June 19, 1956 H. J. RIBLET 2,751,586

SIGNAL-WAVE TRANSMISSION SYSTEMS

Filed Nov. 22, 1950 2 Sheets-Sheet 1

FIG. 1

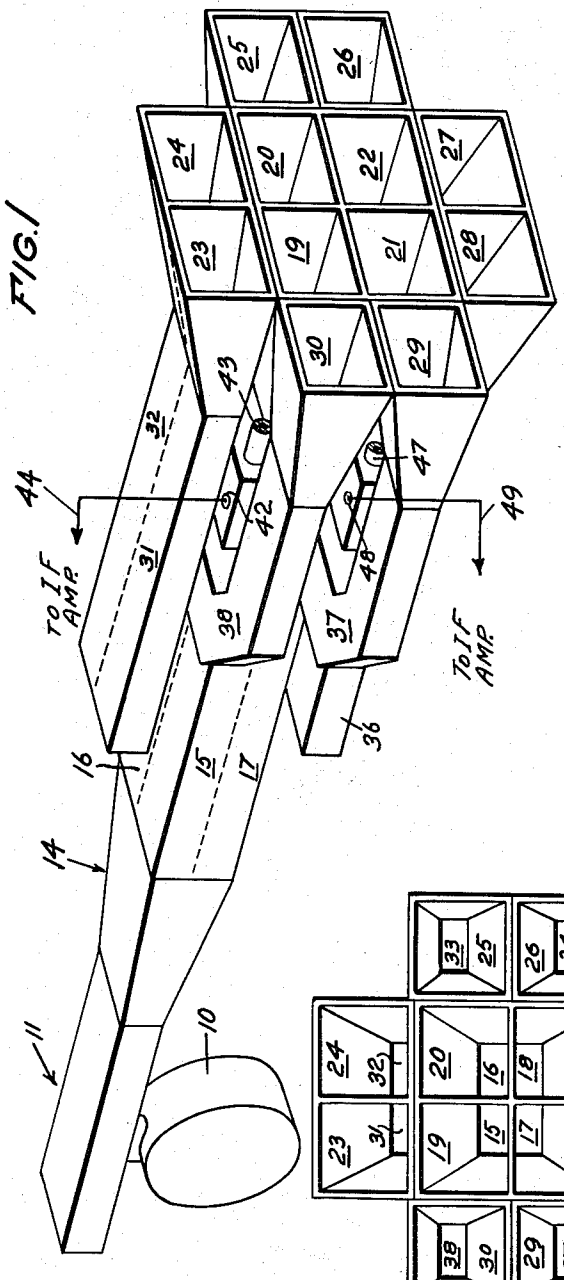


FIG. 2

INVENTOR
HENRY J. RIBLET
BY Elmer L. Gow
ATTORNEY

June 19, 1956 H. J. RIBLET 2,751,586

SIGNAL-WAVE TRANSMISSION SYSTEMS

Filed Nov. 22, 1950 2 Sheets-Sheet 2

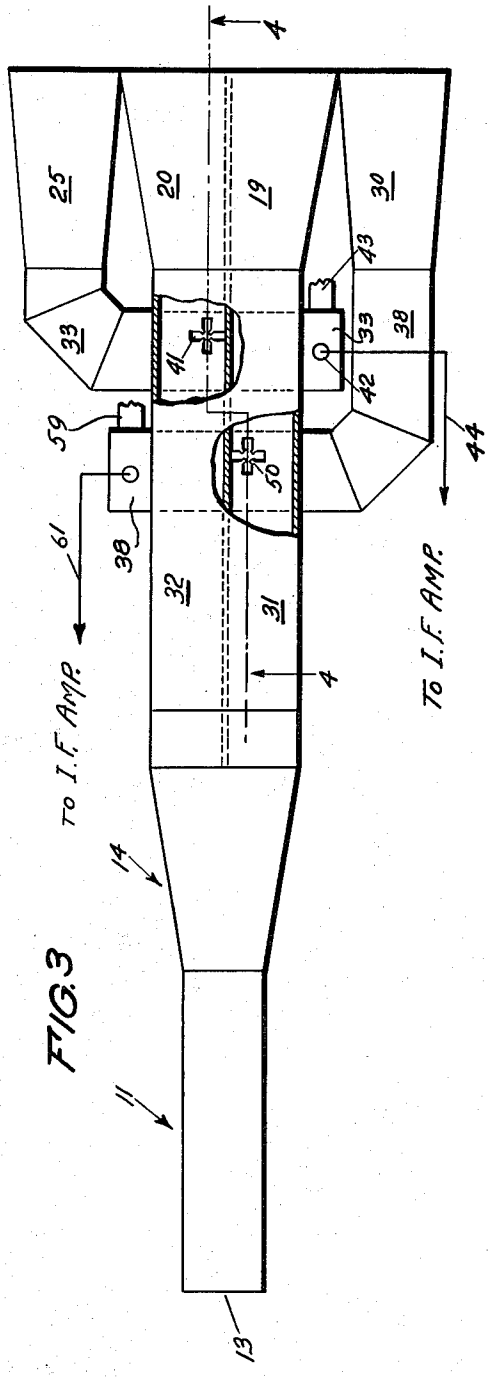


FIG. 3

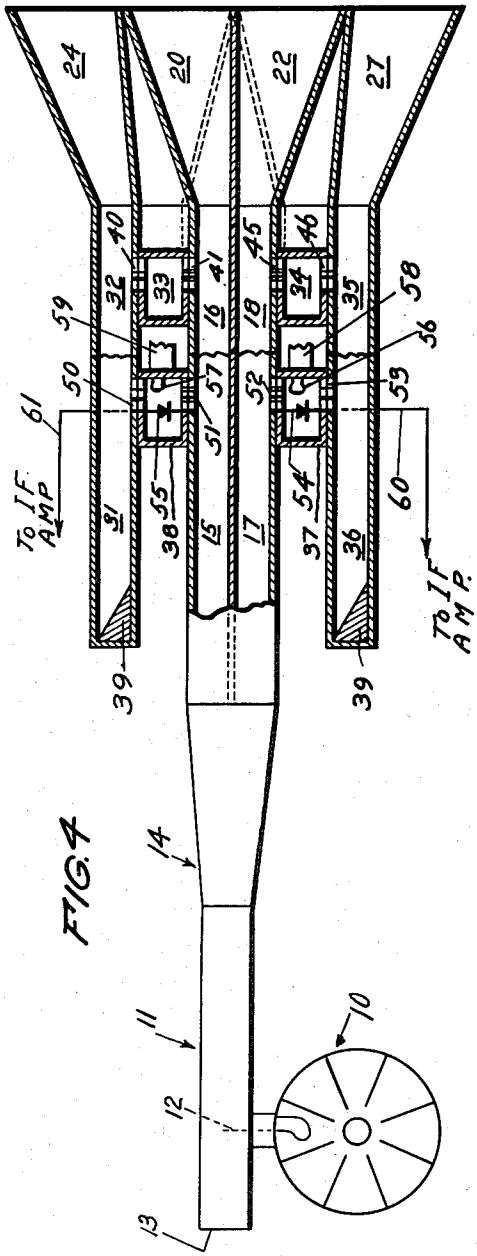


FIG. 4

INVENTOR
HENRY J. RIBLET
BY Elmer J. Gorn
ATTORNEY

United States Patent Office 2,751,586 Patented June 19, 1956

2,751,586

SIGNAL-WAVE TRANSMISSION SYSTEMS

Henry J. Riblet, Wellesley Hills, Mass., assignor to Raytheon Manufacturing Company, Newton, Mass., a corporation of Delaware

Application November 22, 1950, Serial No. 197,137

6 Claims. (Cl. 343—16)

This invention relates to electromagnetic-wave energy radiating and radiating-receiving devices, and more particularly to radiating and radiation-receiving structures comprising common radiating and radiation-receiving elements.

In transmit-receive devices such as, for example, radar systems, it is desirable to utilize a common antenna structure for both radiation and reception of the signals. By this structure, the radiating and receiving antenna may be aimed in a given direction, thus automatically positioning the receiver in the direction necessary to receive echo signals for a given direction of the radiated signals.

In order to obtain a greater degree of accuracy in ascertaining the direction of reception of a target signal, a process, commonly known as lobing, may be used. In previous systems this lobing was carried out by transmitting successive pulses in slightly different directions in the general vicinity of the target and comparing the signal strength of the returning echoes from the various transmitted pulses.

This invention discloses a structure whereby simultaneous lobing in a plurality of different directions may be accomplished. Briefly, this is achieved by transmitting a single pulse from one radiation system in a particular direction and then receiving the reflected signals simultaneously in a plurality of radiation-receiving systems, each system comprising said radiation system and being directive in slightly different directions from each other and from the direction of transmission of the radiated energy. Each set of receiving elements feeds a separate detecting device, and the outputs of the detecting devices are then compared to ascertain the precise direction of the target.

In particular, this invention discloses a system for accurately producing a plurality of sets of radiation-receiving elements which are aligned with the desired directivities. Briefly, this is accomplished by using the radiating elements in conjunction with additional elements adjacent thereto, the composite element array for each group thus forming a directive-receiving antenna.

In order to connect the radiation-receiving elements to a signal-receiving channel, directional couplers may be used. In general, directional couplers are those couplers which will couple energy from one channel into another channel such that a wave propagated in one direction in one channel will be coupled into the other channel by the couplers and be propagated in a predetermined direction therein.

In order to prevent energy from feeding directly from the radiating source into the receiving detectors, suitable switching means are provided between the radiating elements and the adjacent radiation-receiving elements, said switching means substantially preventing energy from feeding from the radiating elements to the radiation-receiving elements during radiation of a pulse of energy from said radiating elements.

Other and further objects and advantages of this invention will be apparent as the description thereof progresses, reference being had to the accompanying drawings, wherein:

Fig. 1 illustrates a perspective view of a radiating and radiation-receiving structure embodied in a system which utilizes this invention;

Fig. 2 illustrates an end view of the radiating elements shown in Fig. 1;

Fig. 3 illustrates a partially broken away top plan view of the device shown in Fig. 1; and

Fig. 4 illustrates a partial longitudinal, sectional view of the device shown in Figs. 1, 2 and 3, taken along line 4—4 of Fig. 3.

Referring now to the drawings, there is shown a source of microwave energy **10** indicated, by way of example only, as a magnetron, said magnetron being connected to a section of wave guide **11** and adapted to propagate energy thereinto by means of a probe **12**. One end of wave guide **11** is closed by means of an end plate **13**, the distance of end plate **13** from probe **12** being governed by considerations of impedance match between the magnetron **10** and the wave guide **11** in accordance with well-known principles. The other end of wave guide **11** is attached to a tapered wave guide section **14** which effectively increases the dimensions of wave guide **11** in both directions until they are substantially double their original size.

Attached to the larger end of the tapered section are four wave guides **15**, **16**, **17** and **18**, respectively, the cross-sectional dimensions of which are substantially the same as those of wave guide **11**. The other ends of wave guides **15**, **16**, **17** and **18** are attached to radiating elements, shown here, by way of example, as horns **19**, **20**, **21** and **22**, respectively. Horns **19**, **20**, **21** and **22** are aimed substantially in the same direction, and, therefore, when the magnetron **10** is energized, a pulse will be transmitted down wave guide **11** through tapered section **14**, being divided substantially evenly between among the wave guides **15**, **16**, **17** and **18**, and then being radiated by horns **19**, **20**, **21** and **22** in a relatively narrow or highly directional signal intensity pattern.

Reflected echoes from the radiated signal will then be received simultaneously by a plurality of systems of radiation-receiving elements in the following manner. Positioned above horn **19** is a horn **23**. Positioned above horn **20** is a horn **24**. Positioned on the opposite side of horn **20** from horn **19** is a horn **25**. Positioned on the opposite side of horn **22** from horn **21** is a horn **26**. Positioned below horn **22** is a horn **27**. Positioned below horn **21** is a horn **28**. Positioned on the opposite side of horn **21** from horn **22** is a horn **29**, and positioned on the opposite side of horn **19** from horn **20** is a horn **30**. Horns **23** through **30** are attached to wave guides **31** through **38**, respectively.

Wave guides **31**, **32**, **35** and **36** terminate in energy-absorbing material **39**. Wave guide **33** makes a substantially right angular turn and passes across on top of wave guides **15** and **16**, and below wave guides **31** and **32** such that the upper wall of wave guide **16** is adjacent the lower wall of wave guide **33**, and the lower wall of wave guide **32** is adjacent the upper wall of wave guide **33**.

Positioned in the adjacent walls of guides **32**, **33** and **16** are directional coupling devices **40** and **41**, respectively. While it is to be clearly understood that any desired coupling may be used, the particular directional couplings shown here comprise pairs of crossed slots **40** and **41**, respectively, points of intersection of the slots lying on diagonals of the respective common surfaces of the adjacent walls of the guides. The crossed-slot coupler **41** which connects wave guide **16** with wave guide **33** has a plurality of probes extending toward the point of intersection of the slots from the edges thereof, said probes having gaps therebetween which are small enough to break down when the pulse of energy is produced by the magnetron and propagated down the guide **11**, tapered section **14** and out through the horns. Therefore, sub-

stantially none of this energy will be coupled through the slot 41. However, received echo signals picked up by the horn 20 will be coupled through the slot 41 into the guide 33 in the same direction as echo signals which are picked up by the horn 25 are fed into the guide 33.

Similarly, echo signals picked up by the horn 24 will be coupled through crossed slot 40 into the guide 33 in the same direction as the echo signals propagated in the guides 33 from the horn 25. Thus, it may be seen that horns 24, 20 and 25 comprise a system of radiation-receiving elements all feeding energy into the common wave guide 33. At the end of wave guide 33, there is positioned a detector 42 of any desired type, shown here, by way of example, as a crystal diode. Energy from a local oscillator is fed into the guide 33 by a loop coupling through a coaxial cable 43, said energy beating with the incoming signals from the horns 20, 24 and 25 to produce an intermediate-frequency signal in a well-known manner which is fed out through a line 44 to an intermediate-frequency amplifier.

Similarly, wave guides 18 and 35 couple energy into wave guide 34 through slots 45 and 46, respectively, slot 45 having breakdown probes therein. Signals are introduced into guide 34 from a local oscillator by means of a loop coupling fed by a coaxial cable 47, and the resultant signal is detected by a detector 48 which feeds the detected signal to an intermediate-frequency amplifier through a line 49.

Similarly, guides 31 and 15 feed energy into guide 38 through slots 50 and 51, respectively, and guides 17 and 36 feed energy into guide 37 through slots 52 and 53, respectively. Slots 51 and 52 have breakdown probes similar to slots 41 and 45. Guides 37 and 38 terminate in detectors 54 and 55, respectively, which operate in conjunction with local-oscillator signals coupled into guides 37 and 38 through loops 56 and 57 fed by coaxial cables 58, 59, respectively, the outputs of detectors 54 and 55 being fed to intermediate-frequency stages through lines 60 and 61, respectively. Thus, it may be seen that horns 19, 20, 21 and 22 act together to radiate a signal in a particular direction, but that horn 19 acts separately with horns 23 and 30 to receive echo signals in one direction. Horn 20 acts with horns 24 and 25 to receive signals with a slightly different directivity. Horn 22 acts independently with horns 26 and 27 to receive signals in a still different directivity, and horn 21 acts with horns 28 and 29 to receive signals with an additional different directivity.

Furthermore, these four sets of horns receive signals simultaneously, and hence it is not necessary to send out four different signal pulses, as was the case of previous lobing systems, in order to obtain the desired signal ratios to ascertain the direction of a target echo.

Furthermore, it has been found that, by utilizing a portion of the radiating system used to radiate the pulses, the effective centers of the separate sets of receiving antennas may be placed closer together. As a result, the lobe patterns of the sets of receiving antennas overlap up to substantially greater distances from the antenna than would be the case if separate receiving antenna systems were used. As a result, a lobing system is produced which is effective both at long ranges and at close ranges to ascertain the direction of the received echo signal with high precision.

This completes the description of the particular species of the invention described herein. However, many modifications thereof will be apparent to persons skilled in the art without departing from the spirit and scope of this invention. For example, the same principle of utilizing portions of the signal-radiating system in conjunction with additional signal-receiving elements to improve the overall lobe pattern may be applied to other lobing systems than the one described herein. For example, it could be applied to a lobing system of the so-called sequential type which is now in general use today.

Furthermore, the particular configuration and wave-guide structures, shown here, are by way of example only, and any desired wave guide structure or wave-transmission structure could be used. Therefore, it is desired that this invention be not limited to the particular details of the embodiment illustrated herein, except as defined by the appended claims.

What is claimed is:

1. An echo ranging system comprising means for radiating signals, and a directive-receiving channel fed by radiation-receiving means differing in radiation directivity from said radiating means, said radiation receiving means including said radiating means, said radiation-receiving means being connected to said channel through directive-coupling means.

2. A signal-wave transmission system comprising means for directively radiating signals comprising a radiating horn, and a receiving channel fed by radiation-receiving means differing in radiation directivity from said radiating means, said radiation receiving means comprising said horn and an additional horn adjacent said first-mentioned horn, and a directional coupler connecting said first-metioned horn with said receiving channel.

3. An acho ranging system comprising a source of signals, a signal-radiating channel fed by said source and feeding means for directively radiating said signals, a receiving channel fed by radiation-receiving means differing in radiation directivity from said radiating means, said radiation-receiving means including said means for directively radiating said signals, and switching means disconnecting said signal-radiating channel from said signal-receiving channel in response to signals from said source.

4. A signal-wave transmission system comprising a source of signals, a signal-guiding channel fed by said source and feeding means for directively radiating said signals, a receiving channel fed by radiation-receiving means including said radiating means but differing in radiation directivity from said radiating means, and switching means connecting said signal-guiding channel with said signal-receiving channel, said switching means being operative in response to signals from said source to disconnect said signal-receiving channel from said signal-guiding channel in response to signals from said source.

5. A signal-wave transmission system comprising a source of signals, a signal-guiding channel fed by said source and feeding means for directively radiating said signals, a receiving channel fed by radiation-receiving means including said radiating means but differing in radiation directivity from said radiating means, and switching means connecting said signal-guiding channel with said signal-receiving channel, said switching means comprising a directional coupler.

6. An echo ranging system comprising a source of signals, a signal-guiding channel fed by said source and feeding means for directively radiating said signals, a receiving channel fed by radiation-receiving means including said radiating means but differing in radiation directivity from said radiating means, and switching means connecting said signal-guiding channel with said signal-receiving channel, said switching means comprising a crossed-slot directional coupler.

References Cited in the file of this patent

UNITED STATES PATENTS

2,473,274	Bradley	June 14, 1949
2,480,829	Barrow et al.	Sept. 6, 1949
2,514,351	Smith	July 4, 1950
2,523,398	Southworth	Sept. 26, 1950
2,567,197	Fox	Sept. 11, 1951
2,587,590	Brewer	Mar. 4, 1952

FOREIGN PATENTS

575,432	Great Britain	Feb. 18, 1946
627,690	Great Britain	Aug. 15, 1949