A high-voltage power transmission line in the form of a hollow tubular conductor which serves as a conduit for a high-intensity light beam modulated with data having security requirements. The high voltage of the power line effectively precludes unauthorized access to the data carried by the light beam enclosed therewith.

10 Claims, 2 Drawing Figures
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DUAL PURPOSE TRANSMISSION LINE

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefore.

BACKGROUND OF THE INVENTION

It is becoming increasingly difficult to transfer confidential information from one place to another with assurance that it can not be (or has not been) compromised. Papers may be intercepted and copied, telegraph and telephone wires may be tapped, and radio and television broadcasts may be monitored. Coding of the data is only temporarily successful, since all codes can eventually be broken. Consequently, some method whereby secrecy of the material being conveyed can be assured will find widespread utilization.

A large part of the civilized world is covered by a network of transmission lines connecting power-generating plants to the ultimate consumer. These lines are usually high-voltage cables strung on towers and suspended by insulators. When energized, it is extremely hazardous for an individual to approach within several feet of such a line, and of course direct contact usually causes a fatal shock. Such conductors would consequently serve admirably for the transmission of confidential data, but unfortunately such a supplemental use has not been practicable due to the magnitude of the voltages present on the line as well as to the technical difficulty of working with the high power levels encountered.

A recent development in the communications field has been the discovery that light may be transmitted through solid materials for considerable distances and in other than straight lines. Such a transmitting material may be in the form of a flexible rod, and in many cases a number of such rods are assembled in a bundle, with the intensity of the light carried through each individual being independent of the amount of light being transmitted by each remaining rod. This light-transmission technique has been termed "fiber-optics," and in practice has been found to involve a fairly low loss factor. However, it is obvious that any modulation of the transmitted light by an intelligence signal is readily detectable by an individual having access to the transmission medium at any point therealong.

SUMMARY OF THE INVENTION

The present concept combines the data-transmission advantages realized from the modulation of a high-density light beam with the security against unauthorized data appropriation afforded by the presence of a high-voltage power transmission line. In a preferred embodiment, the latter is in the form of a hollow tubular conductor, and the light beam passes therethrough between the points of data transmission and reception. No access to the data modulation in the light beam can be obtained without breaking into the tubular conductor, and such action would in all likelihood result in certain injury or death to any individual making the attempt. Since presently installed power transmission lines can readily utilize hollow tubular conductors, the expense of a change-over is minimal in view of the extra benefits derived therefrom.

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STATEMENT OF THE OBJECTS OF THE INVENTION

One object of the present invention, therefore, is to provide a dual-purpose line for transmitting both electrical power and intelligence signals.

Another object of the invention is to provide a high-power transmission line over which messages may be sent without danger of unauthorized appropriation.

A further object of the invention is to provide a power transmission line in the form of a hollow tubular conductor capable of passing a high-intensity light beam therethrough, such light beam being modulated by an intelligence signal.

Other objects, advantages, and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a portion of an air-filled power transmission line designed to enclose a high-intensity light beam therewith; and
FIG. 2 is a sectional view of a power line enclosing a fiber-optics bundle, and incorporating one suitable means for boosting or amplifying the transmitted light beam to a higher level of intensity.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 of the drawings is illustrated a preferred embodiment of the present concept in the form of a section of a high-power transmission line designed to operate at a level of approximately 300,000 volts or above. This line section comprises a hollow tubular conductor 10 having a highly reflective inner surface 12. The latter is desirable in order that the conductor 10 pass therethrough a light beam 14 with a minimum of attenuation. Although the conductor 10 is illustrated in FIG. 1 of the drawings as being filled with air, it is within the scope of the present concept to utilize other gases (either pressurized or not, as may be desired) or to substitute therefor some solid light-conducting substance, such as the fiber-optics bundle 16 shown in FIG. 2.

The conductor 10 is designed to transmit in customary fashion power supplied thereto over a connection 18 from a generating source (not shown) to a utilization device 20. In accordance with the invention, this same conductor 10 is also employed to transmit the output of a data-modulated light source 21 to a detector and demodulator 22 at some receiving station, where the demodulated data is supplied to a suitable reproducing device (not shown).

Either the air-filled conductor of FIG. 1 or the fiber-optics bundle of FIG. 2 may be utilized as the light-transmission medium, depending to some extent on the nature and intensity of the particular light source 21 employed. Alternatively, a partial vacuum may be established within the hollow conductor 10 if the efficiency of transmission is found to be increased by such an expedient. In any event, one or more "booster" units may be needed if the data-modulated light is to be conveyed over any appreciable distance. One design for such a light-amplifying unit is illustrated in FIG. 2 and identified by the reference numeral 24.
The unit 24 is made up of an annular sleeve 26 joining two spaced-apart sections of the power transmission line 10, this sleeve being composed of material having sufficient electrical resistance such that a voltage drop is established between the two points designated as A and B in FIG. 2 of the drawings due to current flow in the line.

A pair of electrically conductive rings 28 and 30 support therebetween an instrument package composed of a light detector 32, an amplifier and modulator 34, and a high-intensity light source 36, the ring 28 being located approximately at point A and the ring 30 being located approximately at point B. Operating power for each of the units 32, 34 and 36 is derived from the voltage drop between the rings 28 and 30, and supplied to the units over a pair of conductors 38 and 40, as shown.

The light detector 32 receives light arriving thereto from the source 21 through the fiber-optics bundle 16. It demodulates such light, which demodulated energy is amplified by the unit 34 and employed to modulate the high-intensity light source 36. The output of the latter is fed into the following section of the fiber-optics bundle 16 at a higher intensity than that possessed by the light arriving at the detector 32.

Obviously any necessary number of amplifying units 24 may be employed, depending at least in part on the distance over which the data is to be conveyed to the detector 22 at the receiving station. The high voltages and currents in the power line are affected only to a slight degree by the energy loss caused by the unit 24.

Although any suitable high-intensity light source may be employed for the unit 21 (as well as for the booster source 36) it has been found that light produced by a laser possesses unusually desirable qualities in that it is both coherent and monochromatic, suffering very little attenuation even when transmitted over considerable distances. It will thus be preferred in many cases for carrying out the objectives of the present concept.

Although the power line conductor 10 should be oriented as linearly as practicable to minimize internal reflections and consequent light attenuation, it is possible at or near the terminal receiver to bend the conductor through an angle approaching 90°. In such cases a clamp of the type identified by the reference numeral 42 in FIG. 2 may be found useful. This is entirely optional, however, and in most instances will be neither necessary nor desirable.

Where laser light is transmitted by the invention arrangement, it is possible to increase the intensity thereof at spaced-apart points along the power line by means of compact amplifying units of a type such as disclosed on page 134 of the book "The Laser" by W. V. Smith and P. P. Sorokin (McGraw Hill, 1966). However, this is merely exemplary of the many different expedients that can be resorted to in order to minimize loss of data by light diminution.

Where a number of high-power transmission lines are arranged in closely spaced parallel relationship and bear a given phase relationship to one another, power may be derived at any point therealong by means of a jumper interconnecting any two of the lines. This obviates the necessity of developing an IR drop between the two points A and B in FIG. 2 of the drawings.

I claim:
1. A system for according to a high-power transmission line the added capability of conveying confidential data between any two points therealong with assurance that the data so conveyed has not been or will not be compromised, the combination of:
a high-power transmission line in the form of a hollow tubular conductor;
a source of optical energy modulated with confidential data to be conveyed from a first point along said high-power transmission line to a second point along such line;
means for injecting modulated optical energy from said source into said power transmission line at said first point, said optical energy being conveyed through said hollow tubular conductor to said second point;
means at said second point for receiving and detecting the optical energy arriving at such point;
the high power of said transmission line acting to preclude unauthorized access to the said optical energy as it is conveyed within said hollow tubular conductor between said two points.
2. A system according to claim 1 in which said hollow tubular conductor is filled with air.
3. A system according to claim 1 in which said hollow tubular conductor is filled with a gas other than air.
4. A system according to claim 1 in which said hollow tubular conductor encloses a fiber optics bundle.
5. A system according to claim 1 in which the inner surface of said hollow tubular conductor is highly reflective to optical energy.
6. A system according to claim 1 in which at least one light-amplifying unit is enclosed within said hollow tubular conductor between said two points.
7. A system according to claim 1 in which each light-amplifying unit includes means for detecting and demodulating the light arriving at such unit through said fiber optics bundle, means for amplifying the light so detected and demodulated, a source of high-intensity light, means for applying the output of said amplifying means to modulate the high-intensity light output of said source, and means for returning the modulated high-intensity light to said fiber optics bundle to continue its passage to said second point.
8. The combination of claim 7 in which the energy required to operate each said light amplifying unit is derived from the said high-power transmission line within which such unit is enclosed.
9. The combination of claim 8 in which the energy required to operate each said light-amplifying unit is derived from an IR drop developed between two spaced-apart connections to said high-power transmission line.
10. A system according to claim 6 in which said source of optical energy is a laser, and in which each light-amplifying unit comprises a laser amplifier.

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