

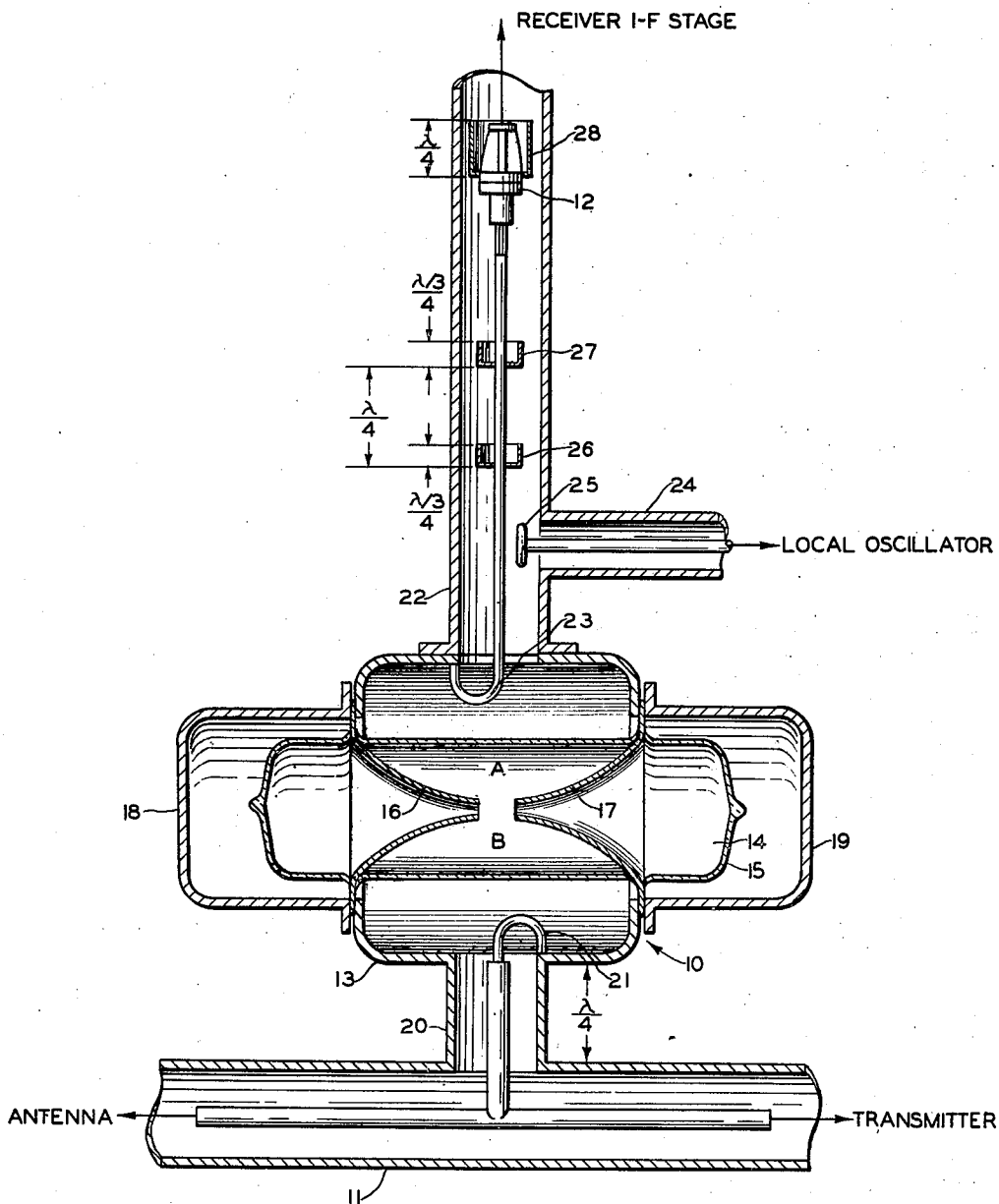
June 7, 1949.

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2,472,196

TRANSMIT-RECEIVE SYSTEM

Filed May 17, 1945



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## UNITED STATES PATENT OFFICE

2,472,196

## TRANSMIT-RECEIVE SYSTEM

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Application May 17, 1945, Serial No. 594,270

4 Claims. (Cl. 250—13)

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My present invention relates generally to a radiant energy system wherein a single antenna is used both for transmitting and receiving pulsed wave energy, and is more particularly directed to a protective arrangement in connection with said radiant energy system for reducing the amount of transmitted power reaching the receiver.

When, in a radar system, a single antenna is used both for transmitting and receiving, it is conventional to employ a duplexing unit or a transmit-receive box for the purpose of transferring the antenna connection from the receiver to the transmitter for the duration of the transmitted pulse. Since, in microwave receivers, the input circuit associated with the antenna is ordinarily a first detector stage, which is easily damaged by heavy applied signals (this condition being particularly true of crystal mixers) it is desirable to employ means for reducing below the safety limit the amount of transmitted power reaching the receiver input stage.

I have discovered that the magnetron, an ultra-high frequency oscillator commonly used in radiant energy systems, while it generates a sine wave of fairly good form, there is also an appreciable amount of third harmonic energy present, the other order of harmonics being virtually negligible. Since the transmit-receive box, which is conventionally interposed between the magnetron and the receiver, behaves as a high Q transformer and is tuned to the magnetron fundamental wavelength, the third harmonic is not attenuated to nearly the same degree as is the fundamental, hence the third harmonic energy leaks through to the crystal mixer in considerable proportion with a resultant shortening of the crystal life.

Accordingly, having discovered this effect and having measured the magnitude of third harmonic energy present, it is my primary object to devise an arrangement adapted to eliminate the third harmonic energy from the mixer circuit without otherwise affecting the operation thereof.

Briefly stated, this object is attained by providing a plurality of chokes so arranged as to filter out the third harmonic while at the same time cancelling reflections which may occur for the fundamental frequency because of the presence of said chokes.

For a better understanding of this invention, as well as other objects and features thereof, reference is made to the following detailed description to be read in connection with the ac-

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companying drawing wherein there is shown in longitudinal section a conventional transmit-receive box whose output energy is applied through a preferred embodiment of a choke arrangement, in accordance with the invention, to a crystal mixer.

Referring now to the drawing, there is shown a transmit-receive box 10 electrically interposed between a coaxial transmission line 11, connecting a radiating antenna to a transmitter, and a crystal detector 12. The transmit-receive box 10 comprises a generally rectangular shaped metal chamber 13 having mounted therein along its transverse axis a switch tube 14.

Switch tube 14 comprises a cylindrical glass envelope 15 enclosing two conically shaped electrodes 16 and 17, said electrodes being mounted with faces juxtaposed to act as a spark gap. Electrodes 16 and 17 are brought out through glass envelope 15 and connected to the sides of chamber 13 to complete the resonant cavities A and B, said cavities being defined by the surfaces of electrodes 16 and 17 and the inner surface of chamber 13. Switch tube 14 is partially evacuated, while the transmit-receive box 10 is maintained at atmospheric pressure. The glass ends of switch tube 14 are protected by metal caps 18 and 19 fitting thereover.

Cavity A is coupled to coaxial transmission line 11 by a quarter wavelength stub line 20 having its inner conductor perpendicularly connected at one end to the inner conductor of line 11 and at the other end to cavity A by means of an input coupling loop 21. Cavity B is connected to the intermediate-frequency stage of a radiant energy receiver through a coaxial line 22 whose inner conductor is connected to cavity B at one end by an output coupling loop 23 and at the other end to one terminal of crystal detector 12. Communicating with coaxial line 22 is a coaxial line 24 extending from the local oscillator of the receiver, the inner conductor thereof being terminated within coaxial line 22 by a probe 25.

In effect, cavities A and B act as two resonant tank circuits in shunt relation, each tuned to the magnetron fundamental wavelength. Cavity A may be regarded as a step-up transformer, with input loop 21 representing the primary winding and the cavity itself the secondary winding. Likewise, cavity B may be regarded as a step-down transformer with the cavity itself representing the primary winding and the output loop 23 the secondary winding. If switch tube 14 does not break down, the input voltage applied by loop 21 to cavity A is transformed

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thereby to a high level and then reduced to its original level in cavity B. Thus, the combination of cavities A and B performs as a highly selective transformer with substantially a 1:1 turns ratio.

If the input voltage is of large enough magnitude, it is transformed to a voltage sufficient to break down the spark gap between electrodes 16 and 17. When the gap conducts, cavity A is effectively short circuited and a short circuit is therefore reflected into input loop 21. Although this conduction does not constitute a perfect short circuit, it cause a very low impedance to appear at input coupling loop 21. This very low impedance is inverted by the quarter wave length stub line and therefore connects a high impedance to the T junction between transmission line 11 and stub line 20, since said T junction lies a quarter of a fundamental wavelength away from the short circuit. The circuit to the receiver, therefore, is disconnected by the conduction of switch tube 14.

However, as has been pointed out in the foregoing discussion, while the transmit-receive box 10 serves to reduce the amount of fundamental energy reaching crystal 12, a considerable amount of third harmonic energy leaks through to the output. To obviate this effect, there are disposed within coaxial line 22 along the inner conductor thereof, a pair of cup shaped chokes 26 and 27, concentrically mounted thereon, each choke being dimensioned to a quarter of the third harmonic wavelength, the spacing therebetween being a quarter of the fundamental wavelength. The open end of each cup amounts to an open-circuited line, and the length inverts this high impedance so that the effect is that of a substantial short circuit at the closed end. Thus it will be seen that third harmonic energy is unable to harmfully load crystal 12, the energy being suppressed by chokes 26 and 27, which are not chokes in the usual sense, but series resonant loads at that frequency.

Since chokes 26 and 27 are spaced a quarter of the fundamental wavelength apart, reflections which may occur because of the presence of the chokes are cancelled out. It is, of course, obvious that chokes 26 and 27 do not attenuate the fundamental when passed by transmit-receive box 10, nor do they impede the local oscillator energy. Mounted on the terminal plate of crystal 12, connected to the receiver intermediate-frequency stage, is a choke 28, dimensioned to one quarter of the fundamental wavelength, which serves to impede unrectified fundamental energy from leaking through to the receiver.

Thus there has been described a method and means for choking out one undesired frequency from a radio-frequency system, without substantial cancellation of a desired frequency by undue reflections from the chokes. Clearly, more than two chokes may be employed for this purpose, providing they are properly spaced. The invention is not limited to the particular transmit-receive box 10 shown, which is included merely by way of illustration, the invention being operable with any other suitable duplexing device.

While there has been described what is at present considered a preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention. In construction the usual adjust-

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ments are made in the precise cup dimensions and spacing for proper tuning.

I claim:

1. The combination in a transmit-receive radio system comprising a magnetron oscillator, a receiver, an antenna, a transmission line connecting said magnetron to said antenna, a stub line extending from said transmission line to said receiver, means for introducing an impedance in said stub line during the time of transmission which is very high for the fundamental frequency of the transmitted energy, and means on said stub line for attenuating the passage of energy whose frequency is the third harmonic of the transmitted energy.

2. The combination in a transmit-receive radio system comprising a magnetron oscillator, a receiver, an antenna, a transmission line connecting said magnetron to said antenna, a stub line extending from said transmission line to said receiver, and means for introducing an impedance in said stub line during transmission which is very high for the fundamental frequency of the transmitted energy, and at least two chokes on said stub line, said chokes being spaced from each other a quarter of the fundamental wavelength, each choke being dimensioned to a quarter of the third harmonic wavelength.

3. The combination in a transmit-receive radio system comprising a magnetron oscillator, a crystal detector, an antenna, a transmission line connecting said magnetron to the antenna, a stub line extending from said transmission line to said detector, a transmit-receive box interposed in said stub line for disconnecting said detector from said transmission line during the time of transmission, at least two chokes on said stub line interposed between said transmit-receive box and said detector, said chokes being spaced from each other a quarter of the fundamental wavelength, each choke being dimensioned to a quarter of the third harmonic wavelength, a local oscillator, and means for introducing energy from said local oscillator into said stub line at a point after said transmit-receive box.

4. A transmit-receive radio system comprising an antenna, a transmitter, a receiver, means connecting said transmitter to said antenna and a concentric line connecting said receiver to said antenna, said line including: means responsive to a high energy level during operation of said transmitter to introduce a high impedance into said line at the fundamental frequency of transmitted energy, and further means to attenuate a harmonic frequency of the transmitted energy including an open-ended cup with its closed end connected to said line and having a length of an odd integral number of one-quarter wave lengths at the harmonic frequency to effectively short circuit said harmonic frequency, at least one further cup similarly connected to said line, the connections of said cups being spaced from each other an odd integral number of one-quarter wave lengths at the fundamental frequency, whereby response of said receiver to transmitted energy at said harmonic frequencies is substantially eliminated and reflections of the fundamental frequencies at the cups cancel each other.

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