June 4, 1963 C. F. AUGUSTINE ET AL 3,092,793

PHASE SHIFT APPARATUS ADJUSTABLE BY MOVEMENT OF DIELECTRIC SLUG

Filed Sept. 28, 1959

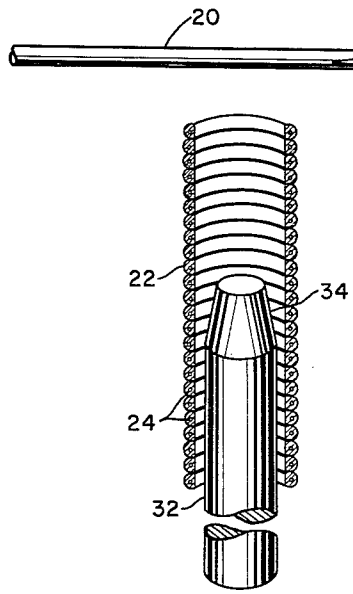


Fig. 2

Fig. 1

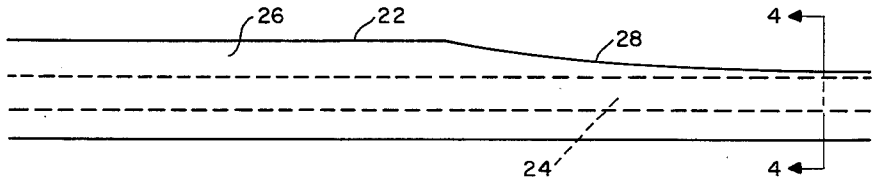


Fig. 3

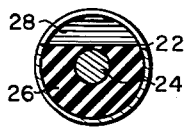


Fig. 4

INVENTOR.
CARROLL F. AUGUSTINE
JAMES CHEAL
BY VINCENT J. Mc HENRY

Richard J. Seeger
ATTORNEY

United States Patent Office 3,092,793 Patented June 4, 1963

3,092,793

PHASE SHIFT APPARATUS ADJUSTABLE BY MOVEMENT OF DIELECTRIC SLUG

Carroll F. Augustine and Vincent J. McHenry, Farmington, and James Cheal, Inkster, Mich., assignors to The Bendix Corporation, a corporation of Delaware

Filed Sept. 28, 1959, Ser. No. 842,966
12 Claims. (Cl. 333—31)

This invention pertains to a phase shift apparatus and, more particularly, to an apparatus for shifting the phase of a signal in a linear ratio to an input motion.

It is an object of this invention to provide a phase shift apparatus of a small size and rugged construction which has a linear relation between input movement and phase shift, which requires relatively low driving torque for operating the input member and is capable of performing over a very wide range of frequencies.

It is an object of this invention to provide a phase shift apparatus including a helix of coaxial cable which has the outer cable conductor and a portion of the cable insulation removed along the inner helix surface so that the inner cable conductor can come into a close registration with a cylindrical member or slug as it is inserted in the helix to vary the dielectric constant of the helix and correspondingly change the phase of the signal in the helix.

These and other objects will become more apparent when a preferred embodiment of this invention is considered in connection with the drawing in which:

FIGURE 1 is a partially schematic view of a helix with a plug partially inserted therein;

FIGURE 2 is a section taken along 2—2 of FIGURE 1;

FIGURE 3 is an elevational view of the coaxial cable showing the tapered cut-away of the removed portion; and

FIGURE 4 is a section taken along 4—4 of FIGURE 3.

In the drawing there is shown a coaxial cable **20** having outer conductor **22**, inner conductor **24**, and insulation **26** therebetween. The coaxial cable **20** may be a miniature 50 ohm cable which has an outside diameter of .085 inch with the dielectric **26** being of polytetraflouroethylene resin available from Du Pont under the trade name "Teflon." The cable has the outer conductor **22** and a portion of the insulation **26** removed along a side thereof for a predetermined distance, thereby placing the inner conductor **24** near the insulation surface. Satisfactory results are also obtainable when the insulation **26** is cut away sufficiently to expose inner conductor **24**. The outer conductor **22** is cut away at a taper **28** both at the beginning and end of the removed portion. The cable **20** is then closely wound about a cylindrical mandrel (not shown) or other means so that the removed cable portions are facing inwardly of the helix **30**. The outer conductor **22** of the individual coils of helix **30** are soldered together while the inner conductor **24** of the coils of helix **30** are insulated from one another by insulation **26**. The helix in this embodiment is 2.25 inches long and has an inner diameter of .450 inch.

A slug **32** having a tapered end **34** is inserted into helix **30** and has, in this embodiment, a clearance of about .002 inch with the inside helix diameter. The taper **34** on the inserted end of slug **32** effects a better impedance match. The slug preferably has a dielectric constant of 15 and a loss tangent of .001. The clearance is preferably small so that the high dielectric constant slug will have the maximum effect on the fields around the exposed inner or center conductors **24**.

A screw **36** is attached to the upper end of slug **32** and is turned by motor **38** through gear reducer **40**. Controls are available on motor **38** to insert slug **32** a desired distance into helix **30**. Insertion of the slug **32** into helix **30** changes the dielectric constant of the helix and this correspondingly changes the phase of the signal in the helix. The degree of phase shift corresponds in linear relation to the insertion length of slug **32** in helix **30**.

In the above embodiment phase shift can be provided for a wide band of signals, for example from 400 megacycles to 6 kilomegacycles. The total phase shift for 1.8 inches of slug penetration is 490° at 2.97 kmc. and is linear to within plus or minus 3°. Maximum insertion loss at 3 kmc. is less than 2 decibels. If lower loss is desired, a slug formed of Alite or aluminum oxide of equivalent properties can be used. Also, by using a slug of high loss matreial a compact variable attenuator is provided.

Although this invention has been disclosed and illustrated with reference to particular applications, the principles involved are susceptible of numerous other applications which will be apparent to persons skilled in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

Having thus described our invention, we claim:

1. A phase shifter comprising a coaxial cable having a center conductor and a coaxial shield for said center conductor with insulation therebetween, a circumference sector of said cable having a predetermined portion of the shield removed, a dielectric member having a predetermined dielectric constant movable in increments relative said conductive member to cover a total length of said conductive member corresponding to said total movement and movable in close proximity to said circumference sector of said cable having said shield portion removed, so that the flux lines from one portion of said member are substantially shielded from other portions of said conductive member but are unshielded from said flux modifying member.

2. The phase shifter of claim 1 wherein said circumference sector of said cable having the shield portion removed also has a predetermined portion of said insulation removed.

3. The phase shifter of claim 2 wherein said cable is formed in a helix with the circumference sector of said cable having the shield and insulation removed facing the center of the helix and forming a substantially smooth shaftway through the center of said helix, said dielectric member being cylindrical in shape and movable through and close fitting with said shaftway.

4. The phase shifter of claim 2 wherein said shield and insulation are removed sufficiently so that said dielectric member is spaced a predetermined distance from said center conductor of said coaxial cable.

5. An attenuator comprising a coaxial cable having a center conductor and a coaxial shield with insulation therebetween, a circumference sector of said cable having a predetermined portion of the shield removed, a high loss member having a predetermined loss characteristic movable in increments relative said conductive member to cover a total length of said conductive member corresponding to said total movement and movable in close proximity to said circumference sector of said cable having said shield portion removed, so that the flux lines from one portion of said member are substantially shielded from other portions of said conductive member but are unshielded from said flux modifying member.

6. The attenuator of claim 5 wherein said circumference sector of said cable having the shield portion removed also has a predetermined portion of said insulation removed.

7. The attenuator of claim 6 wherein said cable is formed in a helix with the circumference sector of said cable having the shield and insulation removed facing the center of the helix and forming a substantially smooth shaftway through the center of said helix, said high loss member being cylindrical in shape and movable through and close fitting with said shaftway.

8. The attenuator of claim 6 wherein said shield and insulation are removed sufficiently so that said high loss member is spaced a predetermined distance from said center conductor of said coaxial cable.

9. Apparatus comprising

a conductive member adapted to carry a signal to be modified,

said conductive member being electrically shielded about a predetermined portion of its cross sectional circumference and unshielded about the remaining portion of its circumference,

a member having predetermined flux modifying characteristics movable in close proximity to the unshielded portion of said conductive member,

said flux modifying member movable in increments relative said conductive member to cover a total length of said conductive member corresponding to the total movement,

the flux lines from said shielded portion of said conductive member being confined within said shielding and substantially all of the flux lines of the unshielded portions covered by the total length of said flux modifying member entering said flux modifying member.

10. The apparatus of claim 9 wherein said flux modifying member is semi-conductive.

11. The apparatus of claim 10 wherein the portion shielded is at least as large as the portion that is unshielded.

12. The apparatus of claim 11 wherein said conductive member is formed in a helix with said unshielded portion being on the inside of the helix,

said semi-conductive flux modifying member being movable through the center of said helix closely adjacent said unshielded portion.

References Cited in the file of this patent

UNITED STATES PATENTS

2,419,907	Mole	Apr. 29, 1947
2,454,530	Tiley	Nov. 23, 1948
2,507,358	Waggoner	May 9, 1950
2,512,945	Kallmann	June 27, 1950
2,527,608	Willoughby	Oct. 31, 1950
2,636,148	Gorham	Apr. 21, 1953
2,811,696	Berkley	Oct. 29, 1957
2,908,746	Fairhurst	Oct. 13, 1959
2,951,999	Marchese	Sept. 6, 1960
2,993,140	Westbrook	July 18, 1961
3,031,632	Krakau et al.	Apr. 24, 1962

FOREIGN PATENTS

130,561	Australia	May 2, 1946
632,834	Great Britain	Dec. 5, 1949