Jan. 11, 1927. 1,613,686

G. S. VERNAM

METHOD OF AND APPARATUS FOR SECRET ELECTRICAL TRANSMISSION OF PICTURES

Filed Dec. 5, 1924 2 Sheets-Sheet 1

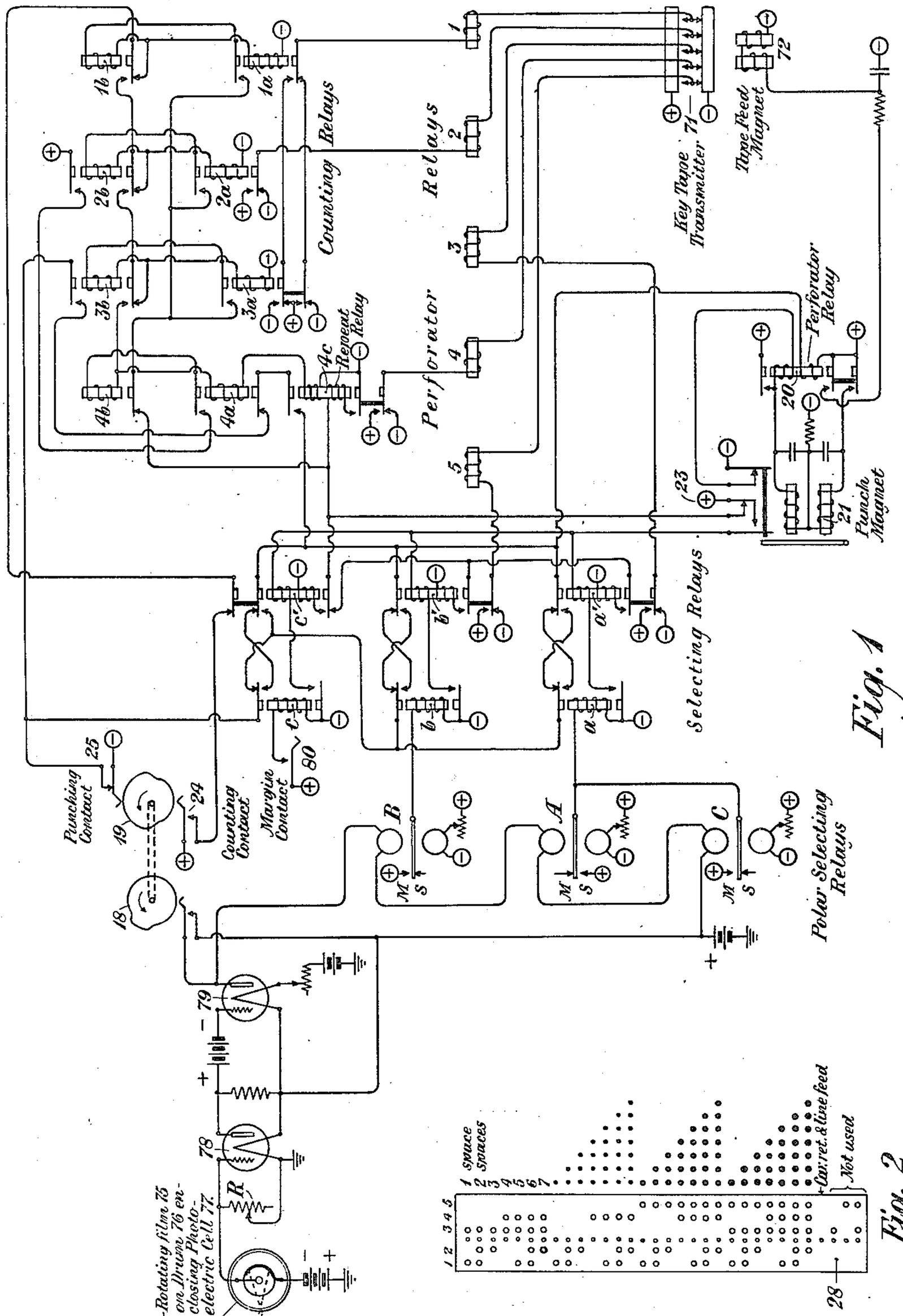

Fig. 1

Fig. 2

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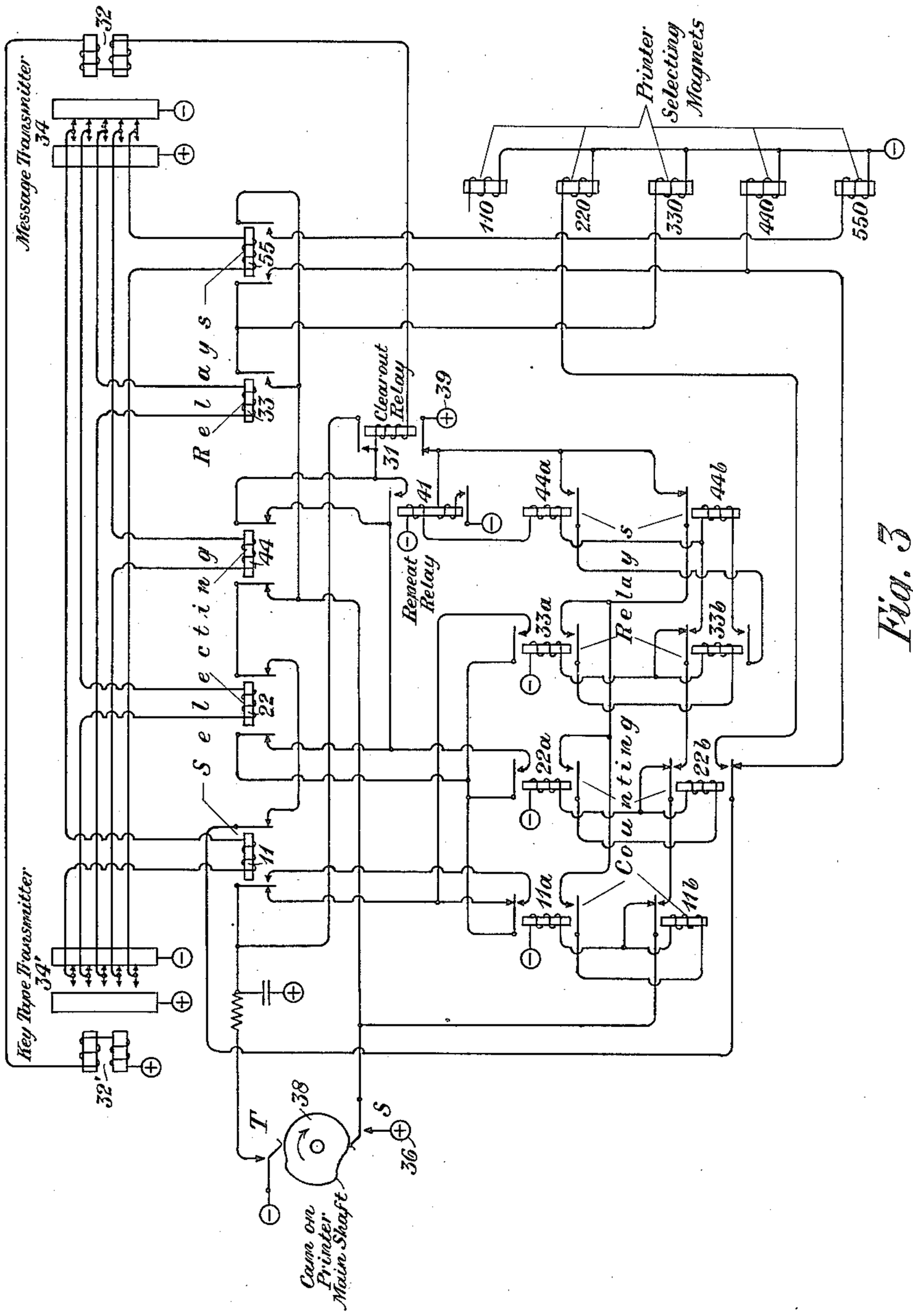

Fig. 3

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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR SECRET ELECTRICAL TRANSMISSION OF PICTURES.

Application filed December 5, 1924. Serial No. 754,166.

This invention relates to an improved method of and apparatus for transmitting pictures to a distance by electrical impulses. One of the objects of the 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 the invention has relation to transmitting a single code combination for a sequence of elements of like shade, the combination indicating both the degree of shade and the number of elements in sequence. A further object of the invention consists in providing for absolute secrecy in the transmission of the code combinations sent out representing the elements of the picture so that any unauthorized person who might have access to the medium through or over which these code combinations might be transmitted would not be able to obtain a likeness of the picture therefrom. These and various other objects and advantages of the 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 circuit diagram showing the transmitting apparatus, Fig. 2 is a plan showing the code as punched in a section of the tape, and Fig. 3 is a circuit diagram showing the receiving apparatus.

The picture to be transmitted is in the form of a semi-transparent film 75 which is wrapped about the glass drum 76; this drum is rotated on its axis and meanwhile traversed relatively slowly along its axis so that the portion of the film 75 adjacent to the opening in the screen 74 describes a helical course of adjacent turns on the film 75. The light from source 73 shining through the opening in the screen 74 and through the underlying portion of the film 75 falls on the photoelectric cell 77. The current in the circuit of the cell 77 is accordingly varied in correspondence with the varying degree of shade in the spot of the film 75 adjacent to the opening in the screen 74. This varying current through the cell 77 causes a correspondingly varying electromotive force in the input circuit of the amplifier 78 and amplifier 79. Three marginal polar selecting relays A, B and C are in the output circuit of amplifier 79. The adjustments of these relays are such that for a part of the film 75 corresponding to white none of the relays A, B or C will operate; for light gray only A will be operated; for dark gray A and B will operate but not C; and for black all three relays A, B and C will be operated.

The cams 18 and 19 rotate once for each unit or element of the picture film 75 lying under the opening of the screen 74.

The tape shown in Fig. 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 75 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 79 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 lower or spacing contacts.

With the armature of relay A on its spacing contact, relay *a* will be energized so that when the cam 19 closes contact 25 a circuit will be made through the back contact of relay *c*, front contact of relay *a*, back contact of relay *a'*, to the perforator relay 20, which

will cause the later to lock up and energize the punch magnet 21. This will punch in the tape 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 the positive 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 the relays b', and c', and releases them if they or either of them have previously been locked up. Also the operation of the punch magnet 21 releases any of the counting relays 1^a, 1^b, 2^a, 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 the battery 23, through the lower back contact of relay c', and the lower front contact and winding of relay a' to lock up relay a'. Also, the operation of relay a' closes the circuit to energize the selector magnet 3.

The cam 19 continues to rotate and closes a contact at 24, the counting contact. This closes a circuit from battery through the upper back contact of relay c', back contact of relay 1^b and the winding or relay 1^a, which latter relay operates accordingly. This connects battery 23 through the back contact of relay 4^b and the front contact and armature of 1^a to the winding of 1^b, but 1^b 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 1^b.

Also, the operation of relay 1^a closes the circuit for selecting magnet 1 and causes it to to operate. It is pointed out at this point that the circuits of the selecting magnets 1, 2, 3, 4 and 5 are not connected directly to negative battery but are connected to the negative bus-bar of a key tape transmitter 71 provided for purposes of secrecy as will be pointed out in detail hereinafter. To set up the combinations in unciphered form, as shown in the code of Fig. 2, a blank tape will be inserted in transmitter 71 to hold the contacts on the negative bus-bar.

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

We have already assumed that only a single element of white shade is to be transmitted so that acordingly the shade will now change. Assume that it changes to light gray. Marginal relay A will be energized and relay a will be released. When the cam 19 makes the contact 25 a circuit is closed through the contact 25, back contact of relay c, back contact of relay a, front contact of relay a' to the perforator relay 20. This operates as previously described 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 and relay a' by breaking their circuit at the contact adjacent to battery 23, and the system is ready to start over again. The perforator selecting magnets will also be released at this time.

Let us go back and suppose that instead of a single white element in the film 75 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 contacts of relays a and a'. However, the counting contact 24 will close a circuit from battery, through the upper back contact of relay c', front contact of relay 1^b, back contact of relay 2^b, through the winding of counting relay 2^a, which will operate at once. By the operation of 2^a, battery 23 will be applied to the winding of relay 2^b, and as soon as the contact 24 opens, opening the shunt around 2^b, battery 23 will become effective and operate 2^b as well as 2^a. Perforator selecting magnet 2 will be energized at this time.

On the next revolution of the cams 18 and 19 corresponding to the next element of the picture film 75, counting relays 3^a and 3^b will be operated and locked up in similar manner. Selecting magnet 1 will be released. Then, on the next rotation of the cams 18 and 19 for another element of the film 75, relays 4^a and 4^b will be operated in like manner. It will be noticed that relay 4^a has its winding in series with a winding of relay 4^c so that relay 4^c operates simultaneously with 4^a and 4^c locks up by current from the battery 23 through its lower winding. Also 4^c closes a direct circuit from battery, through the selecting magnet 4, which operates at this time.

When the counting contact at 24 opens after the fourth count, relay 4^b operates by reason of the opening of the shunt around it. The operation of 4^b breaks the circuit from battery 23 to the relays 1^a, 1^b, 2^a, 2^b, 3^a and 3^b, and allows them to release, releasing also selecting magnet 2. Then, when 2^b releases it breaks at its upper front contact the circuit for 4^a and 4^b but relay 4^c 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 75, the

relays 1^a and 1^b 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 75, 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 4^c locks up; on the fifth count 1^a and 1^b are operated; on the sixth count relays 2^a and 2^b are operated, and on the seventh count relays 3^a and 3^b are operated. 3^b closes at its upper front contact a circuit to battery, through the winding of perforator relay 20, upper front contact of relay 4^c, back contact of relay 4^a and upper front contact of relay 3^b, when 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 margin contact 80 is associated with the transmitting drum 76 and is closed through to a battery at the edge of the film 75. 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 75 is reached by the contact 80. 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 75 reaches the contact 80 and breaks it. During this time, 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 80 is broken, relay *c* releases and the circuit for perforator relay 20 is established through the upper back contacts of relay *c* and a front contact of relay *c'*, which remains locked up. The circuits of relays *a'* and *b'* are both open at the lower back contact of relay *c'* at this time and the counting relays are all released and therefore all the selecting magnets will be deenergized so that 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.

A contact operated by 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 combination.

In order to provide for secrecy in the transmission of the code combinations set up on the perforator selecting magnets 1, 2, 3, 4 and 5, a tape transmitter 71 is provided, having positive and negative bus-bars and a tape feed magnet 72, controlled by the perforator relay 20. If a blank key tape were inserted in this key tape transmitter 71 so that all of the contacts would be against the negative bus-bar, as pointed out previously, the code combinations set up on the selecting magnets 1, 2, 3, 4 and 5 would correspond to the code illustrated in the tape of Fig. 2. However, a cipher key tape having a series of arbitrarily chosen code combinations will be inserted in the tape transmitter 71 and these code combinations will be combined, in effect, with the code combinations which would otherwise be set up on the selecting magnets 1, 2, 3, 4 and 5, in order to produce a scrambled or unintelligible set of code combinations for transmission to the distant station. Such a cipher system is disclosed in detail in United States Patent No. 1,310,719, in the name of G. S. Vernam, and for a more complete understanding of the principles of operation thereof reference may be had to this patent.

One end of the winding of each of the perforator selecting magnets 1, 2, 3, 4 and 5 is shown connected to a corresponding contact of the tape transmitter 71. If the contacts of this tape transmitter are all resting against the lower bus-bar, as shown in the drawing, so as to connect the selecting magnets to the negative side of the power supply, the operation of the perforator and the relays would give a normal indication of the

code combinations illustrated in Fig. 2. In other words, these code combinations would not be ciphered. If a cipher tape is now inserted in the tape transmitter 71 and any of the transmitter contacts are thereby allowed to move against the upper or positive bus-bar, the action of the relay contacts on the corresponding selecting magnets will be reversed. For example, we may assume that the code combination representing two light gray picture elements is to be recorded in order to print two small dots or periods at the receiving station. In this case, the selecting relays will all be released and the counting relays 1^a, 1^b, 2^a, and 2^b will be energized. This would normally energize perforator selecting magnets 1 and 2. If we assume that the contacts 1, 3 and 4 of the tape transmitter 71 are against the upper bus-bar, the return side of the windings of selecting magnets 1, 3 and 4 will be connected to the positive terminal of the power supply, while magnets 2 and 5 will remain connected to the negative terminal. As relay 1^a is energized and relay 3^a deenergized, both ends of the winding of selecting magnet 1 will be connected to positive polarity, and this magnet will not be energized. Magnet 2 will be connected to the positive terminal at the front contact of relay 2^a, and to the negative terminal at the lower bus-bar of the tape transmitter. This magnet will, therefore, be energized. Magnets 3 and 4 will be connected to positive at the transmitter and to negative at the back contacts of relays a' and 4^c, respectively. These magnets will both be energized. Magnet 5 will have negative potential applied to both ends of its windings and will remain deenergized. When the punch magnet operates, the combination 2, 3, 4 will be perforated therefore, instead of the normal combination 1, 2. This form of code combination normally represents seven white elements or spaces so that the key tape has, in effect, ciphered the code combination in the perforator tape so as to change the number of repetitions as well as the shade it represents. When the perforator relay 20 operates to energize the punch magnet 21 it also establishes a circuit for operating the tape feed magnet 72 of the tape transmitter 71. This causes the key tape to feed forward one step in the usual manner so that a different key will be used for the next character to be punched in the code tape.

The enciphered and unintelligible picture message tape will then be transmitted in any desirable manner to the receiving station such as is shown in Fig. 3. It will then be inserted in the message transmitter 34. At the receiving station there will be provided a key tape identical with the one utilized at the sending station to scramble the picture message. This key tape will be inserted in the key tape transmitter 34′. The code combination of the key tape will then combine in effect with the code combination of the enciphered picture message tape to set up on the selecting relays 11, 22, 33, 44, and 55 the code combinations representing the elements of the picture just as if these had not been sent out in enciphered form from the sending station. The principles of this operation are explained in detail in the aforementioned Patent 1,310,719 to G. S. Vernam. For purposes of illustration let it be assumed that the scrambled code combination, heretofore referred to sent out representing two light gray elements is to be unscrambled. This code combination according to the code illustrated in Fig. 2 would be 1, 2. When this was sent out in scrambled form it resulted in 2, 3, 4. Accordingly, the combinations 2, 3, 4 will be set up in the message transmitter 34 and the code combination in the key tape in the transmitter 34′ will be 1, 3, 4. Under these conditions the selecting relays 11 and 22 will be energized as the terminals of their windings are connected to oppositely poled bus-bars, while the relays 33, 44 and 55 will remain deenergized. The combination set up in the selecting relays will accordingly be 1, 2 which according to the code represents two light gray elements. Accordingly, the printer at the receiving station will record two small dots or periods in a manner to be pointed out in more detail hereinafter.

The printing is done on a page as in a page printing receiver in which the printer selecting magnets 110, 220, 330, 440 and 550 are employed. 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 enciphered picture message tape, as has been pointed out, is inserted in the transmitter 34 and the key tape is inserted in the transmitter 34′. A circuit will be closed at T by the cam 38 on the printer main shaft which rotates continuously. This circuit is traced 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

magnets 32 and 32′. Upon closure of this circuit the clear-out relay 31 and the tape transmitter magnets 32 and 32′ are operated, and they release when the circuit opens at T.

The cam 38 is designed to allow sufficient time to elapse after the contact T opens for the tape transmitter magnets 32 and 32′ to release and for the transmitter contacts at 34 and 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 indicated 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 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 on the selecting relays 1. A reference to Fig. 2 shows that this corresponds to a sequence of two medium dots. The relays 11, 22 and 55 are accordingly in energized condition. 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 a circuit from battery 36, through contact S, and 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 connect battery through the front contacts of relays 11, 11^a to the armatures of the relays 22, 22^a and 33^a but as these are all opened, the transmitter magnets 32 and 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, battery 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 tape transmitter magnets 32 and 32′. The tapes will now step ahead to new signal combinations. The actuation of the clear-out relay 31 establishes a direct circuit from battery through the contact T and front contact of relay 31, through said relay 31 and the tape transmitter magnets 32 and 32′; this insures that the tape transmitters 34 and 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 the relays 11 and 44 are both energized, the tape feed circuit controlled by the 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 will now be described. In this case when the contact T opens, 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, through back contacts of relays 44, 22, 11 and 22^b to printer selecting 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 deciphered code combinations 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.

While the arrangements of the invention have been disclosed in certain specific arrangements which are deemed desirable, it is understood that they are capable of embodiment in many and widely varied forms without departing from the spirit of the invention as defined by the appended claims.

What is claimed is:

1. The method of secretly transmitting a picture which consists in analyzing it into sequences of elements of like shade, setting up code combinations representing the number of elements in each sequence and the shade of those elements, combining these code combinations in effect with a series of arbitrarily chosen code combinations, and transmitting the code combinations resulting from such combining.

2. The method of secretly transmitting a picture which consists in analyzing it into sequences of elements of like shade, setting up code combinations representing the number of elements in each sequence and the shade of those elements, changing the character of these code combinations in an arbitrary and varied manner, and transmitting said code combinations as so changed.

3. The method of secretly transmitting a picture which consists in analyzing it into sequences of elements of like shade, setting up code combinations representing the number of elements in each sequence and the shade of those elements, combining these code combinations in effect with a series of arbitrarily chosen code combinations, transmitting the resulting code combinations to a distant station, recombining said resulting code combinations at said distant station with a series of arbitrarily chosen code combinations similar to the series utilized at said first station to restore said resulting code combinations to the original state, and reproducing the picture from said restored code combinations.

4. In a picture transmitting system, means to explore successive elements of the picture and to set up code combinations corresponding both to the number of elements in a sequence of like shade and to the shade of the elements of such sequence, and means for combining in effect said code combinations with a series of arbitrarily chosen code combinations.

5. In a picture transmitting system, a plurality of selecting magnets, means whereby successive elements of the picture may be explored, means whereby there may be set up on said magnets code combinations corresponding both to the number of elements in a sequence of like shade and to the shade of the elements of such sequence, a key tape transmitter associated with said magnets, and a key tape therefor having a series of arbitrarily chosen code combinations thereon whereby the operation of said magnets will be under the joint control of said key tape combinations and said first mentioned combinations.

6. The method of secretly transmitting a picture which consists in analyzing it into elements of different shades, setting up code combinations representing said elements of different shades, combining these code combinations in effect with a series of arbitrarily chosen code combinations, and transmitting the code combinations resulting from such combining.

7. In a picture transmitting system, means to explore successive elements of the picture and to set up code combinations corresponding to the shade of each successive element, means for combining in effect said code combinations with a series of arbitrarily chosen code combinations, and means for reproducing the picture from said combined code combinations.

8. The method of transmitting a picture which consists in exploring the elements thereof successively for degree of shade, counting the number of elements of like shades in a sequence, making a non-pictorial record of the number and shade of the counted elements in each sequence, combining the effects of said non-pictorial records with another arbitrarily chosen non-pictorial record, transmitting currents controlled by said combined non-pictorial records, and printing the picture from the received currents.

In testimony whereof, I have signed my name to this specification this 4th day of December, 1924.

GILBERT S. VERNAM.