PASSIVE COMMUNICATION SYSTEM

Filed Aug. 13, 1962

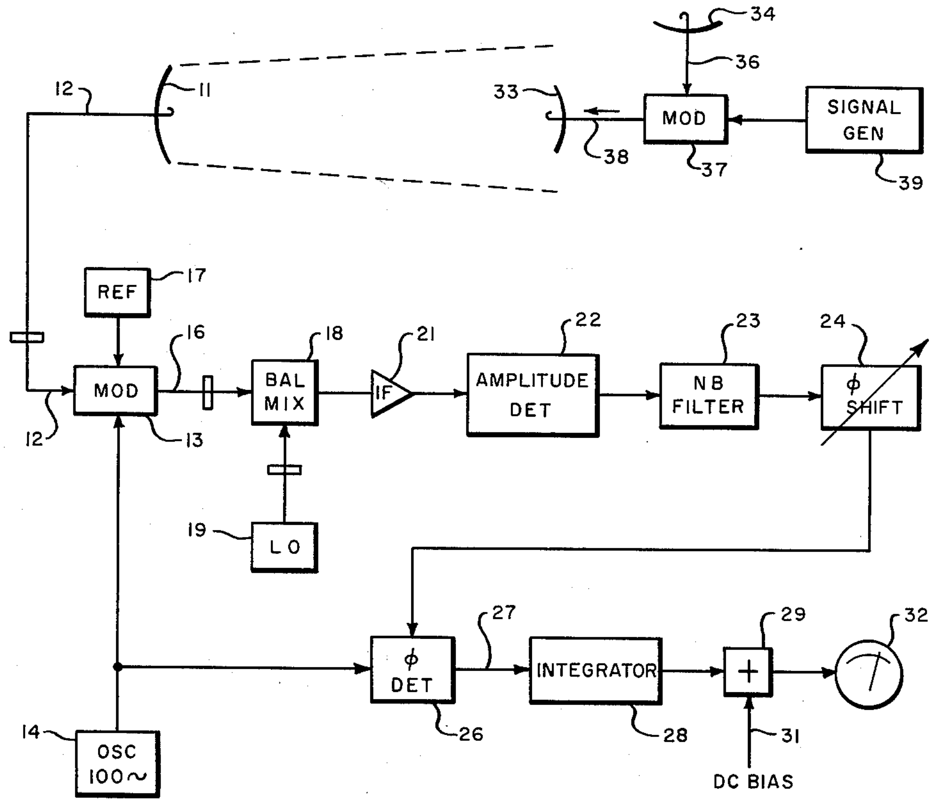

FIG. 1

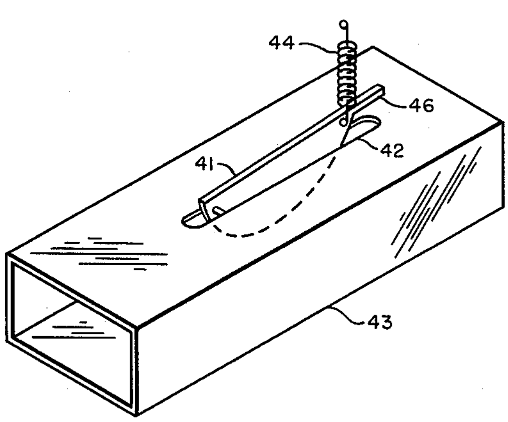

FIG. 2

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United States Patent Office

3,204,240
Patented Aug. 31, 1965

3,204,240
PASSIVE COMMUNICATION SYSTEM

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Filed Aug. 13, 1962, Ser. No. 216,422
4 Claims. (Cl. 343—100)

This invention relates to microwave systems for point-to-point communication.

All objects emit electromagnetic radiation at temperatures above absolute zero, and in the case of solids and liquids the radiation spectra are continuous and cover all frequencies, including microwave frequencies. Although the amounts of radiation energy are generally small in the microwave region, this radiation can be detected and measured by sensitive microwave receivers which, when designed for this use, are commonly termed microwave radiometers.

The amount of microwave radiant energy emitted by an object is dependent on its temperature and on its coefficient of emissivity. The microwave energy emanated from an object also includes reflected microwave energy. This energy is generated elsewhere, intercepted by the object and reflected thereby to the radiometer. The amount of this reflected energy depends on the coefficient of reflectivity of the object and the temperature of the generator of the energy.

The magnitude of the electromagnetic energy received by a radiometer is dependent on both of these factors and is commonly described as a temperature on the Kelvin scale. When the antenna of a microwave radiometer is pointed at the sky it registers a very small amount of microwave emission, generally of the order of 30° K. at 1 cm. wavelengths. Objects on the earth, such as the terrain of a hillside, will register a larger amount of microwave radiation, usually about 300° K.

The present invention employs a microwave radiometer, including a narrow-beam antenna, as the receiver of a one-way microwave communication link. The transmitter consists of two microwave antennas joined through a microwave waveguide in which is inserted a modulator. The modulator may be of any suitable type. The system is completely passive in the sense that no artifically generated microwave energy is required at any time although in those instances in which telephonic modulation is utilized a direct current or low frequency power source may be required at the transmitter location. The modulating signal may be telegraphic, telephonic, or of any other character provided that the system time constants are suitable for the frequencies to be transmitted.

In preparing to operate over a distance of several hundred yards, the radiometer antenna is pointed in the direction of the transmitter, and at the transmitter one of its antennas is aimed at the radiometer antenna. The other transmitter antenna is pointed at the sky. Thus, when the waveguide and modulator connects two transmitter antennas together, the 30° K. microwave energy amplitude picked up by the antenna pointed to the sky is transmitted through the waveguide to the other antenna pointed at the radiometer. When, however, the modulator is caused to interrupt this waveguide transmission, the antenna pointed at the radiometer is provided with some other amount of microwave energization, for example, an intensity characterized as 300° K.

In operation, the narrow radiometer receiving beam is pointed at an area and, in the absence of the transmitter, registers a microwave radiation intensity of about 300° K. However, when the transmitter is located at the are encompassed by the receiving beam and the transmitting sky antenna transfers its 30° K. intensity to the other transmitting antenna, the radiometer perceives a

lowered average intensity in the area intercepted by the receiving beam, and registers this intensity. The transmitting antenna signal is then modulated by a suitable intelligence and this modulated signal is received at the radiometer.

Two-way communication can be effected by providing two links, each similar to that described, with some parts in common, as for example, the temperature reference **17** might be the same as the sky directed antenna **34**, etc.

An object of this invention is to provide electrical communication between two points by utilizing the sensitivity of a microwave radiometer to the spontaneous generation of microwave energy by any object within its field.

Another object of this invention is to provide a system for secret communication between two points employing no transmitter carrier power beyond the electromagnetic radiation spontaneously generated by all solid and liquid objects.

Still another object of this invention is to provide one-way telegraphic or telephonic communication with the only electrical power supplies located at the receiver and without the radiation of artificially generated radiation at either receiver or transmitter.

A further understanding of this invention will be secured from the detailed description and drawings in which:

FIGURE 1 is a functional schematic diagram of an embodiment of the invention.

FIGURE 2 is a view of a form of waveguide modulator suitable for use in the invention.

Referring now to FIGURE 1, a microwave radiometer includes a dish antenna **11** and the components connected to it. The diameter of antenna **11** is such as to provide a receiving beam of about one degree diameter. The signal received by antenna **11** is applied through a waveguide **12** to a modulator **13** to which the output of an oscillator **14** is also applied. The frequency of this oscillator may be, for example, 100 c.p.s., which is high enough to permit use of an information signal frequency of 40 c.p.s. As an example of use, telegraphic signals are to be transmitted at a speed not higher than about 100 words per minute.

The modulator **13** performs the function of a single-pole double-throw switch, switching the output waveguide **16** either to the antenna waveguide **12** or to a noise reference **17**. This reference may consist of a resistor maintained at a suitable temperature or may consist of an active noise source, such as an electronic discharge tube, together with a suitable attenuator.

The waveguide **16** is connected to a balanced mixer **18** also receiving the output of a local microwave oscillator **19** having a frequency in the microwave band in which it is desired to operate. The mixer output is applied to a wideband intermediate frequency amplifier **21**. This amplifier may have, for example, a center frequency of 600 m.c.p.s. and a bandwidth of 300 m.c.p.s. The output is applied to an amplitude detector **22** having such time constant as to permit the 100 c.p.s. modulating frequency to appear in the output. This output is filtered in a band filter **23** centered at 100 c.p.s. and having a bandwidth of approximately 80 cycles per second. Its output is applied to a manually adjustable phase shifter **24** and its output is in turn applied to a phase detector **26** referenced to the oscillator **14**. The direct-current output in conductor **27** of the phase detector **26**, upon which is superimposed the communication signal, is applied to a smoothing filter **28**. The output is connected to an adding circuit **29** for the purpose of adding direct current bias from conductor **31** having for its purpose the maintenance of a selected range of output potential values and also to prevent overloading of the output indicator **32**. This indicator may be a galvanometer, a telegraph printer, an ink recorder, a sounder, or any other form of telegraphic code receiving instrument.

The operation of this radiometer is obvious and is well known. Its design and operation are based on the work of R. H. Dicke as described in "The Measurement of Thermal Radiation at Microwave Frequencies," published in "The Review of Scientific Instruments" for July 1946, on pages 268–275. Other radiometer configurations may also be used as will be apparent to one skilled in the art.

Briefly, a very wide range of electromagnetic frequencies is picked up by the antenna **11** and all which are transmittable by the waveguide **12** are applied to the modulator **13**. The signal is of the nature of very wideband noise. This signal is alternated with that from another source **17**, having a different noise temperature, at the 100 c.p.s. rate in modulator **13**. In the mixer **18** the alternated noise signal is heterodyned by the local oscillator **19**, and the sidebands accepted by the amplifier **21** consist of the sum of two bands, originating at two frequency locations above and below the local oscillator frequency and separated from it by the amount of the intermediate amplifier center frequency. At each of these locations a 300-mc.-wide section of the input noise signal is utilized. The amplified intermediate frequency signal is rectified in the detector **22** and the resulting 100 c.p.s. signal is filtered by the filter **23**. The output is phase shifted to secure maximum efficiency of synchronous detection in the phase detector **26**, resulting in a direct current signal in conductor **27** containing the information signal. Noise variations are further removed in the integrator **28**, bias is added in the sum circuit **29**, and the signal is indicated by the indicator **32**.

The transmitting end of the communications link includes two microwave antennas **33** and **34**. The antenna **34** is joined by a waveguide **36** to one terminal of a modulator **37**. Another microwave terminal of the modulator is joined by a waveguide **38** to the antenna **33**. A microphone or other type of intelligence signal generator **39** is connected to operate the modulator **37**.

The modulator **37** may be of any type which can be inserted in a waveguide and which is capable of modulating microwave energy. For telegraph dot frequencies some form of on-off switch is suitable such as, for example, that described in Patent Number 2,960,539. For voice frequencies any of the common forms of ferrite modulators may be suitable such as, for example, the type described in Patent Number 2,983,883.

FIGURE 2 depicts a simple modulator which may be employed as the modulator **37**, FIGURE 1. It is a flap attenuator which has an absorbing graphite card, **41**, pivoted to enter a slot **42** in one broad face of a waveguide **43**. The card **41** is held out of the slot by a tension spring **44**. Pressure of the finger on the rod **46**, depressing the card, causes substantially complete attenuation of microwave energy passing through the waveguide and movement of the card can modulate the microwave energy in the telegraph code. In this case the signal generator **39**, FIGURE 1, is replaced by operator manipulation and the transmitter is not only passive in the sense of not transmitting any artificially generated microwave energy but also in the sense of not requiring the use of any electrical sources.

Such an attenuator, here used as a switch, is described in Patent Number 2,591,329.

In the operation of the passive communication system the radiometer is trained on a hillside, forest, or other terrain feature at a range of, say, 300 yards. Its one-degree beam spans an area at that range having a diameter of about 15 feet and an area of about 177 square feet. The microwave energy received by the radiometer from this terrain area results in an indication of the indicator **32** representing a microwave energy of about 300° K. The transmitting antenna **33** having, for example, an effective area of one square foot, is positioned in the beam and aimed at the radiometer antenna **11**. The antenna **34** is aimed at the sky and the modulator **37** is adjusted to transmit microwave energy between the antennas 33 and 34. The radiometer now perceives less than 300° K. temperature because of the cooler antenna **33** area, the temperature change, ΔT, being

$$\Delta T = (300-30)\frac{1}{177} = 1.5^\circ \qquad (1)$$

Such a temperature change is readily perceptible by even a moderately sensitive radiometer. The modulator **37** is now changed to interrupt the connection between the antennas 33 and 34, and the temperature of the antenna **33** now perceived is that of the resistive card **41**, about 300° K. and indistinguishable from that of the terrain perceived by the rest of the beam. Thus the radiometer perceives two different average temperatures, depending on which of the two positions which the card **41** has, in or out of the waveguide, and the radiometer indicator **32** exhibits two different corresponding indications. Thus code communication can be effected from the transmitter to the radiometer.

It is obvious that the several electrical components of the transmitter and of the radiometer which introduce delays, have modulating frequency limits or which possess time constants must be designed for the transmission of the desired upper limit of communication frequencies. These components include the modulator **37**, modulator **13**, oscillator **14** and the integrator **28**.

What is claimed is:

1. A passive communication system comprising,

a radiometer having input and output terminals,

a first radiant electromagnetic energy sensing member connected to said input terminal, said member sensing radiation from a selected delimited terrestrial area,

transmitting means,

a second radiant electromagnetic energy sensing member therein, said second member being directed toward a selected celestial area emitting a low level of electromagnetic radiation,

an electromagnetic energy radiating member in said transmitting means,

an electromagnetic energy transfer path interconnecting said second sensing member and said radiating member and transmitting energy therebetween,

and modulating means inserted in said transfer path having an intelligence signal applied thereto.

2. A passive communication system comprising,

a radiometer having input and output terminals and constituting a receiving member,

a first electromagnetic radiant energy sensing element connected to said input terminal, said element having a narrow beam sensing radiation from a selected delimited area on the surface of this earth,

a transmitting member,

a second electromagnetic radiant energy sensing element therein, said second element being directed toward a selected celestial area emitting a lower level of electromagnetic radiation,

an electromagnetic energy radiating element in said transmitting member pointed toward said first sensing element and positioned in the beam thereof,

an electromagnetic energy transfer path interconnecting said second sensing element and said radiating element,

a modulator inserted in said electromagnetic energy transfer path,

and communication signal generating means connected to operate said modulator for modulating electromagnetic energy transferred from said second sensing element through said transfer path to said radiating element in accordance with the intelligence information contained in said communication signal whereby said communication signal modulation is sensed by said radiometer receiving member and appears on the output terminal thereof.

3. A passive communication system comprising,

a radiometer for operating in a selected frequency range having input and output terminals and constituting a communication receiving member,

a first electromagnetic radiant energy sensing element connected to said input terminal, said element having a narrow beam sensing radiation in said selected frequency range from a selected delimited area on the surface of this earth,

a communication transmitting member for operating in said selected frequency range,

a second electromagnetic radiant energy sensing element incorporated in said transmitting member, said second element being pointed toward a selected celestial area emitting a low level of electromagnetic radiation in said selected frequency range,

an electromagnetic energy radiating element incorporated in said transmitting member, said radiating element being pointed to radiate toward said first sensing element and the latter being directed to sense the radiations produced by said radiating element,

an electromagnetic energy transfer path interconnecting said second sensing element and said radiating element,

a modulator inserted in said transfer path,

an indicator connected to said output terminal,

and communication signal generating means connected to operate said modulator for modulating electromagnetic energy passed therethrough from said second sensing element to said radiating element whereby said communication signal is sensed by said radiometer receiving member and is indicated by said indicator.

4. A passive communication system comprising,

a radiometer for operating in the microwave frequency range and having input and output terminals,

an indicator connected to said output terminal,

a first microwave narrow-beam antenna connected to said input terminal, said antenna being aimed to sense microwave radiation from a selected, delimited area of the surface of the earth, said radiometer, indicator and first antenna constituting a communication signal receiving member,

a communication signal transmitting member for operating at microwave frequencies,

a second microwave antenna incorporated therein, said second antenna being directed toward a selected celestial area emitting a low level of microwave radiation,

a third microwave antenna included in said transmitting member, said third antenna being positioned in the beam of said first antenna and aimed thereat,

a waveguide section interconnecting said second and third antennas,

a modulator of microwave energy inserted in said waveguide section,

and communication signal generating means connected to operate said modulator for modulating the microwave energy passing therethrough from said second antenna to the said third antenna.

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CHESTER L. JUSTUS, *Primary Examiner.*