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APPARATUS AND METHOD FOR ELECTRICAL TRANSMISSION OF PICTURES

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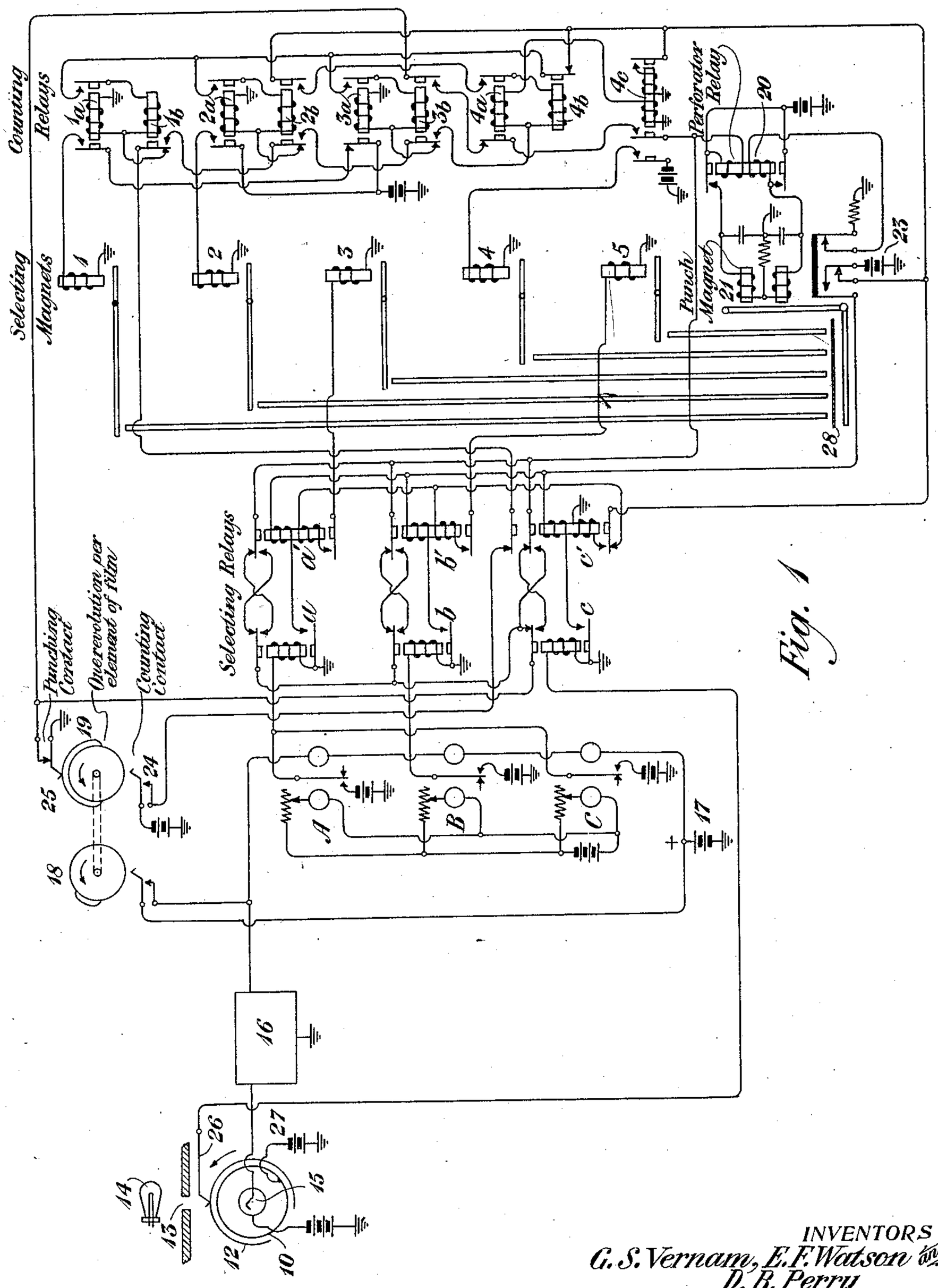

Fig. 1

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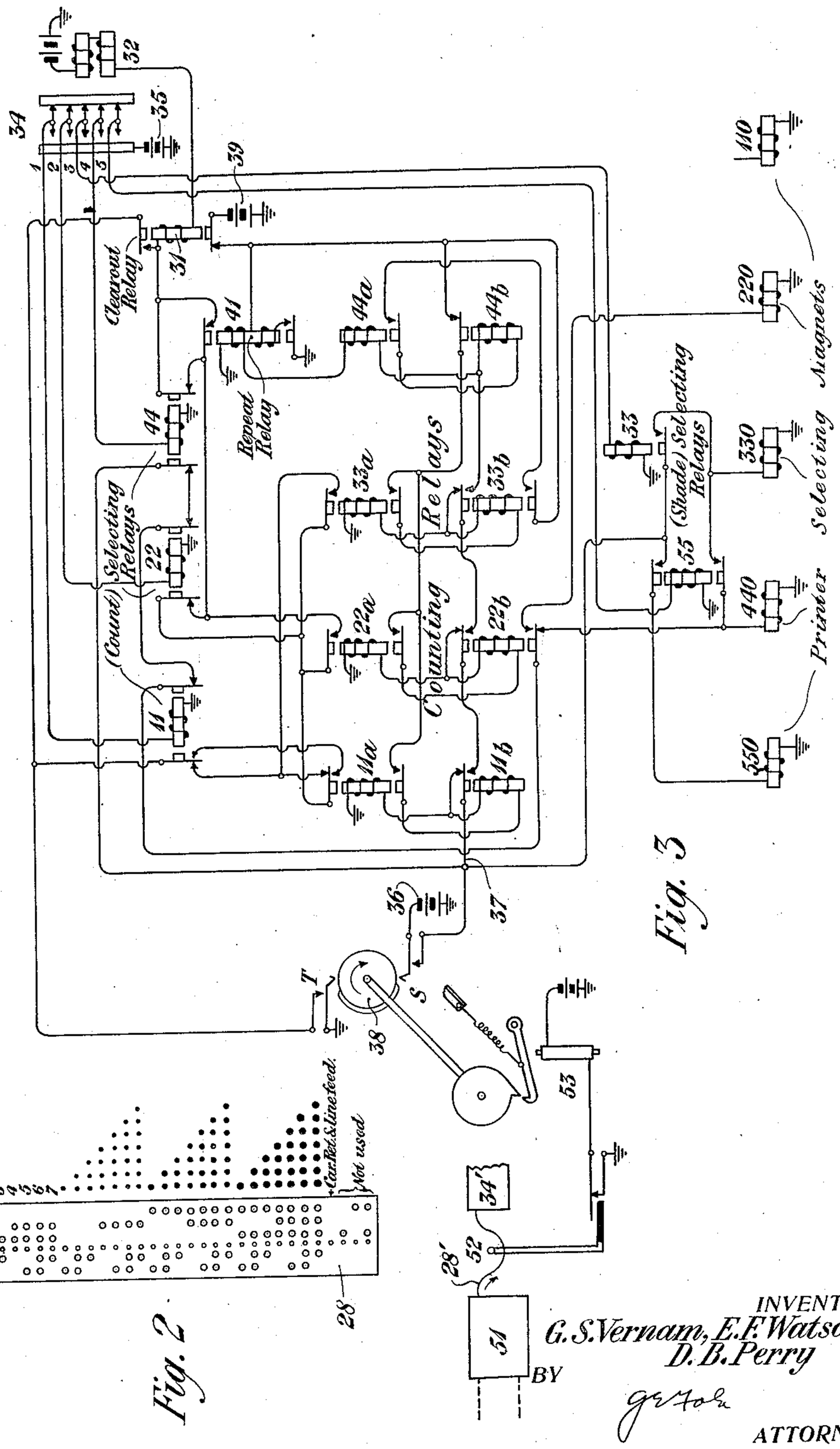

Fig. 3

Fig. 2

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UNITED STATES PATENT OFFICE

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APPARATUS AND METHOD FOR ELECTRICAL TRANSMISSION OF PICTURES

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The principal object of our invention is to provide a new and improved method and suitable apparatus for transmitting pictures to a distance by electrical impulses. Another object of our invention is to provide for analyzing a picture into small elements of area and transmitting code combinations corresponding to the degree of shade of the successive elements. Another object of our invention has relation to transmitting a single code combination for a sequence of elements of like shade, the combination indicating both the degree of that shade and the number of elements in the sequence. These and various other objects and advantages of our invention will become apparent on consideration of the specific example of the practice of the invention which we have chosen to disclose in the following specification and illustrate in the accompanying drawings. It will be understood that the invention is defined in the appended claims and that the following specification relates to the particular example here presented to illustrate the invention.

Referring to the drawings, Figure 1 is a diagram showing the transmitting apparatus, Fig. 2 is a plan showing the code as punched in a section of tape and Fig. 3 is a diagram showing the receiving apparatus.

The picture to be transmitted is in the form of a semi-transparent film 12 which is wrapped about the glass drum 10; this is rotated on its axis and meanwhile traversed relatively slowly along its axis so that the portion of the film 12 adjacent to the opening in the screen 13 describes a helical course of adjacent turns on the film 12. The light from the source 14 shining through the opening in the screen 13 and through the underlying portion of the film 12 falls on the photoelectric cell 15. The current in the circuit of the cell 15 is accordingly varied in correspondence with the varying degree of shade in the spot of the film 12 adjacent to the opening in the screen 13. This varying current through the cell 15 causes a correspondingly varying electromotive force in the input circuit of the amplifier 16. The three marginal relays A, B and C are in the output circuit of the amplifier 16. The adjustments are such that for a part of the film 12 corresponding to white none of the relays A, B or C will pick up; for light grey A only will pick up, as shown in Fig. 1; for dark grey A and B will pick up but not C; and for black all three relays A, B and C will pick up.

The cams 18 and 19 rotate once for each unit or element of the picture film 12 lying under the opening of the screen 13.

The tape 28 (shown both in Figs. 1 and 2) is punched with a code combination when the shade changes to indicate the preceding shade and to indicate the number of picture elements in sequence having that same shade. The code employed is the usual five unit code the same as for ordinary printing telegraphy. The third and fifth positions are for the four degrees of shade and the first, second and fourth positions are for the number of unit elements in the sequence having the same shade. As shown in Fig. 2, this number of units permits counting a number of elements up to seven inclusive, and as will be pointed out presently, if a sequence of seven elements of like shade is encountered in the picture to be transmitted, the count is made to seven and then the apparatus is cleared ready to repeat.

Suppose that a single white unit in the picture film 12 is to be transmitted. A glance at Fig. 2 shows that the corresponding code impression in the tape comprises holes punched in the first and third positions, the punch in the first position meaning a single unit and the punch in the third position meaning the white shade.

As already stated, for the white shade the current in the output circuit of the amplifier 16 will be so low that none of the marginal relays A, B and C will be operated and their armatures will all be on their back contacts at the left.

With the armature of relay A on its back contact, relay *a* will be energized so that when cam 19 closes contact 25 a circuit will be made through the back contact of relay *c*, upper front contact of relay *a*, back contact of relay *a'* to the perforator relay 20, which will cause the latter to lock up and energize the punch magnet 21. This will punch in the tape 28

whatever combination is set up at the time by the selecting magnets 1, 2, 3, 4 and 5 and this combination will show the preceding shade in the picture and the number of picture elements having that shade.

The operation of the punch magnet 21 closes a circuit from battery 23, through the upper winding of relay a' and causes it to operate. Also, the operation of the punch magnet 21 breaks the locking circuits for relays b' and c' and releases them if they or either of them had previously been locked up; also the operation of the punch magnet 21 releases any of the counting relays $1a$, $1b$, $2a$, etc., that may have been locked up previously. The operation of the punch magnet 21 also breaks the locking circuit for the perforator relay 20, which opens and thereby releases the punch magnet. The release of the punch magnet then closes a circuit from battery 23, through the lower back contact of relay c' and the lower winding and front contact of relay a' to energize selector magnet 3 and also lock up relay a'.

The cam 19 continues to rotate and closes the contact at 24, the counting contact. This closes a circuit from battery, through the upper back contact of relay c', the back contact of relay $1b$ and the winding of relay $1a$, which operates accordingly. This connects battery 23 through the armature of $4b$ and the armature of $1a$ to the winding of $1b$, but $1b$ does not operate at this time because it is already shunted by the low resistance path just traced through the contacts at 24, c' and $1b$.

Also, the operation of relay $1a$ closes the circuit for selecting magnet 1 and causes it to operate.

When the counting contact 24 opens, this opens the shunt around relay $1b$, which operates and transfers the counting circuit (through the upper back contact of relay c') so that now, instead of connecting to $1a$ and $1b$ it connects to $2a$ and $2b$.

We have already assumed that only a single element of white shade is to be transmitted so that accordingly the shade will now change. Assume that it changes to light grey. Marginal relay A will be energized and relay a will be released. When the cam 19 makes the contact 25, a circuit is closed from ground, through the contact 25, back contact of relay c, back contact of a, front contact of a' to the perforator relay 20. This operates as described before and the punch magnet 21 operates as described before, and selector magnets 1 and 3 having been previously energized, holes are punched at the first and third positions, as shown in Fig. 2. The operation of the punch magnet 21 releases the counting relays by breaking their circuit at the contact adjacent to battery 23 and the system is ready to start over again.

Let us go back and suppose that instead of a single white element in the film 12 there were five such elements in succession. Then, when the punch contact 25 closes, instead of getting the result last described, the perforator relay 20 will not operate because its circuit will be open at the back contact of relay a. However, the counting contact 24 will close a circuit from battery, through the upper back contact of relay c', front contact of relay $1b$, back contact of relay $2b$, through the winding of counting relay $2a$, which will operate at once. By the operation of $2a$, battery 23 will be applied through the winding of relay $2b$, and as soon as the contact 24 opens, opening the shunt around $2b$, battery 23 will become effective and operate $2b$ as well as $2a$.

On the next revolution of the cams 18 and 19 corresponding to the next element of the picture film 12, counting relays $3a$ and $3b$ will be operated and locked up in similar manner. Then on the next rotation of the cams 18 and 19 for another element of film 12, relays $4a$ and $4b$ will be operated in like manner. It will be noticed that relay $4a$ has its winding in series with a winding of relay $4c$ so that relay $4c$ operates simultaneously with $4a$, and $4c$ locks up by current from the battery 23. Also $4c$ closes a direct circuit from battery through the selecting magnet 4.

When the counting contact at 24 opens after the fourth count, relay $4b$ operates by reason of the opening of the shunt around it. The operation of $4b$ breaks the circuit from battery 23 to the relays $1a$, $1b$, $2a$, $2b$, $3a$ and $3b$ and allows them to release. Then, when $2b$ releases it breaks at its right-hand front contact the circuit for $4a$ and $4b$ and they release, but $4c$ remains locked up.

On the fifth revolution of the cams 18 and 19 corresponding to the fifth successive element of white shade in the film 12, relays $1a$ and $1b$ are operated again successively upon the closure and subsequent opening of the contact 24, causing selecting magnet 1 to be operated. After the fifth revolution the shade changes in the film 12, operating one or more of the relays A, B and C and thus, as described heretofore, establishing a circuit for the perforator relay 20 and allowing the punch magnet 21 to operate and punch holes at positions 1, 3 and 4, indicating a sequence of five white elements as shown in Fig. 2. The operation of the punch magnet 21 clears the counting relays by breaking the circuit from battery 23, as previously described.

If a shade recurs more than seven times in succession a punch will be made on the seventh count and the count will be begun again for another series. We have already seen that on the fourth count the relay $4c$ locks up; on the fifth count $1a$ and $1b$ are operated; on the sixth count relays $2a$ and $2b$ are operated and on the seventh count relays $3a$ and

3*b* are operated. 3*b* closes at its front contact on the right a circuit from battery, through the upper winding of perforator relay 20, inner left contact of relay 4*c*, back contact of relay 4*a*, right front contact of relay 3*b*, and this circuit is completed at 25 to operate the perforator relay 20 and the punch magnet 21. The operation of the punch magnet 21 punches holes in the second and fourth positions to indicate seven elements of like shade and other holes (or a blank) in other positions to indicate the degree of shade; also the operation of the punch magnet 21 clears out the counting relays, as described heretofore, ready to begin over again.

A contact 26 at the transmitting drum 10 is closed through battery 27 at the edge of the film 12. The circuit thus established through the winding of relay *c* energizes the latter and closes the upper front contact of relay *c* so that when the punching contact is made at 25 the circuit is closed for the perforator relay 20, thereby causing the punch magnet 21 to punch whatever combination happens to be set up at that time, that is when the edge of the film 12 is reached by the contact 26. The operation of the punch magnet 21 clears out the counting relays as has been described and causes the relay *c'* to be picked up and locked up by current from the battery 23. This condition continues until the other edge of the film 12 reaches the contact 26 and breaks it; during this time both the circuit for perforator relay 20 and the counting circuits are held open at the upper back contacts of relays *c* and *c'*.

But at the other edge of the picture when the contact 26 is broken, relay *c* releases and the circuit for perforator relay 20 is established through the upper back contact of relay *c* and a front contact of relay *c'*, which remains locked up. The circuits of selector magnets 3 and 5 are both open at the lower back contact of relay *c'* at this time, and when the contact 25 is closed and the perforator relay 20 operates, causing the punch magnet 21 to operate, the blank combination will occur on the tape, which is the code for "carriage return and line feed". This will be explained further in connection with the discussion of the receiving apparatus that is to follow.

The cam 18 closes briefly for each element of the picture, shunting out the marginal relays A, B and C; this allows them to operate always on the same point on their magnetization curves for the same shade, that is on an increasing and not a decreasing current. The contact at 18 is closed momentarily immediately after the punch contact at 25 opens and this gives the marginal relays A, B and C sufficient time to release and operate again before the next punching operation.

The tape produced at the sending end according to the code of Fig. 2 is put through a transmitter and thereby at the receiving end a similar tape is punched out in the perforator 51 of Fig. 3. This received tape is passed through the tape transmitter 34, 34' of Fig. 3, which is of a type used in printing telegraphy. The drawing is meant to indicate symbolically that the contacts numbered from 1 to 5 adjacent to 34 are closed to the battery 35 for each hole in the corresponding position in the tape. These five contacts control circuits to the respective relays 11, 22, 33, 44 and 55, of which 11, 22 and 44 are count selecting relays and 33 and 55 are shade selecting relays.

The perforated tape 28' at the receiving end passes from the perforator 51 to the tape transmitter 34' in a loop under the member 52 so arranged that when the tape 28' is pulled up it will cause the circuit of magnet 53 to open and stop the operation of the receiving printer.

The printing is done on a page in a page printing receiver in which the printer selecting magnets 110, 220, 330, 440 and 550 are employed. The magnet 110 is unnecessary for picture printing, and the remaining four magnets mentioned operate according to the following code:

Printer selecting magnets operated	Characters printed and other printer operations
330	Space or blank
None	Small dot
550	Medium dot
330, 440, 550	Large dot
440	Carriage return
220	Line feed

This particular code arrangement is shown as one suited for use in connection with certain ordinary printing telegraph machines now widely used.

The tape is inserted in the tape transmitter 34 in readiness so that one step will bring it to the first code combination of the picture. The circuit to effect this step is closed at T by the cam 38 on the printer main shaft which rotates continuously. This circuit is traced from ground as follows; through contact T, back contacts of relays 11, 11*a*, 22 and 44 and through the windings of the clear-out relay 31 and the tape transmitter magnet 32 to battery. Upon the closure of this circuit the clear-out relay 31 and the tape transmitter magnet 32 are operated, and they release when the circuit opens at T.

The cam 38 is designed to allow a sufficient time to elapse after the contact T opens for the tape transmitter magnet 32 to release and for the transmitter contacts at 34 to energize the respective relays with which they are connected before the contact S closes at 38.

If relay 33 of the two shade selecting relays is energized, then when contact S closes battery 36 will be connected through printer selecting magnet 330. This will cause the printer to record a space or blank as indi-

cated in the foregoing table. If relay 55, but not 33, is energized, the contact closure at S will connect the battery to printer selecting magnet 550 and a medium dot will be printed. If relays 33 and 55 are both energized, then contact closure at S will apply battery to magnets 330, 440 and 550 in parallel and a large dot will be printed. If neither relay 33 nor 55 is energized, no impulse will be sent through the printer selecting magnets, and a small dot will be printed.

For an example to explain the action of the counting relays 11, 22 and 44, let it be assumed that the code combination 1, 2, 5 has been set up in the tape transmitter. A reference to Fig. 2 shows that this corresponds to a sequence of two medium dots. The transmitter contacts at 34, numbered 1, 2 and 5, will be closed to the battery 35, and therefore the relays 11, 22 and 55 will be energized. When the cam 38 closes contact S, printer selecting magnet 550 will be energized thus preparing the printer for recording a medium dot. At the same time the relay 11*a* will be energized by the closure of the contact S through a circuit from battery 36 through the back contact of relay 11*b*. Accordingly the relay 11*a* will connect battery 39 to the lower end of the winding of relay 11*b*, but relay 11*b* will not operate until contact S opens, because meanwhile relay 11*b* is shunted through said contact S. When relay 11*b* does operate, it transfers the counting circuit 37 to the armature of relay 22*b* and thence to the winding of relay 22*a*.

As the cam 38 continues to rotate, contact T will be closed and will connect ground through the front contacts of relays 11 and 11*a* to the armatures of relays 22, 22*a* and 33*a*, but as these are all opened, the transmitter magnet 32 will not be energized. When contact S closes on the next revolution, the printer selecting magnet 550 will be energized again to cause the printer to record another medium dot, and relays 22*a* and 22*b* will be energized in succession in the manner heretofore described for 11*a* and 11*b*. Then when contact T is again closed by the further rotation of the cam 38, ground will be connected through T and the front contacts of relays 11, 11*a* and 22*a* and the back contact of relay 44 to the windings of the clear-out relay 31 and the tape transmitter magnet 32. The tape will now step ahead to a new signal combination. The actuation of the clear-out relay 31 establishes a direct circuit from ground through the contact T and front contact of relay 31, through said relay 31 and the tape transmitter magnet 32; this insures that the tape transmitter 34 will receive a full length impulse. The opening of the back contact of relay 31 removes battery 39 from the counting relays and releases them.

In what goes before, we have traced the operation for the code combination 1, 2 and 5 corresponding to a sequence of two medium dots as shown in Fig. 2. 1 and 2 determine the count and 5 determines the shade. Assuming that the shade is the same, other settings of the count selecting relays 11, 22 and 44 will cause the selected shade character to be recorded a different number of times as follows:

If relay 11 is energized alone, the tape feed circuit controlled at T will be closed through the front contacts of relays 11 and 11*a* and back contacts of relays 22 and 44 after a single contact closure at S. If relays 11 and 22 are both operated, the said tape feed circuit controlled at T will remain open until contact S has operated twice as in the case previously followed through in detail. If relay 22 alone is operated, contact S must operate three times so as to energize relays 11*a*—22*a* and 33*a* and then close the tape feed circuit controlled at T through the back contact of relay 11, front contacts of relays 33*a* and 22*a* and back contact of relay 44.

If relay 44 alone is operated, four revolutions of the cam 38 must take place which will operate all four of the pairs of counting relays. Thereupon, with the operation of the relay 44*a*, the repeat relay 41 will operate and lock by current from battery 39. Relay 44*b* releases all the counting relays to the left thereof, and relay 33*b* then releases 44*a* and 44*b* so that after four operations of contact S the repeat relay 41 is the only relay remaining energized of the counting group. The tape feed circuit controlled by T is now closed through back contacts of relays 11, 11*a* and 22 and the upper front contact of repeat relay 41.

If relays 11 and 44 are both energized, the tape feed circuit controlled by T will be held open until the repeat relay 41 pulls up on the fourth revolution as described above and until relay 11*a* is energized again by the fifth operation of contact S. The tape feed circuits from T for this case of five characters, and also for the cases of six or seven characters, are the same, respectively, as for counts of 1, 2 or 3 as described heretofore, except that in each case the tape feed circuit extends through the front contact of the relay 41 instead of the back contact of relay 44.

The foregoing description covers the operations of printing from one to seven like characters from the respective code combinations of the tape. The carriage return and line feed operations which are determined when no holes are punched in the tape will now be described. In this case when the contact T opens, the tape transmitter contacts at 34 will all be held away from connection with battery 35, and all five selecting relays 11, 22, 33, 44 and 55 will remain deenergized. Then when contact S closes, a circuit will be established from battery 36, through back contacts of relays 44, 22, 11 and 22*b* to printer select-

ing magnet 440, which, in accordance with the foregoing table controls the carriage return operation of the printer. Relays 11*a* and 11*b* will also be operated by the closure and subsequent opening of contact S, and on the second revolution of the cam 38 a second impulse will be sent through magnet 440 over the same circuit as before. This will have no effect on the printer except to provide more time for the carriage to return, and at this time relays 22*a* and 22*b* will be energized. Then when contact S closes the third time, an impulse will be sent through printer selecting magnet 220, instead of 440 (due to the energization of relay 22*b*). This causes the printer to feed the paper one line in accordance with the last entry in the foregoing table, and at the same time relays 33*a* and 33*b* are energized. When contact T closes, the tape transmitter magnet 32 will be energized over a circuit from T, through back contact of relay 11, front contacts of 33*a* and 22*a*, back contact of relay 44, winding of relay 31 and tape transmitter magnet 32 to battery.

Thus it will be seen that, with the tape reproduced at the receiving station in accordance with the code of Fig. 2, the code combinations control the receiving printer to print a space or a dot of varying size and to repeat each such space or dot any number of times from one up to seven, and automatically to perform the operations of carriage return and line feed.

We claim:

1. In a picture transmitting system, means to explore successive elements of the picture and to automatically transmit code currents corresponding both to the number of elements in a sequence of like shade and to the shade of the elements of such sequence, means for varying said code currents in accordance with the number of elements in a sequence, and means to receive such currents and reproduce the picture accordingly.

2. In a picture transmitting system, means to automatically explore successive elements of the picture and to punch code combinations in a tape corresponding both to the number of elements in a sequence of like shade and the shade of said sequence, said code combinations varying in accordance with the number of elements in a sequence and means to reproduce a similar tape at the receiving end and therefrom to reproduce the picture accordingly.

3. In a picture transmitting system, means to automatically produce a tape punched with code combinations to represent the number of picture elements in a sequence of elements of like shade and to represent that shade, said code combinations varying in accordance with the number of elements in a sequence, means to impress a character of corresponding shade at a corresponding position on a picture receiving surface, and means to repeat that same character in successive positions on that surface the number of times corresponding to the number embodied in the code.

4. In a picture transmission system, marginal relays, a circuit therefor, means to automatically send sequences of current impulses to said relays, means to count current impulses in a sequence of like strength to said relays, means operable on change of strength in successive impulses to record the number of impulses in the counted sequence and the degree of strength of those impulses and picture reproducing means responsive to the recorded impulses.

5. In a picture transmission system, marginal relays, a circuit therefor, means to automatically send sequences of current impulses to said relays, counting relays, means to operate the counting relays for a sequence of impulses of equal strength through the marginal relays, means to record the count and also to record the number and degree of strength of the impulses when the degree of strength of those impulses changes through the marginal relays and picture reproducing means responsive to the recorded impulses.

6. In a picture transmission system, the combination of a tape perforator, means for operating said perforator in accordance with received current corresponding to picture characteristics, a tape transmitter to be operated by the tape from said perforator, picture receiving apparatus controlled by said transmitter, and means depending upon the condition of said tape for controlling the speed of said receiving apparatus.

7. In a picture transmission system, a tape perforator, means for operating said perforator in accordance with received currents corresponding to picture characteristics, a tape transmitter governed in its operation by said tape, picture receiving apparatus controlled by said transmitter, a stop for said apparatus, a magnet and a control circuit for said stop, and a switch for said circuit governed by said tape.

8. In a picture transmitting system, means to explore successive elements of the picture, means to count the number of like elements in a sequence, means to make a record of said count, said record varying in accordance both with the number of elements in a sequence and with their shade, means to transmit code currents corresponding to said record, and means to receive such currents and reproduce the picture accordingly.

9. In a picture transmitting system, means to automatically produce a code record with code combinations in accordance with both the number of picture elements in a sequence of elements of like shade and in accordance with that shade, means to impress a corresponding degree of shade at a

corresponding position on a picture receiving surface, and means to repeat that same impression in successive positions on that surface the number of times corresponding to the number embodied in the code.

10. The method of transmitting a picture which consists in analyzing it into sequences of elements of like shade, automatically transmitting a code combination of currents for each sequence, each combination varying in accordance with the number of elements in the sequence and the shade of those elements, and reproducing the picture from these currents.

11. The method of transmitting a picture which consists in analyzing it into sequences of elements of the same shade, for each sequence of a different number of elements automatically transmitting a corresponding code combination, and for each such code combination received printing a sequence of characters of the corresponding number and shade on a receiving surface.

12. In combination, a picture having groups of elemental areas the size of each group determined by the number of successive areas with the same degree of shade, means for testing and counting the number of elements in a group, and means responsive to said count for making a single code record indicating the number of elemental areas counted and their degree of shade.

13. The method of transmitting a picture, which consists in exploring its elements successively for degree of shade, counting the elements of like shade in sequence, recording a code combination for the number of the sequence and the shade when the shade changes, and reproducing the picture from this record.

In testimony whereof we have signed our names to this specification this 13th day of December, 1923.

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