

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Computer Driven CRT Recording System

We, TEXAS INSTRUMENTS INCORPORATED, a Corporation organised according to the laws of the State of Delaware, United States of America, of 13500 North Central Expressway, Dallas, Texas, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an on line information display and more particularly to computer controlled cathode ray tube display of seismic traces and annotating means related thereto.

Historically, data display for seismic exploration has been characterized by the use of the multichannel galvanometric produced oscillographic cameras. To produce a cross-section presentation the paper records would be taped together.

More recently, rotating drum cameras or section plotters have been developed. The latter instruments provide more precise timing alignment of records on one piece of paper or film. To provide more of a facsimile type of presentation various innovations in display are employed. Over a period of years, oscillographic wiggle line, variable intensity (facsimile type), variable area, combination of wiggle line and variable area, and combination of wiggle line and variable intensity types of presentations became standard in the seismic exploration industry.

Section plotter cameras have two significant disadvantages. They are comparatively slow in recording data and have fixed timing scales. Normally, such a system operates at a timing scale to produce records of either 7.5 or 10.0 inches per second.

As part of the display system, simple geometric corrections have been incorporated into the section plotter systems. Both static and NMO corrections generally have been accom-

plished. Means for carrying out simple analog processes, such as stacking, have been added to the system. Use of digital computers for seismic data processing introduced two significant requirements for data display, i.e. high production and increased flexibility. To realize both of these requirements, a multi-mode strip camera has been used for the basic display.

However, there remained the requirement for better quality display and precise timing for seismic analog tape to digital transcriptions. Still more recent systems which are completely automatic for plotting a record section require manual control of the setup for the hundreds of different modes of operation. Setup time and the requirement for skilled operators therefore presented the major system disadvantages.

The present invention provides a seismic data recording system wherein signals processed in digital form by a computer and representing a plurality of seismic traces are to be permanently recorded, said system comprising: means for converting the digitized signals representing the plurality of traces to analog signals, a recording unit having an input channel for receiving the analog signals from said converting means, and control means for operably connecting said converting means and said recording unit to the computer for slaving said recording unit to the computer so as to provide for on-line presentation of seismic data in analog form from digital signals issuing from the computer.

Preferably, the recording unit includes a cathode ray tube, the recording unit may also include a camera disposed to view said cathode ray tube for recording seismic traces written on said cathode ray tube.

The system may include annotation signal generating means connected between said control means and said tube for producing selected annotation symbol signals, and mode selector

means provided by said control means and being responsive to the computer so as to be operative between the intervals during which the seismic traces are written on said tube for applying said annotation symbol signals to pre-selected locations on the face of said tube for identification and explanation of said traces.

By way of example, a recording system in accordance with the invention will be described with reference to the drawings in which:—

FIGURE 1 is a perspective view of a unit embodying the recording system;

FIGURE 2 is a block diagram illustrating components of the system;

FIGURE 3 is a more detailed diagram illustrating the system; and

FIGURE 4 illustrates the permanent recording of information displayed on the cathode ray tube shown in FIGURES 2 and 3.

In FIGURE 1 an embodiment of the invention has been illustrated wherein the recording system comprises a console unit A which is operated in response to signals from a digital computer system 10. The console A includes a cathode ray monitor screen presentation 24, a flying spot scanner annotation symbol signal generator 20 and a pair of photographic units B and C, each of which, as will hereinafter be described, includes a high resolution CRT unit (i.e. a unit having a rated maximum spot size of the order of 0.001 inch) and a motor driven camera. The console unit A also includes suitable control panels D and E and associated power supply and control compartments F, G, and H.

In FIGURE 2 the computer 10 is employed to control a recording system. A controller 1 receives digital data and instructions by way of channels 12 from computer 10 for the control of three primary units. The first unit is a recording unit 14 which includes a pair of high resolution cathode ray tubes 15 and 16, each of which has a camera associated therewith such as cameras 17 and 18.

The second unit is an annotation signal generator 20 which is employed to produce legend information on tubes 15 and 16.

The third unit is a storage tube monitor display system 22 including a storage tube 23 and a monitor display tube 24.

Seismic data signals from controller 11 are applied to a seismic format generator 26, the output of which is applied as by way of channel 27 of one of the cathode ray tubes 15 and 16 and to the storage tube 23. It will be understood that the output of the seismic format generator 26 may be applied through channel 27 to both of the cathode ray tubes 15 and 16 at the same time, if desired, by employing a suitable switching

assembly (not shown) in the circuit illustrated in FIGURE 2.

The recording system shown in FIGURE 2 receives data from computer 10 and processes the same to produce an ultimate display of data on the face of tubes 15 or 16 where the display is then photographed by means of cameras 17 or 18. In intervals between the appearance of data signals, the system is then changed to operate in a different mode to provide time lines and annotation signals to the tubes 15 or 16. Two display tubes 15 and 16 are employed to permit the continuous acquisition and recording of data even though one of the units requires shut down for change of film and so forth.

The cameras 17 and 18 are provided with control motors 30 and 31, respectively. The motors are provided for moving the film in cameras 17 and 18 in synchronism with the recording of data. The motors 30 and 31 are controlled by unit 32 which determines the size of steps the film is moved.

The monitor unit 22 is provided with a conventional storage tube 23 to provide a flicker-free presentation on tube 24 of data in the array on tubes 15 and 16.

The annotation symbol generator 20 includes a flying spot scanner operating with an annotation symbol mask 37 for selection of any one of a plurality of symbols to be applied in the data array on the tubes 15 and 16. The symbols will be presented at positions dependent upon the operation of an annotation position control unit 38.

In FIGURE 3 seismic data words, in digitized form, are applied by way of channel 50 to a digital/analog converter 52, the output of which is applied by way of a smoothing filter 53 and an attenuation control unit 54 to the format generator 26.

A three-bit data word is applied by way of channel 56 for control of the mode of operation of the format generator 26.

The system has five operating modes as follows:

- Mode 1—seismic plots;
- Mode 2—annotation;
- Mode 3—grid line plotting;
- Mode 4—general plotting; and
- Mode 5—film positioning.

In Mode 1 seismic traces may be displayed on the high resolution tubes 15 or 16 in unit 14 in any one of a plurality of different formats including wiggly trace, variable area, variable density, or combination of wiggly trace and variable area. The base line of a variable area display is controlled by a digital signal on channel 58 which is converted by D/A converter 60, the output of which is applied to the format generator 26. A variable density trace width signal is applied by way of channel 62 to the generator 26.

A switch actuator 64 operates in dependence upon the control signals supplied by way of channel 66. In its upper position, the triple pole, triple throw switch 67 applies video intensity modulating signals on channel 68 to units 14 and 22 and an x deflection voltage on line 69 to units 14 and 22.

Two-bit words applied by way of channels 72 to a symbol raster generator control the size of the raster and thus the size of the symbols. Any one of four different symbol sizes may thus be selected by application of the proper coded word on channel 72. A raster start signal appears on channel 76. A symbol complete signal appears on channel 78.

The output of the symbol raster generator is applied by way of channels 80 to switch 67 and thence to units 14 and 22. The output is applied by way of channels 82 to the symbol generator unit 20. The output of the symbol generator unit 20 is applied by way of channel 84 to the second and third terminals of the upper section of switch 67 and by this means to units 14 and 22.

An on-off voltage state is applied by way of channel 86 and AND gate 88 to the symbol generator 20.

A symbol code signal is applied by way of channels 90 to D/A converters 92 and 94. The outputs thereof are applied to the symbol generator 20 by way of channels 96 and 98. The voltage on channel 96 controls the x position of the raster generated by unit 74 and the voltage on channel 98 controls the y position of the raster.

The scan converter 22 has an input channel control switch 100 which is actuated by an operator 101 under the control of a signal on line 102. In the upper position of switch 101 a scan converter auxiliary signal is applied by way of a D/A converter 104 and channel 105 to the scan converter 22. In this operation the computer program can slave the trace position on the monitor when the film is incrementally stepped between traces or groups of traces on the high resolution CRT. In the lower position the main seismic time sweep signal applied by way of channel 106 and D/A converter 108 and gain control unit 110 is then applied to the scan converter unit.

On the input of the gain control unit 110 is a three channel switch 112 operated under control of an operator 114. In the upper position the output of converter 108 is applied to the control unit 110 without filtering or smoothing. In the second position, a high frequency filter 116 operating to smooth the 32 kc data rate is inserted in the circuit between converter 108 and 110. In the bottom position the low frequency filter operating on the 16 kc data rate is included in the channel.

The output of the unit 110 is applied to the scan converter 22 by way of a switch

120 when in its upper position. Switch 120 is operated under the control of an operator 122 and which also controls a second switch 124. The output of the gain control unit 110 is connected to the bottom terminal of switch 124.

Operator 114 is controlled by a filter select voltage on channel 126. Operator 122 is actuated under control of voltage on the x-y select line 128.

The main deflection voltage channel 2 includes a multi-channel line 130 which leads to a D/A converter 132, the output of which is applied to filters 134 and 136. Switch 138 controlled by operator 114 may thus select any one of two filtered outputs or an unfiltered output of the D/A converter 132 for application to a summing amplifier 140. A ramp amplitude control channel 142 leads to a ramp generator 144 for generating trace timing. Generator 144 has an output which is applied by way of channel 146 to the second input of summing amplifier 140. The second input to the ramp generator 144 is a trigger pulse on line 142'.

A scan blanking pulse is applied to the converter 22 by way of channel 147 and OR gate 148. An intensity control signal is applied to the system on channel 150 where it is applied to a D/A converter 152 whose output is applied by way of channel 154 to the intensity control terminals on units 14 and 22.

A photographic camera control signal is applied by way of channel 160 to the record unit 14. A master blanking pulse is applied by way of channel 162 and OR gate 164 to the record unit 14. The master blanking pulse is also applied by way of OR gate 148 to the converter unit 22.

A section plot blanking pulse is applied by way of channel 166 and OR gate 164 to record unit 14. A format blanking signal is applied from the generator 26 to the control 11 by way of channel 168. An attenuation control voltage is applied into the attenuator unit 54 by way of channels 170. A trace polarity selector voltage is applied by way of channel 172 to the attenuator unit 54.

A monitor blanking pulse is applied by way of channel 174 to an OR gate 176 to the scan converter 22 and the monitor screen unit 178. An erase control is applied by way of channel 180 to the scan converter unit 22.

A TV raster generator 184 applies a raster to the scan converter 22. The converter 22 applies video signals by way of channel 186 to the monitor screen unit 178.

FIGURE 4 illustrates a top view of a portion of the recording system 14 and, more particularly, the cathode ray tube 15 and the camera 17. In the embodiment illustrated in FIGURE 4 the cathode ray tube 15 is a high resolution tube having a diameter of about 5 inches. The lens assembly 17a of the

camera 17 is mounted to view the face of the tube 15. The camera 17 is provided with a film supply magazine 17b and a film takeup magazine 17c. Film from magazine 17b moves
 5 along an image plane 17d under the control of a set of power driven rollers including a roller mounted on shaft 17e. The camera is provided with a door 17f hinged at point 17g to facilitate initial loading of the film.
 10 The door 17f has a spring-loaded latch 17h and is formed to maintain the film compartment light tight when closed. The advance mechanism for the film includes a precision drive including a pulley 17i mounted on shaft 17j. A worm gear 17k on shaft 17i is provided to drive a gear 17m to move the film. The system is set up to move the film, with precision, in steps at a rate of 0.001 inches per step under the control of a stepping motor 17n. The motor 17n is coupled to an output shaft 17o of a gear drive and magnetic clutch assembly 17p. A second motor 17q is provided for rapidly advancing the film a full frame at a time. The shaft 17o is provided with a pulley 17r which is coupled by belt 17s to pulley 17i.

In operation, each time stepper motor 17n is energized the film will advance 0.001 inches. The motor 17n will be energized in synchronism with the writing of separate traces on the tube 15 to advance the film at the end of each trace and before the next trace is started.

In contrast, the film in the camera 17 may be held in fixed position while a seismic record section comprising many traces is completely written on the tube 15 with the successive traces being spaced apart under the control of suitable stair-stepped bias voltages on the deflection control system. At the end of such an operation, then motor 17q may be energized to advance the film rapidly to provide a new frame in the camera. Alternatively, the system may be operated with combinations of the two different sets of controls. For example, a set of twenty-four traces may be written on the tube 15 with deflection voltages being controlled for the proper spacing between the traces as they are successively written. Thereafter, a series of twenty-four pulses would be applied to the motor 17n to advance the film a distance equal to that occupied by the twenty-four traces, whereupon a second set of twenty-four traces could be written adjacent to the first set.

It should be appreciated that the specific numbers of traces involved will depend on the recording system employed. In the present case reference was made to twenty-four traces because 24-trace recording system are widely used.

In one embodiment of the system above described, the scan converter 22 was a duo-gun high resolution cathode ray tube with simultaneous write and read capability and was of

the type CK-1383 manufactured and sold by Raytheon of Newton, Massachusetts.

The recording units 15 and 16 used high resolution cathode ray tubes having a diameter of 5 inches and a full deflection angle (i.e. from one side of the tube to the other) of 40°, part no. L-4123 with P-11 phosphor, manufactured and sold by Litton Industries of San Carlos, California. This tube employed a spot of diameter less than 0.0015 inch over a screen diameter of 4.25 inches (a marginal portion of the tube screen remaining blank).

It will be apparent that, by application of suitable sweep pulses in the X and Y directions, timing lines, grid lines, and curves may be written on the high resolution cathode tubes 15 and 16, as well as the multi-trace seismic record sections.

The cameras 17 and 18 employed a lens as manufactured by Elgeet Optical Co. of Rochester, New York, and identified as no. CRT5-8612-1.

By utilization of the symbol generator 20, annotation symbols are applied to selected locations on the face of the units 15 and 16. The sizes of such symbols are controlled by suitable code on channel 72.

The symbol generator 20 employed a cathode ray tube having a diameter of 5 inches and a full deflection angle of 16°, manufactured and sold by Sylvania Electronic Products, Inc., Industrial and Military CRT Dept., Seneca Falls, N.Y., and identified by part no. SC-3168 with P-16 phosphor. A mask 37, FIGURE 1, placed in front of the tube has 256 symbols including the numerals, the alphabet in upper and lower case, and other desired symbols. A lens photomultiplier system 20b was employed for focusing the illuminated symbol on the mask 37 onto a photomultiplier tube. The lens of the latter system was part no. CRT5-8013-5 manufactured and sold by Elgeet Optical Co. and the photomultiplier tube was part no. 6292 manufactured and sold by Fairchild, DuMont Laboratories of Clifton, N.J.

The Flying spot scanner operates by positioning the beam at one corner, for example, of a desired symbol to be generated and thereafter, a raster-type sweep is carried out. The raster is generated at the rate of 10 kilocycles for writing symbols at that rate. The output of the lens photomultiplier system 20b is applied to the recording unit to reproduce in black and white format, the selected symbol in the synchronism with the raster generated by the unit 74. The lens of the photomultiplier system 20b operates in conjunction with the photomultiplier to produce output pulses synchronized with the raster generated by unit 74.

WHAT WE CLAIM IS:—

1. A seismic data recording system wherein signals processed in digital form by a com-



camera 17 is mounted to view the face of the tube 15. The camera 17 is provided with a film supply magazine 17b and a film takeup magazine 17c. Film from magazine 17b moves along an image plane 17d under the control of a set of power driven rollers including a roller mounted on shaft 17e. The camera is provided with a door 17f hinged at point 17g to facilitate initial loading of the film. The door 17f has a spring-loaded latch 17h and is formed to maintain the film compartment light tight when closed. The advance mechanism for the film includes a precision drive including a pulley 17i mounted on shaft 17j. A worm gear 17k on shaft 17i is provided to drive a gear 17m to move the film. The system is set up to move the film, with precision, in steps at a rate of 0.001 inches per step under the control of a stepping motor 17n. The motor 17n is coupled to an output shaft 17o of a gear drive and magnetic clutch assembly 17p. A second motor 17q is provided for rapidly advancing the film a full frame at a time. The shaft 17o is provided with a pulley 17r which is coupled by belt 17s to pulley 17i.

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The Flying spot scanner operates by positioning the beam at one corner, for example, of a desired symbol to be generated and thereafter, a raster-type sweep is carried out. The raster is generated at the rate of 10 kilocycles for writing symbols at that rate. The output of the lens photomultiplier system 20b is applied to the recording unit to reproduce in black and white format, the selected symbol in the synchronism with the raster generated by the unit 74. The lens of the photomultiplier system 20b operates in conjunction with the photomultiplier to produce output pulses synchronized with the raster generated by unit 74.

WHAT WE CLAIM IS:—

1. A seismic data recording system wherein signals processed in digital form by a com-

puter and representing a plurality of seismic traces are to be permanently recorded, said system comprising: means for converting the digitized signals representing the plurality of traces to analog signals, a recording unit having an input channel for receiving the analog signals from said converting means, and control means for operably connecting said converting means and said recording unit to the computer for slaving said recording unit to the computer so as to provide for on-line presentation of seismic data in analog form from digital signals issuing from the computer.

2. A system as set forth in claim 1, wherein said recording unit includes a cathode ray tube.

3. A system as set forth in claim 2, wherein said recording unit further includes a camera disposed to view said cathode ray tube for recording seismic traces written on said cathode ray tube.

4. A system as set forth in claim 2 or claim 3, further including a seismic format generator connected between said tube and said converting means for receiving analog signals converted from digitized seismic trace signals by said converting means at the computer data rate and applying said analog signals to said tube at said rate, and means operable in either of at least two modes for conditioning said analog signals for application to said tube in either of at least two formats.

5. A system as set forth in claim 4, wherein said control means includes a control channel extending to said seismic format generator for selecting one of said modes in response to a computer-generated command.

6. A system as set forth in any one of claims 2 to 5, wherein said control channel extending to said recording unit for controlling the relative positional relationship on said tube of successive seismic trace signals.

7. A system as set forth in any one of claims 2 to 6, further including annotation signal generating means connected between said control means and said tube for producing selected annotation symbol signals, and mode selector means provided by said control means and being responsive to the computer so as to be operative between the intervals during which the seismic traces are written on said tube for applying said annotation symbol signals to pre-selected locations on the

face of said tube for identification and explanation of said traces.

8. A system as set forth in claim 7, further including raster generation means connected to said control means, said raster generation means being coupled to said tube and to said annotation signal generating means and serving to display selected symbols on said tube in response to a computer-generated command.

9. A system as set forth in claim 4 or claim 5, wherein said control means includes circuitry for applying x-y beam co-ordinate control signals to said tube from the computer independently of said seismic format generator, and selector means provided by said control means so as to interconnect said seismic format generator with the computer for selectively blanking the output of said seismic format generator for either simultaneous application of said analog signals and said x-y beam co-ordinate control signals to said tube or the application of said x-y beam co-ordinate signals only to said tube.

10. A system as set forth in claim 9, wherein said control means is provided with means for generating a ramp sweep voltage for one of said x-y beam co-ordinate control signals, and a selector circuit connected to said control means and being responsive to the computer for selective interchange of said x-y co-ordinate control signals.

11. A system as set forth in claim 10, further including means for generating one of said x-y beam co-ordinate control signals with higher resolution than the other x-y beam co-ordinate control signal.

12. A system as set forth in any preceding claim, further including a computer for producing a flow of digitized seismic trace signals successively from a storage medium to a computer output channel which is connected to said control means.

13. A seismic data recording system substantially as described herein with reference to, and as illustrated by, the accompanying drawings.

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