Jan. 22, 1935. G. VIARD 1,988,989

RETARDATION DEVICE

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Fig.1

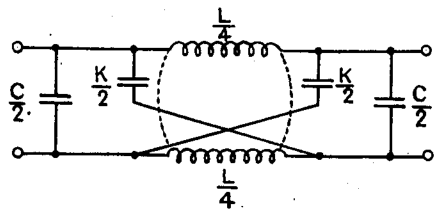

Fig.2

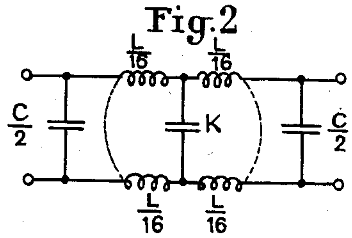

Fig.3

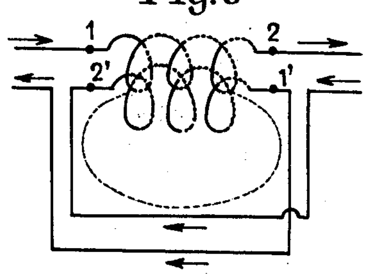

Fig.4

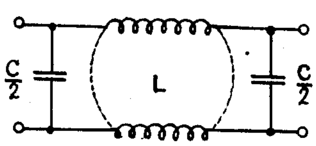

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Fig. 5

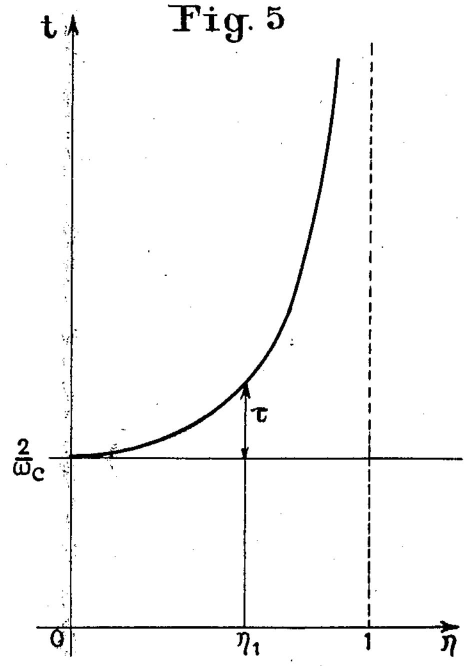
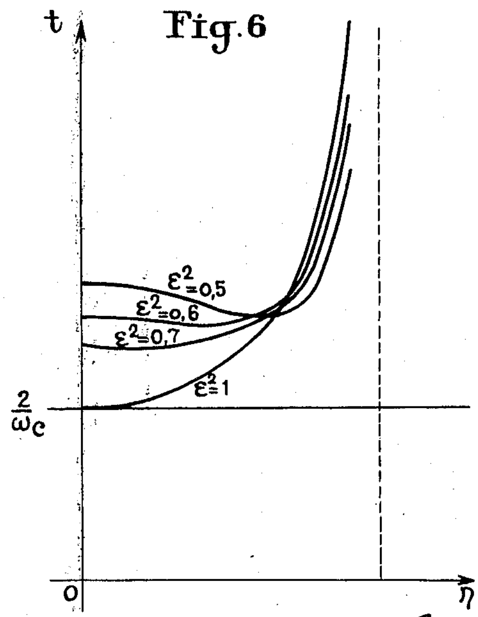


Fig. 6



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Patented Jan. 22, 1935

1,988,989

UNITED STATES PATENT OFFICE

1,988,989

RETARDATION DEVICE

Georges Viard, Paris, France, assignor to Lignes Telegraphiques et Telephoniques, Paris, France, a corporation of France

Application October 31, 1931, Serial No. 572,370
In France December 18, 1930

1 Claim. (Cl. 178—44)

The present invention relates to retardation devices for use in electrical transmission systems.

It is well-known that the operation of certain devices in transmission systems is sometimes controlled by the communication currents, and in this case, it is generally necessary to retard the subsequent transmission of these currents in order to permit the previous operation of the devices controlled.

The retardation devices usually employed comprise network sections composed of series connected inductance coils and shunt condensers. In order to obtain an appreciable retardation, it is necessary, however, to use a large number of these sections, which becomes very expensive.

The present invention has for object to overcome the above disadvantage and provide a new type of retardation section which allows of obtaining a much greater retardation than with the sections hitherto employed.

A second object of the invention is to provide a retardation section whereby the retardation of the current is, for a wide band of frequencies, independent of the frequency of the said current.

Other objects and advantages of the invention will be apparent from the description taken hereinafter with reference to the accompanying drawings, in which:

Figs. 1, 2 and 3 represent diagrammatically sections of retardation networks constructed according to the invention.

Fig. 4 represents the type of retardation section customarily employed hitherto.

Figs. 5 and 6 represent retardation curves of the network sections described with reference to Fig. 4 and Fig. 1 respectively.

With reference to Fig. 1, the quadripole section according to the invention is of the diagonal cross-connected type and is composed of series-connected inductances

$$\frac{L}{4}$$

cross-connected condensers

$$\frac{K}{2}$$

and two condensers

$$\frac{C}{2}$$

connected in shunt at the ends. The inductance is advantageously formed, in the style of a Pupin coil, by two windings wound round a core. In Fig. 2, the network section according to Fig. 1 is illustrated in its equivalent T form. Further, by a suitable arrangement of the two windings, the condensers placed in the diagonal branches may be replaced wholly or in part by the uniformly distributed capacity of the two windings; such a section is diagrammatically represented in Fig. 3. The end capacities

$$\frac{C}{2}$$

are not shown in this figure.

The artificial lines hitherto employed are composed of sections, one of which is illustrated in Fig. 4. The pulsatance corresponding to the cut-off frequency of this network section is:

$$\omega_c=\frac{2}{\sqrt{LC}}$$

and within the transmission band the phase constant per section is given by the equation:

$$\sin\frac{a}{2}=\frac{\omega}{\omega_c}$$

It is known, on the other hand, that the duration t of the propagation, (i. e., the retardation time) per section, is given by:

$$t=\frac{da}{d\omega}$$

that is, by taking:

$$\frac{\omega}{\omega_c}=\frac{2\pi f}{\omega_c}=\eta$$

$$t=\frac{da}{d\omega}=\frac{2}{\omega_c}\times\frac{1}{\sqrt{1-\eta^2}} \qquad (1)$$

The curve in Fig. 5 represents the graph of t as a function of η. From this curve, it is seen that for a frequency f_1 corresponding to η_1, the retardation time t is given by:

$$t=\frac{2}{\omega_c}\,\frac{1}{\sqrt{1-\eta^2_1}}$$

But the duration of the transients of the transmission system, which may be calculated by the formula:

$$\left(\frac{da}{d\omega_1}\right)-\left(\frac{da}{d\omega}\right)=a$$

minimum, (where $\omega_0=0$), has been increased y the quantity τ, where:

$$\tau=\frac{2}{\omega_c}\left[\frac{1}{\sqrt{1-\eta_1^2}}-1\right]$$

If N similar sections are used, the duration of the transients will be increased by $N\tau$.

This effect may be harmful for it is generally endeavoured, in transmission systems, to limit the duration of the transients as much as possible.

This detrimental effect can only be diminished by choosing for ω_c a higher value, which reduces η_1. But at the same time, the value of t is reduced. One is then led to increase the number N of the sections in order to retain the same retardation value.

It will be shown in the following that with sections constituted according to the present invention, the variation of the retardation with the frequency is rendered absolutely negligible for a considerably wider band of frequencies than was possible with the section illustrated in Fig. 4. The duration of the transients is therefore increased only by a negligible quantity. Moreover, the constant value of the retardation for the sections proposed is considerably higher than the minimum value of the retardation obtained with ordinary sections having the same cut-off frequency.

The phase constant of the section shown in Fig. 1 is given by the equation:

$$a=\cos^{-1}\left[1-\frac{1}{2}\frac{\omega^2L(K+C)}{1+\frac{KL\omega^2}{4}}\right]$$

or:

$$\sin\frac{a}{2}=\frac{1}{2}\frac{\omega\sqrt{L(K+C)}}{\sqrt{1+\frac{KL\omega^2}{4}}} \qquad (2)$$

It is deduced from this Equation (2) that the pulsatance corresponding to the cut-off frequency of the section is:

$$\omega_0=\frac{2}{\sqrt{LC}}$$

as for the section of Fig. 4.

If we put:

$$K+C=\frac{C}{\epsilon^2}\text{ or } K=C\left(\frac{1}{\epsilon^2}-1\right)$$

and

$$\frac{\omega}{\omega_0}=\eta$$

the Equation (2) becomes:

$$\sin\frac{a}{2}=\frac{\eta}{\sqrt{\epsilon^2+\eta^2(1-\epsilon^2)}} \qquad (2')$$

The retardation time t is given, from Equations (1) and (2'), by:

$$t=\frac{da}{d\varpi}=\frac{2}{\varpi_c}\times\frac{1}{\sqrt{1-\eta^2}}\times\frac{\epsilon}{\epsilon^2+\eta^2\,(1-\epsilon^2)}$$

In Fig. 6 t is plotted against η for several values of ϵ^2. It is seen that for ϵ^2 approximate to 0.6, which corresponds to:

$$K=\frac{2}{3}C$$

the retardation time varies but very slightly with the frequency for a wide frequency band, hence there is but a very slight increase of the duration of the transients. Moreover, the constant value of retardation is considerably increased in comparison with the curve $\epsilon^2=1$, which corresponds to the value $K=0$, that is to say therefore, in comparison with the section of ordinary line illustrated in Fig. 4 and having the same cut-off frequency. For $\epsilon^2=0.6$, the increase is about 30%. To obtain a pre-determined retardation without increasing the duration of the transients by too large a quantity, a much smaller number of sections will thus be necessary, by employing the present invention, than would be the case with an artificial line constituted from sections such as that of Fig. 4.

On the other hand, the new network sections according to the invention having but a single inductance, like ordinary sections, their cost will not be appreciably higher.

I claim:—

An electric retardation network section consisting essentially of a network of the diagonal cross-connected type having inductances in the series branches and capacities in the shunt branches thereof, and capacities shunted across the ends of said network, said inductances and capacities being proportioned such that the pulsatance corresponding to the cut-off frequency of the section is the same as that of a simple series-shunt type network having the same cut-off frequency and the capacity in each diagonal of said cross-connected network is approximately equal to 0.6 times the value of the capacity shunted across an end of the said network.

GEORGES VIARD.