

Aug. 11, 1936.

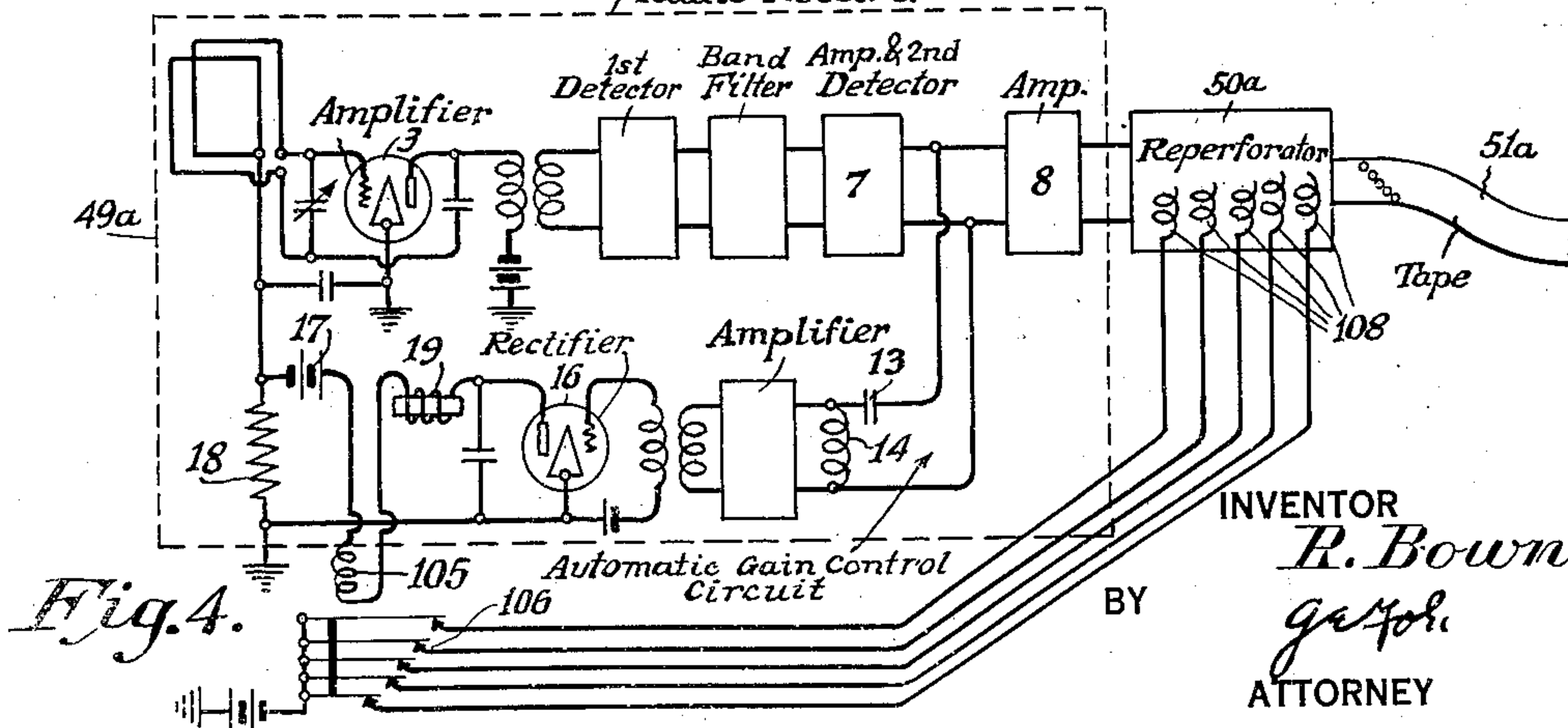
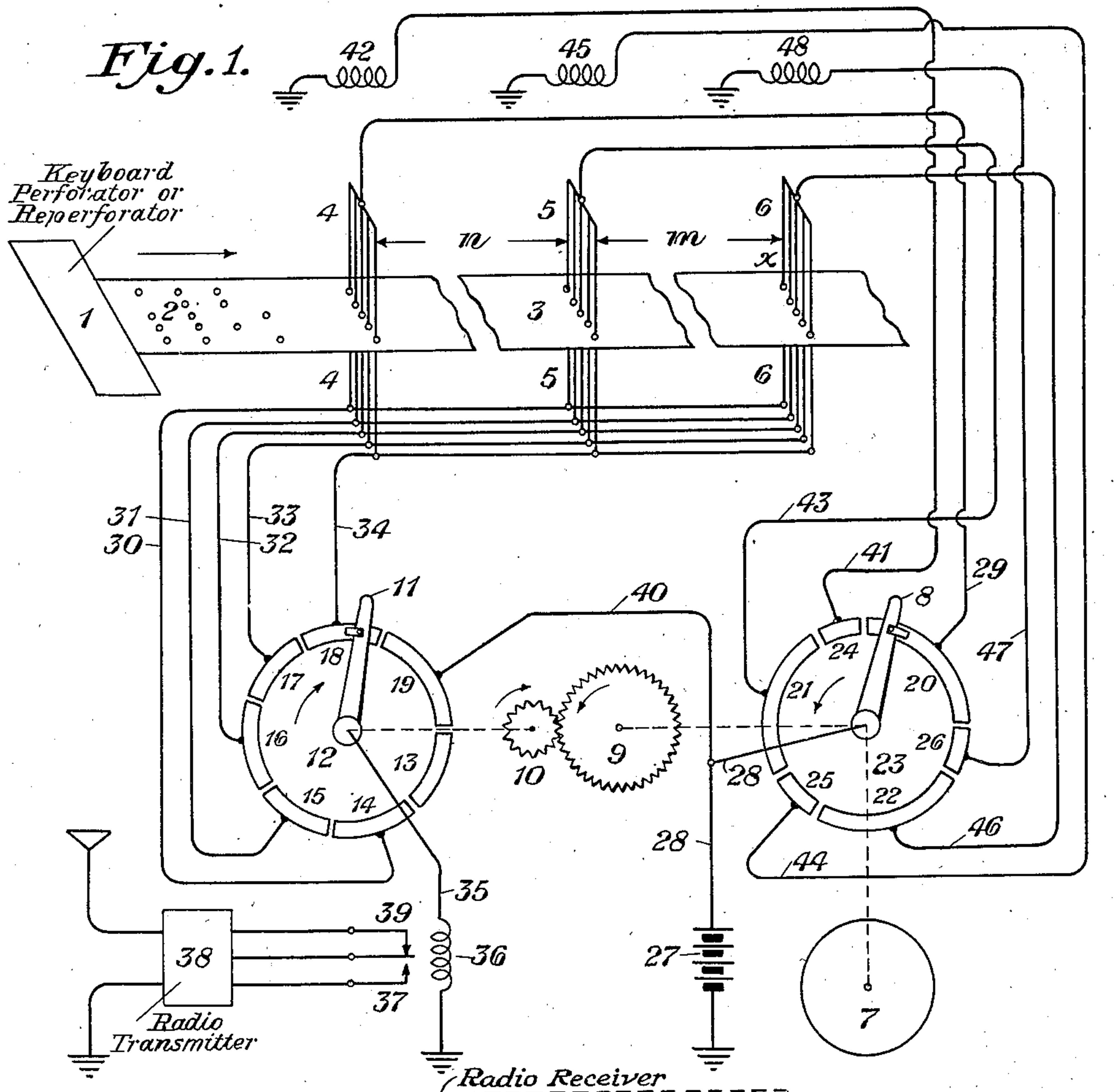
R. BOWN

2,050,265

ITERATIVE TELEGRAPH SYSTEM

Filed July 14, 1933

2 Sheets-Sheet 1



INVENTOR
R. Bown
BY
gator
ATTORNEY

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R. BOWN

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2 Sheets-Sheet 2

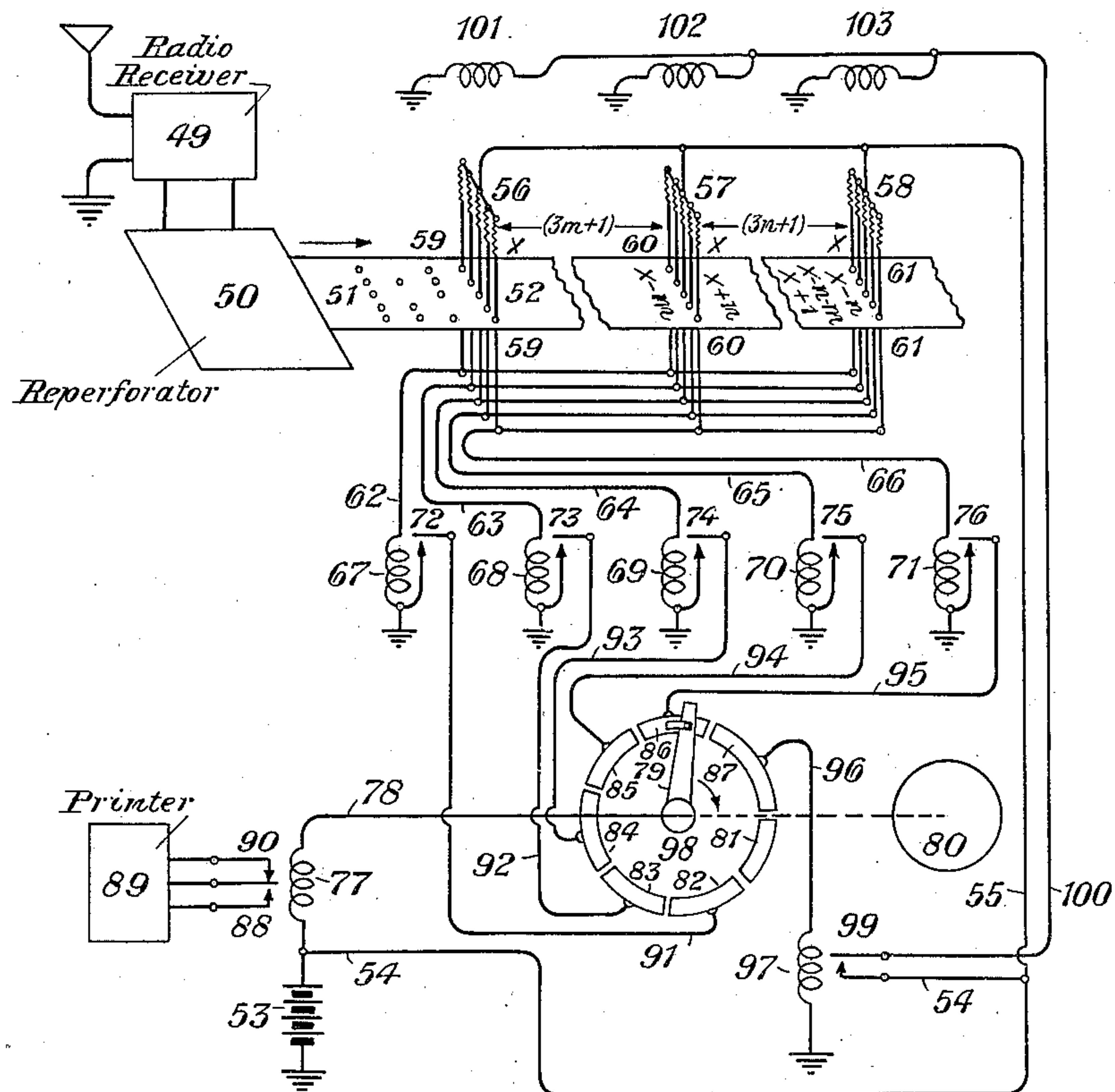


Fig. 2

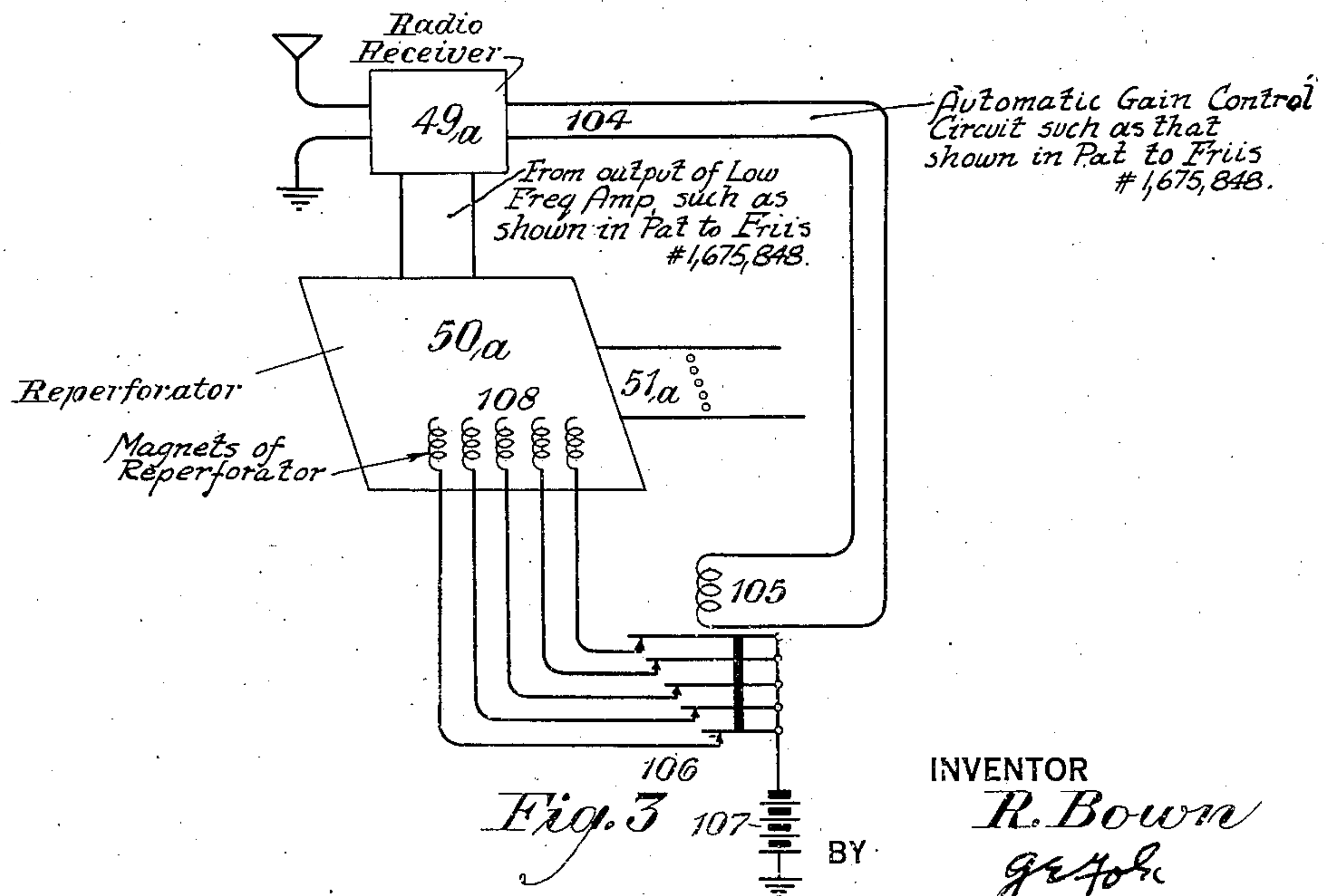


Fig. 3

INVENTOR
R. Bown
BY
ATTORNEY

UNITED STATES PATENT OFFICE

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ITERATIVE TELEGRAPH SYSTEM

Ralph Bown, Maplewood, N. J., assignor to
American Telephone and Telegraph Company,
a corporation of New York

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7 Claims. (Cl. 250—8)

This invention relates to a system for preventing errors in printing telegraphy due to noise or transmission variations. More particularly it relates to a system for repeating signals automatically at intervals and automatically comparing the received signals with each other to eliminate errors.

In radiotelegraphy by older methods such, for example, as manual sending and aural receiving it has been customary to send each word twice or three times when necessary to overcome the effects of static in obliterating occasional words and characters. Systems have been proposed for applying this arrangement to printing telegraphy by repeating each character one or more times and selecting for record at the receiving end the character indicated by the summation of the repeated signals. The present invention provides a system whereby this principle is further extended to mitigate not only the effects of noise but also the effects of fading.

The fading of radio signals often occurs at such a slow rate that repetition of signals by the ordinary method is ineffective since all repetitions are lost in a fade out. An object of the present invention is to lengthen the intervals between repetitions to avoid this difficulty. The rates of fading, while sometimes regular for considerable periods, may be widely different at other periods, thus any fixed repetition interval may at times synchronize with the fading rate and cause all repetitions to be lost. A further object of this invention is to provide means for changing the repetition interval from time to time and means for employing simultaneously two or more different repetition intervals. Another object is to provide means automatically to reject from consideration signals too weak to be accurate or signals definitely obliterated by static or noise.

This invention will be fully understood from the following description when read in connection with the accompanying drawings of which

Figure 1 illustrates transmitting apparatus, Fig. 2 illustrates receiving apparatus, Fig. 3 illustrates a modification of the invention, and Fig. 4 shows in greater detail the modification shown in Fig. 3.

These illustrations show how the invention may be practiced using many of the devices now common in printing telegraph systems. Obviously simpler mechanisms more specifically designed for the purpose could be employed without departing from the essential principles of the invention.

This illustration of the invention as shown in

the appended drawings provides that messages be sent from perforated tape which passes through three or more control senders working in rotation, each sender repeating the character at a time (greater than one character interval) subsequent to the transmission of the character from the next previous sender. The time intervals between successive transmissions of a character are not fixed nor necessarily uniform in length and may be adjusted to suit prevailing conditions in the transmitting medium. Without limiting the scope of the invention but to simplify the description thereof, it will be assumed that signals will be transmitted three times, requiring three control senders, although in practice any number of such senders may be used, with increasing accuracy of reception as the number of repetitions increases. The control senders may be connected directly to the transmitting medium or indirectly through a master sender.

The type of receiving mechanism herein described takes the characters as they are received and records them in order by perforating a tape. The tape passes through three senders so spaced on the tape that they pick up simultaneously the repetitions of each character. Indications sent by these senders are combined for each character element to make a single element (for the printer mechanism) which represents the "majority vote" of the senders on the element. Thus an element may have one of its three transmissions mutilated and recorded as an error on the tape without causing an error in the printer. When transmission is repeated more than twice, more errors, of course, would be allowable.

Referring to the diagrams: Figure 1 is a schematic diagram of a type of apparatus suitable for controlling printing telegraph impulses sent from a radiotelegraph transmitting station, Fig. 2 is a schematic diagram of apparatus suitable for controlling the printing of the characters by the receiving telegraph printer after the characters which were received from the transmitting station have been recorded in the order received on the receiving tape, and Fig. 3 is a schematic diagram of a modification of the invention which eliminates signals known to be in error because of fading or heavy static.

In Fig. 1, 1 is a standard teletypewriter (telegraph printer) which makes perforations 2 on tape 3 in accordance with the 5-unit code for the characters to be transmitted by radio to the receiving printer. 1 may be a keyboard perforator, such, for example, as that shown in the patent to Krum, No. 1,884,753, or a reperforator such, for

example, as that shown in the patent to Kleinschmidt, No. 1,884,743, the latter being used where the signals are previously transmitted over a circuit and are received at the station shown in Fig. 1. Sender contacts 4, 4 are aligned with the rows of perforations 2 so that electrical contact is made through each perforation and is broken where no perforation exists. The contacts 4, 4 may, for example, be those shown in the patent to Benjamin, No. 1,298,440. Similar operations are performed by sender contacts 5, 5, and 6, 6 which are spaced from contacts 4, 4 by $(n-1)$ and $(m+n-1)$ intervening characters, respectively, on tape 3, (m) and (n) being any assigned integers. Numbering characters from right to left, if contacts 6, 6 are on character " x ", contacts 5, 5 are on character $(x+m)$ and contacts 4, 4 are on character $(x+m+n)$.

Motor 7 drives brush 8 and gear 9 which meshes with pinion 10, having a 1-3 ratio with gear 9. Pinion 10 drives brush 11 of selector 12 over segments 13 (start), 14, 15, 16, 17, 18 and 19 (stop) so arranged that the printer impulses are of proper duration. Segments 20, 21 and 22 of distributor 23 are of such length as to be traversed by brush 8 while brush 11 is traversing segments 14, 15, 16, 17 and 18. Segments 24, 25 and 26 are of such length as to be traversed by brush 8 while brush 11 is traversing segments 19 and 13. One small segment and one large segment together cover 120° (in the case of 3 senders), because brush 11 makes 3 revolutions to 1 revolution of brush 8.

While brush 8 is on segment 20 and contacts 4, 4 are on character $(x+m+n)$, battery 27 is connected through lead 28, brush 8, segment 20 and lead 29 to sender contacts 4, 4. If 5 perforations appear on the tape under contacts 4, 4, battery is connected through the contacts to buses 30, 31, 32, 33 and 34, which in turn are connected respectively to segments 14, 15, 16, 17, and 18 on selector 12. If any of the five positions for perforations are not perforated, the corresponding buses and segments do not have the battery connection. While brush 11 is traversing a segment which has battery connection, current from battery 27 goes through the circuit established to the segment, through brush 11, lead 35 and relay 36, which, now being energized, closes contacts 37 and causes a marking pulse to be sent to the transmission system 38. While brush 11 is traversing a segment which has no battery connection, a space impulse is sent to the transmission system 38 by the closing of contacts 39.

The radio transmitter 38 may be of any type that is capable of translating marking and spacing impulses into suitable radio telegraph signals, which may be of any wave length or lengths. The said signals are impressed on the associated antenna for transmission therefrom.

When brush 8 leaves segment 20 and is traversing segment 24, battery 27 is connected through leads 28 and 40 to segment 19, thereby causing, when brush 11 is on segment 19, relay 36 to be energized and close contacts 37, whereupon a marking impulse is transmitted from radio transmitter 38. When brush 11 is on segment 13, which has no battery connection at any time, a space impulse is sent out by transmission system 38. The spacing impulse from segment 13 and the marking impulse from segment 19 constitute the start and stop impulses for synchronizing the transmitting printer with the receiving tape cutter by the ordinary start-stop method. Obviously any other well-known method of synchro-

nizing the transmitter driving motor 7 and the tape cutter 50 of Fig. 2 could be employed.

After brush 8 has passed over segment 20 all the segments from 13 to 18, inclusive, have been passed over by brush 11, and it is then on segment 19. Brush 8 then passes over segment 24, establishing a connection from battery 27, through lead 28, brush 8, segment 24 and lead 41 to magnet 42 which causes the tape 3 at contacts 4, 4 to step forward to the next character $(x+m+n+1)$ and stop in accordance with the operation of well known tape sender devices.

Brush 8 is then moved on to segment 21, where the operations described for segment 20 are repeated, except that character $(x+m)$ is undergoing transmission through lead 43 and contacts 5, 5. Likewise, when brush 8 reaches segment 25, current passes through lead 44 and magnet 45, which steps tape 3 to character $(x+m+1)$. Character (x) is transmitted through segment 22, lead 46 and contacts 6, 6. Current through brush 8, segment 26, lead 47 and magnet 48 causes the tape to step to character $(x+1)$, whereupon the cycle of transmission begins again on character $(x+m+n+1)$, through contacts 4, 4.

The order of transmission of characters would be $x, x-n, x-n-m, x+1, x-n+1, x-n-m+1, x+2, x-n+2, x-n-m+2, \dots, x+n, x, x-m, x+n+1, x+1, x-m+1, \dots, x+m, x+m-n, x-n \dots x+m+n, x+m, x, x+m+n+1, x+m+1, x+1, x+m+n+2, x+m+2, x+2$, etc. It becomes evident then, that a given character which appears initially at x appears second as character $x+3n+1$, third as $x+3(n+m)+2$, in the order of transmission and reception. Such spacing is illustrated in the scheme in Fig. 2.

At the receiving station, shown in Fig. 2, the impulses are picked up by the radio receiver 49, which may be of any type suitably designed to receive the signals sent by transmitter 38 and to translate those signals into their equivalent marking and spacing impulses which are amplified and relayed to the tape reperforator 50. This may be of any type well known in the art, such, for example, as that shown in the patent to Kleinschmidt No. 1,884,743, which is of the start-stop type. That reperforator cuts perforations 51 in the tape 52, according to the way the receiver 49 receives the transmitted impulses, with or without errors due to interference mutilation. While the invention has been disclosed as embodied in a start-stop system it is not so limited but may be equally well employed in a synchronous system, in which case the reperforator would be of the type shown, for example, in the patent to Krum et al. No. 1,174,427. The tape 52 passes through three senders so spaced that they simultaneously pick up the repetitions of the characters. Those devices may be of the type heretofore referred to in describing the transmitting station, as disclosed, for example, in the patent to Benjamin, No. 1,298,440. Thus since character (x) of Fig. 1 was transmitted again as character $(x+3n+1)$ and $(x+3(m+n)+2)$, it appears first as character (y) on the receiving tape 52, where the characters are numbered from right to left, next as character $(y+3n+1)$, third as character $(y+3(m+n)+2)$.

Battery 53 is connected by leads 54 and 55 to resistances 56, 57 and 58 which are in series, respectively, with sender contacts (59, 59), (60, 60) and (61, 61). These contacts are connected by buses 62, 63, 64, 65 and 66 to relays 67, 68, 69, 70 and 71, respectively, which require current from

at least two senders to make them operate and close contacts 72, 73, 74, 75 or 76, respectively. Resistances 56, 57 and 58 are of such value that current passing through only one resistance will not operate a relay. As long as two transmissions of a character element (5 elements per character) were received correctly, the element will be recorded correctly. If the character element sent was a blank, and two blanks and one perforation are received the current resulting from the contact through the single perforation will be insufficient to operate the relay and a blank will be registered by the relay. On the other hand if the character element sent was a perforation and one blank is received the current resulting from the contacts through the two perforations will be sufficient to operate the relay and a perforation will be registered.

From battery 53, connection is made through relay 77 and lead 78 to selector brush 79, which, driven by motor 80, wipes segments 81 (start), 82, 83, 84, 85, 86 and 87 (stop) in turn. This selector system 98 is substantially identical with that of 12 in Fig. 1 and is adapted to transmit start-stop printer signals to the recording device 89 which may be a reperforator like 50, shown in the patent to Kleinschmidt, No. 1,884,743, or a standard receiving teletypewriter. When current flows through relay 77, contacts 88 are closed, causing a marking impulse to be sent to printer 89. When relay 77 is not operated, space impulses are sent through contacts 90 to the printer. Current will flow through relay 77 only when brush 79 is grounded through segment 82, 83, 84, 85 or 86; lead 91, 92, 93, 94 or 95 and contact 72, 73, 74, 75 or 76, respectively, or through segment 87, lead 96 and relay 97. Thus, selector 98 causes the marking and space impulses to be sent to the printer in accordance with the majority vote of the multiplied perforations on the tape. While brush 79 is on segment 87, current flowing through relay 97 operates the relay which closes contacts 99 and connects battery 53 through lead 54, contacts 99 and lead 100 to stepping magnets 101, 102 and 103. All three magnets operate simultaneously and cause the tape to advance three characters at each sender.

When, during a fade out or during a heavy static impulse, the signal to noise ratio is so poor that the received signals are likely to be entirely incorrect when recorded on tape 51 it evidently would be better to throw out such signals from the combining process. A modification of the invention including this feature is illustrated by Fig. 3, which shows a radio receiver 49a and an automatic tape perforator 50a, which are broadly similar to those devices shown in Fig. 2 at 49 and 50, respectively, but also, are capable of performing additional functions. The automatic gain control circuit 104 of the receiver is brought out to include relay 105 arranged to break five contacts 106 when current above a certain value flows in its winding and to make these five contacts when the current in the winding falls below a certain value. The automatic gain control is assumed to be of the well known type, such as is shown in the patent to Friis, No. 1,675,848, which is shown schematically in Fig. 4 of the drawings. In the circuit of that figure, in which the same symbols have been used as in the patent to designate corresponding parts, the rectified signal current is passed through the resistance 18, the drop of potential across which is used as grid bias for the amplifier tubes, such as tube 3, thereby changing the gain to maintain substan-

tially constant signal output. The circuit 104 carries this rectified signal current through the relay 105 which may be in series with the battery 17, coil 19 and the plate filament path of rectifier 16 as shown in the aforesaid patent to Friis. When signals become weak this rectified current falls off, the control ceases to maintain constant signal output and the signals become unreliable. In the present arrangement the relay 105 is adjusted to release its armature at the reduced current corresponding approximately to this gain control limit. The five contacts are then made and current from battery 107 is caused to flow to the five magnets 108. These five magnets in the tape cutter are those which operate in response to received signals to control respectively the cutting of the five holes in the tape. In the tape cutters of this well known type, when current flows in any magnet a corresponding hole is punched in the tape. It is evident that as long as relay 105 is released and contacts 106 are made five holes will be punched in the tape for each character no matter what code signal is received. In the printer code, five holes represent a blank or an erasure rather than a letter or other character.

It is now assumed that the tape 51a is fed to a combining and recording system identical with that to which tape 51 is fed in Fig. 2 with the exception that four senders are employed instead of three. In other words it is a quadruple system rather than a triple system. Also the relays 67—71, inclusive, are adjusted so that current through three sender contacts rather than two is required to operate them. It is further assumed that the transmitting system is a quadruple one and the characters are sent four times at intervals rather than three times.

The functioning of such an arrangement is as follows: When signals are strong the relay 105 remains operated and the system functions just like the triple system already described except that it is a four-element system rather than a three. If signals become so weak as to release relay 105, rows of five holes representing blanks will be punched on the tape instead of received code combinations until the signals again become strong. As these perforations pass under a sender element such as 56, contact is made on all five contactors and one current element is sent to each of the relays 67—71, inclusive. Since each relay requires three current elements for operation and will not operate on two elements it is evident that the characters under the remaining three senders of the quadruple system will govern the choice of character recorded by the indicator 89 on a two out of three basis. That is, when signals are good the apparatus will function as a three out of four system and when signals are lost it will function as a two out of three system. In other words, the apparatus automatically rejects the evidence from signals known to be in error and uses only the remaining evidence.

Strong static impulses usually produce errors in ordinary systems by causing all five holes to be punched. In this system such errors are automatically rejected and the effect of strong static is thereby mitigated.

Other methods of repeating, recording and interpreting the signals could be employed without departing from the novel principles herein disclosed. For example, the perforated tapes and the plurality of senders could be replaced by phonograph records or the wire of a telegraph

employing a plurality of spaced pickup devices, the signals being sent and received as audible tones. Also the application of the invention is not limited to printing telegraphy, since any
 5 form of record capable of being conveyed by telegraphic type signals may be employed, such for example, as tape sending and curve drawing tape recording. Also the invention may be applied
 10 to facsimile and picture transmission, particularly those forms in which the image is built up of individual black and white elements transmitted by telegraphic type signals.

What is claimed is:

15 1. A mark and space signal transmitter adapted to send code groups of signals repeatedly, a transmitting medium through which said signals are sent, said medium introducing variations in signal strength, a receiver for said signals,
 20 means for storing received signals, means for combining stored signals corresponding to the repeated sending of each code group, means for indicating the result of said combination, and means connected to the said receiver and responsive to a predetermined drop in signal
 25 strength to automatically produce upon said storing means a clear-out signal whenever any impulse of a received signal falls below a prefixed level.

30 2. In a signaling system for mark and space signals the combination with means for sending each code group of signal elements a plurality of successive times separated by time intervals not all of equal length during which intervals
 35 other code groups are sent, a transmitting medium, means for receiving said signals including automatic means for summing the effects produced by the reception of the several repetitions of each signal and means for indicating the code combinations identified by such summation.

40 3. In a signaling system for mark and space code signals the combination with means for sending each signal element a plurality of successive times separated by time intervals not all of equal length during which one or more code
 45 combinations of signal elements is sent, a transmitting medium, receiving means including means for storing the received effects, means for automatically comparing said received effects to choose therefrom a majority effect and means for
 50 indicating the said majority effect.

4. Means as in claim 3 wherein the said send-

ing means is adapted to permit alteration of the lengths of said time intervals.

5. A receiving system for mark and space signals sent in repeated code groups comprising
 5 means for receiving signals, means for recording the said received signals, the said recording means including storage means upon which a record is made, means for combining the stored signals corresponding to the repetitions of each
 10 code group, means for indicating the result of each such combination of stored signals corresponding to the said repetitions, means associated with said receiving means and responsive to the strength of the received signals and operative upon
 15 said means for recording to produce upon the said storage means a positive clear-out symbol, whenever the strength of any impulse of a code group falls below a predetermined value, which symbol indicates that the said signal is erroneous.

20 6. In a radiotelegraph system, the method of avoiding errors due to fading and noise which comprises sending more than once the signals corresponding to every character of a message, receiving the said signals, recording the signals received above a predetermined value of signal
 25 strength creating a characteristic record upon the recording means whenever any signal impulse falls below a predetermined value, which characteristic record is in substitution for the signal character then being received, combining all records
 30 corresponding to the several sendings of each character of the said message, and producing the message corresponding to the combined records.

35 7. A receiving system for mark and space signals sent in repeated code groups, each group consisting of a plurality of impulses, comprising means for receiving such signals, means for recording such received signals, the said recording means including means for storing the signals as
 40 received, means for effectively combining the signals of each code group, means for indicating the resultant signals of each group as thus stored, and a relay adjusted to respond whenever the strength of a signal impulse falls below a prefixed
 45 limit to impress upon said storage means a characteristic symbol in substitution for the record of the code group that would have been recorded if such diminution in signal strength had not occurred.

RALPH BOWN. 50