United States Patent [19]

Ikrath et al.

[11] **3,902,118**

[45] **Aug. 26, 1975**

[54] **BODY-COUPLED PORTABLE TRANSMITTER**

[75] Inventors: **Kurt Ikrath**, Elberon; **William Kennebeck**, Eatontown, both of N.J.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

[22] Filed: **Apr. 4, 1974**

[21] Appl. No.: **457,869**

[52] **U.S. Cl.** **325/118;** 343/718; 343/868

[51] **Int. Cl.**[2] **H04B 1/034;** H01Q 1/12

[58] **Field of Search** 325/118, 178, 179; 343/718, 895, 720, 842, 866, 867, 868, 908

[56] **References Cited**

UNITED STATES PATENTS

1,993,436	3/1935	Eberhard	325/118
2,255,897	9/1941	Rebori et al.	343/720
2,810,068	10/1957	Weisz et al.	325/118
3,646,562	2/1972	Acker et al.	343/895

FOREIGN PATENTS OR APPLICATIONS

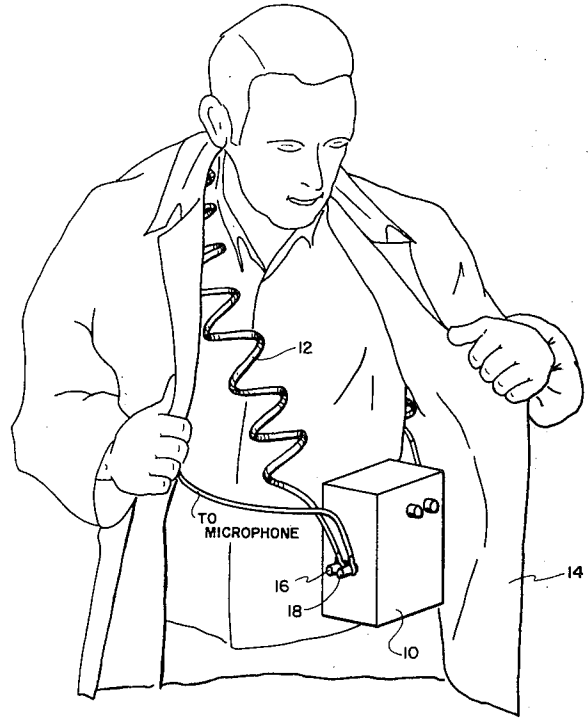
110,364	8/1928	Austria	343/718

Primary Examiner—George H. Libman
Attorney, Agent, or Firm—Nathan Edelberg; Robert P. Gibson; Arthur L. Bowers

[57] **ABSTRACT**

A body-coupled portable radio transmitter to be worn camouflaged, at about waist level, in the manner of a shoulder bag, under a covering outer garment, and depending from a resilient flexible open coil for coupling RF output of the transmitter to the body to be radiated by the body, the coil diameter being small enough for the coil to be worn under the garment and there being a sufficient number of turns in the coil to be tunable in place on the wearer, the combination with the transmitter being operable at average output power on the order of 1 watt, which is low enough not to be hazardous to the health of the wearer while having good signal-to-noise ratio, in a frequency band high enough for good radiation efficiency, i.e. above 3MHz, but not so high as to introduce health hazards to the wearer, i.e. below 40MHz, and operable with radiation efficiency greater than that of the same transmitter equipped with a whip antenna operated at the same average power and frequency when positioned next to the same person where the whip antenna does not extend above the head of the wearer so as not to be visible.

3 Claims, 6 Drawing Figures



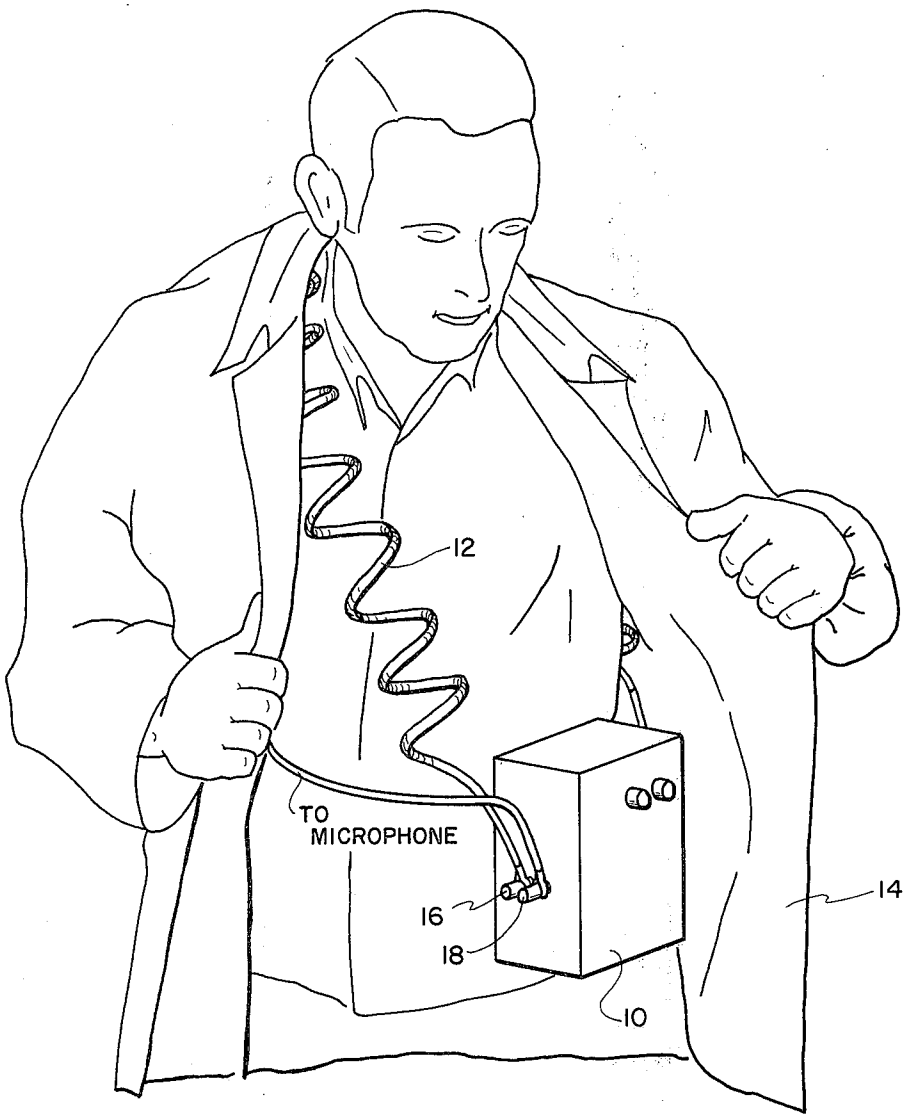


FIG. 1

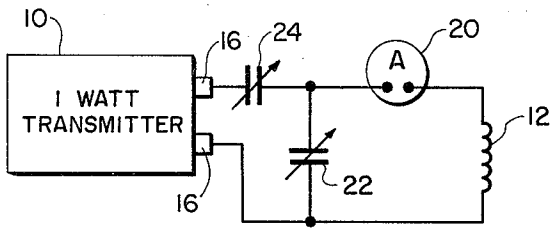


FIG. 2

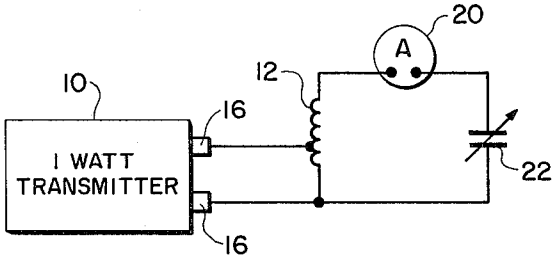


FIG. 3

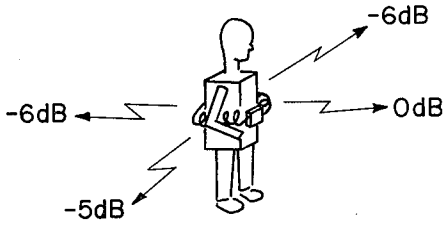


FIG. 4

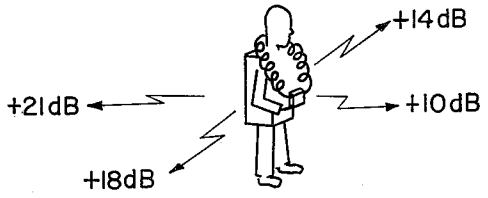


FIG. 5

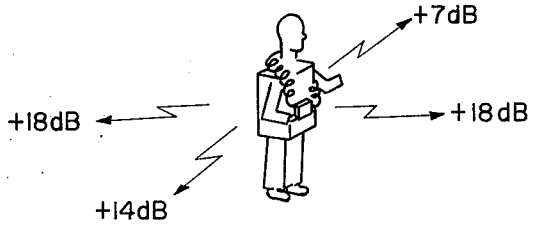


FIG. 6

BODY-COUPLED PORTABLE TRANSMITTER

BACKGROUND OF THE INVENTION

In military on-the-ground operations, a radio operator on foot carrying a manpack radio equipped with a waving whip antenna is more likely to be a target. There have been efforts directed toward eliminating the highly visible whip without sacrificing communication function. These efforts included rod or dipole antenna means sewn into or worn under an outer garment, but much or nearly all of the transmitter output was absorbed by the body of the wearer. Not only were such efforts unsuccessful but the RF absorption heightened awareness of potential hazard of body coupling a radio transmitter to the radio operator. In an inhomogeneous electromagnetic field, dissipative eddy currents that are of vastly differing relative intensities are generated in the various inside body tissues. Resistivities of human body tissues and organs vary as follows: for vascular tissues it is about 100 ohm-cm, for bone tissues it is about 800 ohm-cm, for fat tissue it is about 5000 ohm-cm, for epidermis it is about 5000 ohm-cm. If the human body is in an electromagnetic field that induces currents in the body, the distribution and the intensities of induced eddy currents and electromagnetic force fields inside the body are governed by the locations of the different kinds of tissues relative to the applied electromagnetic field configuration and to the frequency. As frequency is increased, particularly above about 40MHz, there is increased risk of local hot spots in one or more sites in the body that might result in tissue damage at those hot spots. Some degree of electrodiathermy of the radio operator is unavoidable when his body is enlisted for antenna function. However, electromedical therapy information indicates that 1 watt long-time average absorption by the body will not cause tissue deterioration, particularly below 40MHz.

The inventor is coinventor in U.S. Pat. No. 3,646,562 wherein there is disclosed a technique of impressing a tree into service as an antenna to overcome obstruction by surrounding jungle vegetation to radio communication via whip antenna. A coupling coil is supported around a tree trunk. However, a coupling coil worn by a person around his midsection does not work because it has been demonstrated that the midsection functions as a lossy core absorbing essentially all the energy coupled to the body by the coil.

SUMMARY OF THE INVENTION

In this invention a portable transmitter conventionally equipped with a whip antenna has its whip antenna replaced by an open, resilient, flexible body-coupling coil of sufficiently small diameter so that it can be worn under a loose fitting jacket and not be noticeable and that has sufficient turns so that it is tunable in place on a person in a desired frequency band that is between the limits 3MHz and 40MHz when fed by the transmitter and that is strong enough to support the transmitter near the waist, at one side, from the opposite shoulder. Capacitor tuning means is connected to the coil. Below 3MHz it has been determined that radiation efficiency is too low to be practical though there is some electromagnetic radiation down to a frequency below 2MHz; cutoff frequency is related to the person and to other parameters. Above 40MHz there are hazards of localized excessive current densities and resultant hot spots

in one or more sites inside the body. In addition to limiting frequency, power is limited to 1 watt average for continuous long-term operation for the safety of the radio operator. Though the transmitter may be operated with average power considerably lower than 1 watt to further limit electrodiathermy, signal-to-noise becomes too poor and interference becomes too pronounced as the power is reduced.

DESCRIPTION OF THE FIGURES

FIG. 1 shows part of a person in outline wearing an embodiment of the invention under a loosely fitting outer garment;

FIGS. 2 and 3 are circuit diagrams to illustrate the means for coil tuning; and

FIGS. 4, 5 and 6 are sketches showing three different orientations of coupling coil equipped transmitter on representations of the same person and including response at 4.2MHz relative to that obtained when the same person and the same transmitter, but equipped with a whip antenna that is vertical and does not extend over that person's head, are contiguous.

DESCRIPTION OF A PREFERRED EMBODIMENT

In FIG. 1 there is shown a person bearing a 1 watt portable transmitter **10** and resilient, flexible body coupling coil **12** connected to the transmitter output and designed to be small enough to be worn under a loosely fitting outer garment **14** over one shoulder and supporting the transmitter near the waist on the other side of the person. One end of coil **10** is secured in one terminal **16** projecting from one side of the transmitter housing. The other end of the coil and its connection to another terminal on the opposite side of the housing is not visible in FIG. **1.** A microphone cable is connected to terminal **18.** The coil is easy to manipulate, conforms readily to the body of the wearer when put on and when the wearer is moving about, and also can be readily taken off. The coil **12** and the connecting terminals are strong enough to support the pendant transmitter. When the transmitter is operating, the coil couples electromagnetic energy to the body and some of the energy is radiated as RF. The human body has both capacitive and inductive impedance. The coil is designed to have sufficient inductance to be tunable when in place as shown and when the transmitter is operating. The coil diameter and the number of turns are in an inverse relationship in the sense that for a selected frequency band, smaller diameter turns calls for more coil turns and larger diameter turns calls for fewer coil turns for the coil to have the required inductance. A satisfactory design for about 4MHz was determined to be 6.5cm coil diameter, 25 turns, 80cm to 90cm overall length unextended. When worn as shown in the drawing, the spacing between turns is irregular being influenced by the weight of the transmitter and by the manner in which the coil conforms to the body of the wearer.

Two arrangements for connecting the coil **12** to the transmitter and for tuning the coil in place on the person is shown in FIGS. **2** and **3.** Tuning is guided by an RF current meter **20** in series with the oil, not shown in FIG. **1.** A variable capacitor **22** is connected in parallel with the series-connected coil **12** and RF meter **20.** The capacitor **22** is adjusted to optimize the current through the coil. Then a variable capacitor **24** shown in FIG. **2,** in series with one terminal of the transmitter

and one end of the coil is adjusted, followed by additional fine adjustment of both capacitors to optimize the indication on the RF meter. In the arrangement shown in FIG. 3, the transmitter is directly coupled to a few turns of the coil in the manner of an autotransformer.

For operation at about 8MHz, a satisfactory coil design using the same coil diameter was determined to be 16 turns with an overall length between 90cm and 100cm unextended. In place, the separation between turns varies between 5cm and 7cm.

Since the resistivities of human body tissues and organs vary over a very wide range, the interaction between the inhomogeneous human body and an inhomogeneous primary electromagnetic field as generated by the coil 12 produces a resultant inhomogeneous field configuration. Therefore the radiation field pattern from the body coupled transmitter is strongly influenced by the geometry and by the position of the coupler on the person as well as by the operating frequency. The roles of the coupling coil and of the body supporting the coil is reflected by the data in FIGS. 4, 5 and 6. The data is relative field strength levels in decibels of a coil equipped transmitter as described in several orientations on the same person, as referred to the same transmitter equipped with a whip antenna, positioned in front of the person, standing, and where the whip does not extend above the head of that person. The field strength levels were measured at about 4.2MHz with a radio frequency interference analyzer field strength meter equipped with a whip antenna and mounted on the roof of a vehicle about 200 feet away. In FIG. 4, where the coil is supported around a person's waist, there was unacceptable signal attenuation. In FIG. 5, where the person wore the coil around his neck with the transmitter depending to and resting against his abdomen, signal intensity rearwardly was high and was many times greater than in the forward direction. With the arrangement in FIG. 6 where the coil and transmitter were worn on the right shoulder across chest and back, to the left waist, signal intensity forwardly and rearwardly were equal; over at least 270°, variation in signal intensity was 4db. The results obtained with the arrangement shown in FIG. 6 were so favorable that not only does it offer the advantages of camouflage but in addition it offers ease of portability and operating advantages over whip-equipped transmitters under some field conditions.

To avoid energy absorption by the lower torso region of the body which is very lossy, the coil length is limited so that in place on a person it sees as a core, the chest region or upper torso of the person.

What is claimed is:

1. In combination, a compact portable radio transmitter operable in at least a segment of the frequency range between 3 MHz and 40 MHz and at average power output of about 1 watt when operated continuously for a long period of time, a stretchable resilient open coil coupled to the output of the transmitter and physically attached to the ends of the coil, the coil having a mean coil diameter of about 6.5 cm and being of an unstretched length on the order of 90 cm whereby when a person wears the coil on one shoulder and it extends across the front and back of the person with the transmitter depending from the ends of the coil, the coil is stretched by the weight of the transmitter and conforms to the front and back of the person and the transmitter is at about the waist level at his other side, and capacitor means coupled to the coil for tuning the coil when the coil and transmitter are worn by the person and the transmitter is in operation in a selected segment of the frequency range.

2. A method by which a person on foot can carry and safely operate a compact portable transmitter that is equipped with a whip antenna, so that it is camouflaged and has higher radiation efficiency comprising the steps of detaching the whip antenna from the transmitter terminals, coupling to the transmitter terminals a stretchable resilient coil to support the transmitter from one shoulder to the opposite side of the waist of a wearer, operating the transmitter at maximum average output power of 1 watt when operated continuously for a long period of time, setting the transmitter to a frequency between 3MHz and 40MHz and tuning the coil in place on the person for maximum RF current through the coil at the selected frequency and 1 watt average power.

3. A method of communication comprising pendantly supporting a compact portable radio transmitter from the ends of a loop of stretchable resilient flexible open coil, suspending the loop of coil from one shoulder of a person to extend across the front and back of the person to support the transmitter pendantly from its ends at the opposite side of the waist of the person, coupling the RF output of the transmitter to the coil, adjusting the transmitter for maximum average output power of one watt in a frequency band between the limits of 3 MHz and 40 MHz, and tuning the coil in place on the person for maximum RF current through the coil when the transmitter is operated at one watt average power and in said frequency band.

* * * * *