

UNITED STATES PATENT OFFICE.

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METHOD AND APPARATUS FOR TRANSMITTING SIGNALS.

Application filed January 16, 1920. Serial No. 351,898.

To all whom it may concern:

Be it known that I, GUSTAF W. ELMEN, a citizen of the United States, residing at Leonia, in the county of Bergen, State of New Jersey, have invented certain new and useful Improvements in Methods and Apparatus for Transmitting Signals, of which the following is a full, clear, concise, and exact description.

This invention relates to transmission systems and has particular reference to those which are loaded.

In systems which involve loaded circuits in which either loading coils or continuous loading are used, the effective resistance introduced in these circuits due to the energy loss in the magnetic material used for loading forms a limitation of these loaded circuits. This loss generally consists of two components, one due to hysteresis and the other due to eddy currents. The effective resistance due to the hysteresis loss depends on the quality of the magnetic material and prior to this invention it has not been possible to reduce this loss below a certain value. On this account, the effective resistance in the present iron dust-core coils due to the eddy currents may be about 16% of the total loss, whereas that due to the hysteresis may be about 84% at a frequency of 1,000 cycles per second. It is therefore very desirable to obtain some method by which the hysteresis loss can be reduced.

The object of this invention is to reduce the above mentioned hysteresis loss of loading coils and loaded circuits.

Another object is to apply the means for so reducing hysteresis in a manner which makes the invention effectively adaptable to circuits now in use.

My invention in general comprises the application to a loaded circuit of a frequency several times higher in value than the frequency of those currents which are used for transmitting the signals. If it is desired to apply this invention to a carrier wave system, the high frequency applied in accordance with my invention is determined as several times the value of the carrier frequency. For example, assuming voice frequencies to be of an average value of 1,000 and carrier wave frequency to be a value of 10,000, then the high frequency which should be used in accordance with my invention would be in the neighborhood

of 30,000 cycles. That is, the high frequency current for reducing the hysteresis should preferably be of a frequency several times the highest frequency of the signaling currents.

The broad principle of my invention is set forth in the copending application Serial No. 227,564, filed April 9, 1918, G. W. Elmen and Carl F. Ort, entitled "Method and systems for employing variable currents," and United States Patent No. 1,470,965, granted October 16, 1923, to G. W. Elmen, entitled "Transmission systems." In these applications it has been set forth at some length that when a magnetic core is influenced by the impression thereon of a signal-transmitting frequency, the hysteresis losses in the core are reduced by the application thereto of a higher frequency which carries the work of hysteresis and permits the lower frequency to more efficiently transmit signals.

The invention is illustrated in the drawing in which Fig. 1 shows a circuit in which the high frequency is separately applied to each set of loading coils; Fig. 2 shows a circuit in which each set of loading coils is influenced by the high frequency supplied from one source; Fig. 3 shows a circuit in which the high frequency winding is so disposed on the system of loading coils as to prevent the transmission of the high frequency over the signal wires; Fig. 4 shows a type of loading coil in which the high frequency flux will be disposed substantially at right-angles to the signal transmitting flux; and Fig. 5 illustrates this invention applied to a system which is continuously loaded.

In Fig. 1, a plurality of loading coils, 1, 2 and 3, are shown and represent the loading coils at any particular point in the circuits 20—21, 30—31 and 40—41, over which signal currents are to be transmitted. The wires of the above mentioned circuits are wound around their corresponding loading coils in the form of coils 22—23, 32—33 and 42—43. A generator 24 supplies high frequency current to leads 25—26 and these leads are connected to windings 27, 28, 29, 34, 35 and 36 on loading coils 1, 2 and 3. The invention resides in the particular manner of applying a high frequency to a set of loading coils of such a value that it is several times the frequency value of the transmit-

ting currents and takes over the burden of the hysteresis energy permitting the signal carrying currents to be transmitted more effectively. The high frequency windings shown in this figure are cumulatively wound with respect to the signal transmitting windings. In accordance with the application of the invention shown in Fig. 1, a separate circuit and generator will be required at each loading station.

In Fig. 2, the invention is shown in a modified form in which the high frequency windings of the various cores are supplied from one current source. In this figure loading coils 50 to 53, and 54 to 57 inclusive represent two sets of loading coils in a system which may contain many more similar sets. These cores are provided with signal transmitting windings 58, 59 and high frequency windings 60 and 61. The high frequency windings are connected to circuit wires 62 and 63 which may be connected to a source of high frequency at some suitable point, preferably the point where the transmitting frequencies are applied. It will be noted that in this figure, the high frequency windings are wound cumulatively in a manner similar to the high frequency windings shown in Fig. 1.

In Fig. 3, a single loading coil station is shown in which each loading coil is comprised of two separate cores, 64 and 65, each core having transmitting windings 66, 67, 68 and 69 and high frequency windings 70, 71, 72 and 73. The high frequency windings are connected to circuit wires 74 and 75 which may be connected to a suitable source of high frequency at any desired point. The distinction between the previous figures and Fig. 3, resides in the fact that each loading coil is composed of two separate magnetic cores and the high frequency windings on one core are wound in a direction opposite to that in which they are wound on the other core. This arrangement is so that, when desired, the high frequencies may be prevented from getting into the transmitting circuit. This idea in its broad aspects is shown in the above mentioned Elmen-Ort application.

Fig. 4 shows a loading coil having a core comprising two annular flat ring portions 80 and 81 which may be composed of compressed iron dust. Wound annularly in a flat spiral between these ring portions 80 and 81 are the windings 82 of the circuit wires 83 and 84 adapted to carry the high frequency. Windings 85 and 86 are the windings which carry the signal transmitting currents. It will be noted that these windings are wound in such a way as to produce fluxes which will be disposed in planes separated by an angle of substantially 90 degrees. It is found that by using a core of this structure, the high frequency

affects the magnetic core to efficiently eliminate hysteresis and at the same time because of its angular relation of this other flux, it is prevented from being transmitted to the signal carrying circuits.

Although Figs. 1 to 4 of the drawings show the application of what might be called a hysteresis absorption frequency to loading coils, it is clear and well within the scope of my invention to apply such a frequency to a continuously loaded circuit which does not necessarily contain loading coils. Such a circuit would be shown by Fig. 2, if the loading coils were not in the circuit. In this case the invention would merely comprise the application to the circuit wires at any desired point of the high frequency which would be transmitted over the same line wires with the other frequencies and would effectively eliminate hysteresis. This modification is illustrated in Fig. 5 in which a continuously loaded transmission line 90 is supplied through a transformer 91 with a frequency from a source 92 higher than the frequencies employed over line 90 for signaling purposes.

It has been found, by the application of these arrangements to loading coils and loaded circuits, that the hysteretic losses which are generally encountered in such coils and circuits are substantially eliminated.

What is claimed is:

1. A transmission system comprising a circuit wire for carrying signaling current, a loading coil attached to said circuit wire for reducing the attenuation of said signaling currents along said wire, means for applying signaling current to said wire, and means for reducing the hysteresis loss on said loading coil comprising means for applying a high frequency to said loading coil, said frequency having a value greater than any other frequency on the circuit wire.
2. A transmission system comprising a circuit wire adapted to carry a signal transmitting frequency, a loading coil associated with said circuit wire for reducing the attenuation of said signals over said circuit, and means for reducing the effective resistance of said loading coil comprising a high frequency circuit wire coextensive with the signal transmitting circuit wire and adapted to be associated with the coil.
3. A loading coil for reducing the attenuation of a signaling line comprising a magnetic core, a plurality of coils thereon adapted to carry a signal transmitting frequency, means for applying signaling frequencies to said coils, another coil thereon, and means for supplying to this last mentioned coil a frequency greater in value than the signal transmitting frequency.
4. A transmission system comprising a circuit wire, an inductance coil for loading said circuit wire, and designed to reduce attenua-

tion, and means for transmitting signaling currents through said coil without substantial loss due to hysteresis.

5 5. The method which comprises supplying the magnetic losses in the core of a loading coil designed to reduce attenuation from a source of current other than the signaling current.

10 6. The method which comprises supplying the magnetic losses in a line loaded with inductance coils designed to reduce attenuation from a source of current other than the signaling current subjected to such loss.

7. In combination, a transmission line, means for supplying signaling currents to said line, means for loading said line for reducing the attenuation thereof, and means for reducing the hysteresis loss of said loading means comprising means for supplying to said line, currents of a frequency greater than the frequency used in signaling over said line. 15 20

In witness whereof, I hereunto subscribe my name this 14th day of January A. D., 1920.

GUSTAF W. ELMEN.