Oct. 31, 1950 K. W. MILLER 2,527,835

TELAUTOGRAPH SYSTEM

Filed Nov. 4, 1947 2 Sheets-Sheet 1

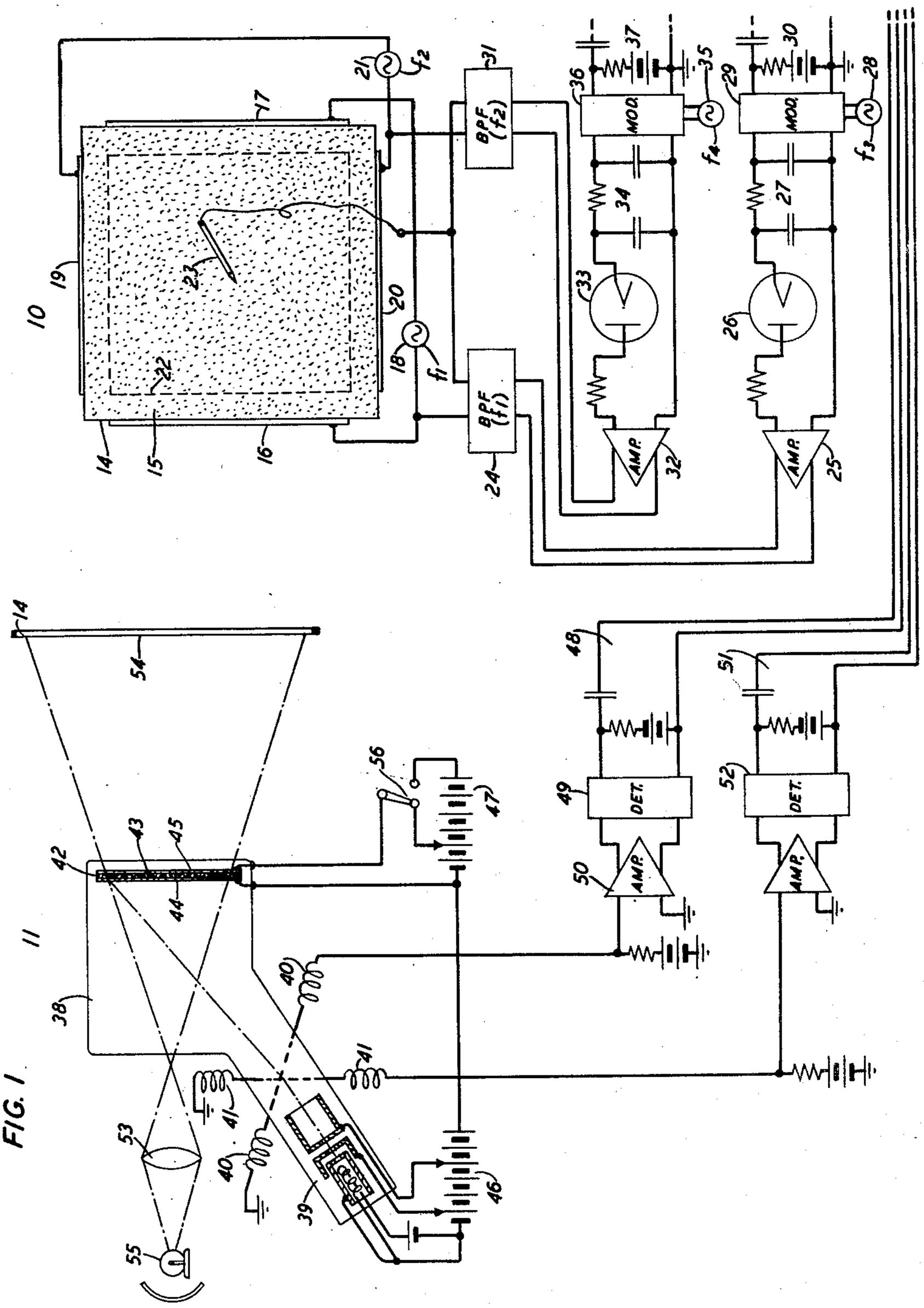

FIG. 1

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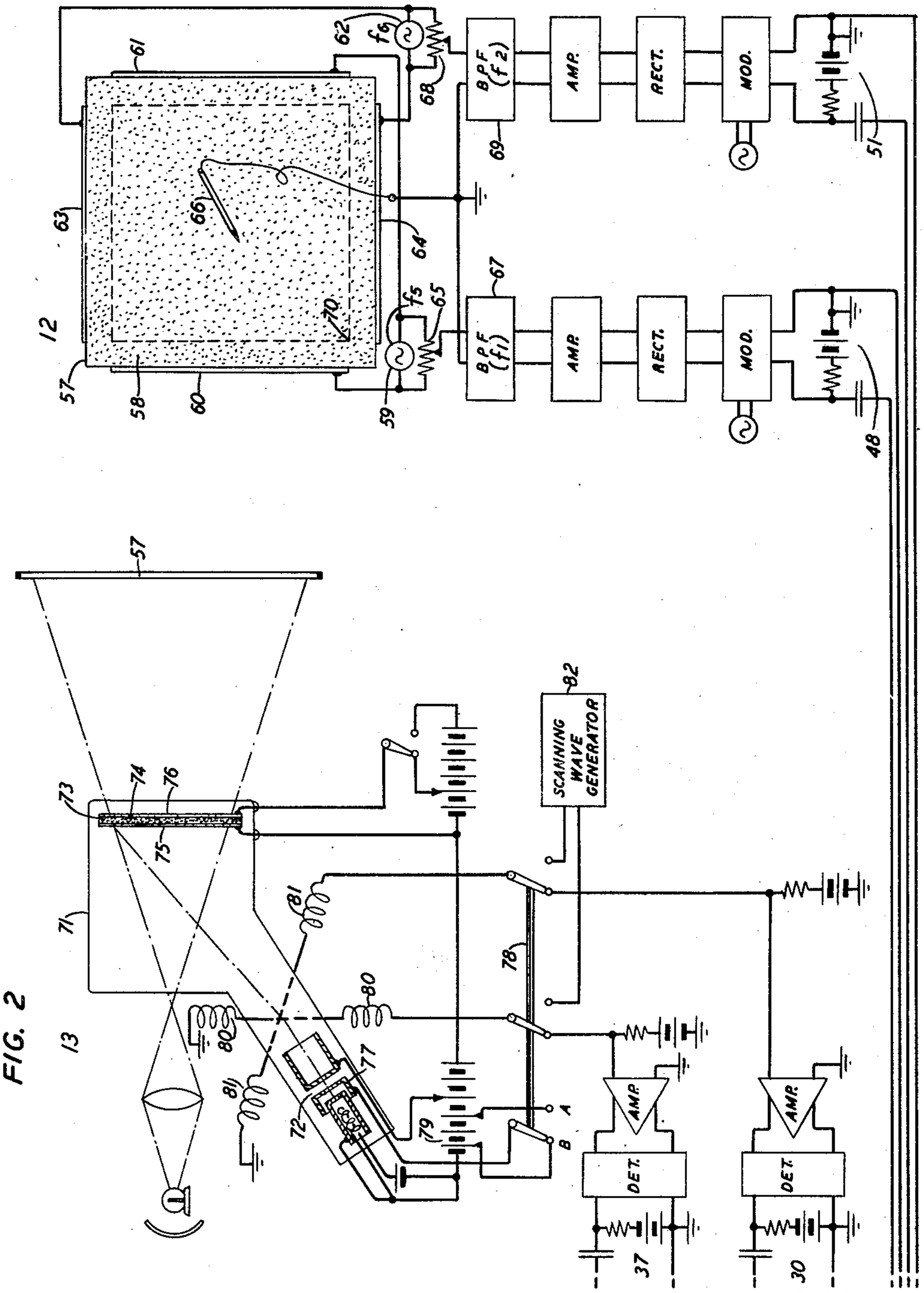

FIG. 2

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Patented Oct. 31, 1950

2,527,835

UNITED STATES PATENT OFFICE

2,527,835

TELAUTOGRAPH SYSTEM

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Application November 4, 1947, Serial No. 783,902

1 Claim. (Cl. 178—19)

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This invention relates to systems for the electrographic transmission of images, and, more particularly, to systems in which writing or other graphic material may be reproduced at a receiving station while being formed at a transmitting station.

There has recently been developed a method of producing a transparent electrically conductive coating which may be applied to sheets of glass or similar transparent materials. The coating has the unique properties of low resistivity together with uniformity of resistance over the coated area and good characteristics for the transmission of visible light.

The present invention is concerned with the utilization of such conductively coated glass sheet as a means for deriving electrical signals representative of the position of a stylus or other writing such as is necessary in telautograph and similar systems. The invention is also concerned with the utilization in such systems of cathode ray tubes of the type having a crystalline target which is normally transparent to visible light but which, when struck by an electron beam, form a deposit which is opaque to visible light. Cathode ray tubes employing targets of that type are particularly adapted for projecting the images formed upon the target upon an external screen and are also useful in applications where it is necessary to retain the images formed for extended periods of time. This latter characteristic is of interest in the art of telautography where artificial signal storage means have been utilized in the past in order to produce a recurring trace upon the screen of the cathode ray display tube. Finally, the invention is concerned with a novel combination of a coated glass sheet employed as a transmission device with a cathode ray tube of the type described above wherein the image received is projected upon the underside of the transparent writing surface. Such an arrangement has the advantage of providing a means whereby an operator at either of two such stations may add to or modify the graphic material being transmitted by the other operator.

Accordingly, it is an object of the invention to provide an improved system for the transmission of graphic information;

It is an object of the invention to provide a system for the reception of graphic images which will retain the received images for relatively extended periods of time;

It is an object of the invention to provide a novel means of deriving potentials representative

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of the position of a writing stylus on a writing surface;

It is an object of the invention to provide a telautograph system suitable for use in conference systems.

These and other objects, features and aspects of the invention will be more readily apparent from a consideration of the following detailed specification and appended claim taken in connection with the accompanying drawings, in which:

Fig. 1 shows a schematic diagram of one station of a telautograph system illustrating one embodiment of the invention;

Fig. 2 shows a schematic diagram of a second station of a telautograph system illustrating alternative embodiments of the invention.

Referring now to Fig. 1, there is shown a telautograph station embodying a transmitting apparatus 10 for deriving signals representative of the position of a writing pencil or stylus into electrical signals for transmission to a remote station, and a receiving apparatus 11 for converting electrical signals received from the remote station into images representative of those being traced at the remote station. Such a remote station is shown in Fig. 2, wherein a transmitting apparatus 12 and a receiving apparatus 13 are essentially similar to the corresponding apparatus of Fig. 1.

The transmitting apparatus 10 of Fig. 1 is provided with a sheet 14 of transparent material having a thin, transparent, and electrically conductive coating on one side thereof which will be designated as a writing surface 15. The sheet 14 may be of plate glass while the conductive coating may be that known as the NESA coating which has a resistance in the order of 100 to 150 ohms per unit area. Such a coated glass is described in the Transactions of the American Institute of Electrical Engineers, at page 789 of volume 65.

The sheet 14 is provided along two of its sides with a pair of electrodes 16 and 17 which serve as terminals whereby alternating potentials of a frequency $f1$ from a source 18 may be applied across the conductive coating in one coordinate direction. Similarly, there is provided along the remaining two sides a pair of electrodes 19 and 20 whereby alternating potentials of a frequency $f2$ from a source 21 may be applied across the conductive coating of the writing surface in the remaining coordinate direction. The voltage gradients thus produced across the writing surface 15 are essentially mutually perpendicular,

at least within an area such as that enclosed by the dashed line **22**, and a writing device **23** in contact with the writing surface will detect voltages of frequencies *f1* and *f2* whose amplitudes are proportional to the two-dimensional coordinate position of the writing device as it moves across the writing surface. The writing device **23** may be a pencil or stylus adapted to provide an electrically conductive path as well as to produce visible marks upon the writing surface **15**.

The voltages detected by the writing device **23** are applied to a band pass filter **24** which is designed to pass only the alternating potentials of frequency *f1*. The transmitted potentials are amplified by an amplifier **25**, rectified by a diode **26**, and smoothed by a filter **27**. The variable amplitude unidirectional potential thus obtained is utilized to modulate a carrier wave of frequency *f3* supplied by a source **28** to a modulator **29** and the modulated carrier transmitted over a wire or radio transmission channel **30** to a remote receiving station such as the receiving apparatus **13** of Fig. 2. Similarly, the potentials of frequency *f2* detected by the writing device **23** will be passed by a band pass filter **31** and amplified by an amplifier **32**. The amplified potentials are converted into a variable amplitude unidirectional potential by a rectifier **33** and a filter **34**, and the resultant wave utilized to modulate a carrier wave of frequency *f4* supplied by a source **35** to a modulator **36**. The modulated carrier is then transmitted over a wire or radio transmission channel **37** to the remote receiving station. It will be realized that, since the only information transmitted is that representative of the instantaneous position of the writing stylus **23**, the transmission channels **30** and **37** may be of relatively narrow bandwidth.

The receiving apparatus **11** includes a cathode ray tube **38** having means to generate an electron beam, such as a conventional electron gun **39**, means for deflecting the electron beam, such as a pair of horizontal deflection coils **40** and a pair of vertical deflection coils **41**, and a target **42**. The target **42** consists of a crystalline layer **43** provided on each side with electrodes **44** and **45** in the form of thin, transparent, sputtered metallic layers or fine meshes. The target **42** is maintained at a positive potential with respect to the electron gun **39** by a source **46** while the electrode **45** is maintained at a potential positive with respect to the electrode **44** by a source **47**.

The crystalline layer **43** of the target **42** is composed of crystals of the class known as "ionic crystals" which are normally transparent to visible light but, upon being struck by an incident beam of electrons, form an opaque deposit of a density proportional to the instantaneous density of the beam. This opaque deposit persists after the beam leaves the area and moves transversely through the crystal toward the positive electrode **45** at a speed determined by the temperature of the crystal and the potential difference between the electrodes **44** and **45**. These effects occur primarily in crystals of the alkali-halides, such as potassium chloride. For a further description of the phenomena, reference may be made particularly to an article entitled "A system of Large-Screen Television Reception Based on Certain Electron Phenomena in Crystals," by A. H. Rosenthal and published in the Proceedings of the Institute of Radio Engineers for May, 1940, at page 203.

The electron beam from the electron gun **39** is deflected over the surface of the target **42** to produce an opaque image of the graphic material being drawn at the remote transmitting station upon the normally transparent target. Carrier waves modulated in accordance with signals representative of the horizontal coordinate position of the writing device at the transmitting station are received over a transmission channel **48** whence they are demodulated by a detector **49**. The potentials so derived are amplified by a direct-coupled amplifier **50** and applied to the deflection coils **40** to produce a horizontal deflection of the electron beam proportional to the horizontal movement of the distant writing device. Similarly, carrier waves modulated in accordance with signals representative of the vertical coordinate position of the writing device at the transmitting station are received over a transmission channel **51** and demodulated by a detector **52**. The potentials so derived are amplified by an amplifier **53** and applied to the deflection coils **41** to produce a vertical deflection of the electron beam proportional to vertical movement of the distant writing device. It is to be understood that the intensity of the moving electron beam is to be maintained at a constant level such that an opaque image of the proper density is formed upon the target **42**.

In accordance with one feature of the invention, the image formed upon the target **42** is projected upon the under surface **54** of the sheet **14** by means of light from a source **55** which passes through the target to produce a reproduction of the target image upon the surface **54**. It is to be understood that the projection system illustrated is symbolic only, since it will usually be necessary for the rays of light from the source **55** to pass through the target in a direction normal to the surfaces thereof over the entire target.

It is an important aspect of the invention that the target **42** has a high storage ratio, that is, the image formed upon the screen is retained for a considerable period after formation by the moving electron beam. This effect is due to the fact that the opaque deposits produced by the electron beam move transversely through the crystal at a relatively slow rate determined by the potential normally applied between the target electrodes **44** and **45**. The necessity for the use of artificial signal storage means such as have been necessary in the past in telautograph systems utilizing the usual type of cathode ray tube for display purposes is thus obviated. It is, however desirable that a means be provided whereby the operator can erase the image at will. Accordingly, there is provided a switch **56** whereby a relatively high potential may be applied across the electrodes **44** and **45**, thereby temporarily hastening the movement of the opaque deposit toward the positive electrode and causing the rapid dissipation of the recorded image. Alternatively, other known means, such as increasing the temperature of the crystal **42**, may be utilized to perform the same function.

Referring now to Fig. 2, the remote station illustrated includes a transmitting apparatus **12** connected by means of the transmission channels **48** and **51** to the receiving apparatus **11** of Fig. 1. Similarly, the receiving apparatus **13** of Fig. 2 is connected by means of the transmission channels **30** and **37** to the transmitting apparatus **10** of Fig. 1. While the receiving and transmitting apparatus **12** and **13** of Fig. 2 is essentially the same as the corresponding apparatus of Fig. **1**, alternative embodiments of certain aspects of the

respective circuits are provided and will be described in some detail.

The transmitting apparatus 12 includes a sheet 57 of transparent material having a writing surface 58 which includes a thin, transparent, electrically conductive coating similar to that of the sheet 14 of Fig. 1. Alternating potentials of frequency *f*5 are applied to the conductive coating along two opposite sides of the sheet 57 by means of a pair of electrodes 60 and 61 while alternating potentials of frequency *f*6 from a generator 62 are applied to the conductive coating along the remaining two sides of the sheet 57 by means of a second pair of electrodes 63 and 64. A potentiometer 65 connected across the generator 59 together with the conductive coating of the sheet 57 combine to form a bridge circuit which becomes more or less unbalanced in accordance with the horizontal position of a writing stylus 66, thus impressing upon a band pass filter 67 potentials of frequency *f*5 whose amplitude varies in accordance with the horizontal position of the writing stylus 66 on the writing surface 58. Similarly, a potentiometer 68 connected across the generator 62 together with the conductive coating of the sheet 57 combine to form a bridge circuit which impresses potentials of frequency *f*6 and amplitude proportional to the vertical position of the writing stylus upon a band pass filter 69. The variable amplitude alternating potentials of frequency *f*5 passed by the filter 67 and the variable amplitude alternating potentials of frequency *f*6 passed by the filter 69 are utilized to modulate carriers for transmission over the transmission channels 48 and 51 after the same fashion as is employed in the transmitting apparatus 10 of Fig. 1.

The alternative circuit just described is advantageous in that the writing stylus 66 may be maintained at ground potential, thus obviating any possibility of even a slight discomfort to the user due to potentials existing between the pencil and the writing surface. However, the bridge circuits including the potentiometers 65 and 68 should preferably be adjusted for balance condition when the writing instrument 66 is in contact with some extreme point in both coordinate directions, such as the point designated as 70, in order that difficulties due to phase reversals of potential are not encountered at the balance point.

The receiving apparatus 13 utilizes the principle that a target of the nature described, that is of alkali halide crystals, when scanned by an electron beam of high intensity so as to produce an opaque deposit of high density and subsequently scanned by a second beam of lesser intensity, will have the opaque deposit produced by the first scanning beam reduced in density to a level corresponding to the intensity of the second scanning beam. There is accordingly provided in the receiving apparatus 13 a cathode ray tube 71 similar to the tube 38 of Fig. 1, having an electron gun 72, and a target 73 composed of a layer of alkali halide crystals 74 and a pair of supporting electrodes 75 and 76. A control electrode 77 of the electron 72 is supplied through a switch 78 by a potential source 79 so that, when the switch 78 is in a first position A, the electron beam is of such an intensity as will produce an opaque deposit in the crystal 74 of a density sufficient to preclude the transmission of light therethrough. When the switch 78 is in a position B the electron beam is of an intensity

such as will reduce the density of the opaque deposit to allow the free transmission of light. An electron beam deflection system comprising the usual deflection coils 80 and 81 is also connected through the switch 78 so as to be made responsive either to incoming signals from the transmission channels 30 and 37 or to signals from a scanning wave generator 82. The scanning wave generator 82 may be of a well-known type which will produce deflection currents for deflecting the electron beam in a raster of closely-spaced scanning lines so as to produce a uniform opaque deposit over the entire surface of the crystal 74 when the switch 78 is placed in position A. Thus, when the apparatus 13 is made responsive to incoming signals by the adjustment of the switch 78 to position B, the electron beam will form an image upon the target 73 which is transparent to visible light. The image then projected upon the sheet 57 by light from a source 83 will be bright upon a dark background rather than dark upon a bright background as in the case of the receiving apparatus of Fig. 1.

In the operation of the invention in the intended fashion, the graphic material drawn on the writing surface of the transmitting apparatus of one station is reproduced as an image upon the underside of the writing surface at the receiving station. The person at the receiving station may therefore, by making appropriate markings upon his writing surface, effectively add to or modify the original sketch. It will thus be seen that the system of the invention is particularly adaptable to use in conference systems wherein it may be desired to exchange ideas or information involving graphic or other symbolic data.

What is claimed is:

In combination, a writing surface composed of a sheet of material having a uniform resistance over an exposed area, a first generator for alternating potentials of a first frequency, means for applying potentials from said first generator across said writing surface in one coordinate direction, a potentiometer connected across said first generator said potentiometer having a tap, a band pass filter having an input circuit connected to said tap, a second generator for alternating potentials of a second frequency, means for applying potentials from said second generator across said writing surface in a second coordinate direction, a potentiometer connected across said second generator, said potentiometer having a tap, a band pass filter having an input circuit connected to said last-named tap, an electrically conductive writing stylus in contact with said writing surface and connected to input circuits of the two said band pass filters whereby the single frequency potentials passed by each filter have amplitudes representative of the coordinate positions of the said writing stylus.

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