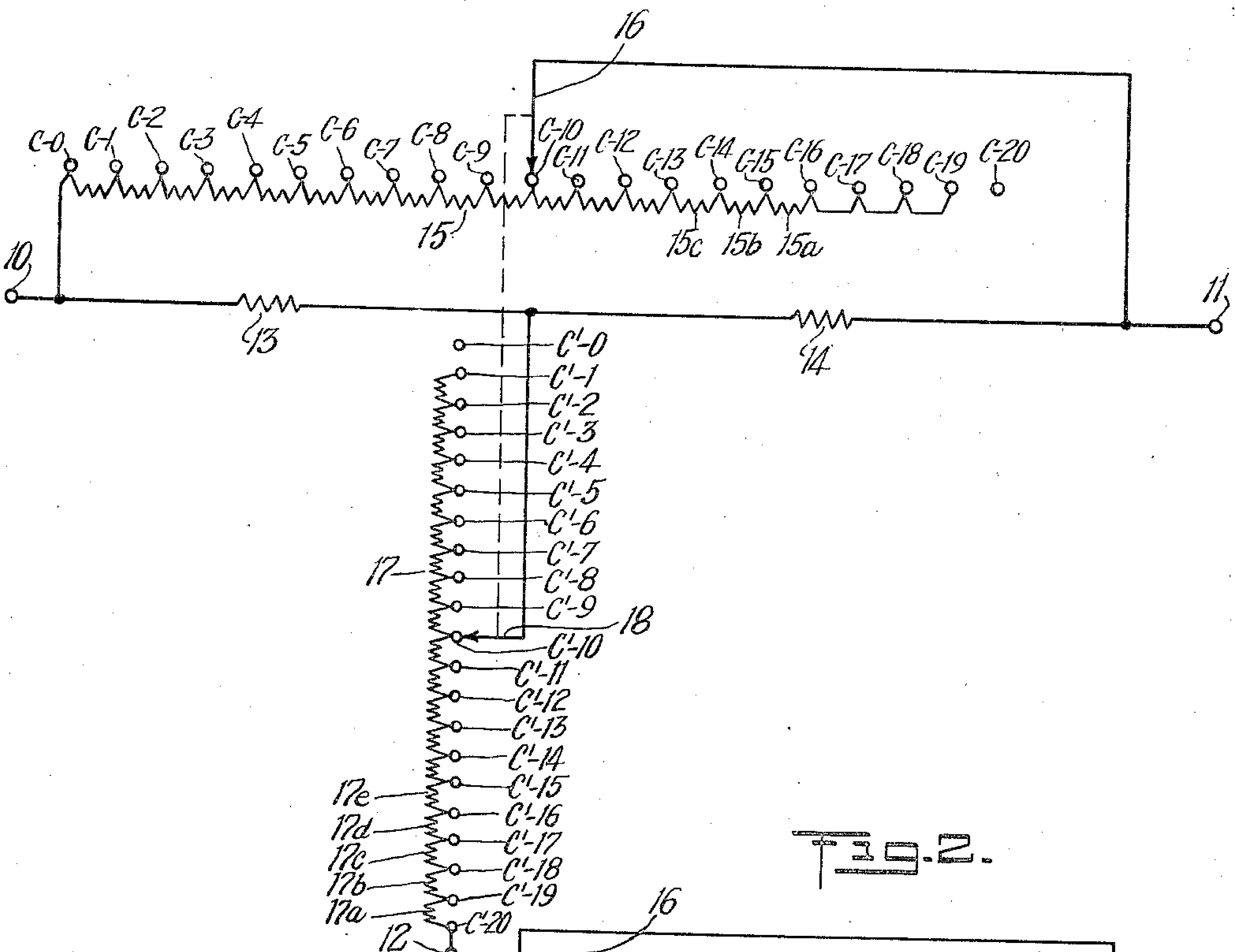

Fig. 2.

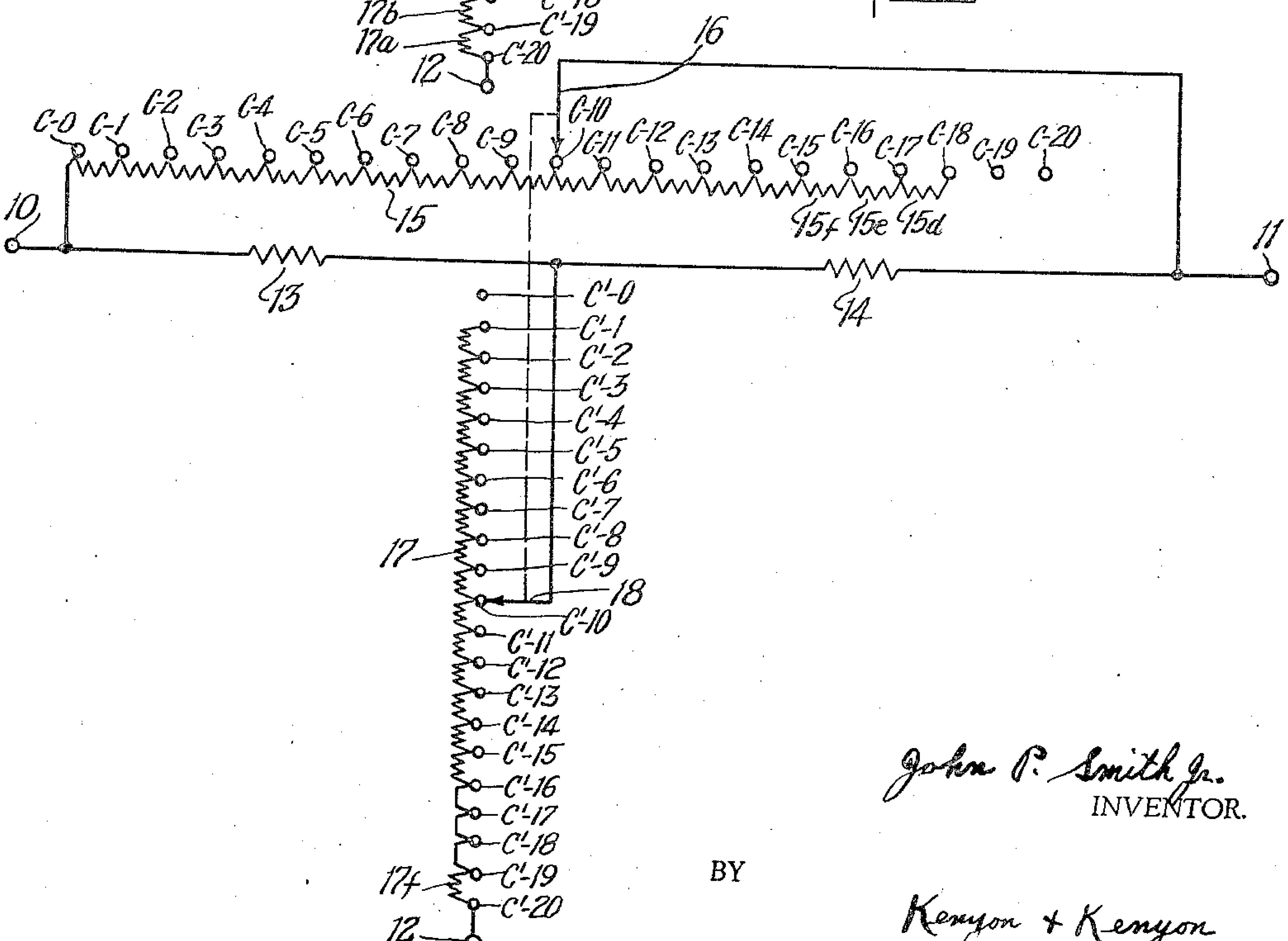

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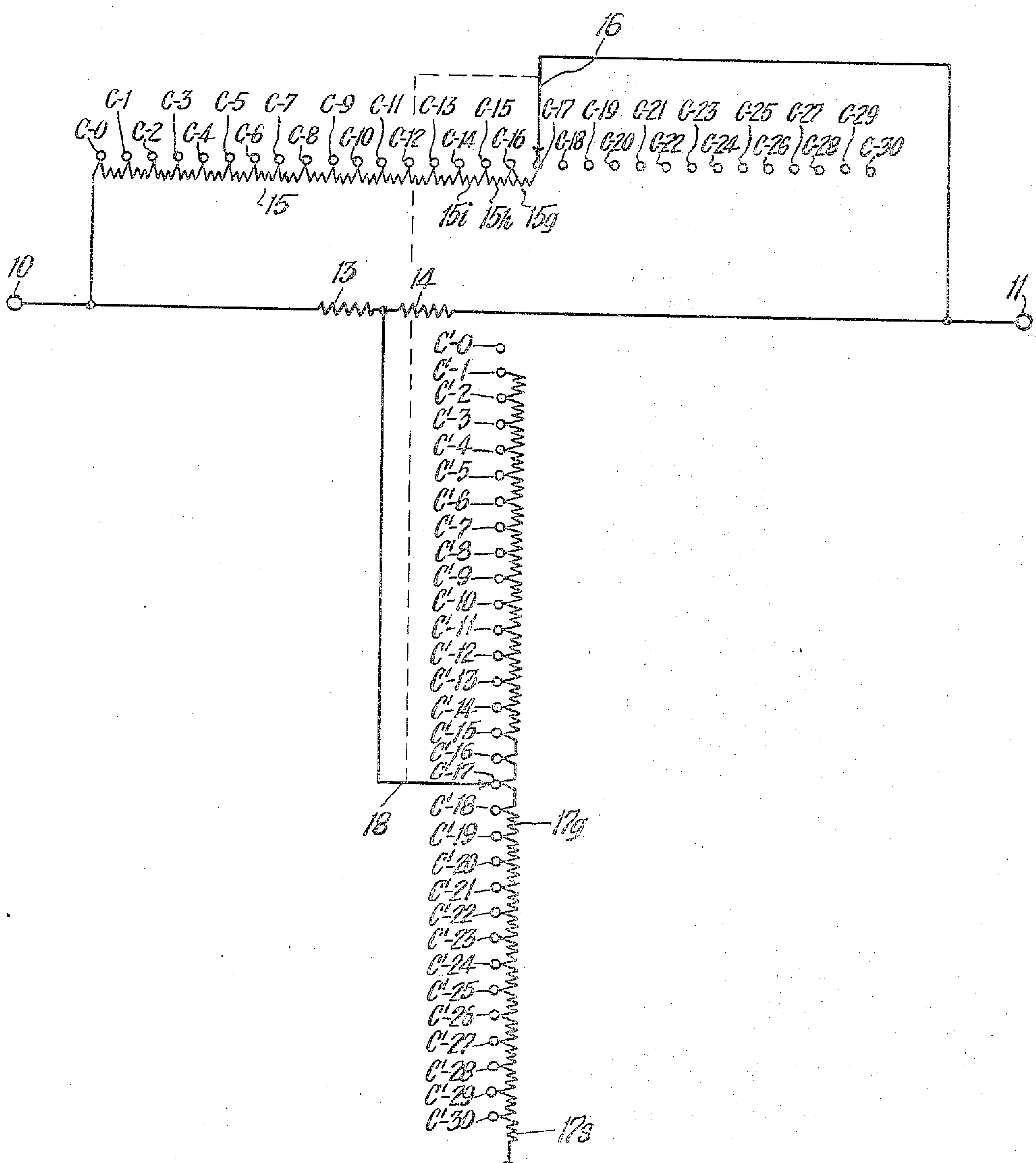
Fig. 3.



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ATTENUATION NETWORK

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6 Claims. (Cl. 178—44)

This invention relates to variable attenuation networks.

In a variable attenuation network of the bridged T type, two switch arms are simultaneously moved over two sets of contacts connected to two sets of series-connected resistance units to vary the resistance in the arms of the network while maintaining the impedance substantially constant, the resistance units being so designed that the attenuation is varied in equal increments. In order to keep the overall impedance constant, the individual resistance units must be wound within tolerances of 2%. It is extremely difficult to wind resistance units of lower value than one ohm within such limits in production and furthermore resistance units about 5,000 ohms are difficult to wind non-inductively unless separate spools are used. This increases not only the cost of manufacture, but also the size of the attenuator and slows down production.

An object of this invention is an attenuation network in which the use of extremely small and extremely high resistance units is obviated thereby facilitating its manufacture and minimizing its cost.

In an attenuation network embodying the invention, a pair of series connected resistors of fixed value are bridged by a variable resistance and a variable shunt resistance is connected between the first-named resistors. For some high impedance networks the arrangement is such that the attenuator is controlled at the higher attenuation positions by keeping the bridged resistance constant and varying only the shunt element while for low impedance networks, this arrangement is reversed, that is the shunt element is kept constant while the bridged resistance is varied. In this latter condition, the attenuator is converted from a bridged T type to a π type at the higher attenuation positions. In the case of a high impedance network at high attenuation steps, the resistance values in the shunt arm are designed to control the network loss variation while the bridge arm is kept constant and in the case of low impedance network at the higher attenuation settings, the resistance values of the bridged arm are designed to control the network loss variation while the shunt arm is kept constant.

In another type of high impedance network, it is possible to maintain the nominal input and output impedance within limits of 5% after a total of 30 decibels attenuation has been reached, by first varying the bridge arm for a few steps while holding the shunt element constant and then opening the bridge arm entirely and varying the shunt arm in logarithmic fashion similar to the variations in a potentiometer. In all types the change in the electrical circuit of the network itself, is permissible only in the higher attenuation values. It is a known fact that a certain amount of attenuation will completely shield impedance variations even of extreme values from being measured thru the attenuator. In these cases, the impedance variations which take place by keeping one element constant while varying the other, occur within the network itself and inasmuch as the attenuation of the network is approximately 30 db. in both directions, the impedance variations which are presented to the attenuator terminals are within commercial limits. Actually, the network is changed from a bridged T to a π whenever the shunt resistance is kept constant while the bridge element is varied.

Other objects, novel features and advantages of this invention will become apparent from the following specification and accompanying drawings, wherein:

Fig. 1 illustrates diagrammatically a high impedance network embodying the invention;

Fig. 2 illustrates diagrammatically a low impedance network embodying the invention; and

Fig. 3 illustrates diagrammatically another high impedance network embodying the invention.

In Fig. 1, 10, 11 and 12 are the input, output and common terminals respectively. A resistor 13 is connected in series with a resistor 14 between the binding posts 10 and 11. A resistance 15 has one end connected between the binding post 10 and the resistor 13 and is composed of a plurality of units for which are provided the contacts C—0 to C—16. Additional contacts C—17, C—18 and C—19 are strapped to the contact C—16. A switch arm 16 is connected between the resistor 14 and the output terminal 11 and is designed to engage the contacts C—0 to C—19 and also a contact C—20 which is arranged after the contact C—19 and is unconnected to the resistance 15. A resistance 17 is connected at one end to the binding post 12 and is composed of a plurality of units for which are provided contacts C′—1 to C′—20. A switch arm 18 is designed to engage the contact C′—0 which is arranged ahead of the contact C′—1 but is unconnected to the resistance 17 and is also designed to engage the contacts C′—1 to C′—20, this switch arm being interconnected with the switch arm 16 for simultaneous movement therewith so that the two switch arms at all times engage corresponding contacts of the resistances 15 and 17.

Zero attenuation is obtained with the switch arms 16 and 18 respectively engaging the contacts C—0 and C′—0 in which condition the resistance 15 is short-circuited and the resistance 17 is opened. When the switch arms 16 and 18 engage contacts C—1 and C′—1 respectively, the first increment of attenuation is obtained and with this arrangement the network is of the bridge T type. Attenuation is increased by moving the switch arms 16 and 18 over the contacts and after the switch arm 16 engages the contact C—16, the network is controlled by the variations in resistance obtained in the shunt arm only. From contact C—16 to C—19, the condition of a bridge T type attenuator is maintained, but with no change in the value of the bridged resistance. The attenuator variation for the last three steps is effected solely by changing the resistance value in the shunt arm. The high value resistance units which would have been required for a standard bridge T type attenuator are thus obviated while the higher attenuator resistance units in the shunt arm all exceed one ohm in value.

In the attenuator just described, the resistors 13 and 14 are of rather high impedance, for example, 500 ohms and with resistors of this value, the resistances 15*c*, 15*b* and 15*a* are respectively approximately 2583 ohms, 3220 ohms and 4100 ohms, while the resistances 17*e*, 17*d*, 17*c*, 17*b* and 17*a* are respectively 4.40 ohms, 3.45 ohms, 5.63 ohms, 4.19 ohms and 3.06 ohms. With the standard bridge type attenuator, the resistance units between contacts C—16 to C—19 respectively will be of much higher value than 15*a* and the avoidance of these resistances simplifies the manufacture of the attenuator and reduce not only its cost but also its size.

In Fig. 2, 10, 11 and 12 again indicate the input, output and common terminals respectively. Also, 13 and 14 indicate resistors connected in series between the terminals 10 and 11. A resistance 15 has one end connected between the input terminal 10 and the resistor 13. This resistance is composed of a plurality of units for which are provided contacts C—0 to C—18. A pair of open contacts C—19 and C—20 are provided after the contacts C—18. A switch arm 16 adapted for engagement with the contacts C—0 to C—20 is connected between the resistor 14 and the terminal 11. A resistance 17 is connected at one end to the terminal 12 and is composed of a plurality of units for which are provided contacts C′—1 to C′—16 inclusive, C′—19 and C′—20. Contacts C′—17 and C′—18 are strapped between contact C′—16 and contact C′—19. A switch arm 18 designed to engage the contacts C′—0 to C′—20 is connected between the resistors 13 and 14 and is mechanically interconnected to the switch arm 16 for simultaneous movement therewith so that the two switch arms at all times engage corresponding contacts.

Zero attenuation is obtained with the switch arms 16 and 18 respectively engaging the contacts C—0 and C′—0 and the attenuation is increased by moving the switch arms over the contacts, the first increment of attenuation being effected with the switch arms engaging the contacts C—1 and C′—1 respectively. The network remains of the bridge T type until the switch arms are brought into engagement respectively with the contacts C—16 and C′—16, at which point the network is contacted into a π type attenuator in which the resistance 15 forms the top and the resistances 13 and 14 form the legs in series with that portion of the resistance 17 lying between the contacts C′—19 and C′—20. This condition is maintained while the switch arms are brought successively into engagement with the contacts C—16 to C—19 and C′—16 to C′—19. The small resistance units which would be required in a bridge T type network between the contacts C—16 and C—19 are obviated and the attenuator is compensated for by use of larger resistance units between contacts C—16 to C—19 than would be required in the bridge resistance of a bridge T type network.

In the attenuator of Fig. 2, the resistors 13 and 14 are of low impedance, for example, 15 ohms. With resistors of this value, the units 15*f*, 15*e* and 15*d* respectively are approximately 122 ohms, 495 ohms and 1985 ohms, while the resistance unit 17*f* is approximately 3.87 ohms. The resistances 15*d*, 15*e* and 15*f* while comparatively large are still considerably less than 5,000 ohms and are, therefore, easy to produce and of low manufacturing cost while the resistance 17*f* is of such size as also to present no manufacturing difficulty.

Fig. 3 discloses an embodiment of the invention in which the resistors 13 and 14 are of higher impedance, for example, 600 ohms. The resistance 15 consists of a series of 17 resistance units for which are provided contacts C—0 to C—17. Beyond contact C—17 are provided open contacts C—18 to C—30. The resistance 17 consists of a series of 14 resistance units for which are provided contacts C′—8 to C′—15 and a second series of 13 resistance units for which are provided contacts C′—18 to C′—30, there being contacts C′—16 and C′—17 strapped between contacts C′—15 and C′—18. Switch arms 16 and 18 are provided as in the other modifications for simultaneously engaging corresponding contacts. Minimum attenuation is obtained with the switch arms 16 and 18 respectively engaging the contacts C—0 and C′—0. Upon to step 15 there is no change from a standard bridge T attenuator. For the next three steps the network is in π form with the shunt resistance constant and the series arm varying in much larger value than would be required in a normal bridge T network. From step 17 to step 30, the bridged element is open so that 13 resistance windings are obviated and attenuation is controlled by adjustment of the shunt arm only. The units in the resistance 17 from contact C—18 to the terminal 12 form a logarithmic variation equivalent to potentiometer design to maintain equal increments in decibels. These units are of larger value than would be required in a standard bridge T and are therefore easier to manufacture. All told 16 resistors are obviated by the arrangement just described which permits the manufacture of a heretofore physically impossible thirty-step attenuator having the characteristics of a T network. When the attenuation is controlled by the shunt element, that is from step 18 to step 30, the two 600 ohm resistors form the series element of the attenuator and the resistance of the shunt element is not over 20 ohms. Under this condition, the impedance presented to the input or output terminals cannot exceed the commercial tolerance of 5%. In a standard bridge T, the bridged resistances for steps 18 to 30 would increase rapidly to approximately ¼ megohm while the shunt resistors would be less than one-half ohm for the last six steps. The resistance units 15*i*, 15*h*, and 15*g* respectively are approximately 3,919 ohms, 11,626 ohms and 31,000 ohms while the resistors 17*g* to 17*s* vary from 4.06 ohms to .235 ohm, all of which present no particular manufacturing problems.

In the attenuator illustrated in Figs. 1 and 2, engagement of the switch arms 16 and 18 with the contacts C—20 and C′—20 opens the resistance 15 and short-circuits the resistance 17 and the same condition exists in the attenuator of Fig. 3 when the switch arms 16 and 18 respectively engage the contact C—30 and C′—30. The attenuator of Fig. 2 becomes a straight T type when the switch arms 16 and 18 engage the contacts C—19 and C′—19 while the attenuator of Fig. 3 becomes a straight T type when the switch arms 16 and 18 engage any of the contacts from C—18 and C′—18 to C—30 and C′—30.

I claim:

1. In an attenuation network, a pair of fixed resistances connected in series, a third and a fourth resistance, an equal number of contacts associated with each of said third and fourth resistances, certain contacts of one of said third and fourth resistances being strapped together, and a pair of interconnected switch arms adapted to simultaneously engage corresponding contacts, said third resistance and its associated switch arm being bridged across said fixed resistances and the contact switch arm for said fourth resistance being connected between said fixed resistances.

2. In an attenuation network, a pair of fixed resistances connected in series, a third and a fourth resistance, an equal number of contacts associated with each of said third and fourth resistances, certain contacts of said third resistance being strapped together, and a pair of interconnected switch arms adapted to simultaneously engage corresponding contacts, said third resistance and its associated switch arm being bridged across said fixed resistances and the contact switch arm for said fourth resistance being connected between said fixed resistances.

3. In an attenuation network, a pair of fixed resistances connected in series, a third and a fourth resistance, an equal number of contacts associated with each of said third and fourth resistances, a plurality of contacts at one end of said third resistance being open and certain intermediate contacts of said fourth resistance being strapped together, and a pair of interconnected switch arms adapted to simultaneously engage corresponding contacts, said third resistance and its associated switch arm being bridged across said fixed resistances and the contact switch arm for said fourth resistance being connected between said fixed resistances.

4. In an attenuation network, a pair of fixed resistances connected in series, a third and a fourth resistance, contacts associated with each of said third and fourth resistances, a pair of switch arms interconnected for simultaneous movement to engage corresponding contacts of said third and fourth resistances, said third resistance and its associated switch arm being bridged across said fixed resistances and the contact switch arm for said fourth resistance being connected between said fixed resistances, said fourth resistance having a greater number of units than said third resistance whereby in certain high attenuation positions of said switch arms said third resistance is open, and said fourth resistance having zero resistance between certain intermediate contacts.

5. In an attenuation network, a pair of fixed resistances connected in series, a third and a fourth resistance, an equal number of contacts associated with each of said third and fourth resistances, certain contacts at the high attenuation end of one of said third and fourth resistances being strapped together, and a pair of interconnected switch arms adapted to simultaneously engage corresponding contacts, said third resistance and its associated switch arm being bridged across said fixed resistances and the contact switch arm for said fourth resistance being connected between said fixed resistances.

6. In an attenuation network, a pair of fixed resistances connected in series, a third and a fourth resistance, an equal number of contacts associated with each of said third and fourth resistances, certain contacts at the high attenuation end of said third resistance being strapped together, and a pair of interconnected switch arms adapted to simultaneously engage corresponding contacts, said third resistance and its associated switch arm being bridged across said fixed resistances and the contact switch arm for said fourth resistance being connected between said fixed resistances.

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