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SPECTRUM ANALYZER

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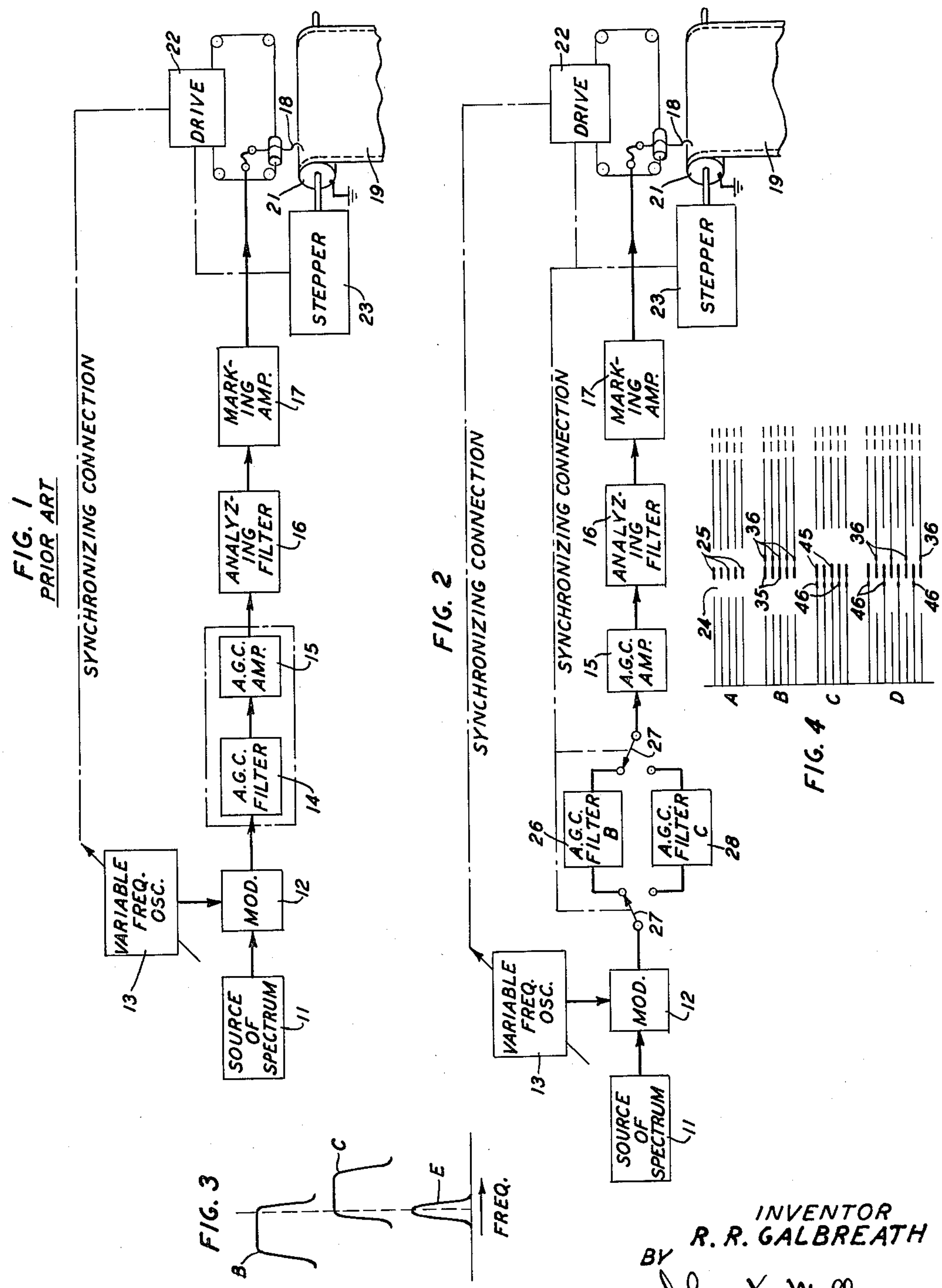

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SPECTRUM ANALYZER

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This invention relates to the analysis of complex waves, and more particularly to spectrum analyzer systems for detecting and displaying a frequency spectrum by the process of progressive analysis of the frequency content of the spectrum.

In spectrum analyzers of the type noted above it is frequently desirable to utilize an automatic gain control stage, or compressor, preceding the narrow band analyzing filter (for example, see the patent to W. Koenig, Jr., 2,403,982, July 16, 1946). Among other things, the AGC makes up for the nonuniformity of the spectrum being analyzed, that is, it "normalizes" the noise background in which the signal is immersed. With a more or less uniform noise background, a signal or signals are more readily recognized. However, in the presence of a strong signal the AGC serves to suppress the display over a frequency range corresponding to the AGC pass-band with the result that a weak signal adjacent (in the frequency spectrum) to a strong signal is often not detected.

Accordingly, it is the object of the present invention to improve the performance of spectrum analyzers when attempting to detect a weak signal adjacent, in the frequency spectrum, to a strong signal.

The primary feature of the present invention lies in an improved AGC means for spectrum analyzers. Rather than using a fixed AGC pass-band with the narrow band analyzing filter centered with respect thereto as in pre-existing prior art arrangements, the instant inventive concept of switching between two AGC pass-bands on alternate analyzer sweeps offers increased detectability in the neighborhood of a strong signal. The narrow band of the analyzing filter is positioned, in the frequency spectrum, in the neighborhood of the upper limit of one of said AGC pass-bands and in the neighborhood of the lower limit of the other of said pass-bands with the result that a weak signal of slightly higher or lower frequency than a strong signal is displayed at least on alternate analyzer sweeps.

Other features and advantages of the invention will become more apparent from the following detailed description which, together with the accompanying drawing, discloses a preferred embodiment.

In the drawing:

FIG. 1 is a block diagram of a typical prior art spectrum analyzer;

FIG. 2 is a block diagram of a spectrum analyzer in accordance with the principles of the present invention;

FIG. 3 shows several curve diagrams which illustrate certain details of design in accordance with the invention; and

FIG. 4 illustrates, symbolically, the visual representations obtainable with the prior art analyzer of FIG. 1 and the improved analyzer of FIG. 2.

Referring now to the drawing, there is shown in FIG. 1 a typical prior art spectrum analyzer. The reference numeral **11** denotes a source of a spectrum which may be of any selected frequency range. While the spectrum will in many instances be an audio spectrum, it will be clear to those in the art that the invention is in no way limited in this regard and the principles of the invention can be applied to any desired band of frequencies.

The general character and manner of operation of panoramic spectrum analyzers, such as shown in FIG. 1, are well known in the art and therefore only a brief description thereof will be given. The spectrum of frequencies to be analyzed is applied to the input of a wide band mixer or modulator **12** wherein it is heterodyned with a signal derived from a source of local oscillations **13**. A filter **14** is coupled to the output of the modulator and it accepts only a relatively small part of the total frequency spectrum. By frequency modulating or scanning the source of local oscillations **13**, successive portions of the frequency spectrum are effectively translated into the filter **14**, in sequence. The action of the system is, then, effectively to sweep the wide band frequency spectrum to be analyzed past the relatively narrow pass-band of the filter **14**, the latter abstracting from the frequency spectrum in succession small increments of signal distributed along the spectrum.

Signals present in the filter **14** are delivered via the AGC amplifier **15**, narrow band analyzing filter **16**, and marking amplifier **17** to marking stylus **18** of the recorder. The recorder is illustrated diagrammatically as comprising a strip of sensitized paper **19** which extends over and is driven by drum **21**. The stylus **18** is driven across the paper (that is, longitudinally of drum **21**), by any known conventional drive **22**. Whenever signal energy is encountered in a frequency scan, corresponding currents pass through stylus **18** and through the sensitized paper **19** to the drum. By virtue of the heat generated locally at the point of contact of stylus **18**, a chemical change takes place and a mark is made on the paper, the darkness or density or blackness of the mark depending on the current strength and therefore on the signal energy encountered in said frequency scan. The progressive change in the operating frequency of the oscillator **13** is electrically or mechanically geared with the progressive change in the position of stylus **18** so that as the stylus moves once across the sensitized paper the oscillator frequency progresses from its one limiting value to another.

The stepper **23** is electrically or mechanically geared to the drive **22** for the purpose of advancing the sensitized paper a fraction of an inch after each analyzer sweep.

As previously indicated, it is frequently desirable to normalize the noise background in which a signal is immersed. To this end, an AGC stage is utilized in spectrum analyzers. Now for satisfactory "normalization," the AGC stage should preferably be of a pass-band width which is narrow with respect to the spectrum of frequencies being analyzed. However, in order not to significantly suppress the very signals to be detected, the AGC pass-band should be of a width somewhat greater than that of the analyzing or scanning filter. In the patent to Koenig, cited above, it was indicated that the AGC, or compressor, pass-band be preferably several times (for example, four times) greater than that of the analyzing filter. Further, as indicated for example in the patent, the AGC and analyzing filter pass-bands should have substantially the same mean pass frequency, that is, they are centered with respect to each other.

In the prior art analyzer of FIG. 1, the AGC amplifier **15** provides the desired gain control. However, the pass-band characteristics of this AGC stage are determined primarily by the filter **14**. The AGC amplifier **15** may, of course, be designed so as to provide good inherent pass-band characteristics, but in general it is easier and more economical to use a filter in conjunction with the AGC amplifier, the former serving to establish the pass-band characteristics for the combination.

As the oscillator **13** sweeps from its one limiting value to the other, successive portions of the frequency spectrum are analyzed (that is, successive portions of the spectrum are passed by the filters **14** and **16**). In coincidence therewith, the stylus **18** traces a path across the sensitized paper **19**. Each elemental area of the trace is individual to a preassigned frequency and thus the density or blackness of the trace provides an indication of the power content throughout the spectrum of frequencies being analyzed.

FIG. 4A illustrates several stylus traces which are symbolic of the type produced by prior art spectrum analyzers, such as shown in FIG. 1. In the presence of a strong signal the AGC stage serves to suppress the display over a frequency range corresponding to the AGC pass-band. This can be appreciated by considering the spectrum as being effectively swept past the AGC pass-band, or vice versa. The gain of the AGC stage is substantially reduced, and hence the display suppressed, during that portion of each sweep that the strong signal falls within said AGC pass-band. The effect of this suppression is a whitening of each trace, as indicated at **24** in FIG. 4A, for a width which corresponds to the width of the AGC pass-band. The strong signal will, of course, override the gain suppression provided by the AGC action and it therefore produces the marks **25** on the sensitized paper. However, a weaker signal adjacent, in the frequency spectrum, to a strong signal is suppressed, that is, it is lost in the whitened portion of each trace.

In FIG. 2 there is shown a spectrum analyzer in accordance with the present invention. The oscillator-modulator combination, the AGC amplifier, analyzing filter, marking amplifier, and recording mechanism are similar in nature and operation to the correspondingly numbered elements of FIG. 1. However, rather than using a fixed AGC pass-band with the narrow band of the analyzing filter centered with respect thereto, a pair of AGC pass-bands are utilized on alternate analyzer sweeps. To this end, the filters **26**, **28** are connected by switch means **27** between the modulator **12** and AGC amplifier **15**. The switches **27** are electrically or mechanically interconnected with the stepper **23** for the purpose of connecting the filters alternately into the circuit on alternate analyzer sweeps.

In FIG. 3 there is illustrated the relationship between the AGC pass-bands B and C and the analyzing filter pass-band E. As indicated in this figure, the narrow band of the analyzing filter is located, in the frequency spectrum, in the neighborhood of (that is, adjacent to) the upper limit of one of the AGC pass-bands (pass-band B) and in the neighborhood of the lower limit of the other of said AGC pass-bands (pass-band C). The AGC pass-bands, here also, are substantially greater (for example, four or more times) than the analyzing filter pass-band.

Considering now the operation of the analyzer shown in FIG. 2, let it be assumed that the AGC filter **26**, having pass-band B, is connected in the circuit. If, with the exception of the AGC filter **26**, everything is as before, the traces of FIG. 4B will include marks **35** located at essentially the same transverse position as the marks **25**. However, the AGC and analyzing filter pass-bands are no longer centered with respect to each other as in the prior art arrangement considered above, but rather are respectively positioned as shown at B and E in FIG. 3. Accordingly, the whitened or depressed portions of the traces of FIG. 4B are not centered with respect to the marks **35** as in the prior art case, but rather are offset with respect thereto in the same fashion that pass-band B is offset with respect to pass-band E.

In further explanation of the operation of the analyzer shown in FIG. 2, assume that the oscillator frequency is swept in a manner such that the lower and then successively higher frequencies of the spectrum are translated into the AGC pass-band B. The effect of this sweep operation can be appreciated by considering a spectrum that extends, from right to left, from a low to a high frequency. If this spectrum is then imagined as being moved or swept to the right, past the AGC pass-band B of FIG. 3, it will be seen that suppression of the display occurs when the strong signal in the spectrum first appears within the said AGC pass-band (that is, adjacent the lower limit thereof). This suppression will continue until the strong signal no longer appears in said AGC pass-band. Hence, the display is suppressed over a frequency range corresponding to this AGC pass-band. However, at the very upper limit of the pass-band B, the strong (overriding) signal falls within the analyzing filter pass-band E and it is therefore passed on by the latter to the marking amplifier and stylus. The above-described operation results in a trace pattern such as that shown in FIG. 4B. A weak signal adjacent to, but of lower frequency than, said strong signal will be suppressed; whereas, a weak signal adjacent to, but of somewhat higher frequency than, said strong signal will produce a mark, such as **36**, on the traces of FIG. 4B.

When the AGC filter **28**, having pass-band C, is connected in the circuit, traces such as shown in FIG. 4C are obtained. Again, with the exception of the AGC filter, everything is as before and hence the traces of FIG. 4C will, expectedly, include marks **45** located at the same transverse position as marks **35**. The AGC pass-band C, like pass-band B, is offset with respect to pass-band E, that is, the latter is located in the neighborhood of the lower limit of pass-band C rather than being centered with respect thereto. However, from FIG. 3, it will be seen that the pass-bands B and C are offset in the opposite sense and hence so are the whitened or suppressed portions of the sets of traces shown respectively in FIGS. 4B and C.

In FIG. 4C, a weak signal adjacent to, but of lower frequency than, a strong signal will produce indicating marks **46**; whereas, a weak signal adjacent to, but of a higher frequency than, a strong signal will most probably be suppressed (that is, lost in the whitened portion of each trace).

During normal operation the filters **26** and **28** are alternately switched into the circuit on alternate analyzer sweeps, the pattern produced thereby being depicted in FIG. 4D. From an examination of FIG. 4D and the foregoing explanation, it will be seen that a weak signal of slightly higher or lower frequency than a strong signal is displayed on at least alternate analyzer sweeps and, therefore, increased detectability in the neighborhood of a strong signal is obtained.

Rather than utilizing two AGC filters and a single AGC amplifier to provide the desired AGC pass-bands B and C, it will be clear to those in the art that a pair of AGC amplifiers, each designed to provide the desired pass-band characteristics, could be used. The AGC amplifiers themselves would then be connected alternately into the circuit. Alternatively, two AGC filter-amplifier combinations might be used, with the said combinations connected alternately into the circuit. However, the first arrangement of two filters and a single AGC amplifier has proven to be the simplest and most economical.

As will be clear to those in the art, the principles of the present invention find utility in other and different types of spectrum analyzers. For example, the invention is equally adapted for use in those spectrum analyzers which utilize a cathode ray tube for recording purposes. In this type analyzer, the beam of the cathode ray tube is swept across a screen, of long persistence, in coincidence with the scan of the local oscillator.

It should be understood, therefore, that the foregoing disclosure relates to only a preferred embodiment of the invention and that numerous modifications or alterations may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A spectrum analyzer for recording on a record receiving surface the relative amplitudes and frequencies of signals contained in a frequency spectrum comprising

a narrow band analyzing filter, means for relatively scanning said spectrum of frequencies and said filter to introduce successive portions of said spectrum into said filter in time succession, a pair of automatic gain control means adapted to be coupled between the first-mentioned means and said analyzing filter, said gain control means having pass-bands substantially larger than that of said analyzing filter with the latter being disposed in the frequency spectrum adjacent the upper limit of one of said pass-bands and adjacent the lower limit of the other, and means for alternately coupling said gain control means between said first-mentioned means and said analyzing filter on alternate analyzer scans.

2. A spectrum analyzer comprising a superheterodyne receiving means having a local oscillator and an output circuit, means coupling a frequency spectrum to be analyzed to said superheterodyne means, means for periodically sweeping the frequency of said local oscillator over a band of frequencies to receive signals comprised in said spectrum in time succession, a narrow band analyzing filter, a pair of automatic gain control means adapted to be coupled between the output circuit of said superheterodyne means and said analyzing filter, said gain control means having pass-bands substantially larger than that of said analyzing filter with the latter being disposed in the frequency spectrum in the neighborhood of the upper limit of one of said pass-bands and in the neighborhood of the lower limit of the other, and means for alternately coupling said gain control means between said output circuit and said analyzing filter on alternate analyzer sweeps.

3. Apparatus for producing a visual display of the relative amplitudes and frequencies of signals contained in a frequency spectrum, a heterodyning means comprising a local oscillator, means coupling said frequency spectrum to the input of said heterodyning means, an analyzing filter having a narrow pass-band, means for periodically sweeping the frequency of said local oscillator over a band of frequencies to effect translation of successive portions of said spectrum into said narrow pass-band, a pair of filters having predetermined pass-bands, an automatic gain control amplifier, switch means for alternately coupling said filters between said heterodyning means and said gain control amplifier, said gain control amplifier being connected at its output to said analyzing filter, the pass-band of said analyzing filter being disposed in the frequency spectrum in the neighborhood of the upper limit of the pass-band of one of said pair of filters and in the neighborhood of the lower limit of the pass-band of the other of said pair of filters, and means connected to said switch means for alternately coupling said filters between said heterodyning means and said gain control amplifier on alternate analyzer sweeps.

4. Apparatus as defined in claim 3 wherein the pass-bands of said pair of filters are of the same width, said width being substantially greater than that of said analyzing filter.

5. In a spectrum analyzer for recording on a record receiving surface the relative amplitudes and frequencies of signals contained in a frequency spectrum, a heterodyning means comprising a local oscillator, means for coupling said frequency spectrum to the input of said heterodyning means, an analyzing filter having a narrow pass-band, means for periodically sweeping the frequency of said local oscillator over a band of frequencies to effect translation of successive portions of said spectrum into said narrow pass-band, and automatic gain control means coupled between said heterodyning means and said analyzing filter, said gain control means having at least a first pass-band substantially larger than that of said analyzing filter with the latter being disposed in the frequency spectrum immediately adjacent one of the limits of said first pass-band.

6. In a spectrum analyzer for recording on a record receiving surface the relative amplitudes and frequencies of signals contained in a frequency spectrum, a heterodyning means comprising a local oscillator, means for coupling said frequency spectrum to the input of said heterodyning means, an analyzing filter having a narrow pass-band, means for periodically sweeping the frequency of said local oscillator over a band of frequencies to effect translation of successive portions of said spectrum into said narrow pass-band, a pair of automatic gain control means adapted to be coupled between said heterodyning means and said analyzing filter, said gain control means having pass-bands substantially larger than that of said analyzing filter with the latter being disposed in the frequency spectrum in the neighborhood of one of the limits of one of said pass-bands, and means for alternately coupling said gain control means between said heterodyning means and said analyzing filter on alternate analyzer scans.

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