Nov. 8, 1938. E. K. VAN TASSEL 2,135,609

LOADED TRANSMISSION LINE

Filed Aug. 27, 1936

FIG. 1

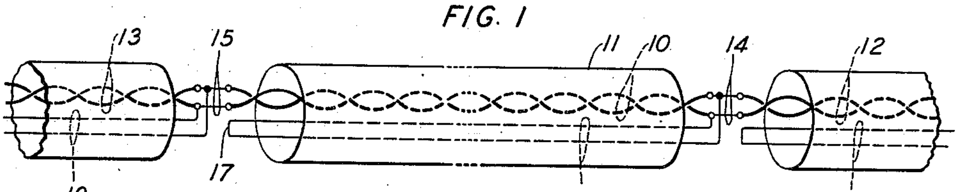
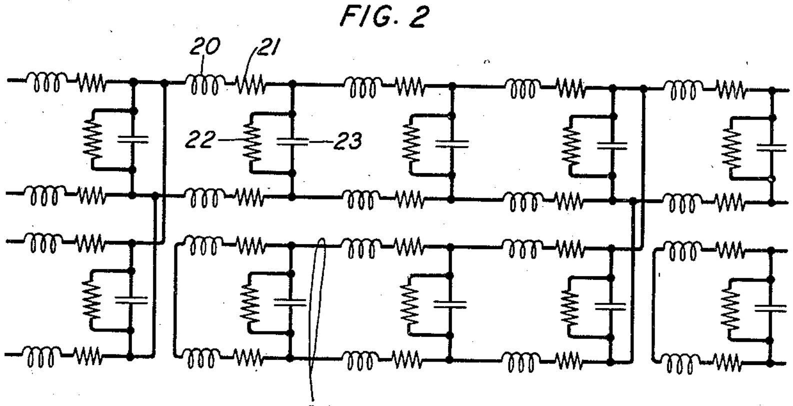


FIG. 2



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LOADED TRANSMISSION LINE

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6 Claims. (Cl. 178—45)

This invention relates to electrical transmission lines and particularly to means for loading such lines.

It is known that the transmission characteristics of a line may be improved by providing loading such as leakage paths between the conductors of the line at intervals along its length. The amount of leakage to be provided depends upon the spacing of the paths, the top frequency to be transmitted, and the chosen compromise between perfect transmission and perfect temperature correction. One method of providing these leakage paths consists in inserting shunt resistances at the proper points along a line. Since these resistances are placed at particular points along a line they are not affected by the same temperature variations as the remainder of the line and hence their compensating effects are not accurate. This means that the transmission loss at any given frequency cannot be accurately predicted and hence the signal might be distorted.

The object of this invention is to provide improved loading for a transmission line.

In its preferred form this invention comprises a loop of resistance wire connected across the line and distributed throughout the cable so that it is subjected to the same temperature variations as the cable itself. These loops may be of any length, but it is preferred that they be of the same length as a reel of cable. A transmission line incorporating this invention, therefore, may consist of pairs of wires connected together at each splicing of a reel and connected across the transmission pair at the opposite end of each reel.

In the drawing which accompanies this specification and forms a part thereof, Fig. 1 shows how the novel loading may be applied to a cable and Fig. 2 shows an equivalent transmission network.

Referring now to Fig. 1, 10 is a pair of conductors forming a transmission line. This pair may be one of several hundred incorporated in a single cable. Transmission pair 10 may be twisted to provide a certain amount of inductive loading as is customary in such construction. Since transmission lines are made up, in general, of a number of relatively small sections, i. e., of a number of reels, these sections must be spliced at intervals to form a continuous line. Two sections, 12 and 13, are shown spliced to transmission pair 10 at 14 and 15 respectively. Within cable sheath 11 is also included a pair of resistance wires 16, the resistance-temperature coefficient of which is the same as that of transmission pair 10. Resistance pair 16 is connected across transmission pair 10 at the cable splice 14 and the opposite end 17 is short-circuited. Transmission pairs 12 and 13 likewise are shunted by resistance pairs 18 and 19 respectively.

Since the resistance wire is distributed throughout the cable instead of being wound on the customary support and located approximately at one point, it is subjected to exactly the same temperature variation as the transmission pair and hence temperature effects upon the transmission characteristics of the cable may be eliminated. This, however, is predicated upon the assumtion that a resistance wire is available which has the correct resistance value for the length employed and at the same time has the same resistance temperature coefficient as the transmission pair. If such a wire is not available, a compromise must be made. It will be necessary to choose between a perfect transmission characteristic and a good temperature correction on one hand, and a perfect temperature correction and a nearly flat transmission characteristic on the other. It is of course possible to obtain compromises between these two extremes.

If desired, the resistance pairs may be incorporated in a separate cable located adjacent the transmission line.

The equivalent transmission network for the loaded cable of Fig. 1 is shown in Fig. 2. It may be considered as a balanced line having series inductances 20 and resistances 21 and shunt resistances 22 and capacitances 23. The resistance loading may be considered to be a similar network 24 shunted across the line at predetermined intervals. For a complete discussion of such networks reference may be made to K. S. Johnson's book entitled "Transmission Circuits for Telephonic Communication", Van Nostrand Company, 1924.

As an illustration of the application of this invention to a specific cable construction, a resistance of 105 ohms at 1° F. having the same temperature coefficient as a 16 gauge pair commonly used for transmission, and shunted across such a pair at 18,000 foot intervals, will result in a practically constant transmission loss for frequencies from 0 to 8,000 cycles. In addition to this leveling effect upon the transmission loss, changes in the loss due to temperature changes in the medium surrounding the transmission pair and shunt will be materially reduced. If it is desired to maintain the same transmission loss for frequencies above 8,000 cycles, it is necessary to increase the resistance of the shunt and decrease the distance between shunts. For example, spacings of 3,000 feet would result in maintaining a substantially constant loss for a frequency range of 0 to 60,000 cycles, and a still further reduction in spacing, such as one shunt of 3,850 ohms at 1° F. for each reel length, i. e., about 500 feet, would extend the upper limit to about 200,000 cycles.

Thus from the design shown in Fig. 1, it is apparent that the load resistances are in the same thermal medium as the transmission line and hence will follow very closely the temperature variations in the line. In addition to this desirable feature, the resistance pair will have a smooth impedance characteristic which may be changed by altering the position of the wires in the cable. A flatter frequency characteristic will result by making the impedance slightly inductive. This system of loading approaches very closely the ideal continuous loading and results in cheaper cable carrier systems since smaller repeaters may be used. Its applicability is not limited to long lines for message and broad band systems, but it may be used for short local circuits designed for any wide band transmission, and when so used, greatly reduces phase distortion, the equalization necessary and the effect of temperature on the overall transmission.

It is understood that the foregoing description is merely illustrative of the invention and that the scope of the invention is not to be determined thereby, but by the appended claims.

What is claimed is:

1. A transmission line comprising a cable, a sheathing therefor, and shunt resistances within the sheathing for loading said line, said resistances comprising wires which extend substantially the entire length of the cable between points of connection to the line.

2. A transmission system comprising a plurality of reel lengths of cable spliced together, each reel length of cable including a reel length of line and a pair of resistance wires having substantially the same resistance-temperature coefficient as the line, the wires of said pair being connected together at one end of the reel length of cable and connected across the line at the opposite end of the reel length of cable to form a shunt resistance load which is coextensive with the reel length of line and subject to the same temperature variations as the reel length of line.

3. A transmission line comprising a plurality of spliced lengths of four-wire lead, each length comprising two parallel conductors of good conductivity and one loop conductor of low conductivity, said loop conductor permanently connected across the said parallel conductors at one end of said lengths, and the temperature-conductivity characteristic of said loop adapted to provide loading for said parallel conductors.

4. A transmission line comprising a plurality of spliced lengths of four-wire lead, each length comprising two parallel relatively high conductivity conductors and one pair of relatively low conductivity conductors permanently connected together at one end to form a loop conductor, the temperature-conductivity characteristic of said loop adapted to provide loading for said parallel conductors, and the said loop permanently connected across said parallel conductors so as to provide equally spaced loads along said transmission line.

5. A wide frequency range transmission system comprising a plurality of spliced equivalent cable lengths each comprising a cable sheath enclosing one or more transmission lines laid up together with an equal number of loops of resistance wire coextensive with said transmission lines, the ends of each of said resistance wire loops permanently connected across its associated transmission line and the specific resistivity and resistance-temperature coefficient of each of said resistance wire loops adapted to provide compromise loading means for its associated transmission line throughout the designed range of operating temperatures and of frequency transmission of said transmission line.

6. A transmission line comprising a plurality of equal lengths of four conductor leads, one pair of said leads of higher conductivity and spliced length to length to form the main channel of the transmission line, the other low conductivity pair cross-connected at one end of said length to form a loop and at the other end connected in shunt across said high conductivity pair so that at each splice of the high conductivity pair there is shunted the loop of the low couductivity pair, and the temperature resistance coefficient of the low conductivity loop substantially equivalent to the temperature resistance coefficient of the high conductivity pair.

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