United States Patent

[11] 3,601,684

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[73] Assignee International Standard Electric Corporation
New York, N.Y.
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[33] Great Britain
[31] 13249/69

[54] **PHASE-SHIFTING ARRANGEMENT**
7 Claims, 5 Drawing Figs.

[52] U.S. Cl. 321/54, 333/7, 333/31
[51] Int. Cl. H02m 5/00
[50] Field of Search 328/21, 24, 155; 332/45; 331/43; 333/7, 29, 31; 321/50, 54

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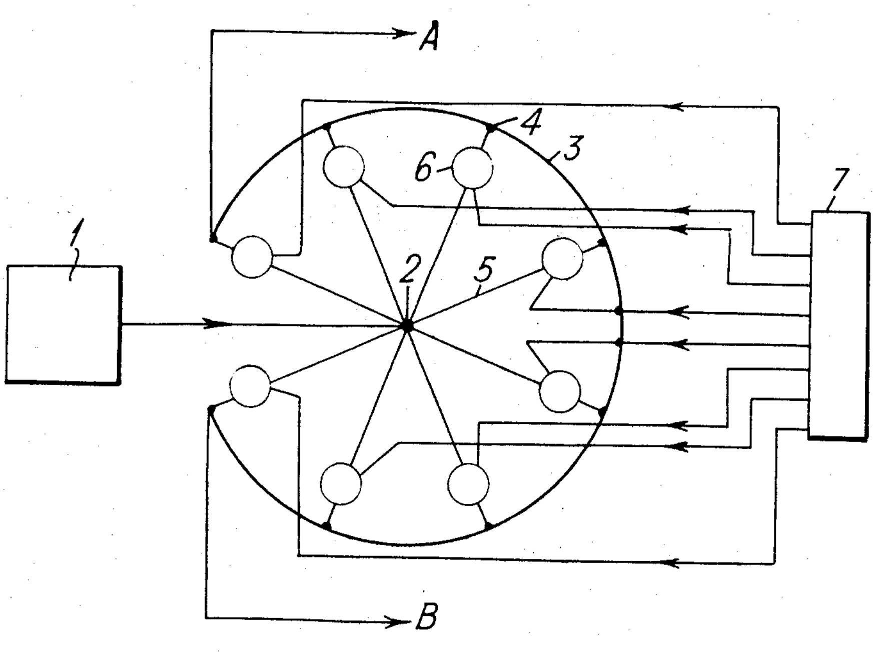
ABSTRACT: A phase-shifting arrangement wherein a source is cyclically coupled to predetermined and equally spaced points of an arcuate transmission line of predetermined length. The coupling is achieved over radial transmission lines having pulse switchable diodes which are sequentially activated at a predetermined frequency by a rotary pulse distributor. At one end of the arcuate line there is derived a positively displaced RF signal, and at the other end of the arcuate line is derived a negatively displaced RF signal.



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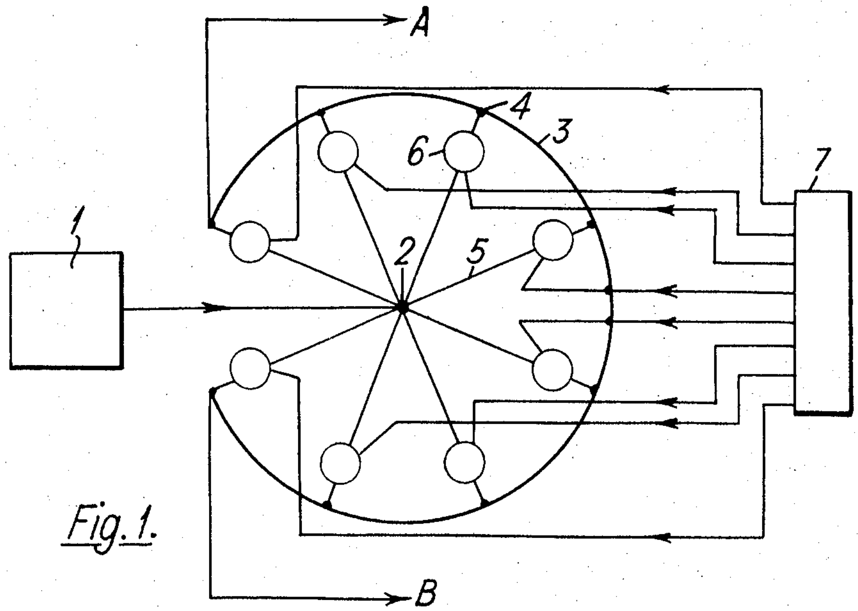

Fig. 1.

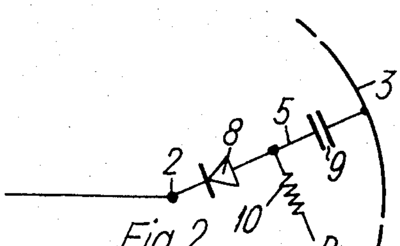

Fig. 2.

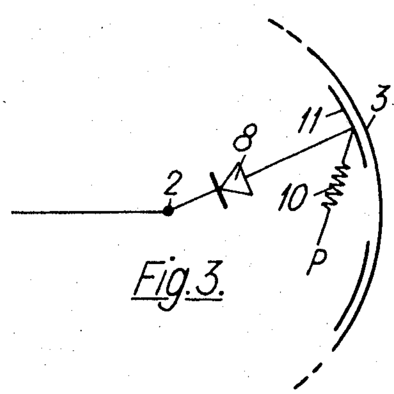

Fig. 3.

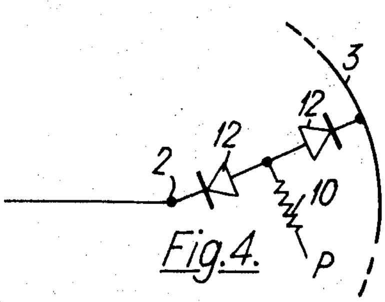

Fig. 4.

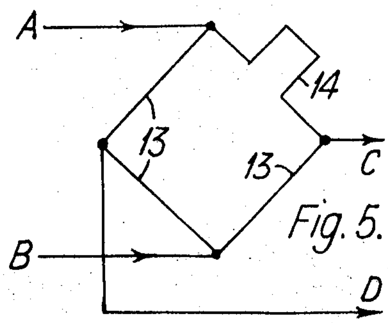

Fig. 5.

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PHASE-SHIFTING ARRANGEMENT

BACKGROUND OF THE INVENTION

This invention relates to a phase-shifting arrangement, for universal phase shifting of a radio frequency source.

The arrangement is particularly applicable, but not limited, to frequencies of the order of 100 MHz. up to sever GHz.

The arrangement has particular application for offsetting the frequency of a radiofrequency wave, that is for generation of single sidebands, in Doppler type radio navigational aids, and also for generation of the double sideband waves required in conventional navigational aids such as ILS.

The arrangement is able to operate at considerably higher power levels (one to ten or more watts) than conventional arrangements, which commonly involve the use of ring-modulators with which it is difficult to exceed a maximum power level of five milliwatts.

SUMMARY OF THE INVENTION

According to the invention there is provided a phase-shifting arrangement including an input terminal for connection to a radio frequency source, a radio frequency transmission line of arcuate form centered on said terminal and connected thereto at equally spaced points along its length by *n* switchable radial feeds, *n* being equal to or greater than three and the spacing between the end ones of said points being equal to $(^{n-1}/n)$ times the transmission line wavelength at the frequency of said source, and means for cyclically and successively switching said radial feeds to connect the input terminal the to the corresponding successive spaced points along the transmission line.

BRIEF DESCRIPTION OF THE DRAWING

Preferred embodiments of the invention will now be described with reference to the accompanying drawing, in which:

FIG. 1 shows the general configuration of a phase-shifting arrangement according to the invention;

FIGS. 2 and 3 show alternative ways of switching an arm of the arrangement of FIG. 1 using a single diode;

FIG. 4 shows an arm of the arrangement of FIG. 1 having two diodes for switching; and

FIG. 5 shows how double sideband outputs are obtained from the outputs of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a radio frequency source **1** is a connected to an input terminal **2** located at the center of an arcuate radiofrequency transmission line **3**. Star-connected from the input terminal **2** to equally spaced points **4** along the transmission line **3** are radial feeds **5** each switchable at **6** by a pulse from a rotary pulse distributor **7** to connect the input terminal **2** to the corresponding point **4** on the transmission line **3**.

The radius of the transmission-line arc can be of any desired value, but the length of the arc between the two end points **4**, with *n* radial feeds is $^{n11}/n$ times the transmission line wavelength at the frequency of the source.

The transmission line may conveniently be a microstrip transmission line in the form of an arcuate strip conductor closely spaced to a metallic ground plane, and the sandwiched dielectric between strip conductor and ground plane may be such that physical wavelength is much reduced (velocity of propagation in the transmission line being proportional to the square root of the dielectric constant).

In the particular arrangement shown in FIG. 1 there are eight radial feeds **5** to points **4** spaced at intervals of one-eighth wavelength along the line **3**, so that conduction of a single feed by a pulse from the distributor **7** provides two outputs, at A and B, one from each end point **4** which, in general, are of different phase. Switching to an adjacent feed produces two new phases, one advanced by 45° and the other retarded by 45°, according to the direction of rotation of the switching.

Continuous cyclic switching of the feeds **5** in succession by the distributor **7** causes one output to advance in phase continuously by digital steps of 45°, while the other output is retarded continuously in phase by similar digital steps. Thus one output represents a digital upper sideband, and the other output a digital lower sideband, the sideband frequency displacement from the carrier frequency of the source **1** being the frequency of rotation of the switching.

The number of phases necessary for continuous rotation of phase must be at least three, i.e. there must be at least three switchable radial feeds from the arcuate center of the transmission line to equally spaced (one-third wavelength) points along the line, but the number of feeds may be increased to any greater number. Apart from the improved accuracy of definition of sidebands, the use of more phases permits the transmission of greater power, as power transmission capability may be determined by heating of diodes which are used for switching the radial feeds under control of a distributor supplying D.C. pulses.

As shown in FIG. 2 a single diode **8** in a radial feed **5** is used for switching that feed, and a capacitor **9** is placed in series with the diode **8** in order that the switching pulses P thereto may be introduced through a suitable l radiofrequency resistor **10** (or choke).

The series capacitance may be realized, when the transmission line is microstrip, by an additional segmented arcuate strip conductor overlying the continuous arc of the transmission line and separated therefrom by a dielectric layer. This is indicated in FIG. 3, but for clarity the segments **11** (one for each feed) are shown alongside, not over the continuous line. The closely spaced segment and the adjustable portion of the line provide the desired capacitance.

In certain applications, the length of lead or transmission path from the star-connection point **2** of the diodes to be transmission line may be such that it is desirable to connect and disconnect each radial feed at each of its ends. This is shown in FIG. 4 with two oppositely poled diodes **12** being used for each phase and providing for the introduction of the operating pulses P between the diodes without mutual interaction.

By suitable shaping of the operating DC pulses, for example by the use of half-sinusoid pulses overlapping in time between peak-to-end of each pulse with start-to-peak of the next pulse, the output signals may be caused to rotate smoothly to yield substantially perfect frequency offset.

The arrangements so far described generate two single sideband outputs. FIG. 5 shows how the two single sideband outputs from A and B of FIG. 1 when applied to one diagonal of a bridge comprised of three-quarter wavelength transmission lines **13** and one **14** of three-quarter wavelength, yield at the other diagonal double-sideband outputs at C and D.

Each output corresponds to balanced modulation of the original radio frequency source, but differ in that they correspond to modulation-frequency phases in quadrature.

It is to be understood that the foregoing description of specific examples of this invention is made by way ofexample onlyand is not to be considered as a limitation on its scope.

We claim:

1. A phase-shifting arrangement including an input terminal for connection to a radio frequency source, a radio frequency transmission line of arcuate form centered on said terminal and connected thereto at equally spaced points along its length by *n* switchable radial feeds, *n* being equal to or greater than three and the spacing between the end ones of said points being equal to $(^{n11}/n)$ times the transmission line wavelength at the frequency of said source, and means for cyclically and successively switching said radial feeds to connect the input terminal to the corresponding successive spaced points along the transmission line.

2. An arrangement as claimed in claim **1** in which said transmission line is a microstrip transmission line.

3. An arrangement as claimed in claim **1** in which each said radial feed includes at least one switching diode responsive to a DC switching pulse applied thereto to connect the input terminal to the respective point on the transmission line.

4. An arrangement an claimed in claim 3 in which each said radial feed includes a single diode in series with a capacitance, the switching pulse being applied between the diode and the capacitance.

5. An arrangement as claimed in claim 4 in which when the transmission line is a microstrip line, the said capacitance is formed by an individual segment of strip conductor closely spaced from the strip conductor of the transmission line.

6. An arrangement as claimed in claim 3 in which each said feed includes two oppositely poled diodes, the switching pulse being applied between the two diodes.

7. An arrangement as claimed in claim 1 further including a bridge comprised of three-quarter wavelength transmission lines and one three-quarter wavelength transmission line connected across one diagonal thereof to the said end points of the arcuate transmission line, and output terminals connected across the other bridge diagonal.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,601,684 Dated August 24, 1971

Inventor(s) Charles W. Farp - Francis G. Overbury

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 65, cancel "(^{n11}/n)" and substitute therefor --($^{n-1}$/n)--.

Signed and sealed this 14th day of March 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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