March 8, 1938. M. S. BURGESS ET AL 2,110,260

TELEGRAPH SYSTEM

Filed Dec. 17, 1935 5 Sheets-Sheet 1

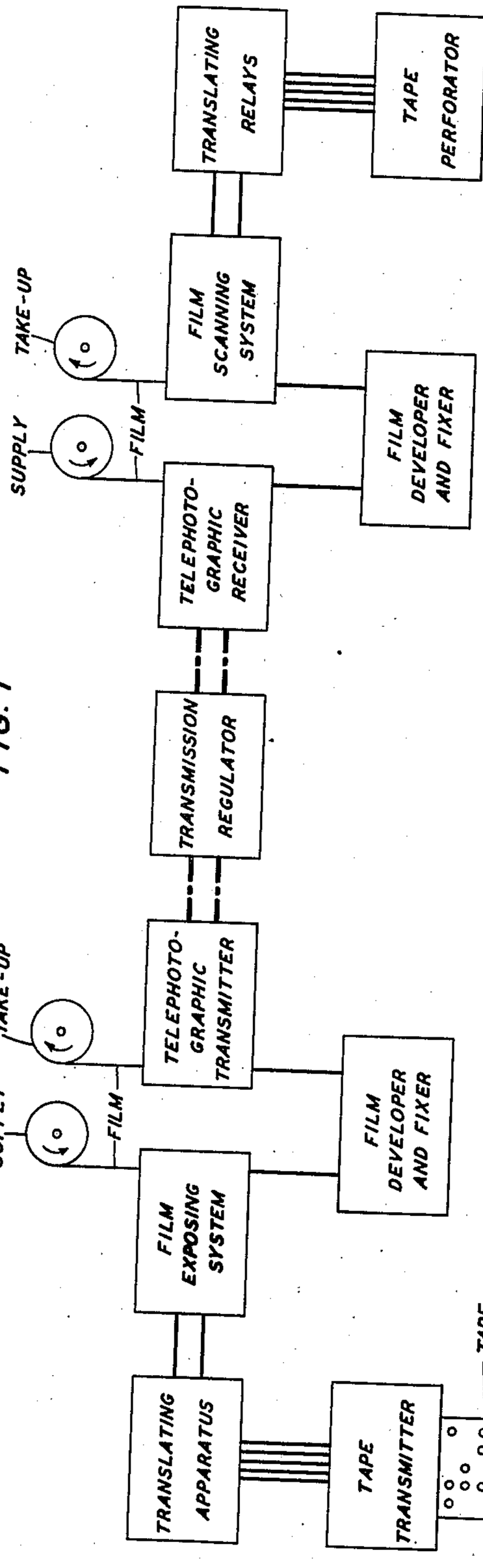

FIG. 1

FIG. 2

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TELEGRAPH SYSTEM

Filed Dec. 17, 1935 5 Sheets-Sheet 2

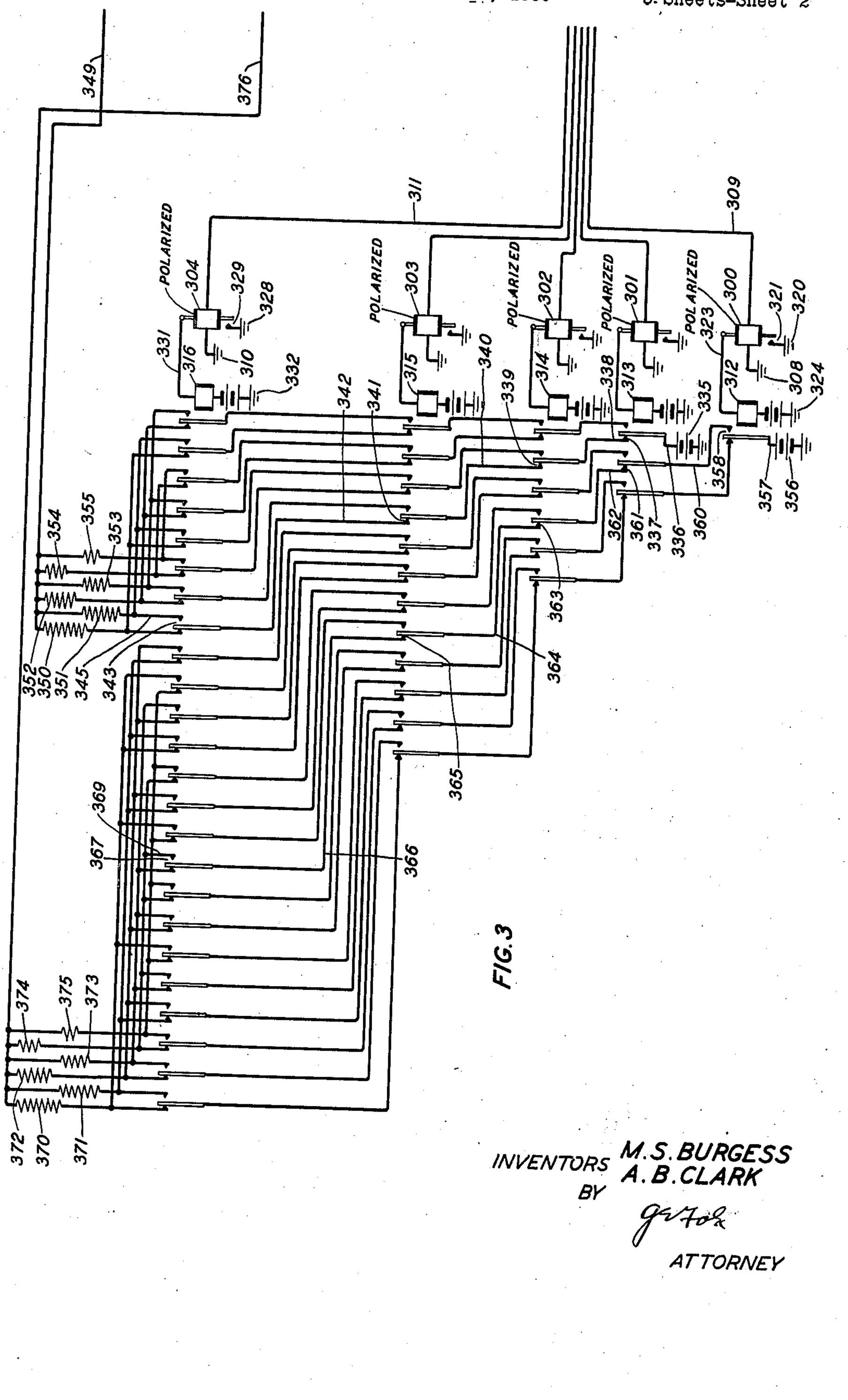

FIG. 3

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TELEGRAPH SYSTEM

Filed Dec. 17, 1935 5 Sheets-Sheet 3

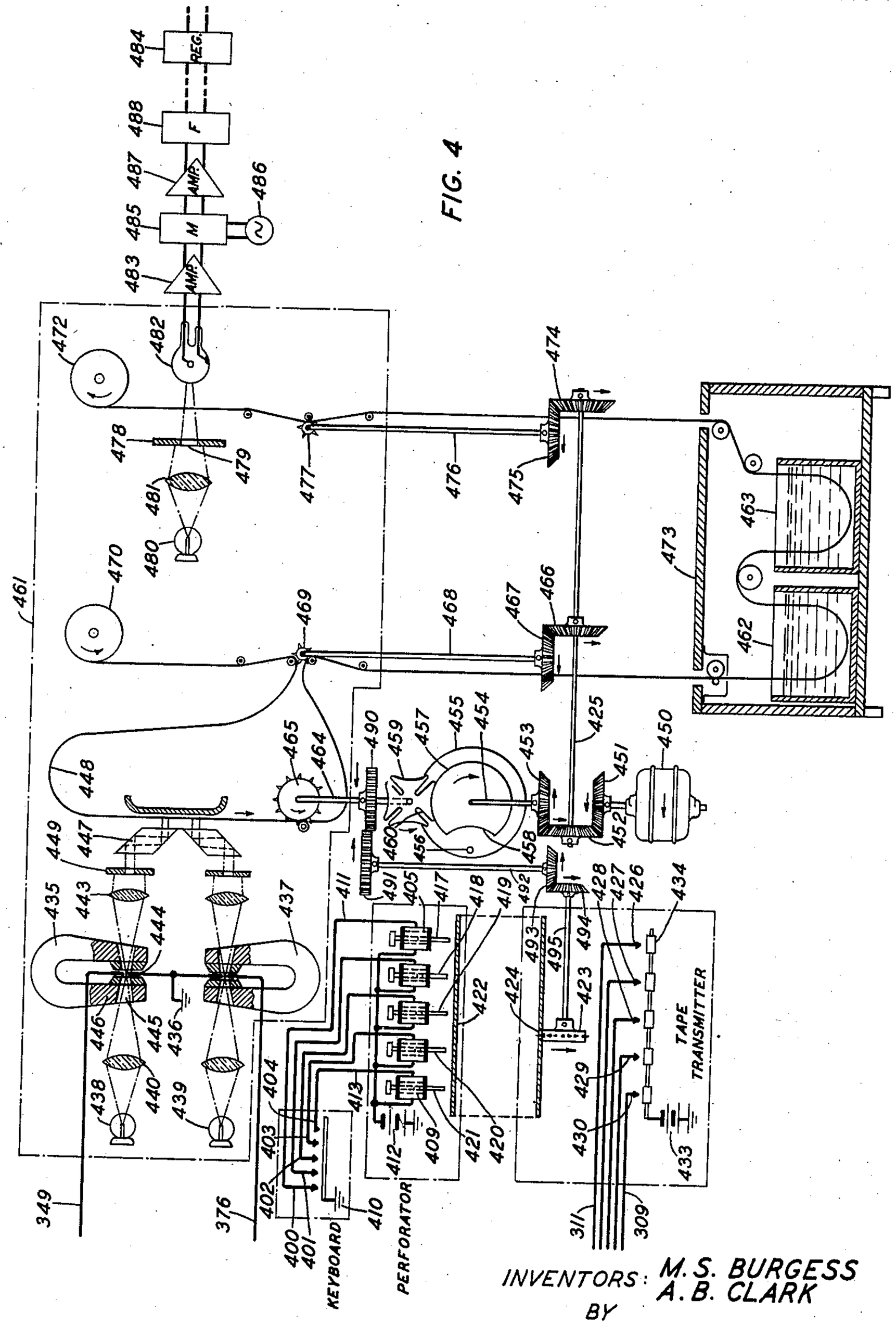

FIG. 4

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TELEGRAPH SYSTEM

Filed Dec. 17, 1935 5 Sheets-Sheet 4

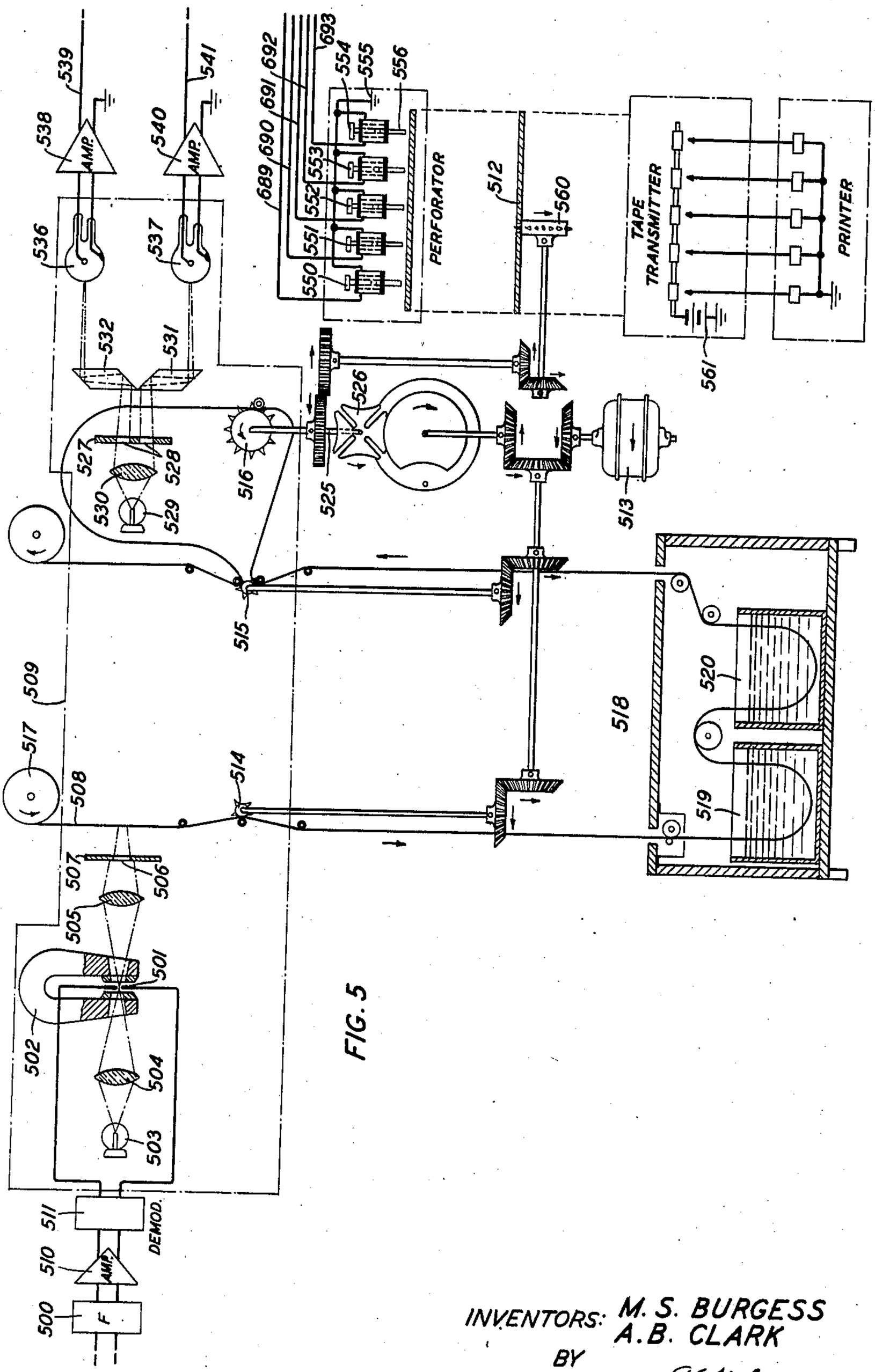

FIG. 5

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TELEGRAPH SYSTEM

Filed Dec. 17, 1935 5 Sheets-Sheet 5

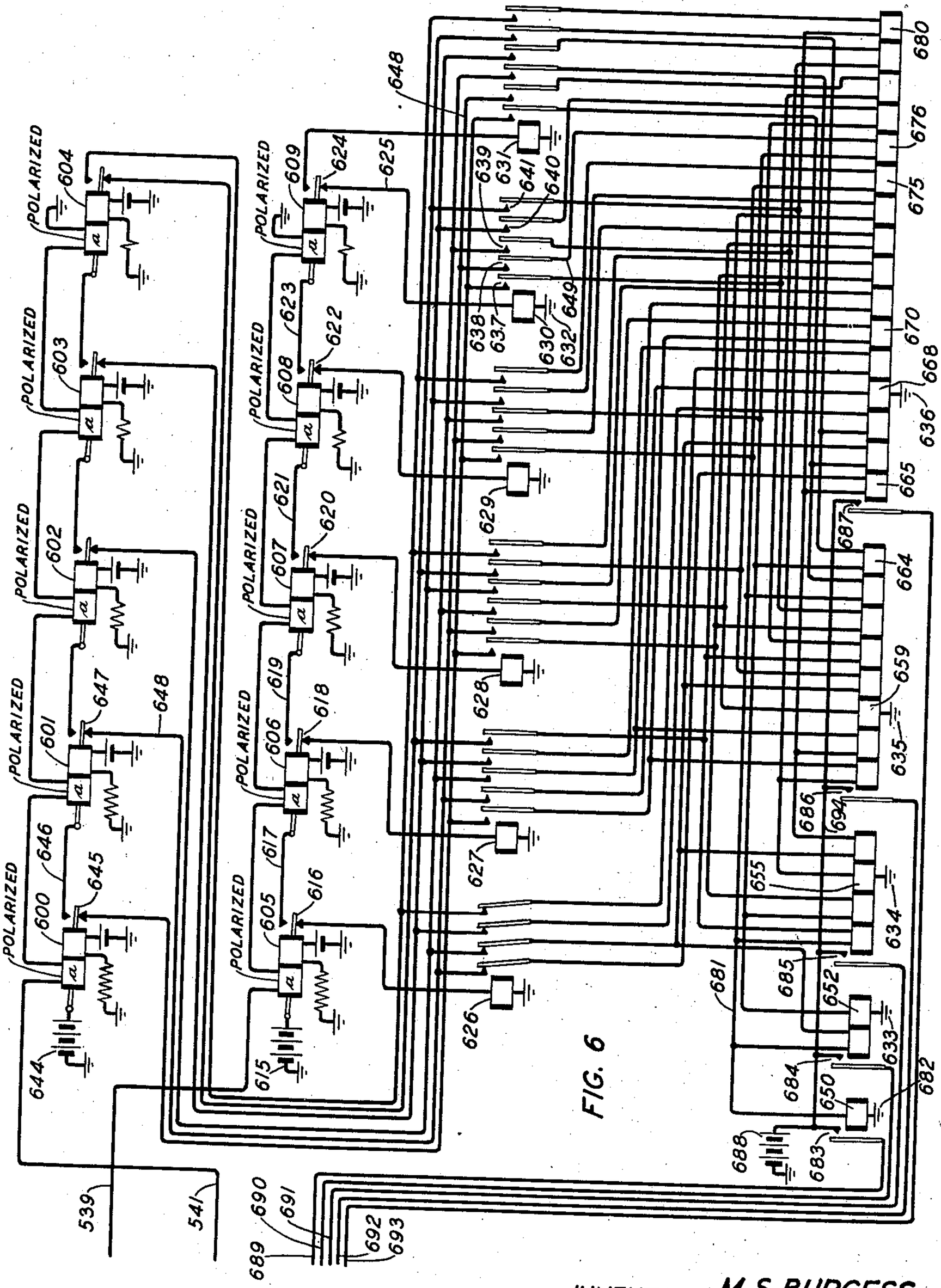

FIG. 6

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Patented Mar. 8, 1938 2,110,260

UNITED STATES PATENT OFFICE

2,110,260

TELEGRAPH SYSTEM

Montague Stephen Burgess, Jackson Heights, N. Y., and Alva Benson Clark, Maplewood, N. J., assignors to American Telephone and Telegraph Company, a corporation of New York

Application December 17, 1935, Serial No. 54,886

9 Claims. (Cl. 178—4)

This invention relates to a telegraph system, and more particularly to a picture transmission system arranged for the transmission of teletypewriter characters.

The message content of a telegraph type of signal depends upon the number of individual discrete current values that may be discerned at the receiving end. In ordinary telegraphy this number usually is two and in ordinary submarine cable telegraphy it is usually three. Assuming the same amount of intelligence transmitted in a given time, the invariable relation between the quantities involved is C^n=constant where C equals the number of discrete current values, and n equals the signal speed. The equation indicates that a given message content can be transmitted over a shorter time with the same available frequency band width as the number of discernible current values is increased. Heretofore, there have been conceived picture transmission systems employing a large number of discernible current values that might be adapted for the transmission of teletypewriter characters.

It is an object of this invention to provide a telephotographic system arranged for the transmission of teletypewriter characters.

The invention comprises a system in which a five-unit two-element permutation code combination representing a character to be transmitted, is translated into a telephotographic permutation code selected from a two-unit six-element combination and recorded on a film. Thereafter, the telephotographic code is transmitted over a picture transmission system. At a receiving station, the telephotographic code is decoded and retranslated into the original five-unit two-element code which is passed into a suitable teletypewriter apparatus to effect a printing of the transmitted character.

In the preferred embodiment as herein described and illustrated, perforate representations of characters to be transmitted actuate a transmitter which passes corresponding five-unit two-element permutation code combinations into a translating arrangement to effect telephotographic permutation code combinations. The latter are recorded on a film as combinations of two elemental areas, each of which may assume any one of six different shade intensities. The film is thereafter advanced into a photoelectric device in which currents corresponding to the shade intensities are produced for transmission over a line circuit. At a receiving station the line currents effect a reproduction of the original telephotographic code combinations on another film. A receiving photoelectric apparatus transforms the shade intensities into corresponding currents which are decoded and translated into the original five-unit two-element permutation code combinations. The latter effect a reproduction of the perforate representations appearing initially in the transmitting apparatus. The perforate reproduction may be employed with a suitable teletypewriter device to accomplish a printing of the transmitted character.

Figure 1 is a block representation of a telephotographic system arranged for the transmission of teletypewriter characters;

Fig. 2 shows the method of arranging the succeeding figures of the drawing; and

Figs. 3 to 6, inclusive, when arranged as indicated in Fig. 2, delineate diagrammatically a telephotographic system adapted for the transmission of teletypewriter characters.

Fig. 1 delineates a block representation of a picture transmission system arranged for the transmission of teletypewriter characters. Referring to Fig. 1 an actuation of a character key on a sending keyboard causes an operation of punches in a perforator to effect a perforate representation of a character to be transmitted. The perforated tape is fed into a transmitter which emits a five-unit two-element code comprising a combination of current and no-current impulses, depending on the positions of the perforations in the tape. The code combination is passed into a translating apparatus that changes the current and no-current impulses into a telephotographic code combination. As a sensitized photographic film is fed into an exposing system, the telephotographic code is recorded thereon as a combination of two elemental areas, each of which may assume any one of six different shade intensities. After development and drying, the film is passed into a telephotographic transmitter which transforms the various shade intensities into corresponding currents for transmission over a line circuit shown in heavy lines and controlled by a suitable transmission regulator to obviate external interferences.

At a receiving station, which operates in synchronism with the sending station, the line currents are retranslated by a telephotographic receiver into a telephotographic code which is recorded on another sensitized photographic film as a combination of two elemental areas, each of which may assume any one of six different shade intensities that are identical with those produced initially by the sending station. After development, the film is fed through a scanning

system wherein the various shade intensities are changed again into corresponding currents. The latter operate certain translating relays to formulate a code combination of current and no-current impulses utilized to actuate a tape perforator to produce a perforate representation which is a duplication of the one initially set up in the sending apparatus. Finally, the perforated tape is advanced into a teletypewriter device to effect a printing of the transmitted character.

Figs. 3, 4, 5 and 6 when placed side by side in accordance with Fig. 2 illustrate a picture transmission system modified for the transmission of teletypewriter characters. A character, which is to be transmitted, is initially prepared by striking an appropriate key on a keyboard so as to effect the closing of certain contacts of a group 400 to 404, inclusive, associated therewith as shown in Fig. 4. For the purpose of this illustration, let it be assumed that contacts 400 and 404 are closed. As a result thereof, energization circuits for punch magnets 405 and 409, respectively, associated with the perforator are completed. The energization circuit for magnet 405 may be traced from ground 410, through closed contact 400, lead 411, winding of magnet 405 to battery 412; and the energization circuit for magnet 409 may be traced from ground 410, through closed contact 404, lead 413, winding of magnet 409 to battery 412. Punches 417 and 421 associated with magnets 405 and 409, respectively, are actuated to provide two perforations in a tape 422, each of which is contiguous with an edge thereof. After withdrawal from a tape supply, not shown, the tape 422 is advanced into a tape transmitter by a toothed wheel 423 engaging longitudinally aligned perforations 424 provided centrally of the tape 422 to effect its advancement. The feed wheel 423 is driven in a manner that will be explained hereinafter.

As the tape 422 is fed into the transmitter, any one or combination of tape pins 426 to 430, inclusive, may be caused to engage associated contact points 434, 434 depending upon the positions of the perforations existing in the tape 422 as it is ejected from the perforator. Since, for purposes of this illustration but two perforations, positioned as previously indicated, were provided in the tape 422, then only tape pins 426 and 430 will be permitted to project through the perforations to engage their associated contact points 434, 434 each of which has battery 433 connected thereto. Obviously, tape pins 427, 428 and 429 will be prevented from further movement by the absence of perforations in the tape 422 and, consequently, battery 433 will not be connected thereto. In this manner, therefore, the transmitter emits a code combination comprising current impulses effected by tape pins 426 and 430 and no-current impulses effected by tape pins 427, 428 and 429, respectively. For a more detailed operation of the tape transmitter, reference may be had to the copending application of E. F. Watson, Serial No. 28,332, filed June 25, 1935, which issued as Patent No. 2,055,567 on Sept. 29, 1936. In the event that it is desired to make a printed record of the code combinations emitted by the tape transmitter, any well-known teletypewriter apparatus may be associated therewith. A suitable device for this purpose is described and illustrated in the patent of Morton et al., No. 1,904,164 issued April 18, 1933.

In Fig. 3, any one or combination of polarized relays 300 to 304, inclusive, may be energized depending on the combination of engagements effected between the tape pins 426 to 430, inclusive, and contact points 434, 434. As previously described, only tape pins 426 and 430 were caused to engage contact points 434, 434, therefore, only those relays of group 300 to 304, inclusive, associated therewith will be energized. Accordingly, an energization circuit for relay 300 may be traced from ground 308, through winding of relay 300, lead 309, and, in Fig. 4, through lead 309, tape pin 430, contact point 434 engaged with the latter, to battery 433; and an energization circuit for relay 304 may be traced from ground 310, through winding of relay 304, lead 311, and in Fig. 4 through lead 311, tape pin 426, contact point 434 engaged with the latter, to battery 433. In Fig. 3, any one or combination of relays 312 to 316, inclusive, may be energized depending on the operation of their associated relays 300 to 304, inclusive. Since, as previously described, only relays 300 and 304 were operated, therefore, only relays 312 and 316 are energized thereby. To facilitate a tracing of circuits in the drawings, it should be kept in mind that relay contacts are shown in normal positions assumed when their associated relays are in an unoperated condition. Accordingly, an energization circuit for relay 312 may be traced from ground 320, closed contact 321 of operated relay 300, lead 323, winding of relay 312 to battery 324; and an energization circuit for relay 316 may be traced from ground 328, closed contact 329 of operated relay 304, lead 331, winding of relay 316 to battery 332. Relays 312 and 316 operate to pull all contact tongues associated therewith to the right, while relays 313, 314 and 315 remain unoperated thereby allowing all contact tongues associated therewith to remain in their normal positions as seen in Fig. 3. As a consequence of the operation of relay 316, battery 335 is connected through lead 336, contact 337, lead 338, contact 339, lead 340, contact 341, lead 342, closed contact 343 associated with operated relay 316, lead 345, resistance 351 and lead 349, and in Fig. 4, lead 349, light valve 435 to ground 436. As a result of the operation of relay 312, battery 356 is connected through lead 357, closed contact 358 associated with operated relay 312, lead 360, contact 361, lead 362, contact 363, lead 364, contact 365, lead 366, closed contact 367 associated with operated relay 316, lead 369, resistance 374, lead 376, and in Fig. 4, lead 376, light valve 437 to ground 436.

In Figs. 3 and 4, it is readily seen that the six resistances of groups 350 to 355, inclusive, and 370 to 375, inclusive, are of different values, and, in addition, that the resistances of each group are arranged to be connected individually in a series circuit extending between their associated light valve and battery in the manner as previously described in connection with resistances 351 and 374. The particular resistance selected determines the value of the current flowing through its associated light valve thereby controlling the size of the aperture in the latter in a manner which will be subsequently explained. The light valves 435 and 437 may be of a suitable type such, for instance, as that disclosed in the patent of E. C. Wente, No. 1,638,555 issued August 9, 1927. In Fig. 4, light from source 438 is focused by lens 440 on a small slot formed by movable elements 444 in an orifice 445 provided in the pole pieces of a permanent magnet 446 associated with light valve 435. As previously described, an electric current flows from battery 335 through light valve 435 and, accordingly,

flows through movable elements **444** thereby occasioning a displacement of the latter by a reaction of the magnetic fields due to the current and the magnet. The image of the orifice of light valve **435** is then focused by lenses **443** and **447** on a sensitized film **448** moving past the point of exposure. An apertured plate **449** precludes diffused light from interferring with the recording. Likewise, in valve **437** light from source **439** is focused therethrough and onto the sensitized film **448** under control of a current flowing from battery **356** in a manner similar to that described in connection with valve **435**. Referring to Fig. 4, it will be observed that when the images of the orifices of light valves **435** and **437** are recorded on film **448**, the image of light valve **437** will always occupy a position in advance of that occupied by the image of light valve **435** due to the advancement of film **448** in the direction indicated by the arrow. Accordingly, the combination of two shades, one after the other on two elemental areas of the film **448**, represents the character which existed initially as perforations in tape **422**. In like manner, therefore, combinations of two shaded areas, each of which may assume one of six different intensities depending upon the resistances selected from group **350** to **355**, inclusive, and group **370** to **375**, inclusive, will provide thirty-six telephotographic code combinations of which thirty-two are sufficient to represent the combinations of current and no-current impulses effected by the perforate representations produced by actuations of the character keys on the sending keyboard.

The combinations of relays operated and resistances selected in the aforedescribed manner to effect a telephotographic code combination of a perforate representation of the usual thirty-two teletypewriter characters are as follows:

Table A

Character sent		Perforated tape representation					Relays operated		Resistances selected
Lower case	Upper case	1	2	3	4	5	300 to 304	312 to 316	
A	-	−	−	+	+	+	300-1	312-13	370 352
B	?	−	+	+	−	−	300-3-4	312-15-16	370 353
C	:	+	−	−	−	+	301-2-3	313-14-15	374 352
D	$	−	+	+	−	+	300-3	312-15	375 352
E	3	−	+	+	+	+	300	312	373 350
F	!	−	+	−	−	+	300-2-3	312-14-15	374 350
G	&	+	−	+	−	−	301-3-4	313-15-16	370 355
H	=	+	+	−	+	−	302-4	314-16	375 355
I	8	+	−	−	+	+	301-2	313-14	372 350
J	△	−	−	+	−	+	300-1-3	312-13-15	372 354
K	(	−	−	−	−	+	300-1-2-3	312-13-14-15	371 352
L	)	+	−	+	+	−	301-4	313-16	374 353
M	.	+	+	−	−	−	302-3-4	314-15-16	372 351
N	,	+	+	−	−	+	302-3	314-15	371 350
O	9	+	+	+	−	−	303-4	315-16	373 353
P	°	+	−	−	+	−	301-2-4	313-14-16	373 351
Q	1	−	−	−	+	−	300-1-2-4	312-13-14-16	370 351
R	4	+	−	+	−	+	301-3	313-15	375 354
S	Bell	−	+	−	+	+	300-2	312-14	371 354
T	5	+	+	+	+	−	304	316	371 351
U	7	−	−	−	+	+	300-1-2	312-13-14	375 350
V	;	+	−	−	−	−	301-2-3-4	313-14-15-16	375 353
W	2	−	−	+	+	−	300-1-4	312-13-16	371 353
X	/	−	+	−	−	−	300-2-3-4	312-14-15-16	375 351
Y	6	−	+	−	+	−	300-2-4	312-14-16	372 355
Z	"	−	+	+	+	−	300-4	312-16	374 351
.....	.	+	−	+	+	+	301	313	373 352
Space		+	+	−	+	+	302	314	374 354
,-----	,	+	+	+	−	+	303	315	372 352
Figures		−	−	+	−	−	300-1-3-4	312-13-15-16	373 355
Letters		−	−	−	−	−	300-1-2-3-4	312-13-14-15-16	372 353
Blanks		+	+	+	+	+	None	None	370 350

The following table shows the current values derived from the use of individual resistances **350** to **355**, inclusive, and **370** to **375**, inclusive, and utilized to actuate light valves **435** and **437**. A substitution of these current values for their corresponding resistances listed in the resistance column of Table A will provide the telephotographic current combinations necessary to effect the various shade intensities on each of the two elemental areas of film **448** to represent the thirty-two conventional current and no-current code combinations.

Table B

Resistance Fig. 3	Light valve current Fig. 4	
	435	437
350	I	
351	1I	
352	2I	
353	3I	
354	4I	
355	5I	
370		I′
371		1I′
372		2I′
373		3I′
374		4I′
375		5I′

The film **448** and tape **422** are simultaneously advanced one character space at a time by a synchronous motor **450** driving the shaft **425** through meshing bevel gears **451** and **452** in a manner that will now be explained. Also meshing with gear **452** is a bevel gear **453** keyed to one end of a shaft **454** which has mounted on its opposite end a drum **455** provided with a pin **456** mounted transversely in an outer periphery thereof. Mounted concentrically with the drum **455** is a second drum **457** having a peripherally recessed portion **458** disposed oppositely to the pin **456**. A cross member **459** affixed to one end of a shaft **464** is provided with four radial slots **460** spaced 90 degrees apart and arranged so that the slots in sequence accommodate the pin **456** during each revolution of the drum **455** thereby imparting an intermit-

tent movement to the shaft **464**. Apparatus for effecting this movement is well known and is described in the patent of Herbert E. Ives No. 1,738,007 issued December 3, 1929. Fastened to the opposite end of the shaft **464** is a feed sprocket **465** engaging the usual perforations aligned along the longitudinal edges of the film **448** to effect its advancement past the point of exposure before the light valves **435** and **437** in amounts corresponding to the angular movements of the cross member **459**. A camera **461** containing the film **448** and arranged for recording and transmitting the telephotographic code combinations may be of any well-known type such, for example, as that disclosed in the patent of Louis M. Potts No. 1,882,893 issued October 18, 1932. The radial slots **460** are arranged so that the intermittent movement imparted to shaft **464** comprises a one-quarter revolution for each complete revolution of the drum **455** thereby effecting an advancement of the film **448** before the point of exposure in an amount equal to the space required for the telephotographic code combination to represent one character. Secured to the shaft **464** intermediate cross member **459** and film feed sprocket **465** is a gear **490** meshing with gear **491** affixed to one end of a shaft **492** having a gear **493** mounted on its opposite end. Gear **493** meshes with a gear **494** fastened to one end of a shaft **495** which has the tape feed sprocket **423** secured to its opposite end. It is to be understood that the mechanism provided to intermittently advance the film **448** one character space at a time also drives the transmitting tape feed sprocket **423** in a manner that the film **448** and the tape **422** are advanced simultaneously one character space at a time. With this arrangement, therefore, the sensitized film **448** is advanced for exposure before the light valves **435** and **437** at the instant the tape transmitter emits the current and no-current combinations effected by the perforations in the tape **422**, and after the emission thereof, the tape **422** and film **448** are simultaneously advanced one character space at a time to make ready for the transmission and recording of the next character.

Also, affixed to the shaft **425** is a bevel gear **466** meshing with a bevel gear **467** mounted on one end of a shaft **468** having a feed sprocket **469** secured to its opposite end. The feed sprocket **469** engages the usual perforations aligned along the edges of the film **448** to effect the latter's withdrawal from film supply **470** and, in addition, to advance the exposed film **448** into a fixing apparatus **473** in which the images on the film **448** are developed. The diameter of feed sprocket **469** is one-fourth that of feed sprocket **465** so as to move the film at a uniform rate of speed that is equal to the average rate of speed at which the film is being exposed to the light valves **435** and **437**. The fixing apparatus **473** containing developing tank **462** and fixing tank **463** may be of any suitable type such, for instance, as that disclosed in the copending application of Herbert E. Ives, Serial No. 291,744 filed July 11, 1928 which issued as Patent 1,989,618 on Jan. 29, 1935.

Also, keyed to an end of the shaft **425** is a bevel gear **474** meshing with a bevel gear **475** fastened to one end of a shaft **476** having affixed to its opposite end a feed sprocket **477** employed to withdraw the developed film from the tank **473** and to advance it before a stationary scanning plate **478** onto a take-up **472**. The diameter of feed sprocket **477**, like that of feed sprocket **469**, is one-fourth that of feed sprocket **465** thereby enabling the developed film **448** to be passed before the scanning plate **478** at a uniform rate of speed which is equal to the average rate of speed at which the sensitized film **448** is being passed before the point of exposure to the light valves **435** and **437**.

The various shades of the two elemental areas of the developed film **448** are transmitted by being passed in order before a scanning aperture **479** provided in plate **478**, at which point the shades are illuminated by a lamp **480** and condensing lens **481**. A beam of light is focussed on the photoelectric cell **482** and as each portion of the film **448** is passed before the scanning aperture **479**, beams of light of varying intensities are focused on the photoelectric cell **482** to produce varying currents representing the shade intensities of the two elemental areas on the film **448**. An amplifier **483** amplifies the currents before their application to a modulator **485**. Oscillator **486**, modulator **485**, amplifier **487**, and filter **488** serve to effect in the well known manner a transmission of a carried wave modulated by the currents produced by the photoelectric cell **482** over the line circuit shown in heavy lines. Filter **500**, amplifier **510**, and demodulator **511** receive the modulated carrier and direct the transmitted photoelectric currents to a light valve **502** shown in Fig. 5. Apparatus for transmitting and receiving photoelectric current signals may be of any suitable type such, for example, as that described in the patent of Maurice B. Long, No. 1,706,032, issued March 19, 1929 and in the patent of Herbert E. Ives, No. 1,738,007 issued December 3, 1929. In Fig. 4 it is seen that the image of the orifice of light valve **437** is always recorded on the film **448** in a position in advance of the image of the orifice of light valve **435** in the manner as hereinbefore described. Therefore, it is obvious that the shade intensity produced by light valve **437** will always be transmitted over the line circuit in advance of the shade intensity produced by light valve **435**.

In Fig. 5, the transmitted photoelectric currents actuate movable elements **501** of light valve **502** in the manner explained in connection with light valve **435**. The image of the orifice in light valve **502** is illuminated by a lamp **503** and condensing legs **504**, and focused by a lens **505** through a scanning aperture **506** provided in scanning plate **507** and onto a sensitized film **508**. Light valve **502** actuated by photoelectric currents representing the transmitted shade intensities now effects a reproduction of the transmitted shade intensities on the film **508** exactly in the order of their appearance on the film **448**. A suitable line regulating apparatus **484** for maintaining the initial values of the photoelectric currents throughout the entire length of the transmission line may be employed. For example, a regulator of the type illustrated in the copending application of A. D. Dowd, Serial No. 734,179 filed July 7, 1934 and is described in corresponding British Patent 453,462, accepted Sept. 11, 1936 would be satisfactory. The employment of the line regulator provides a control of the transmission line characteristics so that the shades of the two elemental areas as produced on the transmitting film **448** will be duplicated with identical intensity on the receiving film **508**.

In Fig. 5, the mechanism at the receiving station for advancing the sensitized film **508** through a receiving camera **509** and actuating a tape **512**

through a tape transmitter is similar to that employed for the identical purposes in connection with camera **461** and tape transmitter of the transmitting station as seen in Fig. 4. The receiving camera **509** may be of any well known type, such as that described in the patent of Louis M. Potts, supra. A synchronous motor **513** is employed to drive the receiving mechanism in synchronism with the synchronous motor **450** associated with the transmitting apparatus. A suitable apparatus capable of effecting a synchronization of the transmitting and reproducing mechanisms as employed in the transmission of pictures may be used to synchronize motors **450** and **513**. For example, the apparatus described and delineated in the patent of Maurice B. Long, supra, would be satisfactory. Film feeding sprockets **514**, **515** and **516** of receiving camera **509** are duplications of the film feeding sprockets **477**, **469** and **465**, respectively, of camera **461**. Therefore, it is apparent that the film **508** of camera **509** is advanced in identical steps simultaneously with the film **448** in camera **461**.

The sensitized film **508** is withdrawn from the film supply **517** by the sprocket **514** and thereafter is exposed to light valve **502** at a uniform rate of speed synchronized with that at which the film **448** is fed past the photoelectric cell **482** so that the transmitted shade intensities are reproduced in succession on the film **508** in the order of their appearance on the film **448**. Therefore, in each telephotographic code combination effected by this invention, the shade representing the orifice of light valve **437** will always occupy on the film **508** a position in advance of that occupied by the shade representing the orifice of light valve **435**. The film **508** is then fed into a fixing apparatus **518** containing a developing tank **519** and a fixing tank **520**. The fixing apparatus **518** is identical with fixing apparatus **473**. From the fixing apparatus **518** the developed film **508** is withdrawn by the sprocket **515** and passed along to a sprocket **516** affixed to one end of a shaft **525** which has a cross member **526** mounted on its opposite end. As previously seen in connection with cross member **459**, the cross member **526** imparts an intermittent movement consisting of one-quarter revolutions to the shaft **525**, thereby effecting an advancement of the film **508** before a stationary scanning plate **527** one telephotographic code combination at a time. In this manner, therefore, the various shades of the two elemental areas comprising a single telephotographic code combination are again converted into photoelectric currents by the passing of the developed film **508** before scanning apertures **528**, **528** provided in the plate **527**. Through the apertures **528**, **528**, a lamp **529** and condensing lens **530** illuminate simultaneously the two elemental areas of the film **508** so that varying beams of light passing therethrough are focused by lenses **531** and **532** upon photoelectric cells **536** and **537**. Obviously, the various shades of the elemental areas of film **508** will effect variations in the intensities of the beams of light focused on the photoelectric cells **536** and **537** and, accordingly, the shade variations will be represented by corresponding variations in the currents produced in the photoelectric cells **536** and **537**. Photoelectric cell **536** is connected through amplifier **538** to selecting polar relays **605** to **609**, inclusive, by lead **539**. Photoelectric cell **537** is connected through amplifier **540** to selecting polar relays **600** to **604**, inclusive, by lead **541**. The selecting polar relays **600** to **609** are each provided with two windings, an operating winding *a* and a bias winding. The bias windings and circuits of polar relays **604** and **609** are arranged to provide the same and the largest biases for these relays which may be readily discerned by referring to Fig. 6. Likewise, the windings and circuits of relays **603** to **600**, inclusive, provide successively diminishing biases for these relays which are equal to the successive diminishing biases of relays **608** to **605**, respectively.

Therefore, when the film **508** is advanced one telephotographic code combination at a time before the scanning apertures **528**, **528**, as seen in Fig. 5, the shade representing the orifice of light valve **437** will produce a current in photoelectric cell **536** and the shade representing the orifice in light valve **435** will produce a current in photoelectric cell **537**. These current values correspond to the current values derived for the purpose of actuating the light valves **435** and **437** at the transmitting mechanism, and the latter current values corresponding to the resistances used with light valves **435** and **437** may be seen in Table B. A suitable shutter arrangement may be associated with the scanning plate **527** so as to obviate the possibility of producing false currents in the photoelectric cell **537** as the film **508** is advancing into the camera **509**. Since, for the purposes of this description, resistance **374** was associated with light valve **437** and resistance **351** was associated with light valve **435**, the current values actuating these light valves are 4I′ and 1I, respectively, which are obtained by substituting the current values of Table B in the resistance column of Table A. The current 4I′ flows on lead **539** through the windings *a* of polar relays **605** to **609**, inclusive, which are connected in series, to overcome the biases on all relays of this group except relay **609** and, accordingly, relays **605** to **608** inclusive are operated while relay **609** continues in the unoperated condition. As a result thereof current from battery **615** flows through armatures **616**, lead **617**, armature **618**, lead **619**, armature **620**, lead **621**, armature **622**, lead **623**, and armature **624** of unoperated relay **609**, lead **625**, winding of neutral relay **630** to ground **632** thereby completing an energization circuit for neutral relay **630**. The latter operates to close contacts **637** to **641**, inclusive. The current 1I flows over lead **541** through the windings *a* of polar relays **600** to **604**, inclusive, which are connected in series, to overcome the bias on relay **600** only and, accordingly, relay **600** operates while relays **601** to **604**, inclusive, remain in the unoperated condition. As a result thereof, current from battery **644** flows through armature **645** of operated relay **600**, lead **646**, armature **647** of unoperated relay **601**, lead **648**, closed contact **638** of operated relay **630**, lead **649**, winding of neutral relay **676**, lead **681**, winding of neutral relay **650** to ground **682** thereby completing an energization circuit for neutral relays **650** and **676**. The latter operate to close contact **687** associated with winding **676** and contact **683** associated with relay **650**. Battery **688** is connected through closed contact **683** to lead **689**, and battery **688** is connected through lead **694** and closed contact **687** to lead **693**. It will be noted that battery **688** may be connected through each of contacts **683** to **687** inclusive, to the latter's associated leads **689** to **693**, respectively, depending on the operations of the relays in the group **650** to **680**, inclusive.

In Fig. 5, it will be observed that leads **689** to

693, inclusive, are connected to one end of the windings of punch magnets 550 to 554, inclusive, of a well known type of perforator. Inasmuch as battery 688 is now connected to leads 689 and 693, the former will be connected to ground 555 associated with the opposite end of each of the windings of punch magnets 550 and 554 thereby effecting an operation of punches 556 associated with the magnets to provide two perforations in tape 512, each of the perforations being contiguous with an edge of the tape 512. In connection with the receiving tape 512 it will be noted that the perforations produced therein occupy positions identical with those appearing in the transmitting tape 422. The tape 512 is advanced by feed wheel 560 into a tape transmitter in which the tape perforations cause the sending out of current impulses from battery 561. Obviously, the absence of perforations in the space intervening between the two perforations produced in the manner as described above, effect no-current impulses. These current and no-current impulses effect an operation of a printer to record the transmitted character. The tape transmitter may be of a suitable type such as that described in the copending application of E. F. Watson, supra, used at the transmitting station. The printer may be of a well known teletypewriter printing apparatus such as that disclosed in the patent of Morton et al., supra.

The following table shows how the various values of photoelectric currents effect the operation of the translating relays to reproduce the transmitted teletypewriter character in a manner similar to that illustrated in connection with currents 4I′ and 1I.

Table C

Photoelectric cell currents		Relays operated				Impulses				
536	537	605–609	600–604	626–631	650–680	Battery 688 and 561				
I′	2I	None	600–1	626	650–51	−	−	+	+	+
I′	3I	None	600–1–2	626	650–63–66	−	+	+	−	−
4I′	2I	605–6–7–8	600–1	630	652–54–62	+	−	−	−	+
5I′	2I	605–6–7–8–9	600–1	631	650–63	−	+	+	−	+
3I′	I	605–6–7	None	629	650	−	+	+	+	+
4I′	I	605–6–7–8	None	630	650–53–61	−	+	−	−	+
I′	5I	None	600–1–2–3–4	626	652–64–67	+	−	+	−	−
5I′	5I	605–6–7–8–9	600–1–2–3–4	631	655–80	+	+	−	+	−
2I′	I	605–6	None	628	652–54	+	−	−	+	+
2I′	4I	605–6	600–1–2–3	628	650–51–60	−	−	+	−	+
1I′	2I	605	600–1	627	650–51–56–58	−	−	−	−	+
4I′	3I	605–6–7–8	600–1–2	630	652–77	+	−	+	+	−
2I′	1I	605–6	600	628	655–57–70	+	+	−	−	−
1I′	I	605	None	627	655–57	+	+	−	−	+
3I′	3I	605–6–7	600–1–2	629	659–74	+	+	+	−	−
3I′	1I	605–6–7	600	629	652–54–73	+	−	−	+	−
I′	1I	None	600	626	650–51–56–65	−	−	−	+	−
5I′	4I	605–6–7–8–9	600–1–2–3	631	652–64	+	−	+	−	+
1I′	4I	605	600–1–2–3	627	650–53	−	+	−	+	+
1I′	1I	605	600	627	668	+	+	+	+	−
5I′	I	605–6–7–8–9	None	631	650–51–56	−	−	−	+	+
5I′	3I	605–6–7–8–9	600–1–2	631	652–54–62–79	+	−	−	−	−
1I′	3I	605	600–1–2	627	650–51–69	−	−	+	+	−
5I′	1I	605–6–7–8–9	600	631	650–53–61–78	−	+	−	−	−
2I′	5I	605–6	600–1–2–3–4	628	650–53–72	−	+	−	+	−
4I′	1I	605–6–7–8	600	630	650–76	−	+	+	+	−
3I′	2I	605–6–7	600–1	629	652	+	−	+	+	+
4I′	4I	605–6–7–8	600–1–2–3	630	655	+	+	−	+	+
2I′	2I	605–6	600–1	628	659	+	+	+	−	+
3I′	5I	605–6–7	600–1–2–3–4	629	650–51–60–75	−	−	+	−	−
2I′	3I	605–6	600–1–2	628	650–51–56–58–71	−	−	−	−	−
I′	I	None	None	626	None	+	+	+	+	+

In Table C, the (−) and (+) signs indicate current and no-current impulses, respectively, with reference to battery 688 (Fig. 6). Since it has been described that these current impulses energize any one or combination of punch magnets 550 to 554, inclusive, thereby resulting in an actuation of the latter's associated punches, the (−) signs may also be construed to indicate the positions of perforations in the tape 512, while the (+) signs may be construed to indicate an absence of perforations in the tape 512. Also, it is obvious that (−) and (+) signs may indicate operation and non-operation, respectively, of the punch magnets 550 to 554, inclusive.

Referring to Fig. 6, it is to be understood that grounds 633 to 636, inclusive, are individual to windings of neutral relays 652, 655, 659 and 668, respectively.

Also, it is to be understood that the motor 513 advances the tape 512 one code combination at a time in unison with the sprocket 516 employed to feed the film 508 before lamp 529 exactly in the steps that motor 450 effected the advancement of tape 422 and film 448 through the sending tape transmitter and camera 461, respectively.

Various modifications of the apparatus described and illustrated herein may be made without departing from the scope of the invention defined in the appended claims.

What is claimed is:

1. A telegraph system for transmitting characters comprising means for translating the characters into code combinations of impulses of light of more than two different intensities, means for producing signaling currents corresponding thereto, and a circuit for effecting a transmission of the signaling currents.

2. A telegraph system for transmitting characters comprising means for translating the characters into code combinations of more than two shades of unit areas, an instrumentality for effecting signaling currents corresponding thereto, and a circuit for transmitting the signaling currents.

3. A telegraph system for transmitting symbols comprising means for translating the symbols into permutation code combinations of shades of unit areas, an instrumentality for producing signaling currents corresponding thereto, a circuit for transmitting the signaling currents, and receiving apparatus for effecting a printing of symbols corresponding to the signaling currents including a decoder and a printing device operated thereby.

4. A telegraph system for transmitting symbols comprising means for producing permutation code combinations of current and no-current impulses representing the symbols, means for translating the first-mentioned code combinations into code combinations of impulses of light of more than two intensities, means responsive to the second-mentioned code combinations for producing signaling currents corresponding thereto, and a circuit for effecting a transmission of the signaling currents.

5. A telegraph system for transmitting symbols comprising means for producing perforate representations of the symbols, means for translating the perforate representations into permutation code combinations of impulses of light, means responsive to the code combinations for effecting signaling currents corresponding thereto, a transmission circuit, and a receiving instrumentality for accomplishing a printing of sym-

bols corresponding to the signaling currents including a decoder and a printing apparatus operated thereby.

6. A telegraph system for transmitting symbols comprising means for producing perforate representations of the symbols, means for producing code combinations of current and no-current impulses corresponding to the perforate representations, means for translating the first-mentioned code combinations into code combinations of more than two shades of unit areas, means for effecting signaling currents corresponding to the second-mentioned code combinations, a circuit for transmitting the signaling currents, and an instrumentality for accomplishing a printing of symbols corresponding to the signaling currents including a decoder and a printing apparatus operated thereby.

7. A telegraph system comprising a communication channel, telephotographic transmitting and receiving apparatus connected to the channel for transmitting and receiving signaling currents representing a plurality of shades of unit areas of photographs, printing telegraph transmitting and receiving apparatus, and means for representing each character transmitted by the telegraph transmitter by a permutation code combination of a plurality of shades of unit areas connected between the telegraph and telephotographic apparatus.

8. A telegraph system for transmitting symbols comprising means for translating the symbols into permutation code combinations of impulses of light of more than two different intensities, means for producing signaling currents corresponding thereto, a transmission circuit, and a receiving instrumentality for effecting a printing of symbols corresponding to the signaling currents including means for reproducing the code combinations of impulses of light produced initially to represent the symbols, means for effecting currents corresponding to the reproduced code combinations, a plurality of relays operated selectively by the last-mentioned currents for effecting teletypewriter code combinations of impulses, and a teletypewriter operated by the last-mentioned code combinations.

9. A telegraph system for transmitting symbols comprising means for translating the symbols into permutation code combinations of shades of unit areas, means for producing signaling currents corresponding thereto, a transmission circuit, and a receiving instrumentality for effecting a printing of symbols corresponding to the signaling currents including means for reproducing the code combinations of shades of unit areas produced initially to represent the symbols, means for effecting currents corresponding to the reproduced code combinations, a plurality of relays operated selectively by the last-mentioned currents for effecting teletypewriter code combinations of impulses, and a teletypewriter operated by the last-mentioned code combinations.

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