July 26, 1960 S. A. W. JOLLIFFE ET AL 2,946,998

DIRECTION FINDER

Filed March 21, 1958 2 Sheets-Sheet 1

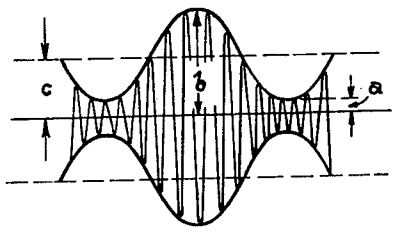


FIG. 1.

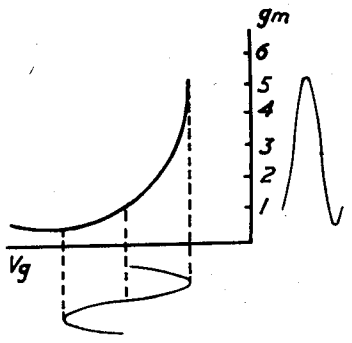


FIG. 3.

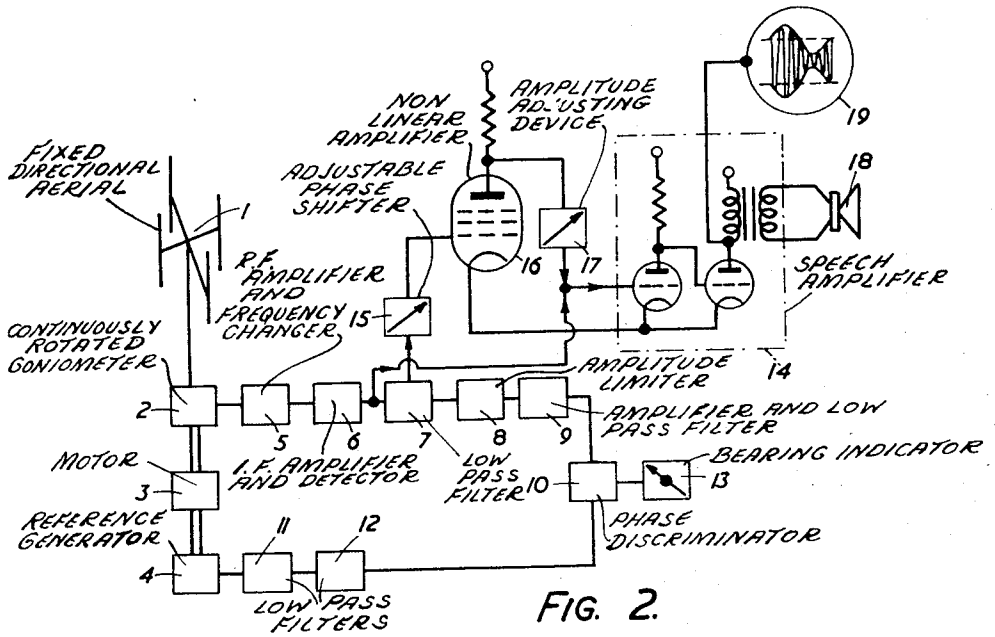


FIG. 2.

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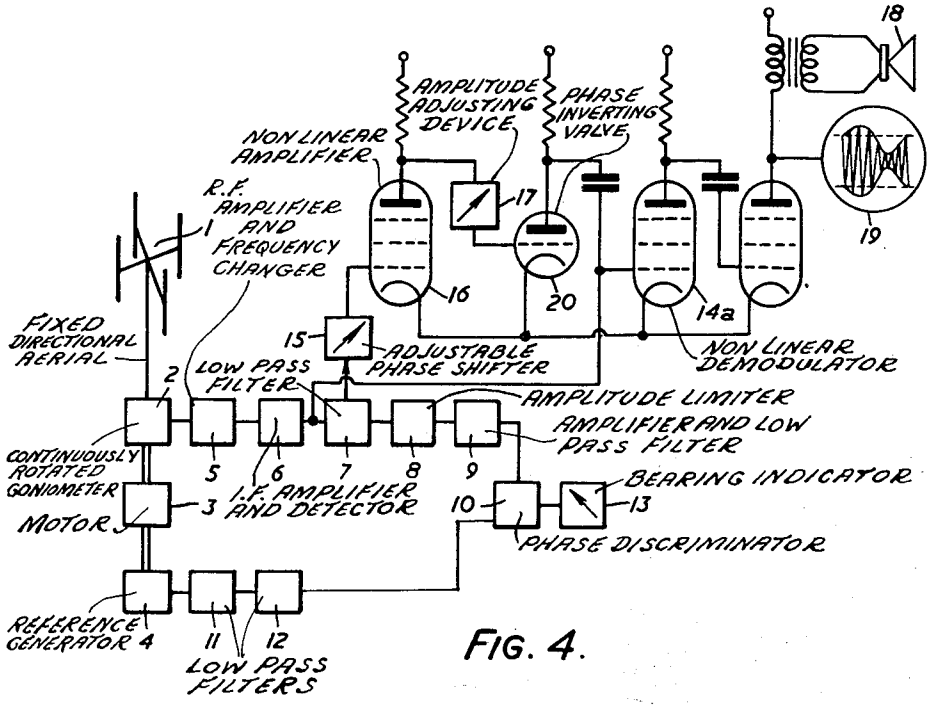


FIG. 4.

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DIRECTION FINDER

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3 Claims. (Cl. 343—118)

This invention relates to direction finders and more specifically to radio direction finders of the kind having continuously rotated directivity and in which the incoming signals whose directions are to be found carry speech or other intelligence modulation which is separated out or utilized at the receiver. Direction finders of this kind are, of course, well known and take many forms, a usual form being that in which a fixed aerial system feeds into the stator of a radio goniometer whose rotor is continuously rotated, incoming signal direction being ascertained by comparing the phase of a signal derived from the rotor output with the phase of a signal derived from a reference frequency generator providing a frequency equal to that of rotation of directivity.

The invention is illustrated in and explained in connection with the accompanying drawings. In the drawings Figs. 1 and 3 are explanatory graphical figures; Fig. 2 is a diagram of an embodiment of this invention; and Fig. 4 shows a modification of the arrangement of Fig. 2.

A difficulty which arises in a direction finder of the kind referred to is that the continuous rotation of directivity superimposes a modulation of the rotation frequency on the received signals and if those signals include speech or other intelligence which is to be separated out and reproduced, the superimposed modulation due to the rotation of directivity may spoil the speech or other intelligence or even make it completely unintelligible, for the frequency of the modulation due to rotation of directivity is a low frequency, 25 c./s. being a common figure.

The difficulty above mentioned cannot be satisfactorily avoided—as would at first sight appear to be the case—by merely superimposing a counterbalancing locally generated frequency equal to that due to directivity rotation on the intelligence signals. The reason for this may be explained with reference to Fig. 1. With a practical direction finder of the kind referred to, sensitivity is dependent on the depth of modulation of the incoming radio frequency carrier and in practice this depth can sometimes be as much as 80%. Thus in order to make speech or other intelligence signals derived from the goniometer rotor satisfactorily intelligible, one has to demodulate a post-detector speech band which may be modulated up to the order of 80% by the goniometer. Fig. 1 represents conventionally an 80% modulated wave. Demodulation of this wave may be deemed to be accomplished if the full line sinusoidal envelope curves are changed into the parallel straight lines (broken lines) passing through the mean amplitude values of the sinusoidal curves. Thus, if the dimensions b, a are such that

$$\frac{b-a}{b+a}\times 100=80\%$$

—which is the case for 80% modulation—the amplitude at the trough will have to be increased in a ratio of 5:1 and the amplitude at the crest will have to be decreased in a ratio of 1.8:1 if both are to be changed to the

mean amplitude. In other words, the overall required change, peak to crest, may be expressed by a ratio of 9:1 for, in Fig. 1, if the dimension $a=1$, $b=9$ and the mean amplitude $c=5$. It will now be seen, therefore, that merely superimposing a counterbalancing locally generated sine wave on the received signal wave will not get rid of the directivity rotation modulation of the intelligence signals. The present invention seeks to get rid of this modulation or to reduce it to an acceptable amount. In its broadest aspect, the invention consists in subjecting a sinusoidal wave of directivity-rotation frequency to gain control in dependence upon the momentary amplitude of that wave and utilizing the gain controlled wave at least partly to counterbalance an undesired component of the same frequency in the directionally received signals.

According to a feature of this invention a radio direction finder of continuously rotated directivity and including a channel for recovering intelligence signals modulating incoming waves whose direction is to be ascertained comprises means for deriving a low frequency wave of the frequency of rotation of directivity, an amplifier connected to amplify said wave and having gain which is a function of and increases with increase of input amplitude, and means for superimposing the output of said amplifier upon the signals in said channel in phase opposition to the component of directivity-rotation frequency which will be present in said signals so as to annul or substantially reduce said component.

It is possible to constitute the amplifier by a simple variable μ valve amplifier but, in practice, variable $-\mu$ valves of sufficient curvature of characteristic may not be readily available. It may therefore be preferred to include a non-linear stage in said channel at a point subsequent to that at which the output of said amplifier is superimposed, said stage operating over a substantially straight part of its characteristic as respects the intelligence signals and the phase of the superimposed signals being so chosen that the curvature characteristic of the non-linear stage supplements that of the amplifier amplifying said low frequency wave.

Preferably said wave is derived by filtering it out from the signals fed in to said channel.

Preferably also means are provided for adjusting the phase and amplitude of the derived wave and, advantageously, a cathode ray tube monitor fed with signals taken from said channel at a point subsequent to that at which superimposition of said output takes place is provided to facilitate adjustment.

Fig. 2 is a block diagram of one embodiment of the invention.

Referring to Fig. 2, reference character 1 represents a fixed directional aerial system of any kind known per se and which supplies signals to a known continuously rotated goniometer represented by the block 2. The rotor of the goniometer is rotated at a desired speed, for example 1500 r.p.m., by an electric motor 3 which also drives the reference generator 4 at a speed such that the frequency from said generator is the same as the frequency of modulation of the goniometer output due to rotation of its rotor, e.g. 25 c./s.

Output from the goniometer rotor is passed to a radio frequency amplifier and frequency changer 5 followed by the usual intermediate frequency amplifier and detector 6. The radio frequency amplifier and frequency changer are both represented by the block 5 and the intermediate frequency amplifier and detector are both represented by the block 6. Detected output from the unit 6 is amplified and passed through a low pass filter at 7, the low pass filter being adapted to pass the frequency of rotation of directivity—in the present case 25 c./s. The output from the unit 7 is fed to an am-

plitude limiter **8**, further amplified by an amplifier **9** including another similar low pass filter, and supplied as one input to a known phase discriminator unit **10**.

Output from the generator **4** is passed through low pass filters **11** and **12** similar to the filters at **7** and **9**, and thence fed as the second input to the phase discriminator **10**. As is well known the phase relation between the two inputs to the discriminator **10** will be a measure of the direction of the incoming signals and the discriminator may operate a known bearing indicator **13** which may be calibrated directly in bearings. The apparatus as so far described is all well known and in accordance with common practice and needs no further description here.

Output from the unit **6** which will consist of intelligence signals, e.g. speech, modulated at the frequency of directivity rotation is fed to a speech amplifier **14** shown schematically as a two-stage amplifier. Output is also taken from the 25 c./s. filter at **7** through an adjustable phase shifter **15** to the control grid of a non-linear valve amplifier which may conveniently be a variable $-\mu$ pentode **16**. This valve is operated as conventionally shown by the graphs in the accompanying Fig. 3 which require no description beyond stating that Vg represents grid voltage and gm represents gain. The output of the valve **16** is fed through an amplitude adjusting device **17** of any known kind, e.g. a potentiometer, and superimposed on the signals from the unit **6** at the input of the speech amplifier **14** shown as a two stage amplifier comprising two triodes of which the first is the demodulator. Output from the speech amplifier **14** is taken to a loudspeaker or telephones **18** and is also taken to a cathode ray tube monitor **19**. As will be seen by suitably choosing and adjusting the operating parameters of the valve **16** and suitably adjusting the phase and amplitude controls **15** and **17**, the 25 c./s. input fed to the control grid of the first valve in the amplifier **14** from the valve **16** may be caused to be, to a sufficiently close degree of approximation, in phase opposition with and such as to cancel out the 25 c./s. component (due to goniometer rotor rotation) present in the input fed to that control grid directly from the unit **6**.

In use the phase and amplitude controls **15** and **17** are adjusted until the 25 c./s. modulated wave (shown as an envelope wave in full lines on the representation of the tube at **19**) are transformed into the partially broken straight lines (also shown in that representation) corresponding to the desired result, or as nearly to those straight lines as can be achieved. Ideally, by adjusting the controls **15** and **17** complete cancellation of the interfering component is possible. Although in practice the "ideal" is not to be expected, a practically sufficient approximation to complete cancellation is readily obtained.

It may not always be conveniently practicable to obtain a variable $-\mu$ valve **16** of sufficient curvature of characteristic and for this reason the modified circuit of Fig. 4 may be preferred. Like references denote like parts in Figs. 2 and 4. In Fig. 4 the demodulator valve here referenced **14***a* also has a non-linear characteristic of the nature of that of the valve **16**. Its control grid is fed from the junction point of the units **6** and **7** as is the demodulator valve (the first valve of the speech amplifier **14**) in Fig. 2 but a phase inverting valve **20** is interposed between the amplitude adjuster **17** and the said control grid of valve **14***a*. The audio frequency level at the junction point of the units **6** and **7** is arranged to be low enough to sweep over only a substantially linear part of the characteristic of the valve **14***a* the gain of which is however, varied by the directivity—rotation modulation frequency, the inverting valve **20** being inserted to procure the result that the effect of the curvature of characteristic of valve **14***a* supplements that of the curvature of the characteristic of valve **16** to produce an overall curvature of characteristic which is sufficient even though that of the valve **16**, alone, is not.

We claim:

1. A radio direction finder of continuously rotated directivity and including a channel for recovering intelligence signals modulating incoming waves whose direction is to be ascertained said direction finder including means for deriving a low frequency wave of the frequency of rotation of directivity, a non-linear amplifier connected to amplify said wave and having gain which is a function of and increases with increase of input amplitude, means to adjust the phase and amplitude of said amplifier and means for superimposing the output of said amplifier upon the signals in said channel in phase opposition to the component of directivity-rotation frequency which will be present in said signals so as to annul or substantially reduce said component.

2. A direction finder as claimed in claim 1 wherein a non-linear stage is included in said channel at a point subsequent to that at which the output of said non-linear amplifier is superimposed, said stage operating over a substantially straight part of its characteristic as respects the intelligence signals and the phase of the superimposed signals being so chosen that the curvature characteristic of the non-linear stage supplements that of the non-linear amplifier amplifying said low frequency wave.

3. A direction finder as claimed in claim 1 wherein there is provided a cathode ray tube monitor fed with signals taken from said channel at a point subsequent to that at which superimposition of said output of said amplifier upon the signals in said channel is effected.

References Cited in the file of this patent

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