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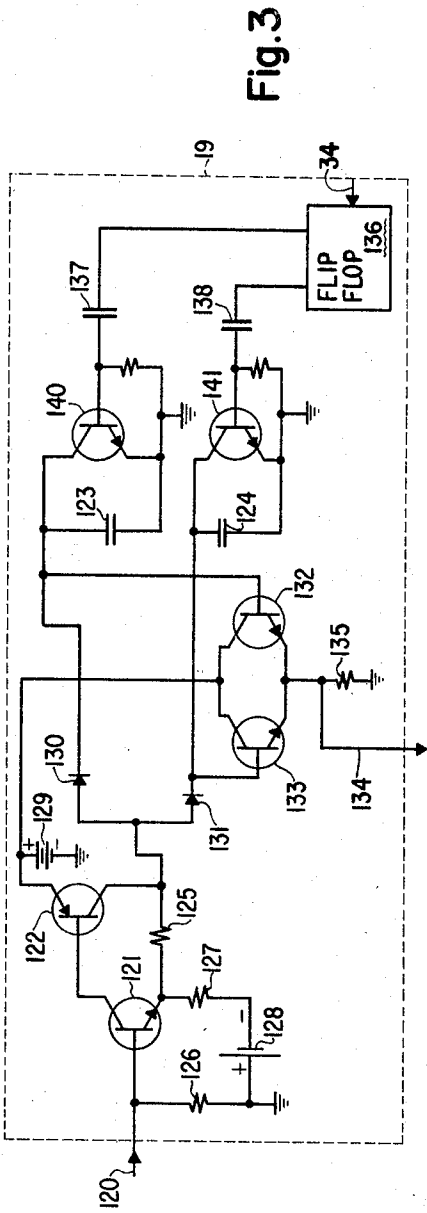
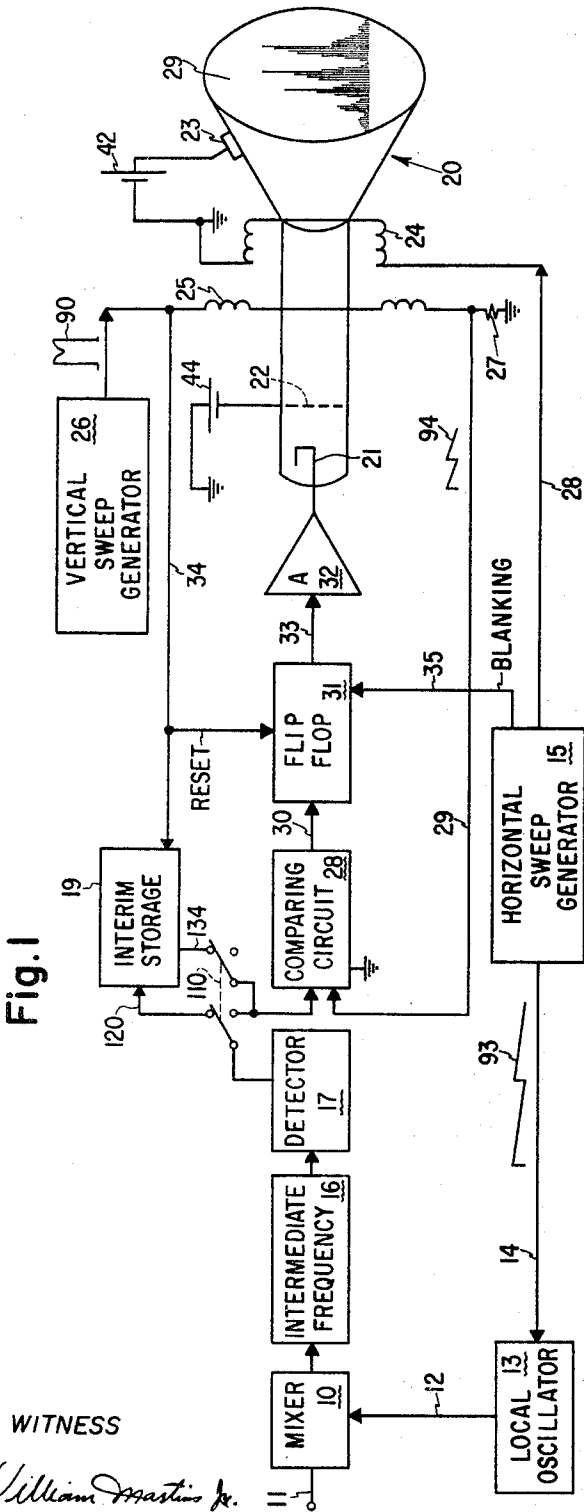
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PANORAMIC SOLID-LINED AND DOTTED GRAPHIC DISPLAY SYSTEMS

Filed July 22, 1965

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

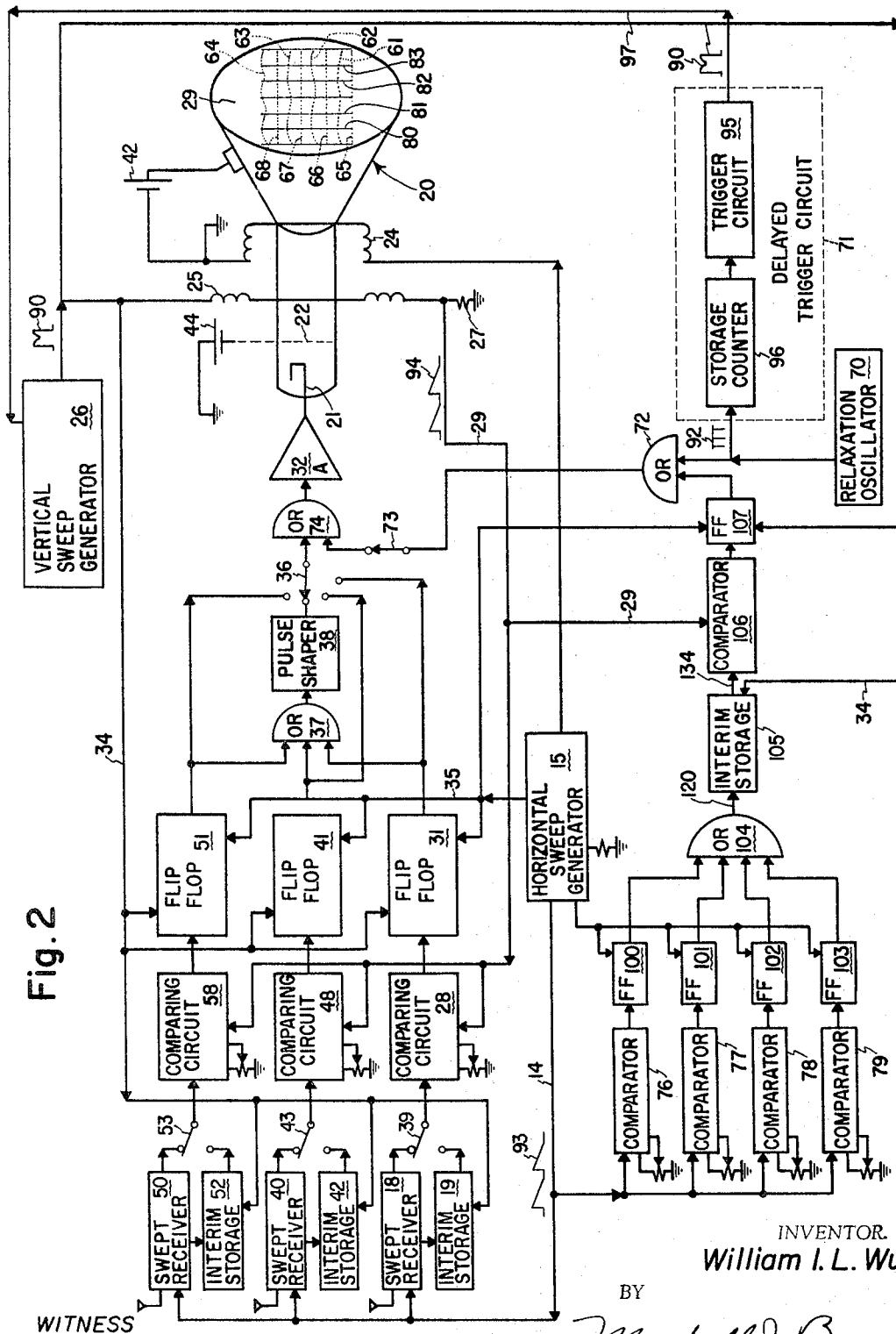


Fig. 2

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PANORAMIC SOLID-LINED AND DOTTED GRAPHIC DISPLAY SYSTEMS

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16 Claims. (Cl. 324-77)

This invention relates to electronic scanning and display systems for panoramic spectrum analyzers employing fast and slow time base generators for scanning, and more particularly this invention relates to display systems employing magnetic deflection, modulation of ray intensity, and a uniform rate of scanning.

In display of electrical signals in a panoramic spectrum analyzer, it is desirable that the display be readily adapted to interpretation. A problem associated with some magnetic deflection cathode ray presentation systems designed for a uniform rate of scanning has been that the only display presented has comprised a series of dots varying in intensity, or a series of dots positioned sufficiently close together to form a trace. However, to the viewer the shape of the curve cannot be interpreted readily with respect to amplitude because the dot type of display is relatively dim and while the system is advantageous for certain purposes it fails to indicate distinctly, the shape of the integral of the wave shape under the amplitude-frequency curve, because the location of the base line is not certain. In addition, in cathode-ray-display systems previously suggested for presenting line displays of amplitude with vertical lines indicating amplitude, the intensity of the cathode ray has been modulated in proportion to the amplitude for each vertical, or ordinate line and extinction has been reached after gradual decrease in intensity in proportion of values of the abscissa or height of the line. However, in such a system, the practice of gradual extinction of the beam renders the exact point at which the beam is extinguished indistinct. Whereas, such forms of display may suffice in certain arts, ease of interpretation of data and accuracy of display of amplitudes is important in spectrum analysis, because such instruments are frequently employed to save time in designing systems or to monitor dynamic conditions. Hence uniform intensity of illumination is extremely desirable.

Further, in prior spectrum analyzers, the display provided has not comprised a solid-lined display of amplitude versus frequency. The display has comprised either discontinuous non-linear deflection in the vertical direction having non-uniform ray intensity and hence varying brightness, which has discouraged use of magnetic deflection in most conventional systems. In some instances a dot display has been employed.

In addition, in prior systems no provision has been made for providing a dot-trace display system which may be adjusted instantly to provide a solid-line display of the amplitude-frequency data. A system permitting presentation of both types of display by means of a single instrument would provide measurements with a degree of facility which has not been possible heretofore. For example, it would be extremely desirable if a spectrum analyzer were adapted to provide a plurality of signals in dot-display form with several, stacked, horizontal axes. Then, if when a particular band of the several bands being displayed became of particular interest, a control could be operated to provide a solid display of the particular band of interest, the instrument would provide an exceedingly versatile and useful function.

Another extremely desirable feature for such a system would be to provide a display of a graticule of amplitude and frequency which would permit more accurate analy-

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sis of the actual coordinates of a given point on the display.

Accordingly, it is an object of this invention to provide a spectrum analyzer having a uniform rate of deflection across coordinates with a greater rate of vertical deflection, providing a solid-lined display of amplitude versus frequency.

It is a further object of this invention to provide such a display in which the intensity of the ray prior to blanking for a particular linear trace comprises a substantially uniform value, whereby the brightness will be uniform and the outline of the display will be clear and distinct.

A further object of this invention is to provide a spectrum analyzer of the above type wherein means are provided for at will providing a dot display, through beam intensification.

A still further object of this invention is to provide multiple panoramic dot displays on the screen of a spectrum analyzer conjointly with presentation of self-generated coordinate reference traces or a graticule.

Further aspects of this invention are described below with reference to the attached drawings wherein:

FIG. 1 is a schematic diagram of a spectrum analyzer in accordance with this invention;

FIG. 2 is a schematic diagram showing a modification of FIG. 1 illustrating a preferred form of this invention; and

FIG. 3 is a schematic diagram showing an interim storage circuit useful in connection with invention.

Referring to FIG. 1, a spectrum analyzer is shown including a mixer 10 having a first input terminal 11 for connection to a source of a band of frequencies. The amplitudes at those frequencies received are to be displayed as a function of frequency. The analyzer could be modified for reception of any passband desired by connecting an antenna and a preselector should it be desired to display passbands in the radio or microwave frequency ranges as is well known to those skilled in the art.

A second input 12 to the mixer 10 is connected to the output of a frequency sweeping or scanning local oscillator 13 which is adapted to be scanned across a desired range of frequencies by means of a variable reactance element included therein. The local oscillator 13 has an input connected by line 14 to the output of a horizontal sweep generator 15. The horizontal sweep generator 15 is preferably adapted to provide a sawtooth wave output 93 on line 14 scanning at a relatively low rate in order to tune the variable reactance of the local oscillator 13 and a pulse on line 28 to provide horizontal deflection of the cathode ray to a cathode-ray tube 20 in a conventional manner as explained below.

The output of the mixer 10 is connected to an intermediate frequency filter 16 which will conventionally include an amplifier. Filter 16 will have a narrow passband in order to pass a signal continuously varying in frequency as a function of heterodyning between the output signal of scanning local oscillator 13 and a particular frequency within the band of frequencies supplied to input terminal 11. Hence, as in conventional scanning spectrum analyzers the output from intermediate frequency filter 16 supplied to detector 17 will comprise the repetitive scanning signal representing amplitudes of successive signals varying as a function of frequency and time, as the frequency of the original signals presented to the input to detector 17 varies as a function of time, as will be well understood by those skilled in the art.

In a conventional spectrum analyzer the signal from the detector 17 would be employed directly to control the degree of vertical deflection of the cathode ray of a cathode-ray tube. But, in the present system, the vertical deflection of the cathode ray occurs at a constant rate, similarly to the raster deflection system employed in television. Ac-

cordingly, vertical deflection is independent of the detector output. Furthermore, although conventional spectrum analyzers employ electrostatic deflection plates, the present invention permits use of magnetic deflection coils, thereby permitting use of more compact and economical cathode-ray tubes.

In that connection the cathode-ray tube 20 includes a cathode 21, a negatively-biased control electrode 22, a positively-biased accelerating electrode 23, a horizontal deflection coil 24, and a vertical deflection coil 25.

A vertical sweep generator 26 is connected to one end of vertical deflection coil 25. The vertical generator 26 provides a sawtooth scanning current at a frequency substantially greater than that of the horizontal generator 15, to flow in the vertical coil 25. The opposite end of the vertical coil 25 is connected to reference potential through a resistor 27. The horizontal deflection coil 24 is connected to an output 28 of horizontal generator 15, which also supplies a sawtooth wave synchronized with that supplied to the local oscillator 13 at the lower frequency referred to above.

The combined effect of the horizontal and vertical scanning waves upon the cathode ray is to provide a scan across the screen 29 of the cathode-ray tube comprising a series of substantially parallel, substantially vertical lines with the ray moving from one side of the screen to the other during each scanning cycle provided by the horizontal sweep generator 15. Hence, when full intensity illumination of all the screen 29 is provided, the display presented will comprise a plurality of parallel vertical lines. Each vertical line represents a different frequency. Preferably, the ratio of the rate of vertical deflection to the rate of horizontal deflection will be sufficiently high so that the vertical lines will be very close together in order to provide maximum signal information. Closer vertical lines permit greater accuracy of display. Also, the contrast between the illuminated and dark portions of the screen will be substantial. In other words, it is intended that the system be capable of presenting a substantially "solid" display of the integral of amplitude (vertical axis) as a function of frequency (horizontal axis), by employing the preferred embodiment of this invention.

To provide a solid display with the above type of scanning, the beam must be intensified at the base line and blanked at a height representing the amplitude of the particular frequency represented by the position of the particular vertical line being traced.

In order to provide blanking of the beam during each vertical trace at a height representing the corresponding amplitude, in accordance with this invention among other elements means must be provided for modulating the cathode ray. In FIG. 1, the cathode is modulated. In order to have blanking occur at such a time to correlate the position on the vertical trace of the cathode ray on the frequency axis with the amplitude of the output provided by detector 17, a comparing circuit 28 and an interim storage circuit 19 which may be connected by switch 110 in series between detector 17 and comparing circuit 28 as is described in detail in connection with FIG. 3 are provided. Comparing circuit 28 may comprise a diode connected with a predetermined source of biasing potential as well as means for providing adjustment of the potential supplied to the diode which will provide an output in response to a predetermined relationship between signals supplied thereto, as is well understood in the art of voltage comparators.

Comparing circuit 28 is connected to the detector 17 (or interim storage circuit 19), thereby receiving the detected output of filter 16, and is connected to vertical deflection resistor 27 by line 29, thereby receiving a fraction of the sawtooth wave 94 generated in response to synchronizing pulse 90 from vertical generator 26. Comparing circuit 28 will provide a trigger output on line 30 when the ratio between the sawtooth wave from resistor 27 and the output potential of detector 17 reaches a pre-

determined value. The time at which this trigger output occurs relative to the time of initiation of the sawtooth wave is a function of the amplitude of the potential supplied to the comparing circuit from detector 17 or interim storage circuit 19. As amplitude is measured from the bottom of the screen 29, and since the cathode ray is deflected upwardly from the base line for each vertical trace, the greater the relevant instantaneous signal amplitude, the later the time of the trigger output from comparing circuit 28 on line 30. Preferably, the sawtooth wave 94 is a descending one and a rectifier in comparison circuit 28 is biased to conduct when the appropriate predetermined potential trigger ratio is reached.

The trigger output on line 30 is employed to set a flip-flop 31 which will have been in a stable reset position initiating and maintaining the illumination of the cathode-ray tube screen 29 since the commencement of the corresponding vertical sawtooth wave as will be explained below. The flip-flop 31 is connected to an amplifier 32 by line 33. Amplifier 32 will drive the cathode 21 positive to cause ray extinction when flip-flop 31 is set by a pulse from comparing circuit 28.

Line 34 is connected from the vertical sweep generator 26 to a second input connection to flip-flop 31. At the commencement of each sawtooth wave, a pulse will be provided on line 34 resetting the flip-flop 31 to turn on the cathode ray. Thus at the base line on each vertical trace, the beam will always be illuminated, at least momentarily, while the flip-flop 31 is in the reset condition.

By adjusting the circuit properly to provide for a maximum potential displayed by the system, blanking will occur automatically before vertical retrace.

However, in connection with horizontal retrace of the cathode ray to the horizontal scanning origin, be it right or left, the horizontal generator 15 will provide a blanking pulse on line 35 connected to flip-flop 31, holding it in the set or blanking condition of operation during each such horizontal retrace, thereby preventing a horizontal retrace line from appearing on the screen 29.

In summary, then, the trace presented on screen 29 of cathode ray tube 20 will comprise a plurality of vertical lines, as shown in FIG. 1 with the vertical axis representing amplitude and the horizontal axis representing frequency. The black vertical lines on screen 29 represent the illuminated portion of the screen. As the lines are very closely spaced, the impression provided from a distance is one of a solid display in the sense that television provides a solid display. The display will present the integral or area of amplitude as a function of frequency. Actually, each vertical line will represent a small band of frequencies within the overall bandwidth represented by the frequency axis, because each vertical line will be traced during a period of time during which sawtooth wave 93 is changing value. For that reason interim storage circuit 19 may be employed to store amplitude information to be presented which is received too late, e.g. subsequent to blanking of a particular vertical trace, or which relates to a different frequency. This is explained in greater detail below with reference to FIG. 3.

In a preferred embodiment of this invention, shown in FIG. 2, the basic circuit shown in FIG. 1 has been modified to provide a versatile spectrum analyzer capable of at will providing a display of frequency and amplitude grids, and by means of operating a control switch, the system can be converted as desired to present a dot display of one or more traces or to provide the integral solid-lined display described above.

Referring to FIG. 2, three conventional spectrum analyzers are combined into a single package utilizing a single horizontal sweep generator 15 connected to three swept receivers 18, 40 and 50. As in FIG. 1, the local oscillators not shown are connected respectively to provide sweep frequency signals to the respective mixers (not shown) and the outputs of the mixers are supplied to respective intermediate frequency filters not shown and

therefrom through respective detectors not shown to comparison circuits 28, 48 and 58, which provide trigger inputs to set flip-flops 31, 41 and 51 respectively. Alternatively, the outputs of the swept receivers 18, 40 and 50 can be supplied to the comparing circuits through interim storage circuits 19, 42 and 52 by operating switches 39, 43 and 53 respectively. As in the case of flip-flop 31, flip-flops 41 and 51 are reset by a synchronization pulse 90 on line 34 at the commencement of each vertical sawtooth wave. As in the case of comparing circuit 28, comparing circuits 48 and 58 are supplied with a horizontal sawtooth wave 94 on line 29. However, when they are to be used for dot display presentation, comparing circuits 48 and 58 are adjusted to have a higher minimum potential below which they will not provide a trigger input intended to indicate magnitude. Hence, for dot display each of comparing circuits 48 and 58 will have progressively higher base lines than comparing circuit 28. The separate potentiometers shown are provided for adjustment of the bias and hence the actuation potentials of the comparing circuits 28, 48 and 58 to provide the desired vertical spacing of corresponding base lines and the quantity of amplitude per linear unit on screen 29 can be adjusted elsewhere. The trigger inputs from the comparing circuits 28, 48 and 58 can be employed to stimulate a beam blanking pulse if one of flip-flops 32, 41 or 51 is connected directly to the beam intensity amplifier 32 through OR gate 74 and switch 36. Note that for solid display, only one flip-flop may be connected directly to amplifier 32 through switch 36, because otherwise the solid displays would overlap and the actuation outputs from the flip-flops would conflict. As will be understood, the comparing circuits could be biased-adjusted to provide low base lines and the amplitudes could be expanded to utilize the full screen 29 adjusting the potentiometers in the comparing circuits 28, 48 and 58 and the amplifier 32.

For dot display, however, all of the flip-flops 31, 41 and 51 are connected through OR gate 37 to pulse shaper 38 which converts the actuation outputs from the flip-flops into brightening pulses for providing instantaneous intensification of the cathode ray. Hence, three dot displays 61, 62 and 63 may be provided as shown on the screen 29, outlining the spectral profiles of three passbands, analyzed by the three spectrum analyzers. Display 64 indicates that a fourth or more swept receivers may be employed. If it is desired to view a single passband, in solid-lined display, then switch 36 may be adjusted to the desired flip-flop output and the corresponding comparing circuit can be adjusted to provide the appropriate vertical scale.

In connection with presentation of the display, it is possible and also desirable to present a graticule of horizontal and vertical grid lines indicating a relative amplitude values and frequency values. By presenting such lines by means of periodically intensifying the cathode ray it is possible to eliminate parallax problems which arise in making measurements when employing screens having etched cover plates and the like.

In order to provide horizontal lines, a relaxation oscillator such as a stable multivibrator 70 having a frequency several times higher than the vertical sweep generator 26 may be employed to provide a series of sharp negative pulses 92.

The pulses 92 will pass through OR gate 72 which will supply them to OR gate 74 and amplifier 32 when switch 73 is closed. Then a brightening pulse will be supplied to cathode 21 for each pulse 92, and since relaxation oscillator 70 has a substantially higher frequency than the vertical sweep generator 26, several dots will be produced during each vertical sweep of the cathode ray to generate horizontal lines such as 65, 66, 67 and 68. If the corresponding pulses 92 are properly timed to provide brightening at the same distance i.e. time delay from the vertical base line, then the several horizontal lines composed of dots will be properly generated in

response to the output of oscillator 70 i.e. they will be straight lines. Such timing can be accomplished by means of providing a synchronizing pulse output generated in response to pulses from oscillator 70 to vertical sweep generator 26. The synchronizing pulse will lock the vertical sweep generator to the output frequency of oscillator 70. An example of a system useful for the purpose of generating such pulses is the delayed trigger circuit 71. Locking the generator 26 to oscillator 70 will provide stable operation of the system in such a manner that a straight horizontal line can be generated. As shown in FIG. 2, the delayed trigger circuit 71 includes a trigger circuit 95 and a storage counter 96 of the type shown in "Pulse and Digital Circuits" by Millman and Taub, McGraw-Hill Book Company, Inc. pp. 346-353, 1956. The storage counter 95 contains capacitors and diodes which will provide an output potential increasing in amplitude as a function of the number of input pulses provided thereto, until the trigger potential of the trigger circuit 95 is reached. At that potential, the trigger circuit 95, acting as a comparator (which may have an adjustable trigger potential) will provide an output pulse on line 97. At the same time, the trigger circuit will discharge the integrating capacitor of the storage counter 96 and restore the counter to its original condition. Hence, the delayed trigger circuit 71 will divide the pulse repetition rate in accordance with the desired relationship between the number of horizontal grid lines desired and the vertical sweep rate. The relationship can be fixed and in the case of display of several traces on the screen, the spacing of the horizontal grid lines 65, 66, 67, 68 . . . will be independent of the amplitude levels of comparing circuits 28, 48 and 58, which determine the level at which pulses will appear. Hence, they can comprise fixed lines, subject to adjustment as desired by adjusting the repetition rate of the relaxation oscillator 70 and the delayed trigger circuit 71.

The vertical sweep generator 26 can be of the variety employed in television systems, such as the synchronized horizontal sweep generators employed in television in this country.

With respect to generation of vertical grid lines such as lines 81, 82, 83, 84 . . . for the purpose of marking frequency values, several approaches will provide satisfactory results. However, as the horizontal sweep rate is used to generate vertical grid lines and is substantially lower than the vertical sweep rate, the operating time of voltage comparators will be considered relatively small. Hence ordinary comparators can be employed for the purpose of providing voltage level information useful in generating vertical grid lines.

Thus a plurality of comparators 76, 77, 78 and 79 are shown connected to line 14. Several more could be used, as desired. Each comparator is adapted to provide a pulse at times when the sawtooth wave 93 from horizontal sweep generator 15 reaches predetermined values. The comparators 76, 77, 78, 79, etc. can include a voltage sensitive nonlinear element such as a Zener reverse breakdown diode, a source of potential and an adjustable element such as a variable resistance. Hence, each time that the sawtooth wave 93 reaches predetermined values, a pulse will be produced from one of the comparators.

As the comparators are adjustable to respond to different potential, the frequency to be represented by the vertical line generated thereby can be adjusted simply by varying a potentiometer. Each comparator will provide an output signal for the selected potential of wave 93 (which will automatically occur at the appropriate time) to the corresponding one of several flip-flops 100, 101, 102, 103, etc., which will then generate a pulse through OR gate 104 and line 120 to an interim storage circuit 105 described below in connection with FIG. 3. The interim storage circuit 105 will retain a pulse received from any of the flip-flops 100, 101, 102, 103, etc. for an interval exceeding the period of one vertical synchronization pulse

96 received on line 34 from the vertical sweep generator, and then will discharge that pulse. During that period, the stored pulse will be presented on line 134 to a comparator 106 connected to compare the amplitude of the vertical sawtooth wave 94 on line 29 with the output from interim storage circuit 105 and provide a trigger output when storage unit 105 is activated at the base line of the vertical trace. The comparator 106 will be connected to trigger flip-flop 107 when there is an output from comparator 106 permitting generation of an entire vertical line. Flip-flop 107 is connected by line 34 to be reset before each vertical sweep by a synchronized pulse 90 in like manner to flip-flops 31, 41 and 51, thereby tending to intensify the beam momentarily until the comparator 106 provides a blanking output indication that the output of interim storage circuit 105 is less than required to generate a vertical line. Also, flip-flop 107 like flip-flop 31, 41 and 51 is connected to the blanking circuit 35 of the horizontal sweep generator 15, whereby no beam intensification will occur during horizontal retrace.

Manifestly, the circuit may provide grid lines or an internally generated graticule for both the solid and dot forms of display.

As many vertical lines may be displayed as desired by employing the generation techniques and systems described above. The interim storage circuit 19 is adapted to store any pulse received during the course of a vertical trace and to present that pulse at its output for more than one vertical sweep cycle up to a maximum of slightly less than two vertical sweep cycles. Such storage is desirable particularly in the case of solid display because, the signal information from the detector of the swept receiver may be received subsequent to blanking of the beam or presentation of a dot during a single vertical sweep. In such cases the flip-flops 31, 41, 51 and 107 would have been set previously and could not respond to such "late" signals. Thus, there could be a failure of the system to present all of the information provided at the comparing circuits 28, 48, 58 or comparator 106. This would apply if a signal to be displayed were of very narrow bandwidth, considerably narrower than the frequency band transversed during the time required for completion of a single vertical trace. In any case, the maximum amplitude information should be presented to the comparator for each vertical line to be presented. Hence it is desirable to store maximum amplitude information when presenting an output with either solid or dot display and to assure generation of vertical lines 80, 81, 82, 83, etc. Among other problems associated with omission of an interim storage circuit, when the spectrum is scanned at a rapid repetition rate, there is a tendency for the trace to jump between various vertical points on successive frames of the complete scan depending upon the time relationships between operation of say the comparing circuit 28 and resetting of the flip-flop 31.

To the end of providing such interim storage, the output from, say the detector 17, FIG. 1 may be supplied to line 120 of the interim storage circuit 19 through one pole of switch 110. A low gain feedback amplifier shown in FIG. 3 comprising NPN transistor 121, PNP transistor 122, resistors 125, 126 and 127 and biasing batteries 128 and 129 is employed to provide charging of a pair of storage capacitors 123 and 124 to potential closely approximating the maximum amplitude received on line 120 during a desired interval. The base of transistor 121 is connected to the input on line 120 and through input resistor 126 to reference potential. The emitter of 121 is connected to reference potential through resistor 127 and battery 128 with battery 128 providing a negative bias at resistor 127. That emitter is also connected through feedback resistor 125 to the collector of transistor 122 and through diodes 130 and 131 to capacitors 123 and 124 respectively, which are connected to refer-

ence potential at their opposite ends. The collector of transistor 121 is connected to the base of transistor 122, whose emitter is connected to the positive bias of a battery 129 having its negative terminal connected to reference potential. Battery 129 will maintain transistor 122 slightly conducting and the batteries may be selected to be nearly equal in order to maintain the collector of transistor 122 near reference potential, with little current flow through resistors 125 and 127. Preferably resistor 127 has several times the resistance of resistor 125, so that the potential of the emitter of transistor 121 will be near, but slightly below reference potential. Under those conditions, transistor 121 will conduct because of the forward bias at its base-emitter junction with the emitter about one volt below reference potential, and the base at a slightly higher potential. Resistor 126 may be in the order of twice the resistance of resistor 127, so that a substantial drop may occur thereacross, tending to retain low base-emitter current in the quiescent condition. When a positive potential appears on line 120, the potential on the collector of transistor 121 derived from the base of transistor 122 will drop due to increased base-emitter potential and lower collector-emitter potential of transistor 121 which will conduct more heavily, and hence, because of greater base-emitter potential, transistor 122 will conduct more heavily, increasing the potential on its collector and thereby charging storage capacitors 123 and 124 if the collector potential relative to reference potential is sufficiently high. By means of feedback through resistor 125, the emitter of transistor 121 will rise in potential as the capacitors charge and thereby reducing its base-emitter potential cause the collector of transistor 121 to gradually rise in potential as diodes 130 and 131 become cutoff. The feedback will eventually reduce base-emitter drop in transistor 121, thereby reducing flow in transistor 122 until equilibrium is reached. At the end of the pulse input on line 120, of course, the quiescent condition of the circuit will be reestablished. A pair of NPN emitter follower transistor amplifiers 132 and 133 will provide the higher of the output potential of the storage capacitors 123 and 124 to output line 134, as will be well understood, because the higher potential base of the two transistors will provide substantially more collector-emitter current flow. If desired, the transistor amplifiers 132 and 133 may drive another transistor in order to reduce current flow from the storage capacitors 123 and 124, by eliminating emitter resistor 135.

As the storage capacitors 123 and 124 must be discharged, a flip-flop 136 is supplied with vertical synchronization pulses 90 by line 34 during vertical retrace. In response thereto flip-flop 136 alternately supplies discharge pulses through coupling capacitors 137 and 138 to turn on NPN discharge transistors 140 and 141 respectively through raising potential on their base terminals sufficiently long to discharge the storage capacitor 123 or 124 connected to the collector of a discharge transistor 140 or 141 respectively.

The emitters of transistors 140 and 141 are connected to the opposite ends of the storage capacitors 123 and 124 and to reference potential. Hence, at the end of each vertical trace, upon generation of the vertical retrace reset pulse, one of the storage capacitors 123 or 124 will be discharged. Thus, after a first reset pulse the maximum duration of storage of a pulse by a storage capacitor will be from after the time that a discharge transistor 140 and 141 has ceased to discharge a storage capacitor 123 or 124, at which time the corresponding discharge transistor will return to cutoff condition until the third reset pulse occurs. At most, then, the duration of a storage cycle of pulse by a storage capacitor would be slightly less than twice the period between synchronization pulses 90 or twice the vertical sweep period.

In like manner, the interim storage unit 105 in FIG. 2 will store vertical grid generating pulses for a similar period and supply them to comparator 106 for a sufficient period of time to assure that the vertical lines will be generated. Such lines will begin only at the bottom of the screen 29, because of the mode of operation of flip-flop 107, which will be set by comparator 106 to provide no beam intensification in the absence of an output from the interim storage unit 105 immediately after the flip-flop 107 is reset by the synchronization pulse 90.

What is claimed is:

1. A frequency analyzer including an input terminal, a heterodyne mixer coupled to said input terminal, a narrow band selective circuit connected in cascade with said mixer, a detector coupled in cascade with said selective circuit, a binary circuit having set and reset states of operation, a comparing circuit connected in cascade with said detector, a rectilinear vertical scanning visual indicator having a first coordinate representative of frequency and a second coordinate representative of amplitude for providing a rectilinearly scanned modulated trace means for modulating the intensity of the trace on said indicator coupled to be modulated by said binary circuit on transition from one of said set and reset states to the other thereof, a vertical sweep generator coupled to said indicator, for providing vertical scanning, and coupled to said binary circuit for resetting said binary circuit in said reset state on each vertical scan, and coupled to said comparing circuit for providing a scanning signal for comparison with the output of said detector, said comparing circuit connected to said binary circuit for setting said binary circuit in said set state for a predetermined relationship between the signals from said detector and said vertical scanning circuit, a horizontal sweep generator coupled to said indicator for providing horizontal scanning, a local oscillator for generating a scanning local signal in response to a scanning input coupled thereto from said horizontal sweep generator, said mixer connected in cascade with said local oscillator.

2. A frequency scanning system comprising, in combination, a cathode ray device having a viewing screen, first means for periodically deflecting said ray across said screen at a first predetermined rate and providing a scanning output proportional to the quantity of deflection of said ray produced thereby, second means for periodically deflecting said ray across said screen at an angle to the deflection produced by said first means and at a second predetermined rate, said second predetermined rate being substantially less than said first rate, third means for varying the intensity of said ray and connected to said cathode ray device, fourth means for receiving a signal, comparing it with said scanning output, and providing a coincidence signal in response to occurrence of a predetermined relationship between said scanning output and the signal, said third means being connected to the output of said fourth means, said fourth means thereby triggering a response in said third means to dim the intensity of said ray in response to the occurrence of a coincidence signal, said first means and said second means having first and second periods respectively of deflecting said ray, said first means connected to said third means for providing an output restoring a bright intensity of said beam at the commencement of each said first period, whereby a portion of said screen is substantially uniformly illuminated representing the integral of the amplitude-frequency curve of a signal supplied to said fourth means.

3. A frequency scanning system comprising, in combination, a cathode ray device having a viewing screen, first means for periodically deflecting said ray across said screen at a first predetermined rate, providing a scanning output proportional to the quantity of deflection of said ray produced thereby and having a reset output for providing a synchronized reset pulse, second means for periodically deflecting said ray across said screen at an angle to the deflection produced by said first means and

at a second predetermined rate, said second predetermined rate being substantially less than said first rate, means for brightening the intensity of said ray, third means having a set input, a reset input connected to said first means for receiving a reset pulse, and an output connected to said means for brightening said third means providing an output for actuating said means for brightening subsequent to reception of pulses at said reset and said set inputs in that order, fourth means for receiving a signal, comparing it with said scanning output, and providing a coincidence pulse in response to occurrence of a predetermined relationship between said scanning output and the signal, said set input being connected to the output of said fourth means, said fourth means thereby triggering a response in said third means to actuate said means for brightening to instantaneously brighten the intensity of said ray in response to the occurrence of a coincidence pulse, said first means and said second means having first and second periods respectively of deflecting said ray, said first means providing said reset pulse at the commencement of each said first period, whereby a trace of dots is presented on said cathode ray device representing the amplitude of the signal supplied to said fourth means, varying as a function of frequency.

4. In a panoramic spectrum analyzer providing an output potential to be displayed, provided in response to a repetitive scan of frequencies by a scanning local oscillator heterodyned with a broad range of frequencies and passing the heterodyned signals through a narrow band intermediate frequency filter and a detector, thereby providing an output from said detector comprising a repetitive scan of voltage as a function of frequency, the improvement wherein a spectrum analyzer is provided having a mixer, a slow time base generator for providing a slow deflection potential and a fast time base generator for generating a fast deflection potential, a spectrum input terminal, a scanning local oscillator connected to said slow time base generator to be scanned by said slow deflection potential, a narrow passband intermediate frequency filter connected to the output of said mixer, a detector in cascade with said filter, a comparing circuit for comparing said fast deflection potential and the output potential of said detector, said comparing circuit connected to said detector and coupled to said fast time base generator for providing an output upon occurrence of a predetermined relationship between said fast deflection potential and the output from said detector, a signal display device having a screen for presenting a visual display, modulating means for varying the intensity of display connected to be controlled by said comparing circuit, slow scan means for controlling deflection in one direction on the face of said device, said slow scan means connected to said slow generator to be driven by said slow deflection potential, fast scan means for controlling deflection in a second direction, said fast scan means connected to said fast generator to be driven by said fast deflection potential, whereby an illuminated display is provided representing the integral of a selected signal parameter as a function of frequency.

5. In a panoramic spectrum analyzer providing an output potential to be displayed, said potential comprising a repetitive scan of frequencies provided by a system comprising a scanning local oscillator providing an output heterodyned in a mixer with a broad range of frequencies to be analyzed and coupling means for passing the heterodyned signals from the mixer to a narrow band intermediate frequency filter, and a detector connected in cascade with said filter for thereby providing an output from said detector comprising a repetitive scan presenting amplitude as a function of frequency, the improvement wherein a spectrum analyzer is provided having a mixer, a horizontal time base generator for cyclically providing a slow deflection potential and a vertical time base generator for cyclically providing a fast deflection potential, a spectrum input terminal, a scanning local oscillator connected to

said horizontal time base generator to be scanned by said slow deflection potential, a narrow passband intermediate frequency filter, connected to the output of said mixer, a detector in cascade with said filter, a comparing circuit coupled to said detector and to said vertical time base prising a scanning local oscillator providing an output generator for providing an output upon occurrence of a predetermined relationship between said fast deflection potential and the output from said detector, a signal display device having a screen for presenting a visual display, bistable modulating means for varying the intensity of display connected and adapted to be controlled by said comparing circuit only in one condition of operation thereof, horizontal scan means for controlling deflection in one direction on the face of said device connected to said horizontal generator to be driven by said slow deflection potential, vertical scan means for controlling deflection in a second direction connected to said vertical generator to be driven cyclically by said fast deflection potential, whereby an illuminated display is provided representing the integral of a selected signal band as a function of frequency, interim storage means for storing maximum signal amplitudes connected between said detector and said comparing circuit, said vertical generator providing a timing pulse for each cycle of said fast deflection potential, said interim storage means connected to said vertical generator for receiving each said timing pulse for discharging of information stored therein during the penultimate cycle of said fast deflection signal, said bistable means having a reset input connected to receive said timing pulse from said vertical generator to reset said bistable modulating means to said one condition of operation.

6. A panoramic spectrum analyzer comprising means for providing an output potential to be displayed, said potential comprising a repetitive scan of frequencies in response to a scanning local signal from a local oscillator heterodyned with a broad range of frequencies and means for passing the heterodyned signals through a narrow band intermediate frequency filter, thereby providing an output from said intermediate frequency filter comprising a repetitive scan of voltage as a function of frequency, said analyzer comprising a mixer, a slow time base generator for providing a slow deflection potential and a fast time base generator for generating a fast deflection potential, an analyzer input terminal, a scanning local oscillator connected to said slow time base generator to be scanned by said slow deflection potential, a narrow passband intermediate frequency filter connected to the output of said mixer, said mixer coupled to the output of said local oscillator and said input terminal, a detector in cascade with said filter, a comparing circuit for comparing said fast deflection potential and the output potential of said detector, said comparing circuit connected to said detector and coupled to said fast time base generator for providing an output upon occurrence of a predetermined relationship between said fast deflection potential and the output from said detector, a signal display device having a screen for presenting a visual display, modulating means for varying the intensity of display on said display device connected to be controlled by said comparing circuit, slow scan means for controlling deflection in one direction on the screen of said device, said slow scan means connected to said slow generator to be driven by said slow deflection potential, fast scan means for controlling deflection in a second direction, said fast scan means connected to said fast generator to be driven by said fast deflection potential, whereby an illuminated display is provided representing the integral of a selected signal parameter as a function of frequency.

7. In a spectrum analyzer, a cathode ray tube having first means for deflecting the ray in a first direction and second means for deflecting the ray in a second direction substantially normal to the first direction, a first time base generator for providing a first cyclical deflection signal, said first generator coupled to said first means to provide

said first deflection signal to said first means to deflect cyclically said ray in said first direction as a function of the magnitude of said first signal, a second time base generator for providing a second cyclical deflection signal having a substantially longer time period than said first time base generator, said second time base generator coupled to said second means to deflect said ray in said second direction, means for blanking said ray, a comparing circuit for comparing two potentials and providing a blanking output on reaching a predetermined ratio of one potential relative to the other potential, means for actuating said means for blanking, said means for actuating being connected to be driven by said comparing circuit, said comparing circuit being coupled to receive said one potential from said first means, said one potential being proportional to said first deflection signal, and said comparing circuit having an input for receiving a said other potential to be displayed and providing a blanking output when said predetermined ratio is reached during each deflection in said one direction, whereby a visual line-display of the amplitude of said other potential as a function of time, is provided having uniform line-intensity, where illumination exists, so that the integral of said amplitude of said other potential is displayed as an area of apparently solid illumination with respect to the time base line defined by the origins of the linear deflections provided in said first direction.

8. In a spectrum analyzer, a cathode ray tube having first means for deflecting the ray vertically and second means for deflecting the ray horizontally, a first time base generator for providing a vertical deflection signal, said first generator coupled to said first means to provide said vertical deflection signal to said first means to deflect said ray vertically, as a function of the magnitude of said first signal, a second time base generator for providing a horizontal deflection signal having a substantially longer time period than said first time base generator, said second time base generator coupled to said second means to deflect said ray horizontally, means for blanking said ray, a comparing circuit for comparing two potentials and providing an output on reaching a predetermined ratio of one potential relative to the other potential, means for actuating blanking coupled to said means for blanking, said means for actuating blanking being connected to be driven by said comparing circuit, said comparing circuit being coupled to receive said one potential from said first means, said one potential being proportional to said first deflection signal, and having an input for receiving a said other potential to be displayed and providing an output when said predetermined ratio is reached during each deflection in said one direction.

9. In a spectrum analyzer, a cathode ray tube having first means for deflecting the ray in one direction and second means for deflecting the ray in a second direction substantially normal to the first direction, a first time base generator for providing a first deflection signal, said first generator coupled to said first means to provide said first deflection signal to said first means to deflect said ray in said first direction as a function of the magnitude of said first signal, a second time base generator for providing a second deflection signal having a substantially longer time period than said first time base generator, said second time base generator coupled to said second means to deflect said ray in said second direction, means for blanking said ray, a comparing circuit for comparing two potentials and providing an output on reaching a predetermined ratio of one potential relative to the other potential, means for actuating said means for blanking, said means for actuating being connected to be operated by said comparing circuit, said comparing circuit being coupled to receive said one potential from said first means, said one potential being proportional to said first deflection signal, said comparing circuit having a scanned signal input terminal for receiving a said other potential to be displayed and operative to provide an output to operate said means for actuating when said predetermined

ratio is reached during each deflection in said one direction, a scanning receiver having a scanning input coupled to said second time base generator to receive a scanning signal synchronized with said second deflection signal, and said receiver having a scanning output terminal connected to said scanned signal input terminal.

10. A spectrum analyzer comprising, in combination, a cathode ray device having a viewing screen, a vertical sweep generator for periodically deflecting said ray vertically across said screen at a first predetermined rate and for providing a vertical scanning output proportional to the quantity of deflection of said ray produced thereby, a horizontal sweep generator for periodically deflecting said ray horizontally across said screen at an angle to the deflection produced by said vertical generator and at a second predetermined rate and for providing a horizontal scanning output proportional to the quantity of deflection produced thereby, said second predetermined rate being substantially less than said first rate, an amplifier for varying the intensity of said ray connected to control the potential of the cathode of said cathode ray device, a scanning local oscillator, an input terminal, a mixer connected to the output of said local oscillator and said input terminal for beating an input signal supplied to said input terminal with the output from said scanning local oscillator, said local oscillator being connected to be scanned by said horizontal scanning output, said mixer having an output coupled in cascade to a narrow passband filter and a detector, comparison means for comparing the output of said detector with said vertical scanning output, and providing a trigger signal in response to occurrence of a predetermined relationship therebetween, a binary circuit connected to the output of said comparison means, said amplifier connected in cascade with said binary circuit, said comparison means thereby operative to trigger a response in said binary circuit to drive said amplifier to blank the intensity of said ray in response to the occurrence of a said trigger signal, said vertical and horizontal sweep generators having first and second periods respectively of deflecting said ray, said vertical sweep generator connected to said binary circuit to provide an output restoring a bright intensity of said beam at the commencement of each vertical sweep with a portion of said screen substantially uniformly illuminated representing the integral of the curve of a signal supplied to said input terminal.

11. In a panoramic spectrum analyzer providing an output potential representing amplitudes within a selected spectral band with varying as a function of a sweep frequency and to be displayed as a function of frequency, said potential being provided by a repetitive scan of a spectrum of frequencies supplied to a mixer by a sweep frequency coupled to the mixer from a scanning local oscillator, the sweep frequency being heterodyned in the mixer with the spectrum of frequencies and the heterodyned signals being passed through a narrow passband intermediate frequency filter and a detector, thereby providing an output from said detector comprising a repetitive scan of amplitudes, as a function of frequency, the improvement comprising a spectrum analyzer including a mixer, a slow time base generator for repetitively generating a slow sawtooth deflection potential wave and a fast time base generator for repetitively generating a fast sawtooth deflection potential wave, an input for a spectrum of signals to be analyzed, said input being connected to said mixer, a scanning local oscillator connected to said slow time base generator to be scanned by said slow deflection potential wave, said scanning local oscillator being connected to said mixer, a narrow passband intermediate frequency filter connected to the output of said mixer, a detector in cascade with said filter, a comparing circuit for comparing said fast deflection potential wave and the output potential of said detector, said comparing circuit being connected to said detector and to said fast time base generator and providing a sharp blanking output

upon occurrence of a predetermined relationship between said fast deflection potential wave and the output from said detector said sharp blanking output occurring subsequent to the commencement of each fast deflection potential wave, a signal display device having a screen for presenting a visual display, modulating means for varying the intensity of the display on said screen connected to be controlled by said comparing circuit, slow scan for controlling deflection in one direction on the face of said device connected to said slow generator to be driven by said slow deflection potential wave in one direction on said screen, fast scan means for controlling deflection to said fast generator to be driven by said fast deflection potential wave, whereby a uniformly illuminated line display is provided representing the integral of amplitudes within a selected spectral band width as a function of frequency.

12. A spectrum analyzer comprising, in combination, a cathode ray device having a viewing screen, first means for periodically deflecting said ray across said screen at a first predetermined rate and for providing a scanning output proportional to the quantity of deflection of said ray produced thereby, second means for periodically deflecting said ray across said screen at an angle to the deflection produced by said first means at a second predetermined rate, said second predetermined rate being substantially less than said first rate, third means for varying the intensity of said ray connected to said cathode ray device, a scanning tuner for receiving a band of signals and sequentially providing a scanning heterodyned and detected output in the form of corresponding direct current signals, in synchronism with deflection at said second rate, fourth means for comparing said detected output with said scanning output and providing a coincidence signal in response to occurrence of a predetermined relationship between said scanning output and said detected output, said third means being connected to be driven by the output of said fourth means, said fourth means thereby triggering a response in said third means to dim the intensity of said ray substantially in response to the occurrence of a said coincidence signal, said first means and said second means having first and second periods respectively of deflecting said ray, said first means operative to provide an output restoring a bright intensity of said beam at the commencement of each said first period, whereby a portion of said screen is substantially uniformly illuminated representing the integral of the curve of a signal supplied to said tuner.

13. A panoramic spectrum analyzer comprising a tuning circuit, a vertical rectilinear scanning system, a comparing circuit for providing a coincidence pulse for a predetermined relationship between signals supplied thereto, an interim storage circuit, and a binary circuit, said tuning circuit including a spectrum input terminal, a scanning local oscillator for providing a scanning local signal in response to a tuning signal, a mixer connected to said spectrum input terminal and said local oscillator for providing a heterodyne output in response to a spectrum supplied to said spectrum input terminal and said scanning local signal, a narrow passband selective filter, connected in cascade with said mixer, a detector connected in cascade with said filter, said interim storage circuit having a signal input and a signal output, a control input, a pair of storage circuits and electronic switching means for selective discharge of the penultimately charged one of said pair of storage circuits in response to each pulse supplied to said control input, said vertical rectilinear scanning system comprising a rectilinearly scannable display device, intensity control means for controlling the instantaneous intensity of illumination provided in scanning said display device, a vertical sweep generator for providing a vertical scanning signal to scan said display device vertically and connected to said control input and said binary circuit for providing vertical synchronization pulses to said control input to operate said elec-

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tronic switching means and to said binary circuit to reset said binary circuit, and a horizontal sweep generator for providing a horizontal scanning signal for scanning said display device horizontally and a synchronous tuning signal for tuning said scanning local oscillator, said scanning local oscillator connected to said horizontal sweep generator, said comparing circuit having a first input connected to receive a portion of said vertical scanning signal, means for at will connecting said comparing circuit in cascade with said detector and in cascade with the combination of said detector and said interim storage circuit, said binary circuit having an output circuit, and set and reset input terminals for respectively setting said binary circuit to provide an immediate readout in response to a coincidence pulse from said comparing circuit and for resetting said binary circuit to permit said set input to provide a response to a pulse, said set input terminal being connected in cascade with said comparing circuit and said reset input terminal being connected in cascade with said vertical sweep generator for receiving vertical synchronization pulses, said intensity control means being coupled to said output circuit of said binary circuit.

14. A panoramic spectrum analyzer comprising a tuning circuit, a vertical rectilinear scanning system, a comparing circuit, and a binary circuit, said tuning circuit including a mixer having two mixer inputs and a mixer output, an electronically tunable local oscillator for providing a scanning frequency signal said oscillator being connected to one of said mixer inputs, a narrow pass-band filter and a detector, and a timing circuit output, said filter and said detector being connected between said output of said mixer and said tuning circuit output, said local oscillator having a tuning input, and said mixer adapted to receive at the other of said mixer inputs a signal to be analyzed by said spectrum analyzer, said vertical rectilinear scanning system comprising a rectilinearly scannable projector having a viewing screen and intensity control means for controlling instantaneous intensity of illumination of said screen, a vertical sweep generator for providing a vertical scanning input to said projector and to said comparing circuit and for providing vertical timing pulses, a horizontal sweep generator for providing horizontal scanning of said projector and for providing a scanning signal to said local oscillator synchronized with horizontal scanning of said projector, said vertical scanning generator being connected to scan said projector, vertically, to time said binary circuit, and to scan said comparing circuit, in synchronism with vertical scanning of said projector, said horizontal scanning generator being connected to said tuning input to scan tuning of said local oscillator and to said projector, said comparing circuit being connected to said tuning circuit output and adapted to provide a comparison pulse in response to a predetermined relationship between the output of said tuning circuit and said scanning signal provided thereto by said vertical sweep generator, said binary circuit being connected to provide presentation of signal

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information on said projector in response to said comparison pulse subsequent to reception of a timing pulse from said vertical scanning generator.

15. A spectrum analyzer comprising an electronically tunable receiver providing a heterodyne output signal at the output thereof, a display unit comprising a cathode ray tube having vertical and horizontal magnetic deflection means, a horizontal sweep generator, a vertical sweep generator, said horizontal sweep generator being connected to drive said horizontal deflection means, said vertical sweep generator having a first output circuit connected to drive said vertical deflection means and a second output circuit, means for modulating the intensity of the ray of said cathode ray tube, said vertical sweep generator providing a vertical scanning signal in said first output circuit and a synchronization pulse in said second output circuit said horizontal sweep generator providing a horizontal sweeping output for tuning said receiver and providing a scanning signal to said horizontal deflection means, a comparison circuit having an output circuit and a pair of input terminals for providing at the output circuit thereof a comparison output pulse for predetermined relationship between signals provided to said input terminals, a bistable circuit connected to the output circuit of said comparison circuit and to said vertical sweep generator to receive said synchronization pulse, said input terminals of said comparison circuit being connected respectively to the output of said receiver and to said vertical deflection means to receive said vertical scanning signal, and providing an output pulse in said output circuit for a predetermined relationship between said input of said receiver and said vertical scanning signal, said bistable circuit having an input connected to said second output circuit and being connected to control said means for modulating the intensity of said ray and providing a pulse thereto for the first output pulse supplied thereto by said comparison circuit subsequent to reception of a synchronization pulse, means for generating vertical lines on said display device coupled to said horizontal sweep generator and coupled to drive said means for modulating the intensity, and means for generating dotted horizontal lines coupled to said means for modulating intensity and coupled to said vertical sweep generator for providing additional synchronization pulses thereto.

16. Apparatus in accordance with claim 15 wherein a plurality of tunable receivers, a plurality of comparison circuits, and a plurality of binary circuits are connected in like manner to corresponding elements in said spectrum analyzers to provide a plurality of displays on said display unit, the output circuits of said binary circuits being coupled to said means for modulating through a pulse shaping circuit.

No references cited.

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