

March 30, 1943.

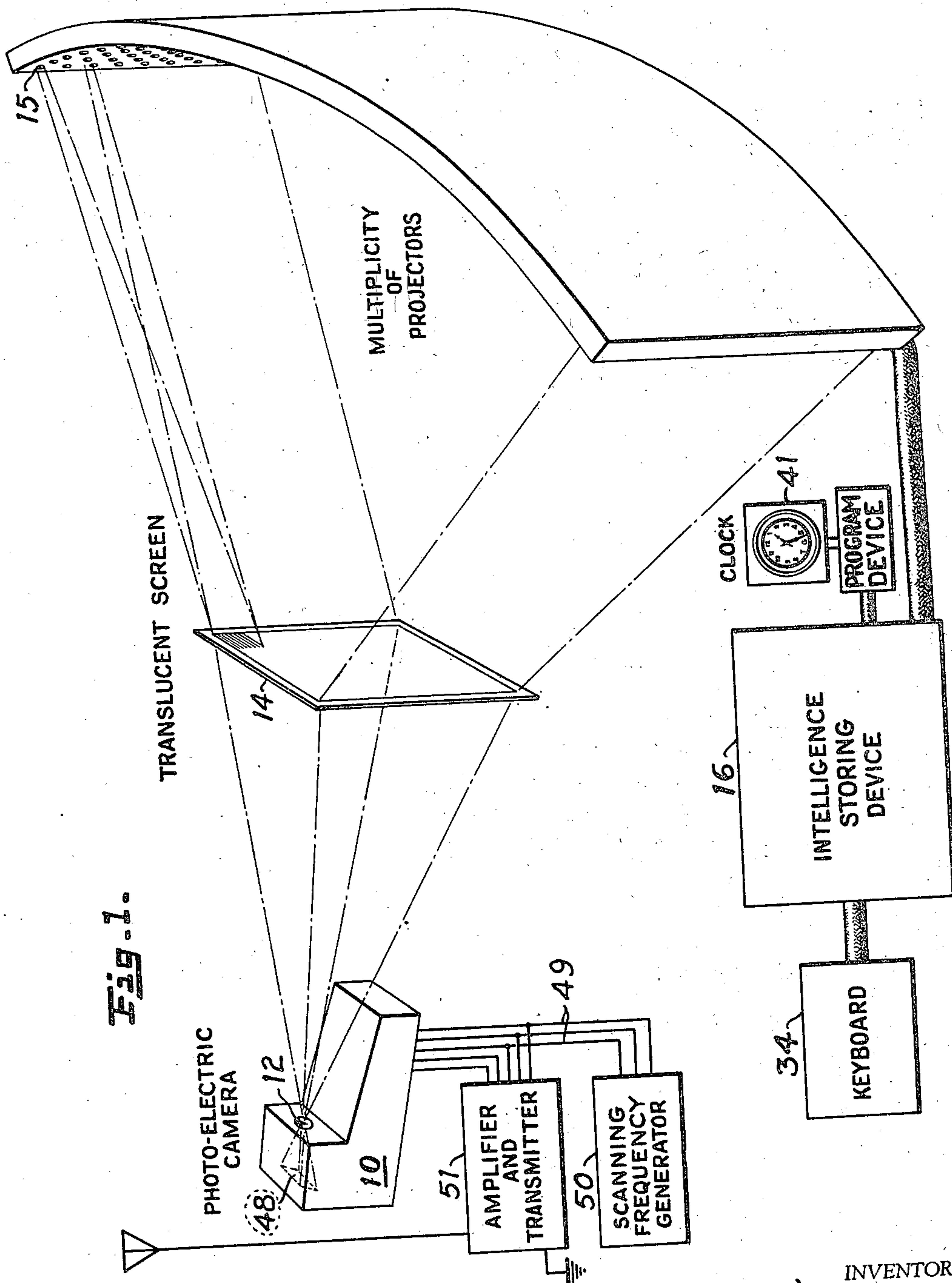
R. W. BUMSTEAD

2,314,920

MULTIPLEX TELEVISION AND FACSIMILE SYSTEM

Filed April 13, 1940

6 Sheets-Sheet 1



INVENTOR.

Ralph W. Burnstead

March 30, 1943.

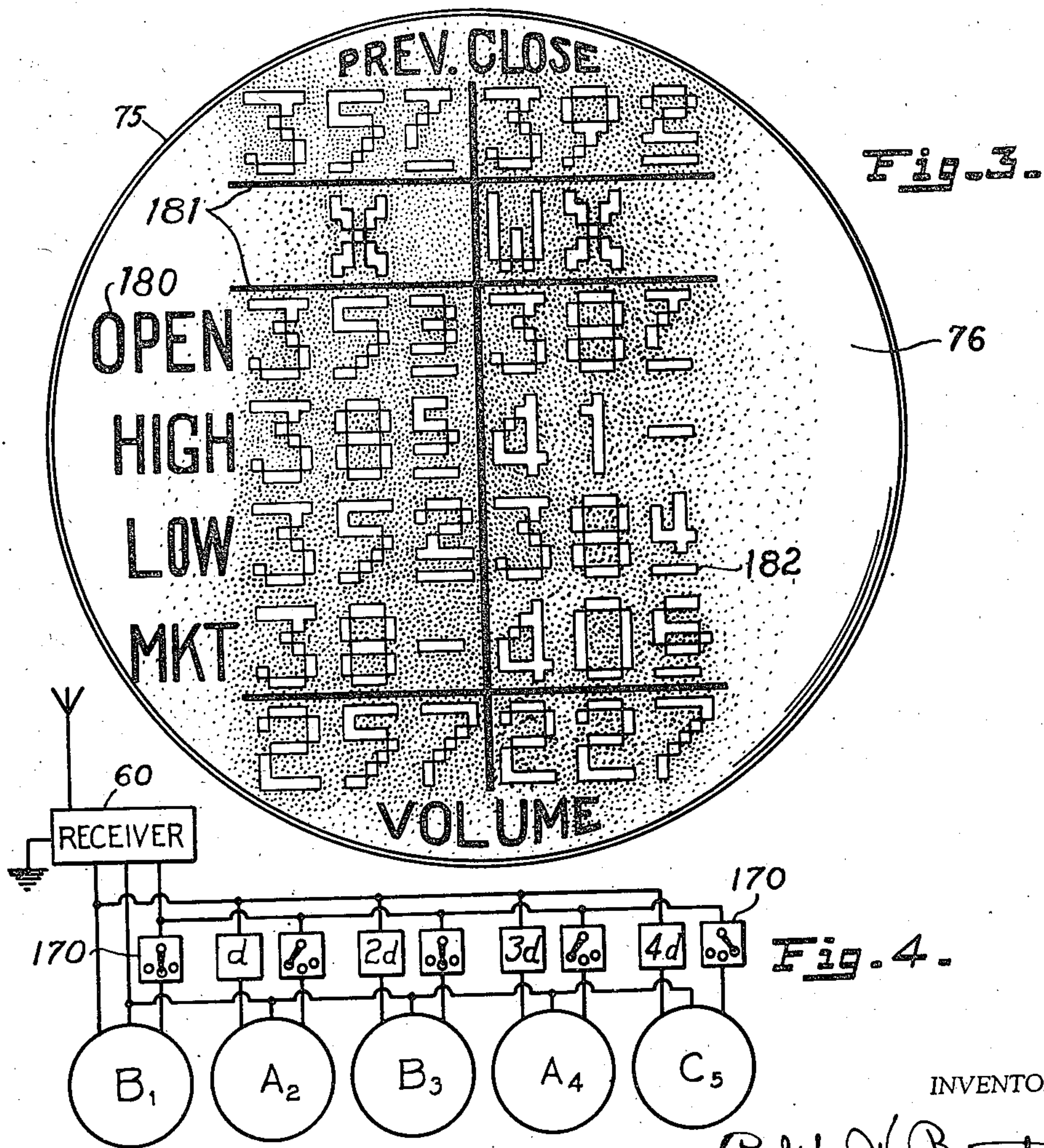
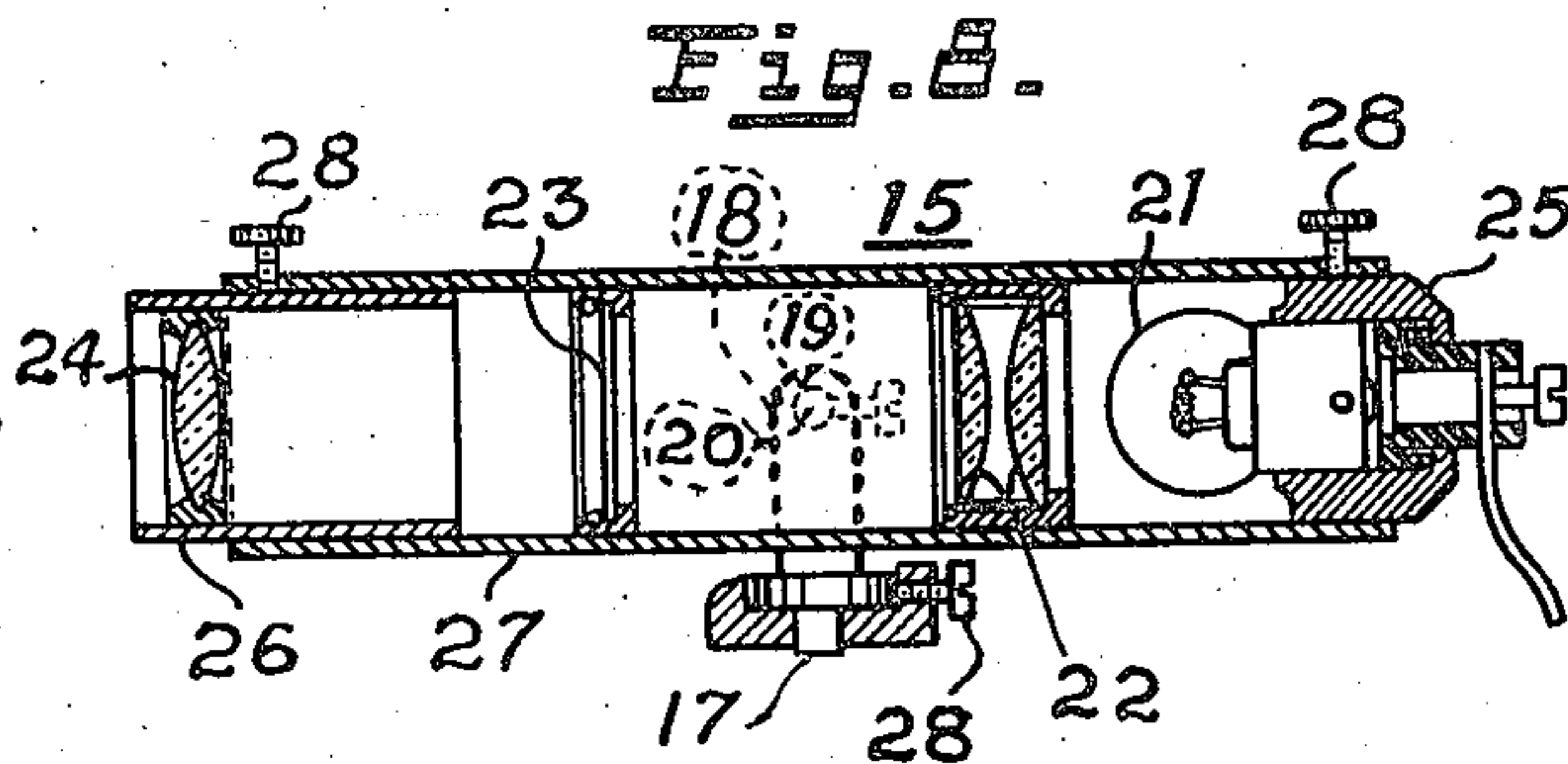
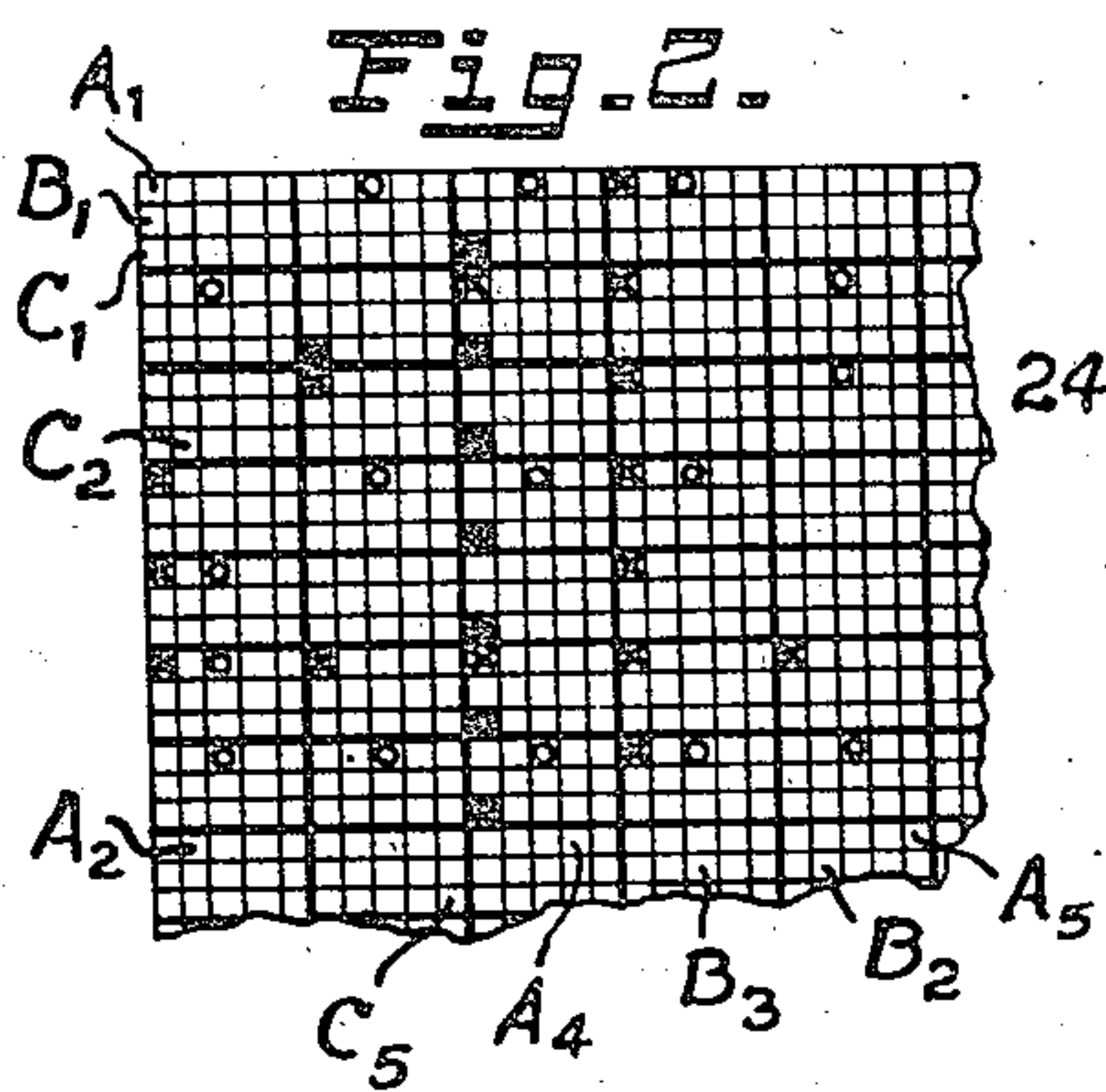
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MULTIPLEX TELEVISION AND FACSIMILE SYSTEM

Filed April 13, 1940

6 Sheets-Sheet 2



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MULTIPLEX TELEVISION AND FACSIMILE SYSTEM

Filed April 13, 1940

6 Sheets-Sheet 3

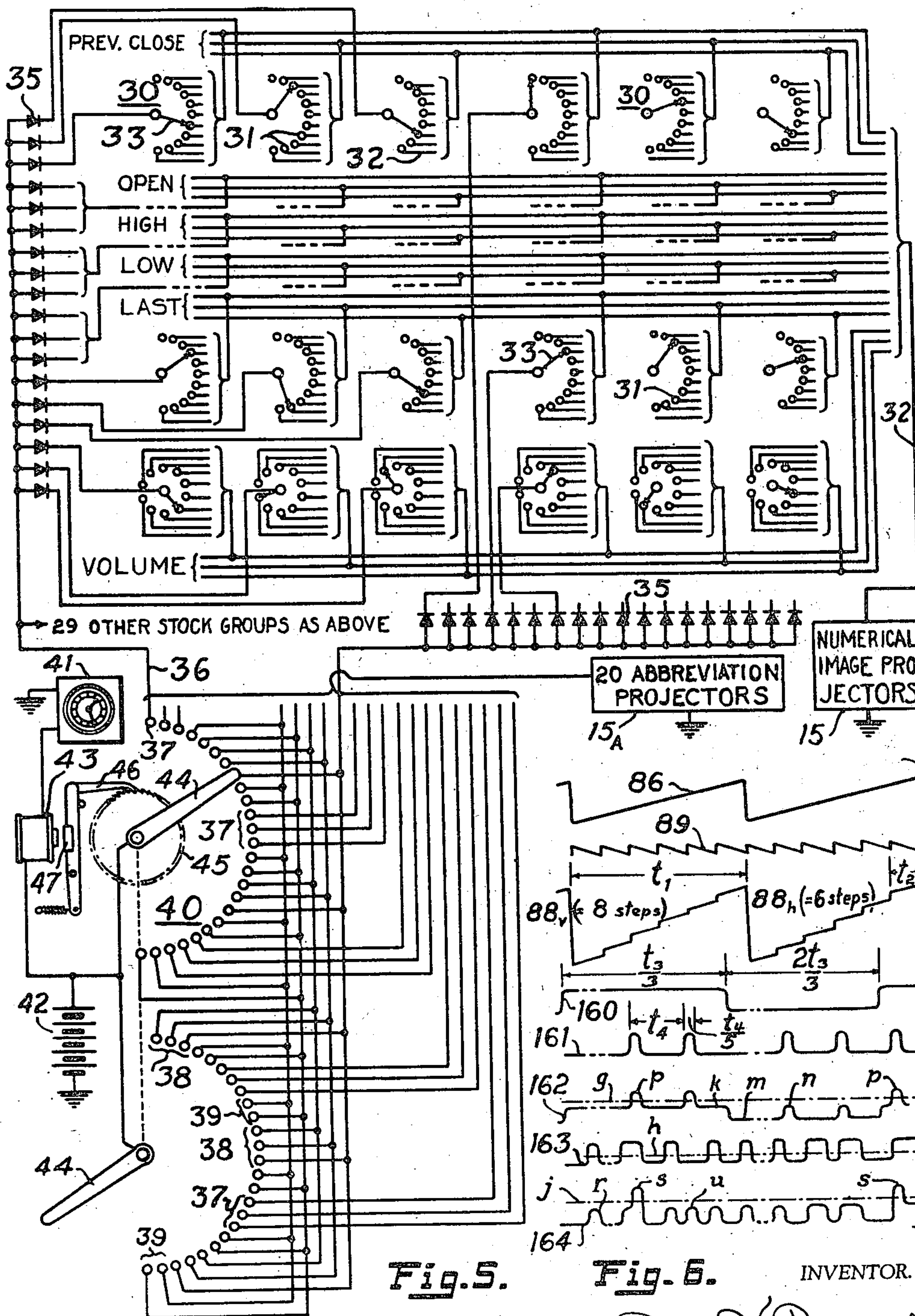


Fig. 5.

Fig. 6.

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March 30, 1943.

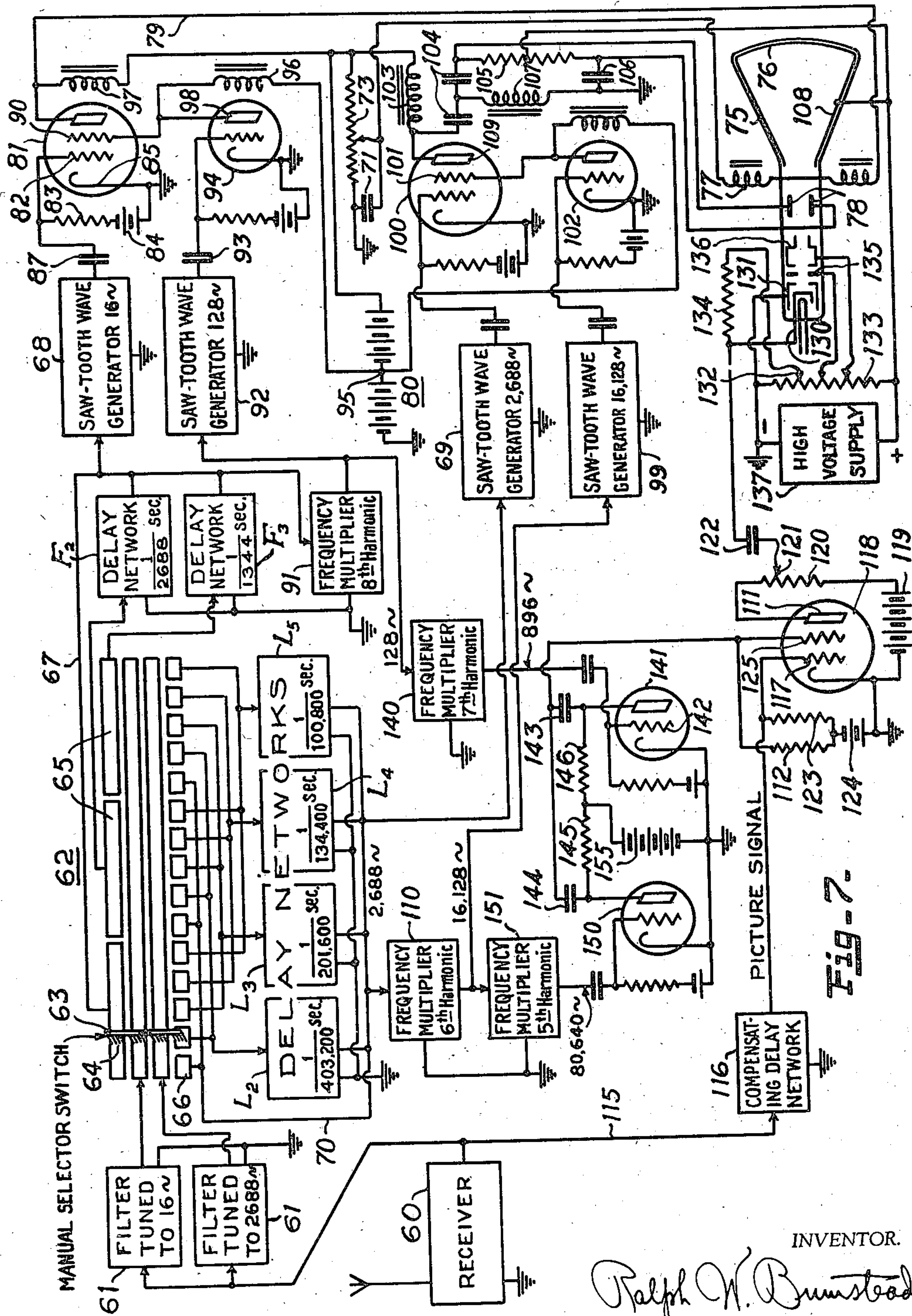
R. W. BUMSTEAD

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MULTIPLEX TELEVISION AND FACSIMILE SYSTEM

Filed April 13, 1940

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March 30, 1943.

R. W. BUMSTEAD

2,314,920

MULTIPLEX TELEVISION AND FACSIMILE SYSTEM

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6 Sheets-Sheet 5

Fig. 9

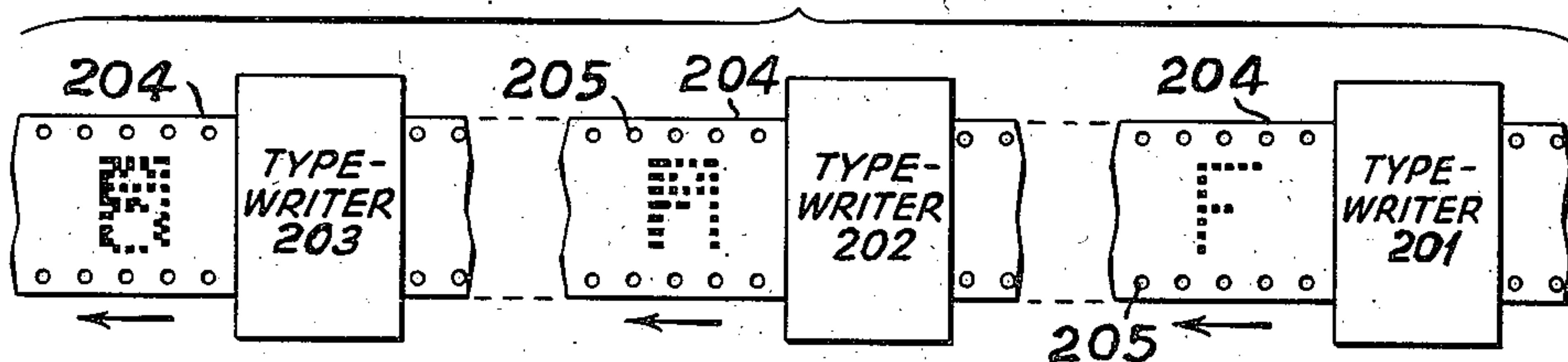


Fig. 10

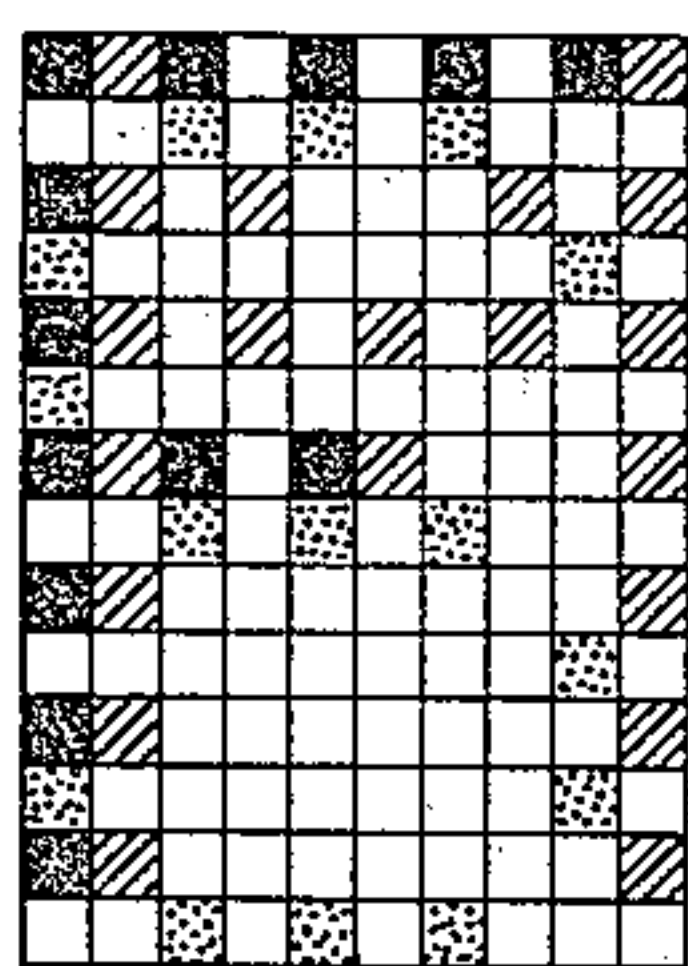


Fig. 11

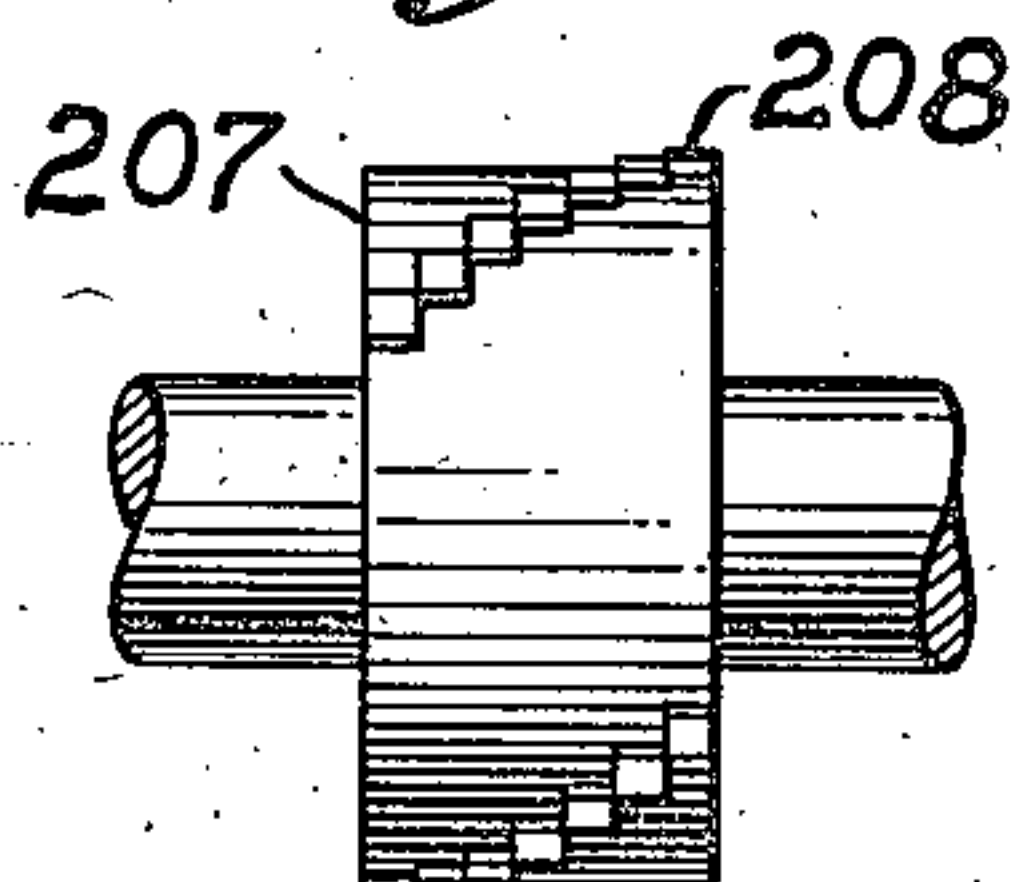


Fig. 12

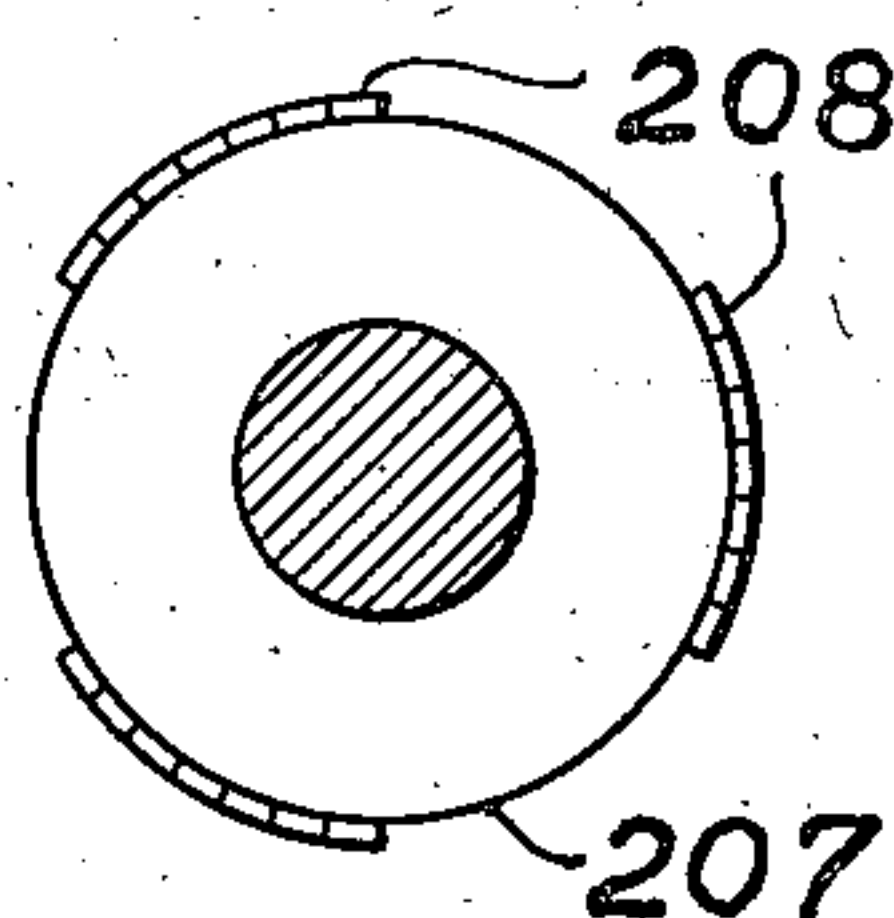


Fig. 13

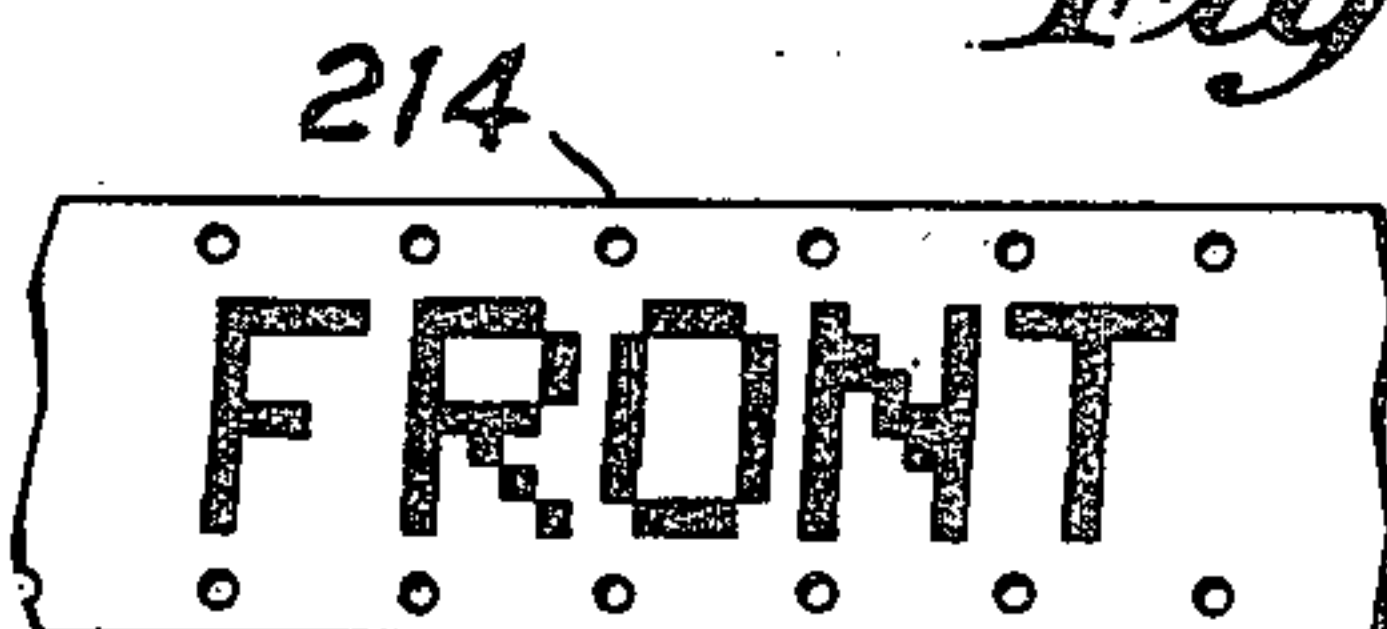
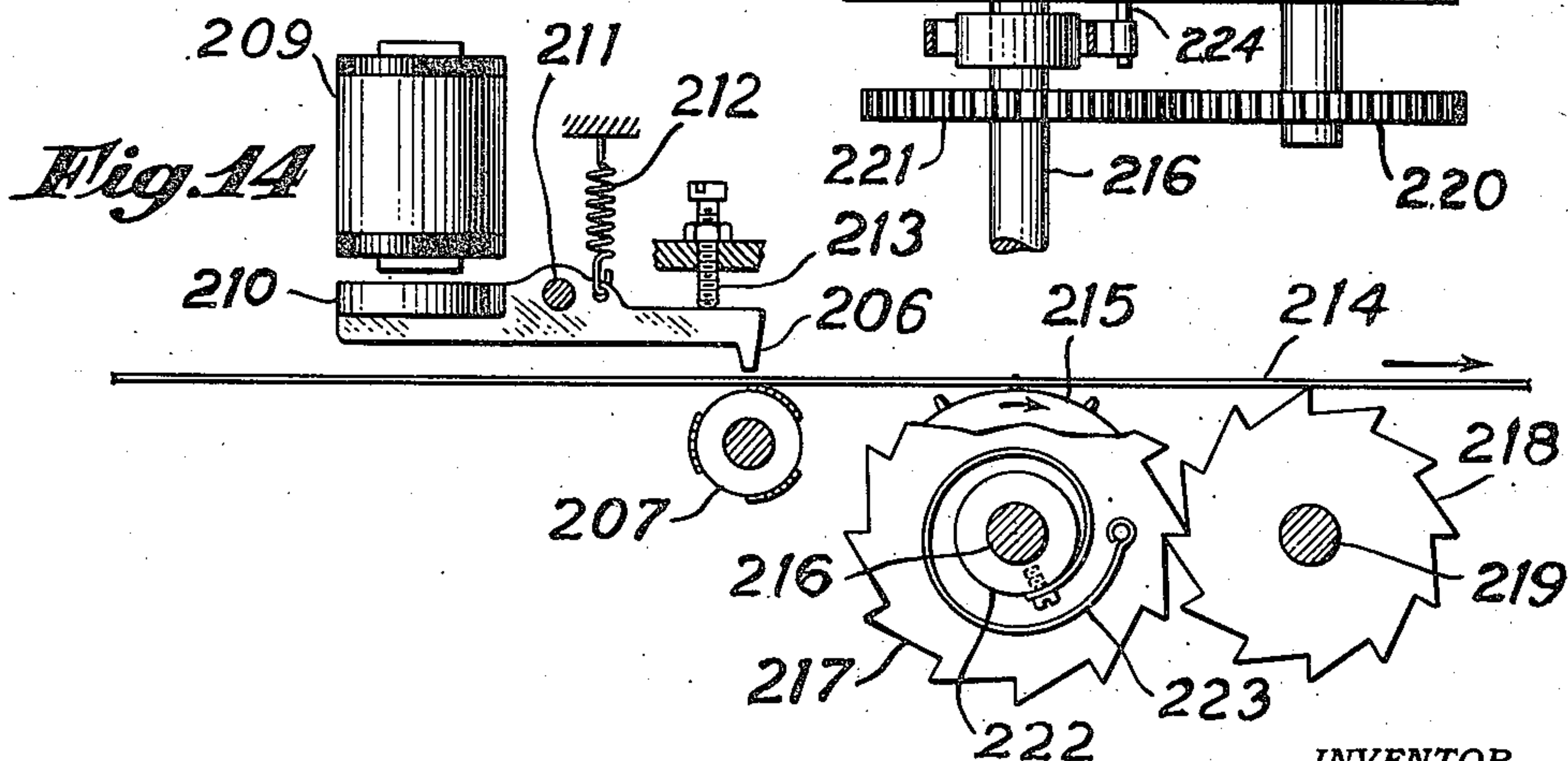


Fig. 15



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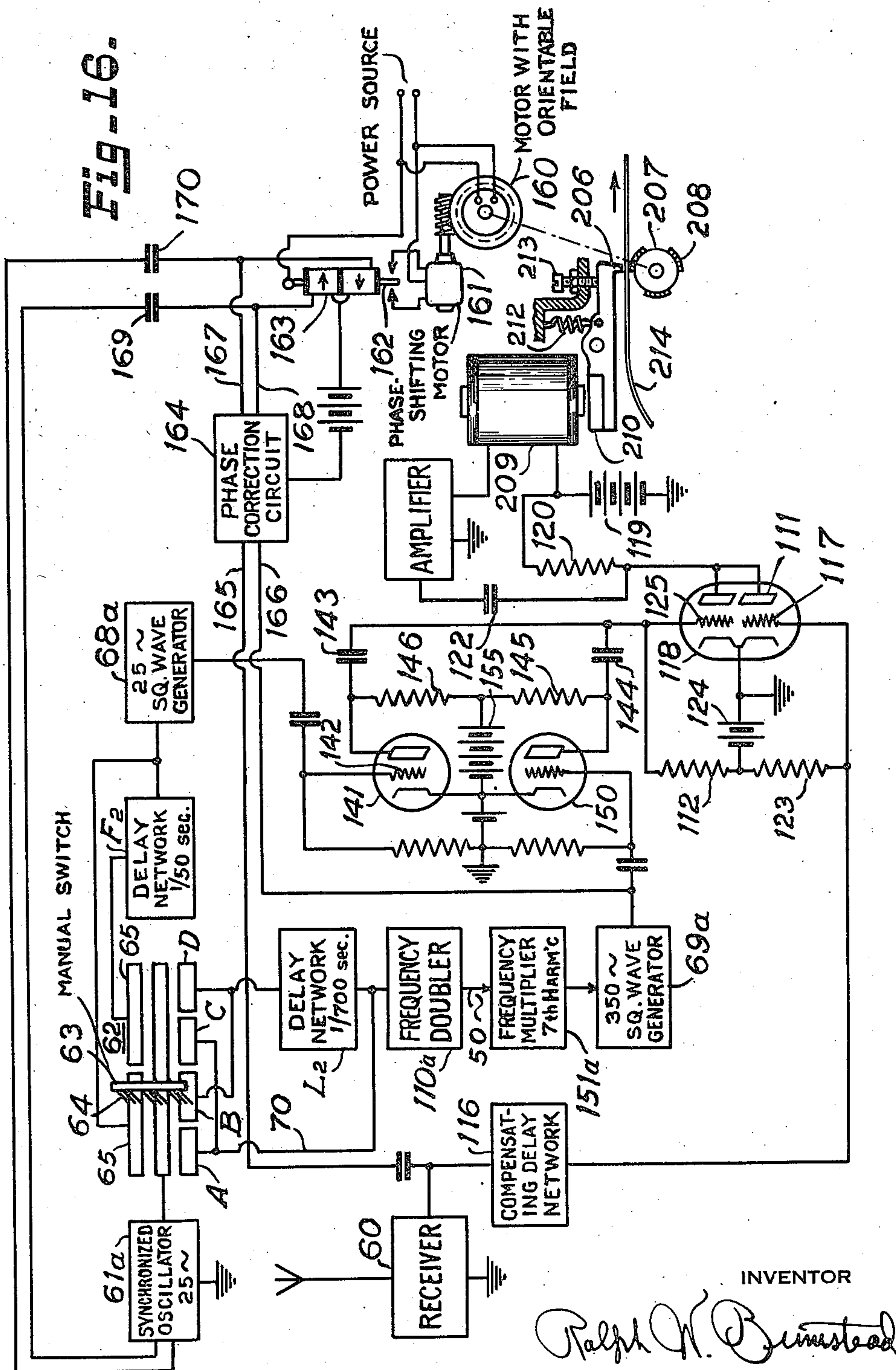
R. W. BUMSTEAD

2,314,920

MULTIPLEX TELEVISION AND FACSIMILE SYSTEM

Filed April 13, 1940

6 Sheets-Sheet 6



UNITED STATES PATENT OFFICE

2,314,920

MULTIPLEX TELEVISION AND FACSIMILE
SYSTEM

Ralph W. Bumstead, Westfield, N. J.

Application April 13, 1940, Serial No. 329,427

19 Claims. (Cl. 178—7.2)

This invention relates to television and facsimile systems, and more particularly to a device for the dissemination of news items and other pieces of intelligence.

The instant application is a continuation-in-part of my co-pending application Serial No. 17,454, which matured into Patent No. 2,207,716 on July 16, 1940.

It is a prime object of my invention to provide a system of multiplex transmission and reception of picture images over a channel of communication. Another object is to provide a device for the dissemination of intelligence by means of character images displayed on a viewing field at a receiving station.

Another object is to provide means whereby the recipient of a train of signals representing multiplexed picture images may select a portion thereof for control of an image producing device while suppressing the effects of picture signals unrelated to the image which it is desired to view. Again, it is an object to provide means at a transmitting station suitable for forming on a screen an array of interwoven character images, and to provide further means for so scanning the transmitting screen that picture signals representing multiplexed pieces of intelligence may be transmitted over one channel of communication.

It is still another object to provide a television or facsimile system in which interwoven images may be displayed on a transmitting scanning field in such manner as to minimize the transmission time function of back-ground areas which convey no intelligence, and to provide means at a receiving station for reproducing character images in such manner as to clearly separate the same one from another by such back-ground areas as may be essential to legibility.

My invention has particular utility in a system for the dissemination of news items such as stock and commodity quotations, game scores and the like. The apparatus disclosed is suitable also for producing word pictures having any desired news significance. The scope of the invention is, however, by no means limited to the fields of usefulness above indicated. Other useful applications will readily suggest themselves to those skilled in the art.

When the system of my invention is to be used for quoting stock market prices and the like, it is preferable to employ a storing device in which the transactions may be tabularly set up as on a quotation board.

When the invention is applied to a television system, I preferably employ a system of projectors for forming character images on a screen to be televised. The projectors for forming these character images are controlled by the aforesaid storing device. The character images used for

displaying different pieces of intelligence are interwoven on the transmitting screen.

When the invention is applied to a facsimile system, I preferably employ a plurality of special typewriters, each adapted to imprint a tape with character images which are constituted by appropriate selections of specific and well defined elemental areas of a scanning field. These character images as typed by different machines in such manner that the elemental areas imprinted by one machine are exclusive of elemental areas imprinted by other machines, and yet the character images themselves are interwoven and may be without back-ground separation from one another.

Whether television methods or facsimile methods are employed, the elemental areas constituting character images may be fitted together closely, like blocks in a mosaic. Substantially the entire screen area is then covered by the significant elemental light and dark areas, so that, when the image thereof is "sensed", by photoelectric scanning means, the resulting picture signals will be substantially continuously significant. Thus the transmission time is conserved by avoidance of the necessity for scanning insignificant background areas.

In order to produce a suitable background on the receiving screen so that the character images may be re-formed legibly and distinctly, I preferably provide a novel system of deflecting circuits for a cathode ray tube constituting part of the receiving apparatus, if television methods are employed. In a modification which follows conventional facsimile practice in certain particulars, character images are formed on a record tape and spaces between the characters are produced by means germane to the receiver.

A feature of my invention which adds to its utility is the provision of means localized at a receiving station for enabling a subscriber to review periodically and at frequent intervals the progress of the transactions in any particular security or group of securities simply by selecting for control of his television receiver a particular train of signals which is interwoven with unwanted trains appropriate to other programs, or groups of securities.

Another feature of my invention is the combination of storage means for news items or quotations, and a time-controlled program device whereby such news items or quotations may be displayed on a reviewing screen periodically, each time with the latest revised accumulations of stored intelligence. This feature is particularly desirable when it is made the practice to display Opening, High, Low and Last prices for stocks or commodities.

Many other features and advantages of my invention will be made apparent in the description

to follow. However, the scope of the invention is limited only as defined by the claims.

In the drawings:

Figure 1 shows somewhat diagrammatically and somewhat in perspective a group of apparatus units suitable for transmitting picture signals representative of multiplexed character images,

Fig. 2 shows a fragment of the transmitting screen on which may be projected the multiplexed character images,

Fig. 3 shows a front view of a cathode ray tube on which selected character images may be received,

Fig. 4 illustrates how different picture images may be simultaneously reproduced on different receiving screens in response to multiplexed signals,

Fig. 5 shows certain details of the electrical system at the transmitter,

Fig. 6 shows certain wave shapes useful in the sweep circuits of a cathode ray tube,

Fig. 7 is a circuit diagram of a picture selecting and reproducing device operable on television principles,

Fig. 8 is a sectional view of one of the character image projectors which may be used at the transmitting station,

Fig. 9 shows a system of special typewriters arranged to form multiplexed, or interwoven character images on a tape in preparation for transmission by facsimile methods,

Fig. 10 shows an enlarged view of a multiplexed character image as it may be formed either for television transmission or for facsimile transmission,

Fig. 11 shows a longitudinal view of a printing platen for use in a facsimile system constituting one embodiment of the invention,

Fig. 12 shows an end-view of the printing platen of Fig. 11,

Fig. 13 illustrates a fragment of a facsimile-recorded receiving tape,

Fig. 14 is a rear view of certain details of a receiving device used in facsimile recording,

Fig. 15 is a plan view of a sprocket-wheel assembly otherwise shown in Fig. 14, and

Fig. 16 shows a circuit diagram suitable for use in the modification herein described which applies to a facsimile system.

In the following detailed description one embodiment of my invention will first be presented which follows the principles and practices of the television art. A second illustrative embodiment of the invention will then be described, and although it possesses many features in common with the first embodiment, yet it may be regarded more as a facsimile recording system.

THE TELEVISION TRANSMITTER

Referring first to Fig. 1, a television transmitter 10 is shown with its optical system including a lens 12 which may be caused to focus an image of the screen 14 upon a photosensitive electrode of a cathode ray tube of the so-called "iconoscope" type. This tube is provided with "sweep-circuits" for causing the electron beam to perform a scanning operation having both horizontal and vertical components. In carrying out my invention, however, each horizontal scanning line is made to cover a row of elemental light and dark squares of suitable size to be used in the formation of character images.

On the screen 14 I preferably form an image pattern made up of elemental light and dark

areas each of which has definite significance when coordinated with the others. Each of the horizontal rows of such elemental areas preferably represents a scanning line. The cathode ray tube scanning device is arranged so that the electron beam successively impinges upon these different elemental areas along each scanning line and scans different lines successively in order to sweep over the entire scanning area. Upon scanning a single line the transmitter translates successively scanned elemental areas into a train of television signals. In this way each integral portion of the signal train is caused to represent a single elemental area of the transmitting screen where each such elemental area is controlled by a sharply focused light beam emanating from the various light sources presently to be described. The image pattern may, if desired, be made up of interwoven character images. Any letter of the alphabet and any of the numerical figures may be legibly formed by suitably disposing black and white squares in a mosaic constituted by seven horizontal rows of such squares and five squares in a row. In some instances the necessary number of squares in a mosaic for a single character may be fewer than thirty five. If preferred, the number may be greater; that is, by spreading a character over more than five squares along a horizontal scanning line, or by making the character more than seven scanning lines in height. In respect to the first embodiment, the image pattern on the screen 14 is optically reproduced on the iconoscope screen 48 in such manner that the elemental areas forming interwoven character images may be translated into a train of picture signals, the sequence being according to a line-for-line scanning operation, as is usual in television systems. In this way each integral portion of the signal train is caused to represent a single elemental area such as may be covered by a sharply focussed light beam projected on the screen 14.

A multiplicity of light sources 15 and optical projectors is provided for forming the image pattern on the screen 14. Each projector contains a mask for composing the elements of a single character. The mask is shown in section at 23 in Fig. 8. The character formation thereon may be obtained by perforations in an opaque sheet, or by the use of a film which is for the most part opaque but which has small translucent spots arranged thereon so as to form the elements of any desired character image.

Fig. 2 shows how the character images of a number of different characters may be interwoven. The screen areas appropriate to different characters are mutually exclusive. Thus, in the fragmentary portion of the screen shown in Fig. 2 character "1" is composed of elemental areas which are distinguished by black squares. Character "2" is formed by light spots impinging on elemental areas designated by small circles. The trace of character "4" may be discerned by reference to the areas marked x. In one of the larger areas (bounded by heavy lines in Fig. 2) will be found fifteen of the elemental areas, each assigned to a corresponding portion of a different character image.

It is optional whether the film or mask in each projector 15 be arranged to project a positive image or a mirror image of each character on the screen 14. In one case the screen 14 would be made opaque and would be viewed from the side on which the light is projected; while in the

other case the screen would be made translucent and would be viewed from the opposite side.

The holes in the mask 23 may be circular, elliptical or rectangular, so long as they admit light beams of sufficient cross section to adequately cover each selected elemental screen area, and without overlapping.

From the foregoing description the method of interweaving the elemental areas of fifteen different character images has been illustrated. The arrangement of the projectors is such that they may be selectively illuminated for the purpose of variably displaying different character images. If, therefore, a space is to be reserved on the screen for displaying letters of the alphabet, then, preferably, twenty-six projectors will be focussed on identical spots of the screen and any one of the twenty-six projectors when illuminated will display its respective letter. If figures only are to be displayed on certain areas, then the number of projectors to be alternatively actuated will be ten. Only seven or eight projectors are necessary in reference to the display of character designations representing "eighths," according to current practice in this country when quoting stocks.

As illustrated in the drawings, a very large number of projectors is to be employed for controlling the formation of a multiplexed character image pattern on the screen. In this particular embodiment it is provided that quotations for fifteen different stocks shall be simultaneously projected on the left half of the transmitter screen and for fifteen other stocks on the right half. The group of quotations for a single stock is displayed on seven character-lines, including a line for the stock abbreviation. Each character line has the height of twenty-one scanning lines, although only seven scanning lines are used in forming a character image. The interspersed scanning lines are used for the multiplexing of different character images. The quotations usually comprise tens- and units-digits, and a digit representing a fraction. A hyphen (-) may be displayed when the quotation is "flat." The other fractions are usually indicated as $\frac{1}{2}$, $\frac{3}{4}$, $\frac{5}{8}$, and $\frac{7}{8}$; the denominator /8 being understood in each case. If a stock is quoted between 100 and 200, the tens-figure can be represented (on the receiving screen) in a space the width of which comprehends only three elemental areas. This leaves room to show a hundreds-figure "1" as a vertical line at the extreme left of the space ordinarily occupied by the tens-figure. If other hundreds-digits are to be indicated, they can usually be provided for by showing two or more dots, vertical dashes, or combinations thereof in place of the "1" which indicates "100".

The seven horizontal rows of characters for a stock group may, if desired, comprise quotations arranged thus:

Previous close
Stock abbreviation
Opening
High
Low
Last (or Market)
Volume ("00" omitted)

If, as shown in Fig. 3, the prices of two stocks are to be displayed simultaneously on a receiving screen, then, preferably, the width of the screen will be divided into six character spaces. On the transmitting screen each of these character spaces is again divided laterally into twenty-five

elemental areas, so that as many as 150 elemental areas exist on each scanning line. Five character images are interwoven laterally and three vertically on the transmitting screen, thus providing for the multiplexing of fifteen different picture images.

The arrangement of projectors 15 and of screen area division thus far described may be tabularly summarized thus:

Horizontal aspect

Each scanning line is occupied by 150 elemental areas, of which 5 are appropriate to each of 30 characters; there being 5 characters interwoven laterally, 3 characters per stock quotation and two stock groups separated by the vertical center line of the screen. A synchronizing signal precedes and follows the transmission of a train of signals representative of the elemental light and dark areas along each scanning line.

Vertical aspect

There are 168 horizontal scanning lines occupied by seven character bands plus one band the time of scanning which is utilized for transmitting a frame synchronizing signal. Each character band occupies 21 scanning lines. So also does the frame synchronizing band, the time component of which is taken up by the return stroke of the vertical beam deflection in the scanning operation. Three character images are intermeshed vertically and each character image is formed by light and dark elemental areas along seven scanning lines.

The picture frame

As constituted at the transmitter, eighteen numerical image patterns are simultaneously arrayed on the screen for each stock group. These eighteen image patterns are divided into six lines of three figures each representing the tens, units and fraction digits of different quotations on each line. The quotations usually provided on an indicator of this type include the following:

Previous closing price, open, high, low, market (or last), and volume. The last mentioned quotation may, if desired, express hundreds of shares of stock sold, up to the moment of display of the prices. From one to three letter-images are also arrayed along the character band to represent each stock abbreviation. Thirty stock groups within the picture frame $\times 21$ character images per stock group $\times 35$ elemental areas per character = 22,050 elemental areas on the screen.

A group of twenty-eight projectors is adequate for displaying any possible quotation from $\frac{1}{8}$ to 997/8. In order, therefore, to provide complete interchangeability of price images for thirty stock groups, each group comprising five prices,

$$5 \times 30 \times 28 = 4200 \text{ projectors}$$

are needed. If volume of transactions is also to be indicated,

$$30 \times 30 = 900 \text{ additional projectors}$$

would then be arranged to cover the bottom character line of the picture.

The image pattern for all the interwoven letters of thirty stock abbreviations may, if desired, be fixedly obtained by using a stencil or mask in a single projector for this purpose. Such projectors, however, will be multiplied in number by

the number of different stock groups to be successively displayed during a cyclic survey of all the stocks whose prices are stored in the intelligence storing device 16. In the illustrative embodiment herein shown, twenty such changes of scene are provided for. Hence there are twenty projectors for the interwoven letter images representing stock abbreviations. The 22,050 elemental screen areas may therefore be controlled by

$$4200 + 900 + 20 = 5120 \text{ projectors}$$

if the news disseminating system is made as herein illustrated.

Referring to Fig. 8, a typical projector 15 is shown swivelled on a support 17 which has a yoke 18 with bearings 19 in which two lugs 20 may rest for vertically adjusting the aim of the projector. The axis of the projector may therefore be oriented both horizontally and vertically in order that its projection of light beams may be properly aimed at the appropriate elemental areas on the screen 14.

The projector comprises a lamp 21, lenses 22 for diffusing the light uniformly over the area of the image film or mask 23 and a lens 24 for focussing the image on the screen 14. Suitable adjustability of these elements with respect to one another is obtained by mounting the lamp 21 on a holder 25 and the lens 24 in a holder 26. Both of these holders slide telescopically within the cylindrical housing 27. Binding screws 28 serve to maintain all adjustments, once they are made.

Fig. 2 illustrates further how the interwoven image patterns may be produced by the cooperation of different projectors. In each rectangle comprehending fifteen elemental areas the spot in the upper left hand corner is assigned to one message which will be termed the A₁-program. On the same scanning line four other picture programs A₂, A₃, A₄ and A₅ are arranged in succession. On the second scanning line are the five programs B₁ to B₅, inclusive and on the third scanning line programs C₁ to C₅, inclusive. It will now be seen that the thirty-five elemental areas reserved for the representation of each numerical character image in program A₁ are controlled by not more than ten selectively actuated projectors 15, while similar projectors are arranged to control corresponding elemental areas of the other fourteen programs. Thus, on the fragmentary screen area of Fig. 2 certain numerals are represented by distinguishing marks merely to denote, by way of example, the spots that would preferably be illuminated for showing—

Numeral	Program	Mark
4	A ₁	X
2	A ₂	O
1	C ₁	■

The angle of incidence of the light beams as projected upon the screen 14 should be held as closely as possible to 90°. Nevertheless, departures from that angle are necessitated by the fact that a plurality of projectors 15 is aimed to cover a mosaic inclusive of many interwoven character images. To compensate for possible distortion of the screen image, the image on the film or mask 23 within the projector may be purposely distorted. One method of doing this is to take photographs of perfectly formed char-

acter image subjects with a camera set in the same position relative to the subject as a given projector will occupy relative to the screen. The resulting film, or a stenciled mask patterned therefrom, may then be used in the correspondingly situated projector. The elemental areas of each of the interwoven character images should therefore occupy their proper positions on the mosaic in perfect registration.

THE INTELLIGENCE STORING DEVICE

The multiplicity of projectors is preferably controlled, according to my invention, by a system of rotary switches 30, as shown in Fig. 5. Each switch, if it is to select a numeral to be imaged on the screen, is provided with eleven contact segments 31, one segment being dead, and the remaining segments being connected respectively to different feeder wires 32 each leading to an appropriate lamp 21 in the projector system.

The switches may be arranged in groups, in the same manner that rotary drum dials are grouped to indicate the desired digits and fractions of stock quotations. The wiper element 33 of each switch may be set and reset as often as necessary to store the intelligence which is to be communicated by a cyclic review of the price fluctuations.

The wipers or selector-rotors 33 may be actuated from a keyboard 34 (Fig. 1) according to a "System for remote control of stock quotation boards" as shown in my U. S. Patent No. 2,264,563, granted Dec. 2, 1941, or other well known means may be employed. No specific actuating mechanism is herein shown because, for the purposes of this invention, it is merely necessary to indicate that any suitable means, such as a keyboard, a perforated tape transmitter, or the like, may be associated with the rotary switches 30 for causing them to distribute power along various circuits 32 at different times, thereby to control the lighting of the projector lamps 21.

According to the herein shown system for continuously cyclic survey of all the prices "posted" on the switches 30, it is preferable that each of the feeder wires 32 be connected in multiple to corresponding segments 31 of a plurality of switches. In order to prevent "feed-back" and uncontrolled dissipation of energy through the wipers of switches other than those selected from time to time to assume control, rectifiers 35 may be placed in series with each wiper 33. Such rectifiers may be of the dry copper-oxide plate type, and because of their low cost, their use is preferable to an alternative arrangement in which an individual make-and-break device would be necessary in the circuit for each wiper 33.

All of the wipers 33 to be simultaneously fed with current at any one moment may be permanently connected through a conductor 36 to one segment 37 of the timing control switch 40. Some of the conductors 36 may, however, be connected to a plurality of segments 38 or 39 in order that the frequency of feeding current to the storage switches may be greater than in the case of the conductors leading to segments 37. The object of this arrangement is to provide a review of quotations for the very active stocks at intervals, say, of thirty seconds; for the less active stocks once every minute; and for the generally least active stocks once every five minutes. In the circuit diagram of Fig. 5 such a program is indicated, where the control switch has a total of fifty segments (arranged in two semi-circular banks as is

usual) of which, the segments 37 lead to the storage switches for stocks that are to be quoted once every five minutes; while segments 38 lead to the storage switches for the "once-a-minute" quotations and segments 39 to switches for the "twice-a-minute" quotations. Only one timing control switch 40 is required for the entire system.

In order that the drawing might not be confusingly elaborated by the number of lines for showing the multiplicity of conductors and rotary switches 30, the general scheme has been illustrated by simply showing the connection to a few such switches. The two groups each comprising three vertical columns of switches 30 are typical of as many switch groups as there are stocks to be quoted. However, the system as herein contemplated is of such capacity as to cover 600 stocks, and the timing control switch makes fifty changes of scene within a five minute period, allowing six seconds for each display period. During the five minute period, quotations for certain stocks are to be communicated by ten showings on the screen, others by five showings, and still others only once. This is all provided for by the arrangement of the twenty conductors 36, to the fifty segments 37, 38 and 39.

Considering that there are three numerical designations per quotation, six lines of quotations (including the "Volume") and fifteen interwoven patterns of the character images and two stock groups to be displayed side by side on each "Program", it will be seen that the number of rotary switches to be simultaneously connected with a power source through the timing control switch 40 is

$$3 \times 6 \times 15 \times 2 = 540$$

and for the twenty conductors 36 which are successively selected by the operation of the switch 40, the number of switches 30 to be fed with power is 10,800.

Each of the twenty conductors 36 is also branched to an abbreviation projector, twenty of which are to be understood as comprehended within the rectangle 15A. It will be recalled that one interwoven image pattern for thirty stock abbreviations may be displayed on the screen 14 by a single projector 15, provided the selection of stock groups to be simultaneously quoted remains fixed.

Thus with each change of scene that produces a multiplexed image pattern according to the latest settings of the rotary switches in the price storage mechanism, an identification of the quotations is obtained by appropriately simultaneously projected images of the stock abbreviations.

The means for actuating the timing control, or program switch 40 includes preferably a clock 41 having a contact device for periodically closing a circuit from the power supply 42 to the motor-magnet 43. The two wipers 44 are mounted on one shaft, as indicated by the broken line joining their rotational axes. The shaft also carries a ratchet wheel 45 with which a pawl 46 engages. The pawl is actuated by the armature 47 of the magnet so as to drive the wipers step-by-step into contact with successive segments. The clock impulses may be of brief duration, say $\frac{1}{20}$ sec., more or less, and the wipers may be permitted to rest on each contact for about six seconds to permit of the persistence of a given image on the receiving screen for sufficient time to comprehend the same.

Due to the considerable wattage of the power for lighting as many as 540 projector lamps simultaneously, it may be desirable to employ re-

lays, either electromagnetic, mercury-pool, or electronic for feeding current to the conductors 36. If this is done, only a feeble current would be required to pass through the wipers 44. It is also desirable that the connection between the power supply 42 and the wipers 44 be broken during the brief interval of stepping from one segment to another. Such arrangements have not been shown in the drawings because they constitute obvious expedients well known in the art, and would only introduce unnecessary complications into the diagram.

The photo-electric camera 10 which senses the images formed on the screen 14 has its own photo-electric screen 48 on which corresponding images are formed. The electron beam scans these images in a line-for-line manner under control of horizontal and vertical deflecting circuits 49 which are fed with suitable saw-tooth waves from the generator 50. The scanning lines followed by the electron beam must "track" with the lines of elemental light and dark areas of the character images in order to avoid confusion of signals. This can be accomplished by suitably focussing and locating the optical image on the photo-sensitive surface 48. The generator 50 supplies the necessary synchronizing impulses with which the picture signals are coordinated in the usual manner.

Apparatus including an amplifier and transmitter 51 may be of any well known type. It is adapted to send out the synchronizing and picture signals over a single channel of communication under joint control of the photo-electric camera 10 and the scanning frequency generator 50. The signals may be impressed as modulations on a carrier wave, preferably of ultra-high frequency, and then radiated through space. Or, the signals may be transmitted by wire or cable.

Due to the fact that in this system a persistence of each image for a period of preferably six seconds is provided for, it may not be necessary to repeat the scanning operation as rapidly as would be the practice in transmitting moving pictures. Objectionable "flicker" effects can be avoided in the display of the received image if the "decay period" for such an image formed on a fluorescent screen is prolonged, according to known methods.

THE RECEIVER

At any one or more points of reception apparatus may be employed which reproduces any one of the multiplexed picture programs independently of the others. Also, a choice of the programs may be had at any receiving station which is changeable thereat under control of an observer during the periods of transmission.

Fig. 7 shows apparatus to be used at each receiving station. First there is a conventional radio receiver 60 for amplifying and detecting the signals. The output energy is distributed three ways—(1) as "frame"-frequency synchronizing impulses, (2) as scanning line frequency synchronizing impulses, and (3) as picture signals. Tuned filters 61 are provided for passing the synchronizing impulses under control of which saw-tooth waves are generated for vertically and horizontally deflecting the electron beam in a cathode ray tube.

A program selector switch 62 follows the filters 61. In the illustrative embodiment herein shown this switch is manually controlled and has fifteen positions to cover a choice of pro-

grams A₁ to A₅, B₁ to B₅ and C₁ to C₅ as heretofore described. The choice is made by introducing more or less delay into the generation of impulses by which all of the picture signals are suppressed except those which are to form the selected picture image. The generation of saw-tooth waves for the sweep-circuits is also conveniently delayed, though it may not be essential to do so.

The selector switch 62 comprises a brush carrier 63 which has two brushes 64 insulated one from the other. Contact segments 65 are fed with frame-frequency impulses at, say, 16 cycles per second. Segments 66 are likewise fed with impulses at a line scanning frequency of say 2,688 cycles per second.

No delay is introduced into either of the circuits established by setting the selector switch into the first position. The next four segments 66 (reading from left to right) lead respectively to different delay networks L₂ to L₅ for differentially delaying the generation of line-scanning waves. The first five positions are for horizontal shifts of the picture frame independently of the picture signals. The delay network utilized in each case is such as to render effective every fifth elemental area signal, starting either with the first, second, third, fourth, or fifth signal from the beginning of each scanning line.

The other delay networks F₂ and F₃ may be used for delaying the frame frequency scanning operation by as much as one or two line-scanning time-intervals respectively. It is to be understood that these delay networks function not only to shift the scanning lines and the vertical framing of the picture with respect to the picture signals, but also (as will hereinafter be shown) to vary the relation between the impulses transmitted through the filters 61 and the picture-signal impulses, so as to suppress all of the latter with the exception of those that are to be utilized in the formation of elemental light and dark areas of the selected picture.

In the first five positions of the selector switch 62 no delay is introduced into the synchronizing impulses which may be fed through the conductor 67 to the frame-frequency saw-tooth wave generator 68. The next five positions of the selector switch are such as to feed the frame-frequency synchronizing impulses through the delay network F₂ and thence to the generator 68, thus obtaining a delay in the vertical scanning operation of $\frac{1}{2688}$ sec. In the remaining five positions of the selector switch 62, the delay network F₃ is brought into play, thus doubling the delay period and making it $\frac{1}{1344}$ sec.

The segments 66 of the selector switch are so connected with the delay networks L₂ to L₅ inclusive and to a conductor 70 which shuts out these delay networks that the line scanning operation may be started either with no delay or with different delays amounting to one or more periods of an elemental area signal. In the illustration given, such a signal period may be of the order of $\frac{1}{403200}$ sec. If, therefore, the delay action of the networks L₂ to L₅, inclusive, corresponds respectively with the time values for from one to four elemental area signals, these values will be as follows:

$$\begin{array}{ll} L_2 = \frac{1}{403200} \text{ sec.} & L_3 = \frac{1}{201600} \text{ sec.} \\ L_4 = \frac{1}{134400} \text{ sec.} & L_5 = \frac{1}{100800} \text{ sec.} \end{array}$$

A cathode ray tube 75 is provided having the usual electrodes for controlling the emission of electrons in a beam against a fluorescent screen

76. This tube is preferably provided with vertical deflecting coils 77 and electrostatic plates 78 for horizontal deflection. In place of the coils 77, electrostatic plates may be used if desired. The deflecting coils 77 are variably energized through a circuit 79 which is fed with power from a source 80 through the choke 97, across which variations in potential are developed when the electron tube 81 becomes more or less conductive. The return circuit from the coils 77 leads to ground (the negative side of the source 80 being grounded) through a portion of the potentiometer 73 and, for surges, through the capacitor 71.

The input circuit of the tube 81 includes a control grid 82, a grid bias resistor 83, biasing battery 84, and the cathode 85. The tube 81 is controlled by the saw-tooth wave generator 68, which may be of any well known type. Fig. 6 shows an outline of a wave 86 which may be so generated and impressed across the capacitor 87 for controlling the tube 81.

In order that suitable separation between certain of the scanning lines may be obtained for producing a background effect between the character lines, I preferably cause the vertical scanning operation to be produced in successive steps as shown in the curve 88_v of Fig. 6. This is accomplished by superposition upon the frame-frequency wave 86 of another wave 89 of saw-tooth shape but inverted. There is considerable choice of well known means for obtaining such superposition, or mixing of two waves. I have shown, by way of example, how the saw-tooth wave 89 may be impressed upon the screen grid 90 of the tube 81. The circuit for this purpose may be traced starting from a frequency multiplier 91 which produces the eighth harmonic of the frame-scanning frequency, in order that there may be eight groups, or bands of scanning lines, the lines of each band being crowded together so as to create background bands constituting horizontal character-line spaces on the screen area. The frequency multiplier 91 feeds energy to a saw-tooth wave generator 92 which provides impulses at the rate of 128 cycles per second.

Although I have shown only seven character lines on the screen 76 of the cathode ray tube 75, it will be understood that a certain time allowance must be made for the return stroke of the vertical deflection. I have conveniently figured this return stroke as taking place during the transmission of 21 blank scanning lines, equivalent to a band of scanning lines for one character-line, or character height. It is for this reason that I preferably use the eighth harmonic of the frame scanning frequency to control the generation of saw-tooth waves as shown by the wave pattern 89 in Fig. 6. I have not shown eight such waves as occupying the time interval of one frame-scanning cycle, although, for this purpose, the showing might have been more accurate; but these curves 86, 88_v, 88_h and 89 are referred to in connection with the description to follow relative to the horizontal scanning operation. However, the superposition of two such waves 86 and 89 to form a composite wave 88_v may readily be understood from the appearance of the wave patterns given in Fig. 6, where t_1 represents the time constant of the vertical scanning cycle, or (from another aspect) of the line-scanning cycle, while t_2 represents the time constant of the saw-tooth wave to be superposed upon one of these frequencies in either case.

The wave produced by the generator 82 may be impressed across a capacitor 93 and thence to the control grid of an electron tube 94. The anode circuit of the tube 94 may be fed with energy from an intermediate point 95 on the source 80 and through an inductive impedance 96. The anode 98 has a connection to the screen grid 90 of the tube 81.

The operation of the vertical deflecting circuit may now be described as follows:

Assuming that the gradual slope of the curve 86 is represented by a positive impulse impressed across the capacitor 87, it will be seen that the tube 81 becomes more and more conductive until suddenly this wave is interrupted completely and the tube is biased to cut-off. At that moment the anode potential will be suddenly built up to full positive value, due to the saturation of the inductance 97 and to the fact that the tube 81 affords a substantially infinite impedance to the further flow of current. The effect is to produce a strong and sudden reversal of current flow in the deflecting coils 77 for producing the return stroke in the vertical deflection of the electron beam in the cathode ray tube 75.

While the current is gradually being increased in value in the tube 81, that increase may be made at two different rates, one while certain of the line scanning operations are being effectively performed and another for causing separation between the bands of scanning lines. This is accomplished through the use of the saw-tooth wave generator 92 which may be assumed to feed current positively across the capacitor 93 and with gradually increasing intensity so that the tube 94 becomes gradually more conductive and the potential on the anode 98 gradually falls. This likewise gradually lowers the potential on the screen grid 90 and slows up without nullifying the increase of conductivity of the tube 81. When, however, the tube 94 is suddenly biased to cut-off by the steep return stroke of the wave 89, then the anode 98 and the screen grid 90 become suddenly more positive and the shape of the wave 88_v is caused to be formed into steps. This provides the desired band separation between successive groups of 21 scanning lines.

Referring now to the horizontal, or line-scanning operation, the frequency for synchronizing the waves generated by the saw-tooth generator 69 is obtained directly from the line scanning frequency signals over the conductor 70 or through any one of the delay networks L₂ to L₅ inclusive. This frequency is assumed to be of the order of 2,688 cycles per second. Here again, the output energy from the generator 69 may be assumed to be increasingly positive as the saw-tooth wave 86 slopes gradually upward. This impulse increases the conductivity of the discharge tube 100 in the same manner as was described above in respect to the operation of the tube 81. The tube 100 also has a screen grid 101, which is connected to the anode of an electron tube 102. The tube 100 may be caused to operate above and below the cut-off of its characteristic in the same manner as hereinabove described in respect to the tube 81. The anode of tube 100 is, however, preferably fed with current from the source 80 through an inductive impedance 103. The step formation of the wave generated by superposing the two waves which are the respective outputs of the saw-tooth wave generator 69 and of the saw-tooth wave generator 99 may be as shown in the

wave pattern 88_h of Fig. 6. This wave may then be impressed across two capacitors 104 and thence to one of the horizontal deflecting plates 78 of the cathode ray tube 75. The other of the deflecting plates 78 is connected to the lower end of a resistor 105 and to a capacitor 106 which may be energized contraphasally to the capacitors 104 by virtue of the delay action introduced through the inductive impedance 107. The circuit arrangement of the elements 104, 105, 106 and 107 is not new and no claim is herein made to this circuit arrangement as such. One of the features of the circuit however resides in the provision of a central tap on the resistor 105 from which a connection may be made to the most highly positive anode 108 in the cathode ray tube 75. This last mentioned connection serves to maintain suitable balance in the horizontal deflection forces so that pictures may be properly framed on the fluorescent screen 76.

The frequency of the saw-tooth wave generator 99 is preferably six times that of the generator 69 in order that six characters and six character separations may be obtained and suitable background areas formed between the characters along a character-line. Hence I provide a frequency multiplier 110 to produce the sixth harmonic of the line-scanning frequency. This multiplier receives its energy from the line scanning frequency impulses at the rate of 2,688 cycles per second. The output energy from the frequency multiplier is in the form of sharply peaked impulses at the rate of 16,128 per second. In this case, therefore, the output waves from the saw-tooth wave generator 99 have a time constant

$$t_2 = 1/16128 \text{ sec.}$$

as against the line scanning time

$$t_1 = 1/2688 \text{ sec.}$$

The cooperation of the tubes 100 and 102 for producing a wave of the pattern shown at 88_h in Fig. 6 is the same as was previously described in respect to such a wave 88_v for the vertical scanning operation. The two waves 88_v and 88_h differ only in their frequencies and in the matter of how many steps occur within one cycle of each fundamental frequency, whether of the frame scanning or the line scanning circuits.

The picture signals from the receiver 60 may be directed through a conductor 115 to a compensating delay network 116 and thence to a control grid 117 of an electron tube 118. The control grid 117 is preferably one of a pair of coplanar grids, the other grid 125 being also employed as a control grid. The purpose of the compensating delay network 116 is to adjust the phase of the picture signal impulses with respect to the phase of the signal-selective impulses as derived from the synchronizing signals passed through the filters 61. It may well be seen that, due to the complexity of the filter circuits and the delay networks, it may not be possible to obtain this phase agreement but for a compensating delay network. The constants of such a network, however, may be maintained fixed, once they are suitably established. The output circuit of the electron tube 118 includes an anode source 119 and a resistor 120 on which it is preferable to provide a tap 121 leading to a capacitor 122. The control grid 117 may be suitably biased by means of a grid resistor 123 and a biasing battery 124. A second control grid 125 is similarly biased by means of a grid resistor 112 and the biasing battery 124. The two grids 117 and 125 may be

normally biased so far below cut-off that the tube will become conductive only when positive impulses are simultaneously impressed upon both grids.

If, then, a signal representing an elemental light area is impressed as a positive impulse on grid 117 and simultaneously a sufficiently positive impulse is impressed upon the grid 125, then the tube 118 will operate to pass the selected picture signal along to the cathode 130 of the tube 75. In this case the light area signals produce an anode current flow in the tube 118. The potential on the anode 111 will be lowered, thereby causing a negative surge across the capacitor 122 which lowers the potential of the cathode 130 in the cathode ray tube 75. The control electrode 131 of this tube may be grounded and through the use of a tap 132 on the potentiometer 133 leading to one end of a biasing resistor 134 a suitable negative bias may normally be maintained on the control electrode 131. When, however, a negative picture signalling impulse lowers the potential on the cathode 130, then the control electrode bias is reduced and a volley of electrons is emitted from the cathode and toward the fluorescent screen 76 at some point determined by the time components of the horizontal and vertical deflecting circuits. The use of the so-called electron gun in the cathode ray tube 75 is well known and needs no detailed explanation here except by way of mentioning that its control is rendered suitably effective by the aid of focussing and accelerating electrodes 135 and 136 respectively and by the anode 108. All of these electrodes receive their polarization charges from a high voltage supply 137. The potentiometer 133 may be placed across the terminals of the voltage supply 137 and taps off the potentiometer may be adjusted to supply suitable potentials to each electrode.

According to a modification which will be apparent to those skilled in the art, the tube 118 may be made normally conductive in the absence of light-area signals and when such signals are to be suppressed. In this case the capacitor 122 would be connected to the control grid 130 and the electron gun would be caused to discharge under control of positive impulses as occasioned when the grids 117 and 125 are simultaneously more negatively biased.

It was mentioned above that the operation of the tube 118 for transmitting picture signals to the cathode 130 of the cathode ray tube may be made contingent upon the impress of a positive charge upon a second grid 125. It will now be shown how this positive charge may be obtained for the purpose of rendering effective only those picture signals which are desired to form a given selected picture.

A frequency multiplier 140 is fed with impulses from the output side of the frequency multiplier 91. A seventh harmonic of the eighth harmonic of the frame frequency is thus obtained, this, as illustrated, being 896 cycles per second. These impulses may be fed to the control grid 142 of an electron tube 141. This tube is normally biased to permit current flow therein but when a sharply peaked negative impulse is delivered to its control grid 142, the tube is biased to cut-off and its anode potential is raised to a point where a strong positive pulse will be delivered across the capacitor 143 and thence to the control grid 125 of the electron tube 118, provided such impulse is not dissipated through a shunt circuit which includes the capacitor 144

and the space current path through a companion tube 150.

This electron tube 150 may be controlled in a similar manner through frequency multipliers 110 and 151. The frequency multiplier 151 delivers sharply peaked impulses which are the fifth harmonic of the impulses delivered by the frequency multiplier 110. These impulses, in turn, have been shown to be the sixth harmonic of the line scanning frequency. Hence the frequency delivered by the frequency multiplier 151 is of the order of 80,640 cycles per second, or one impulse for every five elemental area picture signal impulses.

If, now, it be considered that the electron tube 150 becomes biased to cut-off once for every fifth picture signal it, too, will deliver a strong positive impulse to the control grid 125. The potential derived from a battery 155 and impressed across the resistors 145 and 146 respectively may be such as to permit of the dissipation of energy in the resistor-capacitor loop including the capacitors 143 and 144 without carrying an effectively positive impulse to the grid 125, if some of this energy leaks off through either one of the tubes 141 and 150 while it is conductive. If, however, both of these tubes become biased to cut-off simultaneously then both capacitors 143 and 144 would simultaneously receive charges such as to raise the potential of the grid 125 high enough to render the tube 118 conductive and thereby to pass the picture signals. Thus, the tube 150 tends to let pass one signal out of every five for the duration of one scanning line, while the anode is lowered in potential to avoid charging of the condenser 143 during the period of two scanning lines. It is, therefore, only the one signal out of every five along a scanning line, and only such signals as occur along one scanning line out of three that become effective. Thus all signals along two subsequent scanning lines are blocked out, since they do not represent any portion of the selected picture.

The frequency multipliers 140 and 151 may be of any suitable well known type. Coupled thereto, but not shown, are suitable wave-shaping devices for determining the time intervals to be taken up by the positive peaks in relation to the time components of the negative peaks, for properly controlling the tubes 141 and 150 respectively. Where inequality between the positive and negative peaks is required, this can be accomplished in a well known manner through the use of an asymmetric multivibrator. Furthermore, if desired, the wave peaks may be shaped in accordance with the requirements for limiting the effective time components thereof as shown by the curves 160 and 161 in Fig. 6.

The curve 160 represents a wave form suitable for controlling the tube 141. In this case the positive impulse has a time value of

$$\frac{t_3}{3} = \frac{1}{2,688} \text{ second}$$

whereas the negative peak of this wave has a time value of

$$\frac{2t_3}{3} = \frac{1}{1,344} \text{ second}$$

where

$$896t_3 = \text{one second}$$

The wave form as shown by the curve 161, Fig. 6, is preferably such that its positive and nega-

tive peaks have a time ratio 1:4. Since the full wave time value is of the order of

$$t_4 = 1/80,640 \text{ second}$$

it will be seen that the positive peaks

$$\frac{t_4}{5}$$

endure for a period of $1/408,200$ sec. and the negative peaks persist for a period of $1/100,800$ sec.

In the foregoing description all of the circuits shown in Fig. 7 have been traced. It remains now to show by means of further wave diagrams what is accomplished by the joint operation of these circuits. Fig. 6 is again referred to. Wave form 162 represents the combined output from the two discharge tubes 141 and 150, as impressed across the capacitors 143 and 144. The broken line *g* represents the cut-off point of the negative bias applied to the grid 125 from the battery 124 through the resistor 112. The peaks *p* which lie above the level of the line *g* are obtained only when the waves 160 and 161 are positively peaked at the same time. The wave portions *k*, *m* and *n* all lie below the level of the line *g* and are, therefore, effective in suppressing the effects of the picture signals which have not been selected according to a given setting of the selector switch 62.

The picture signals are typically represented by the curve 163. If the duration of a positive peak is for some multiple of an elemental area signal, the correct inference is that there are contiguous elemental light areas belonging to two interwoven but unrelated picture patterns. The positive picture signals are of sufficient intensity to overcome the steady negative bias on the grid 117, as indicated by the level of the cut-off line *h*, but the cut-off point of the tube characteristic is such that it becomes conductive only when the grids 117 and 125 are simultaneously raised to a potential above their respective cut-off points. The wave form 164, therefore, represents the composite effect of varying the potentials on the two grids. The cut-off point of the tube characteristic is represented by the broken line *j*. Fluctuations of the composite grid bias, such as the peaks *u*, which are below the cut-off point, are ineffective, but when peaks of grid bias occur as shown at *s*, then anode current flows in the tube.

The effectiveness of the delay networks L_2 to L_5 inclusive is apparent for selecting any one of five elemental area signals successively transmitted. Also, when one such signal is chosen, every fifth successive signal on the same scanning line is rendered effective. All picture signals occurring during the scanning of the two succeeding lines are blocked out by the condition of conductivity of the tube 141. When, however it is desired to select a "program" occurring on either of these heretofore rejected scanning lines, the selector switch 62 may be shifted into any one of its last ten positions, five of which bring into play the delay network F_2 and the other five of which render the delay network F_3 effective. This provides a choice of picture signals starting with the second or third scanning line from the beginning of a frame scanning cycle.

In the embodiment shown, it is possible to obtain any desired selection of programs from among the fifteen multiplexed signal trains, where each train of signals is understood to be related to an independent picture program. The word "program," it will be recalled, is considered apt in view of the intention to change the "scene"

after every lapse of a six-second time interval, or other time interval sufficient to read the message conveyed by one scene.

Fig. 3 shows, by way of example, how the characters of a selected scene may be formed on the fluorescent screen 76. Apparently the elemental light areas are, in many instances contiguous, although it will be appreciated that the selected signals for controlling the actuation of the electron gun are discrete. This very desirable effect is obtained by de-focussing the electron beam in the cathode ray tube 75 so that its coverage will be equal to the coverage of fifteen elemental areas if there were to be no suppression of signals in respect to the non-selected programs. The structure of the electrodes in the cathode ray tube and the choice of potentials to be applied to these electrodes may be such that the desired degree of de-focussing may be obtained, all as is well known in the art.

It is possible to practice my invention without employing the very high modulation or keying frequencies shown, by way of example. Thus, if it is desired to slow up the cyclic operation of the deflecting circuits, both at the transmitter and at the receiver, this may be done without loss of detail in the image pattern. The persistence of the image without noticeable flicker is the prime desideratum. Flicker effects can be overcome to a large extent by careful choice of the fluorescent material with which the screen 76 is coated. Some of these materials when electronically excited have a much longer "decay period" than others. If, therefore, the same image is to be flashed on the screen nearly a hundred times without change, rapid fading of the illuminated areas is not to be desired, but, on the contrary, a slowness of "decay" such as will retain the brilliancy of the image between successive frame-scanning operations.

It is known that different fluorescent substances may be used on the screen 76 for varying the color effects produced by electronic impact. Accordingly, it may be desired, in the case of quoting fractional price variation, that the character representing a fraction be shown in a color different from the color of the other characters. If this is done, it then becomes unnecessary to underline the fractional numerators as shown at 182. Instead, it may be preferable to display numerator digits for the "eighths" fully as high as the units- and tens-figures, but distinguished only by their color.

The screen 76 may, if it is to be used solely for quoting prices, be permanently marked as shown at 180, as a guide to the interpretation of each line of quotations. A space between two ruled horizontal lines 181 on the screen surface may be permanently reserved for stock abbreviations. If two or more stocks are to be quoted simultaneously, as herein shown, in different columnar groups, then vertical lines may be ruled on the screen for stock group separation. All such aids to an intelligent presentation of the bare picture impressions will, of course, contribute to the effectiveness of the display without imposing further demands upon the signaling equipment.

Fig. 4 illustrates an arrangement for feeding picture signals from one receiver simultaneously to a plurality of cathode ray tubes, each of which may present a program different from the others. In this case it may be desirable to provide independent selector switches and delay networks in connection with each cathode ray tube. Thus, I have shown (in front view) five such tubes and

have designated them B₁, A₂, B₃, A₄ and C₅, corresponding to the programs thereto allotted. The line synchronizing signals are to be understood as fed through different delay networks, *d*, 2*d*, 3*d* and 4*d* for the cathode ray tubes other than B₁, whereas, the latter has no such delay network because the choice of programs assignable thereto may not need to be varied horizontally of the multiplexed picture pattern, but only vertically. Each of the circuits for controlling the vertical synchronizing is, however, fed through a device 170 which includes a three-point switch and two delay networks, such as F₂ and F₃. In the first position of each switch the networks are shunted out. The middle position connects network F₂ and the third position connects network F₃. It will thus be seen that any one of three programs is available to each cathode ray tube, while the selection made for each tube is always different from that of the others.

It will be apparent from the foregoing that news can be disseminated from one transmitting station to as many receivers as are situated within range of the signals, but that means are associated with each receiver for making a desired choice of programs from among those multiplexed at the transmitter.

THE FACSIMILE SYSTEM

According to the objects of my invention as set forth in my parent application, Serial No. 17,454, now Patent No. 2,207,716, its use is by no means restricted to a television system, but the fundamentals of interweaving the elemental areas of a plurality of pictures and of multiplexing the image signals may be exemplified in a facsimile system as well as in a television system. This fact is borne out, too, by certain of the original claims of record in the parent application as filed; more specifically, claims 1, 2, 5, 6, 9 to 12 inclusive, and 14 to 17 inclusive. Such claims read with equal facility on a facsimile system and on a television system.

It is appropriate, therefore, that I should now describe a typical embodiment of the invention as applied to a facsimile system. Reference will be made to Figs. 9 to 15 inclusive.

Fig. 9 shows a group of typewriters 201, 202 and 203 arranged in alignment so that a single tape may be successively drawn through their operating positions and printed with character images suitable for the transmission of multiplexed facsimile signals.

The tape 204 as it issues from typewriter 201 is shown with a single character F imprinted thereon. The character image is composed of small detached squares in suitable alignment to outline the desired character. These squares are arranged in a definite relationship to the position of certain sprocket wheel perforations 205. It will be understood that the alignment can be maintained by the use of a tape-feed sprocket wheel in each typewriter, the sprocket wheel being driven by the keyboard mechanism as the typewriting proceeds.

Any desired message may be typed on the tape by typewriter 201, and the tape may then be fed to an operating position in typewriter 202. A variation in the relationship between the elemental area positions controlled by typewriter 202 and the sprocket wheel perforations 205 causes different elemental area blanks to be made available for the imprinting of message characters by typewriter 202. The displacement in this case is longitudinally of the tape. As shown in

the drawing, the impression of the letter F, as made by typewriter 201, is displaced from an impression of the character M as imprinted by typewriter 202. The elemental areas appropriate to the two letters are, therefore, mutually exclusive.

After imprinting any desired series of message characters by means of typewriter 202, the tape issuing therefrom may be fed to subsequent typewriters, one of which is shown at 203. Typewriter 203, for illustration, is arranged to control elemental areas in a character space by displacement laterally of the tape with respect to the imprinting positions as controlled by the typewriters through which the tape was previously fed. For the sake of illustration it is shown how the spaces intervening between horizontal lines of the character images imprinted by typewriters 201 and 202 may be occupied by the imprint of a character image S by means of typewriter 203. The longitudinal alignment of the elemental areas composing the letter S is the same as that for the letter F as imprinted by typewriter 201, but the lateral displacement is such that the elemental areas controlled by typewriters 201 and 203 are mutually exclusive.

In the arrangement shown it will be understood that still a fourth typewriter might be employed, since there are elemental areas sufficient for impressing the character images in a fourth position having a lateral displacement with respect to the elemental areas composed by typewriter 202 but having the same longitudinal displacement along the tape. When four typewriters are thus used it is possible to interweave four character images.

After the tape has been prepared, it may be fed through a suitable instrument (not shown) for optical scanning of the image characters, whereby signals may be composed representing the light and dark areas along successive scanning lines of the tape. As is well known in the art, photoelectric sensing means may be employed for this scanning.

A schematic showing of a basic facsimile transmitter which provides for transverse scanning of a narrow tape is given in a paper (Fig. 2, on page 271) on "Tape Facsimile Synchronizing Systems" by Henry Shore and James N. Whitaker, published by R. C. A. Institutes Technical Press, vol. 1, October 1938, the entire volume being entitled "Radio facsimile."

In the instant case it is provided that the scanning lines shall be produced from bottom to top of each character image and five such lines are necessary to indicate the five vertical rows of elemental areas. Successive scanning lines are spread over the elemental areas of the interwoven character images by constant longitudinal feeding of the tape across the transmitting position of the optical scanner.

With the multiplexing system as shown in the drawing there are 35 elemental areas available for each character image, so that with four interwoven character images it is necessary to allot a signalling time unit to each elemental area in the four characters, thus making a total of 140 elemental signalling time units necessary for the transmission of four interwoven character images.

Referring to Fig. 10, an enlarged view of the scanning area necessary for the four interwoven images is graphically delineated. Considering each group of four elemental areas in a square, it will be noted that there are 35 square groups

of such elemental areas. Considering the upper left hand elemental area in each group, it will be noted that this is appropriate to the letter F as formed by solid black unitary squares. In the upper right hand corner of each group certain squares have been shown cross-hatched to indicate the formation of the letter M. Considering now the lower left hand unitary square in each group, those which are necessary to outline the letter S have been indicated by stippling. The fourth position in such group, namely, the lower right hand elemental area square, has been left blank but it will be understood that it could well be occupied by the imprint of the necessary elements for composing a fourth character image.

The principles of selective reception of the signals, as explained in detail in the foregoing description of the television system embodiment, apply with equal aptness to the facsimile system now under consideration.

The circuit arrangement of Fig. 7 may readily be modified by those skilled in the art so that it will apply to the requirements of a facsimile receiving system. Here the cathode ray tube is dispensed with and the signals are applied to the control of a printing bar 206 by a magnet 209, as shown in Fig. 14. In a facsimile system the time constants are long compared with those of the delay networks indicated in Fig. 7.

Reference is made to Fig. 16 for illustratively showing a modification of the circuit arrangement of Fig. 7, such as would be suitable for use in a facsimile receiving system. In this diagram elements which perform the same functions as those shown in Fig. 7 are given like reference numbers.

Let it be assumed that my facsimile system is to include one multiplex transmitting scanner and four tape recorders, and is to be operated at a speed such as to print five characters per second on each of the four tapes. The signal time is then subdivided so that each elemental area dot is printed in $\frac{1}{400}$ second. Along each of the five vertical scanning lines per character there are seven elemental areas, interspersed, however, with seven elemental areas appropriate to another message. Alternate scanning lines are appropriate to different pairs of messages.

In order to select the image signals appropriate to a desired message a manual switch 62, as shown in Fig. 16 will be required to be set in any one of four positions, hereinafter referred to as positions A, B, C and D. These positions will determine the phase relation between the signals and the peaks of locally generated oscillations produced by generators 69a and 68a, respectively, so that only alternate signals along each scanning line will be effective, and only alternate scanning lines will be effective to reproduce the character images of a selected message. Hence, I provide a delay network L₂ having a time constant of $\frac{1}{400}$ second for dot displacement along the scanning line, and another delay network F₂ having a time constant of $\frac{1}{40}$ second for line displacement.

The generator 68a may be used for course adjustment of the phase of the scanning drum 207, while the generator 69a is used for fine adjustment thereof. If desired, a frequency multiplier under control of generator 68a may be used in place of the generator 69a, since it is only necessary to deliver the 14th harmonic of the wave produced by generator 68a.

Any suitable phase correcting and synchroniz-

ing device may be employed in association with the generators 68a and 69a for maintaining the proper speed and phase of the scanning drum 207. So far as this function of the generators is concerned, one of them would be sufficient without the other, assuming that it controls an alternating power supply for driving a synchronous motor, the latter serving to rotate the scanning drum 207 and its associated sprocket wheel 215.

As an example of phase and synchronism control devices, reference is made to U. S. Patent No. 1,747,248, granted February 18, 1930, to W. A. Knoop. Another patent which explains a synchronism corrector technique suitable for use in connection with my facsimile system is 2,258,152, granted October 7, 1941, to E. R. Shenk.

Applying the principles of either the Knoop or Shenk patents, and referring to my Fig. 16, it will be clear to those skilled in the art that the incoming signals received on the unit 60 may be impressed upon the phase correction circuit 164 through conductor 165. These signals are comparable with locally generated oscillations from a 350-cycle square wave generator 68a which are impressed through conductor 166 upon the phase correction unit 164. The phase correction unit 164 supplies correcting potentials which have an "accelerating" effect if they are delivered through output conductor 167; they also have a "retarding" effect if they are delivered on output conductor 168. Through capacitors 169 and 170 voltages are applied to a resonant circuit within the synchronized oscillator unit 61a for causing this oscillator to be maintained in step with the incoming signals.

The synchronized oscillator 61a is indicated as generating a 25-cycle output to be impressed upon the middle ring of the manual switch 62. From this switch, the oscillations are taken off through differently selected segments A, B, C, D and 65 and applied either to one or both of the delay networks L₂, F₂; or the oscillations are applied more directly to the frequency doubler unit 110a and the 25-cycle square wave generator 68a.

A 50-cycle output from the frequency doubler unit 110a is fed into a frequency multiplier 151a from which a seventh harmonic output may be obtained. This seventh harmonic has a frequency of 350 cycles and is used to control the frequency of the square wave generator 68a. The output from the 25-cycle square wave generator 68a is used to control a tube 141 as will be presently explained.

The accelerating and retarding effects produced by the phase correction circuit in accordance with the comparison of the phase of the generator 68a with the incoming signals is also used to actuate relay 163, the armature 162 of which may be moved to one side or the other for reversibly operating a phase shifting motor 161. The shaft of motor 161 is geared to the housing of a motor 160, the latter being used to provide constant rotation of the scanning drum 207. Hence the phase of the scanning drum 207 may be varied in reference to the signals so that the proper printing bosses 208 will be opposed to the print bar 206 when the latter responds to the signals of a selected channel.

In this connection the modification of Fig. 16 includes means to suppress the effects of unwanted signals, so that the printing magnet 209 will respond only to the signals of a selected channel. That is to say, the grid 142 of tube 141 is coupled to the output of generator 68a, and the grid of tube 150 is coupled to the output of

generator 69a. With this arrangement tube 141 acting upon the grid 125 of tube 118 biases the latter to cut-off during every alternate scanning line. Also the tube 150 acting upon the grid 125 of tube 118 biases the latter to cut-off during every alternate elemental area impulse of the multiplexed signals.

Assume now that the elemental areas of the four interwoven images stand in the relation:

B	D
A	C

Then for acceptance of signal A, tube 118 must be unblocked, and on reception of signals B, C and D, the tube 118 must be biased to cut-off so as to render it unresponsive to the unwanted signals. This condition is obtained by setting the switch 63 to position A so that neither of the delay networks will be effective.

If the switch 63 is set to position B, then generator 68 will maintain the same phase as under the first condition, but generator 69a will be delayed by $\frac{1}{100}$ second. This will cause the tube 118 to be unblocked for reception of signals appropriate to the B image.

When the switch 63 is set to position C, generator 68a will be retarded by $\frac{1}{50}$ second, while generator 69a will not be retarded. This will cause a phase shift of one complete scanning line, both in the operation of the scanning drum 207 and in the suppression of signals by means of tube 118. The phase shift in the scanning drum is equal to 60° . The retardation effect upon tube 141 is also sufficient to select the signals appropriate to either of the images C or D, but the C-signals will be selected because there is now no delay in the phasing of generator 69a.

In order to select the signals appropriate to the D-image, switch 63 will be set to the D-position, whereat both delay networks F_2 and L_2 will be effective. This will bring the phase of the scanning drum into proper relationship to the times of acceptance of the signals by tube 118 so as to reproduce the D-image.

Thus it will be seen from the above that the printing magnet 209 is subject to joint control by the more or less delayed local oscillations and by the incoming signals. Using or not using the delay networks in their four permutational associations provides for blocking out the unwanted signals of all but one of the messages.

The scanning cylinder 207 has three groups of spirally arranged bosses 208 disposed about its periphery. Each spiral array extends over an arc of 60° . There are three 60° arcs on the periphery which intervene between the leading and trailing portions of the different spirals. These intervening blank spaces are necessary for skipping alternate vertical scanning lines which extend laterally of the tape.

The motor 160 drives the scanning drum 207 at a constant speed such that it will make one and two-thirds revolutions per character imprint. As each group of bosses in spiral arrangement passes under and in opposition to the position of imprint, as provided by a print bar 206, one vertical scanning line is covered. Since there are five vertical scanning lines necessary to comprehend a single character image, the necessity for rotating the drum 207 one and two-thirds times will be apparent.

Due to the fact that the bosses 208 are relatively four times as great as the elemental areas of the character images formed on the transmitting tape, the character images as reproduced

at the receiver will be fully blocked in and the elemental areas thereof will be adjacent one another as shown in Fig. 13. It follows, therefore, that no detail of the selected image is lost by the skip-selection of the wanted signals.

Referring to Fig. 14, I show a printing magnet 209 having an armature 210 which is pivoted at 211 and normally held by a spring 212 with its print-bar 206 backed up against a stop screw 213.

Fig. 14 is a back elevation view of the recording structure. The tape 214 is, therefore, indicated as traveling from left to right, whereas if the apparatus were viewed from the front, then naturally the imprinting would be such as to deliver the tape out from the left side of the recording apparatus, so that the recording may be immediately read as produced.

The magnet 209 responds to the selected marking signals appropriate to the elemental areas of each desired character image. While one recording unit is made operable to receive one message, other recording units may be made responsive to other trains of signals so that the entire content of the multiplex signal transmission may be made available either at a single station or at geographically separated stations.

A typewriter ribbon (not shown) may intervene between the recording tape and the print bar 206, or the tape itself may be prepared in any suitable way so that discoloration will take place wherever it is struck by the print-bar 206. Many devices of this character are known in the art, one of which includes an electro-chemical process wherein an electric current is caused to pass through the paper during the reception of marking signals. With such a system the print-bar is converted into a stationary electrode, the chemically treated tape constitutes an electric conductor and the spiral platen becomes a complementary electrode. The printing magnet 209 is then dispensed with. U. S. Patent No. 2,143,875 to C. W. Hansell shows an example of a facsimile system which utilizes the electro-chemical recording principle.

Fig. 15 is a plan view of a portion of the apparatus shown in Fig. 14. Considering both of these figures it will be noted that a sprocket wheel 215 is provided having teeth arranged to mesh with perforations on the recording tape. The sprocket wheel 215 is loosely mounted on a drive shaft 216. Integral with the sprocket wheel 215 is a wheel 217 which, as indicated, has preferably twelve saw-teeth. The toothed wheel 217 meshes with another wheel 218 of smaller diameter but having the same number of saw-teeth, preferably twelve. The wheel 218 is mounted on a shaft 219 which carries a gear 220 fixedly mounted thereon. Gear 220 meshes with another gear 221 in a 1 to 1 ratio, the gear 221 being fixedly mounted on the drive shaft 216.

The shaft 216 carries a collar 222 on which is mounted a spiral spring 223. This spring is held at its outer end by a pin 224 driven into the side of the toothed wheel 217. The operation of the structure shown in Figs. 14 and 15 is as follows:

The rotation of the shaft 216 is either speeded up or retarded until synchronism with the incoming signals is obtained, according to well known methods. Assuming that proper phasing of the recorder has been obtained, the tape 214 will be fed by the sprocket wheel 215 in such manner that after each character image has been formed the engaging teeth of wheels 217 and 218 will rotate out of their coincident paths. Since the teeth of wheel 218 are of shorter pitch than the

teeth of wheel 217, a gap will be suddenly closed up by two oncoming teeth of the two wheels which are next to engage with one another. The sprocket wheel 215 will, therefore, jump in response to the action of the spring 223 and will thereafter rotate at a constant speed while the next character is being imprinted in response to the scanning of five vertical lines.

During one revolution of the sprocket wheel 215 twelve characters will be printed. The spaces between the characters have, therefore, been automatically introduced at the receiver despite the fact that there is no interruption of signal transmission from the last elemental area of one character that is scanned to the first elemental area of a subsequently scanned character.

It is within the scope of my invention to employ broad-tape scanning methods in a facsimile system, and to reproduce on a receiving tape any selected one of a plurality of interwoven images as scanned at a transmitting station. Reference to U. S. Patent No. 1,848,862, granted March 8, 1932, to C. J. Young (reissued October 27, 1936, as Re. 20,152) will suggest to those skilled in the art that my method of skip-selection of the transmitted signals and of entire scanning lines may be readily applied to a broad-tape facsimile system. Suitable proportioning of the spiral member on the scanning drum in the recorder produces relatively coarse elemental areas of each individual picture, but this is no drawback when the subject matter consists of character images. These proportionately larger elemental areas of the reproduced image are effectively fused together and occupy spaces corresponding to both selected and unselected elemental areas of the transmitting mosaic.

RECAPITULATION

In the foregoing description I have set forth the details of structure preferably employed for achieving certain new and useful results in the art of news dissemination. The methods adopted are replete with novelty, as will be set forth with particularity in the appended claims. Modifications of structure and of method, if adopted by those skilled in the art, may, possibly, lead to more general applications of the invention than were at first contemplated. For example, it may be found useful to provide a communication system in which code signals are represented by successively scanned light and dark areas on a screen. These code signals may also be interwoven for the sake of rendering the intelligence quasi-secret. The method herein shown of selecting desired elements from multiplexed trains of signals for reproducing a given communication at the point of reception lends itself to photographic recording of code messages and to a subsequent deciphering in any well known manner. If the number of elemental areas to be skipped in the sorting process is unknown to a person attempting to intercept a message, then the risk of unauthorized de-ciphering of the message becomes negligible.

The method I have disclosed in which the entire mosaic of the transmitting screen is occupied by significant light and dark areas of an image pattern, and in which character images are disposed on said mosaic without any background areas intervening, leads to a more economic use of signaling channel time than was possible when character image signals were interspersed with insignificant lapses of time representing background areas. By my method the character separation is obtained on the receiving screen in accordance

with a non-linear control of the horizontal and vertical deflecting circuits.

The field of utility of my news dissemination system can, of course, be extended to cover the transmission of bid and asked prices on stocks, bonds and commodities. The system may also be found useful in communicating details of sporting events, game scores, racing results, betting odds, and word pictures covering any conceivable item of news or other intelligence.

My method of storing in tabularly arranged registering devices the effects of price fluctuations within ever widening limits of price range, and then periodically surveying the stored effects, appears to offer a distinct advantage over the heretofore accepted practice of transmitting quotations over a ticker system in respect to each individual market transaction. To certain parties the details of each transaction may be of interest, but to the majority of people who watch the ticker the matter of chief concern is—how does the last quotation on a given item compare with the opening price, the high and the low for the day. Next to that in importance is the question of volume, up to the minute in respect to the transactions in any particular security. If the market is dull, then a tape watcher may have to wait many minutes for a transaction on some particular stock to be quoted, and even then, in the absence of a quotation board, there is no basis of comparison between the last price and previous price range. This difficulty is, therefore, effectively solved by the periodic survey of all market quotations covered by a more or less complete tabulation as obtained through the use of a price storing mechanism. Furthermore, in a very active market, ticker systems of the types now in use are inadequate; so much so that they cannot keep pace with the transactions as made on the exchange. In other words, the limit of speed for code-signaling of the quotations is soon reached and beyond that point inevitable delays of reporting occur. My periodic survey of the active stocks every thirty seconds and of the least active stocks every five minutes is entirely independent of the volume of transactions on the exchange. Hence it never need fall behind the market.

I claim:

1. In a multiplex system, a plurality of independently operable devices, each for storing a distinct piece of intelligence to be transmitted, means operable by the storage means for graphically spreading a plurality of said pieces of intelligence on a field to be scanned, said field comprising a mosaic of elemental areas divisible into separate groups, each group being appropriate to one of said pieces of intelligence and each group being composed of discrete elemental areas interwoven with elemental areas of other groups, a transmitter having scanning means for transmitting multiplexed signals in accordance with the operation of said scanning means, receiving apparatus comprising a scanner operable in synchronism with the scanning means of said transmitter, means for selecting a portion of the multiplexed signals corresponding with a desired group of said elemental areas, and reproducing means at the receiver under joint control of said scanner and of said selecting means, said reproducing means being operable to graphically display the intelligence conveyed by said selected signals.

2. An image transmitting and reproducing system comprising a transmitting tape, a plurality

of independently operable tape transcribing units, each adapted to graphically spread a piece of stored intelligence on said tape, means for causing elemental areas of said tape appropriate to the use of different transcribing units to be mutually exclusive and interwoven, means for successively scanning said areas, means for transmitting a train of signals representing the scanned light and dark areas of said transcribed tape, a receiver having an image reproducing scanner operable synchronously with the transmitting scanning means for allocating the effects of selected signals to different portions of a receiving field, means cooperating with the receiving scanner for causing the suppression of the effects of received signals representing those portions of the area scanned at the transmitter which are appropriate to all but one of said transcribing units, and means for causing said receiving scanner to apply the effects of the selected signals successively to different elemental areas arranged contiguously on said receiving field.

3. A facsimile transmitting and tape recording system for character images comprising means for storing multiple pieces of intelligence at a transmitting station, means operative in a predetermined sequence for progressively spreading different selected portions of said intelligence on a field, said means including means for interweaving the elemental areas of different unrelated character images on said field, means for successively scanning said elemental areas, a signal transmitter operable in accordance with the light and dark elemental areas successively scanned, receiving means including a signal selector operable to give effect only to a portion of said signals representing a desired one of said pieces of intelligence, means to suppress the effects of the remaining signals, a receiving scanner, a recording tape, and means cooperative with said receiving scanner and responsive to the selected signals for recording character images on said tape.

4. A device according to claim 3 in which said receiving scanner comprises a rotary member having spirally arranged platen elements of quadrilateral shape for recording individual elemental areas along each scanning line successively.

5. A device according to claim 3 in which said receiving scanner includes a rotatable cylindrically formed printing platen having elemental area-recording devices of quadrilateral shape arranged spirally around its periphery, each of said devices being effective to record an elemental portion of a character image, and all of said devices collectively being effective to merge together adjacent portions of said character image.

6. A facsimile transmitting and receiving system comprising means for transmitting intelligence multiplexed signals representing elemental areas of a plurality of interwoven images, a receiver operable synchronously with the transmitting means, a time constant device adjustably operable to make a desired selection of an array of said intelligence signals and to cause the rejection of the remainder of the transmitted intelligence signals, said time constant device comprising means for shifting the phase of its effectiveness with respect to a reference moment in the synchronous operation of the system, and image recording means operable in dependence upon the phase of the time constant device for reproducing on a record surface a desired one of said plurality of interwoven images.

7. In combination, a storage means settable in

accordance with fortuitous price variations of a plurality of items, a time-controlled program device capable of periodically and serially displaying the prices set up on said storage means, a transmitting scanner adapted to formulate signals in accordance with the elemental light and dark areas of a multiplexed picture field on which prices are displayed by said program device, a receiver including a selector appropriate thereto for discriminating between wanted and unwanted signals, and a device operable in accordance with the wanted signals to reproduce successive images of price variations of the stored items to which said signals pertain.

8. In a news disseminating system, selectively settable apparatus for tabularly storing the effects of a fortuitous succession of news items, a display surface on which to spread character images comprehending a predetermined succession of said news items, means including a program device for causing the character images of said items to be spread in said predetermined succession, a transmitter having means for scanning said display surface thereby to compose and transmit in said predetermined succession an array of intelligence signals, receiving means having an image display medium, means adapted to effect a desired selection of said signals, and means for reproducing on said display medium character images representing said desired selection of said news items.

9. In a device of the class described, a display medium comprising a field on which character images may be spread, a storage medium having a plurality of sections in each of which different pieces of intelligence may be stored from time to time in classified order and in a random sequence of introduction thereto, a plurality of character image forming devices each subject to control by said storage medium, and a program device operable to select the intelligence stored in each of said sections in a predetermined sequence and to so actuate the character image forming devices that said intelligence is manifested by the spread of character images in said predetermined sequence on said field.

10. In a communication system, a transmitting station comprising means including settable switches for registering and storing information, a plurality of luminous beam projectors, time controlled means operable in conjunction with the first said means for periodically so actuating said projectors as to produce at a given moment a multiplex array of interwoven patterns of character-images, each pattern being representative of a certain portion of the information at that moment stored on said settable switch means, a screen on which said images may be projected, television means including apparatus for scanning said images, and for transmitting signals in conformity therewith, and means responsive to said signals for separately exhibiting at a remote point the information conveyed by a selected and inter-related portion of said character images.

11. The method of deflecting an electron beam in a cathode ray tube for which sweep-circuits are provided which comprises, superposing a saw-tooth wave of one frequency upon another saw-tooth wave of a different frequency in one of said sweep circuits, causing the combined forces of said waves to so deflect the beam that it scans certain distances along a single scanning line at one constant angularly velocity of forward deflection, and other distances interspersed between

the first said distances at a much greater constant angular velocity of forward deflection, and substantially uninterruptedly modulating the beam during the forward deflection of the same at the two said velocities.

12. The method of horizontally and vertically deflecting an electron beam in a cathode ray tube for which sweep circuits are provided which comprises, introducing two superposed saw-tooth waves of different frequencies into the vertical sweep-circuit, causing the combined forces of said saw-tooth waves to produce single frame scanning deflection in an ever-forward direction but with sudden skips over different horizontal bands of the scanning area, thereby crowding together into bands certain of the individual scanning lines and producing appreciable background separation between certain bands of the scanning lines, and substantially uninterruptedly modulating the beam during the forward deflection of the same at the two said velocities.

13. In a device of the class described, apparatus for tabularly posting and storing market quotations, image signal transmitting means, a plurality of image-forming projectors, means for actuating said projectors in accordance with an automatic and periodic survey of the quotations stored in said apparatus, means for controlling the image signal transmitting means in accordance with the actuation of said projectors, an image-reproducing receiver, and selective means at said receiver operable to cause a series of images to be reproduced under control of a desired selection of the transmitted image signals.

14. In a communication system, an intelligence tabulating and storing instrumentality, an optical system having a plurality of selectively illuminable light-beam projectors, each operative to display on a screen different groups of discrete light spots arranged to form in broken outline character images representative of different portions of the intelligence stored by said instrumentality, translating means for composing a train of signals corresponding with said character images, and means responsive to said signals for reproducing said images at a remote point.

15. In combination, a photo-electric device for projection thereon of a picture constituted by a mosaic of elemental areas, each elemental area being of uniform size and being an aliquot part of the picture area, a plurality of independent circuits each circuit being related to different ones of said elemental areas, an intelligence storing medium, means under control of said storing medium for projecting pictures on said photo-electric device, and means including a plurality of incandescent lamps selectively operable through said circuits for composing the light areas of successive pictures corresponding to different portions of the intelligence stored in said storing medium.

16. A communication system comprising a transmitting tape having spread thereon a mosaic consisting of discrete elemental components of one character image intermeshed with discrete elemental components of a second and independent character image, a transmitting scanner arranged to translate differently characterized areas of the mosaic into a succession of signaling impulses in accordance with the order in which said elemental components are brought to a scanning position, a receiver including a facsimile recorder operative in response to the reception of certain of said signals to reproduce said one character image, said receiver including also a second facsimile recorder operative in response to the reception of certain others of said signals to reproduce said second character image.

17. A communication system comprising a transmitting tape, means including a plurality of keyboard devices through which said tape may be successively fed, said devices being independently operative to spread mutually exclusive portions of a mosaic on said tape for building up thereon an interwoven array of components having character image significance, facsimile sending and receiving equipment arranged to communicate through multiplex signals the intelligence of said mosaic, said receiving equipment comprising a plurality of facsimile tape recorders and selective means for dissociating the signals appropriate to one character from the signals appropriate to a different but interwoven character, and means for causing each tape recorder to reproduce the character images which originate at a corresponding one of said keyboard devices.

18. A communication system according to claim 17 in which said transmitting tape is perforated with sprocket feed holes, and each of said keyboard devices is provided with tape feed means for maintaining the different mutually exclusive image component surfaces in registry.

19. A communication system according to claim 17 and including in each receiving tape recorder mechanism for forming solid line character impressions in response to the reception of discrete signals appropriate to the elemental components of each character.

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