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MULTICHANNEL TELEGRAPH CABLE SYSTEM

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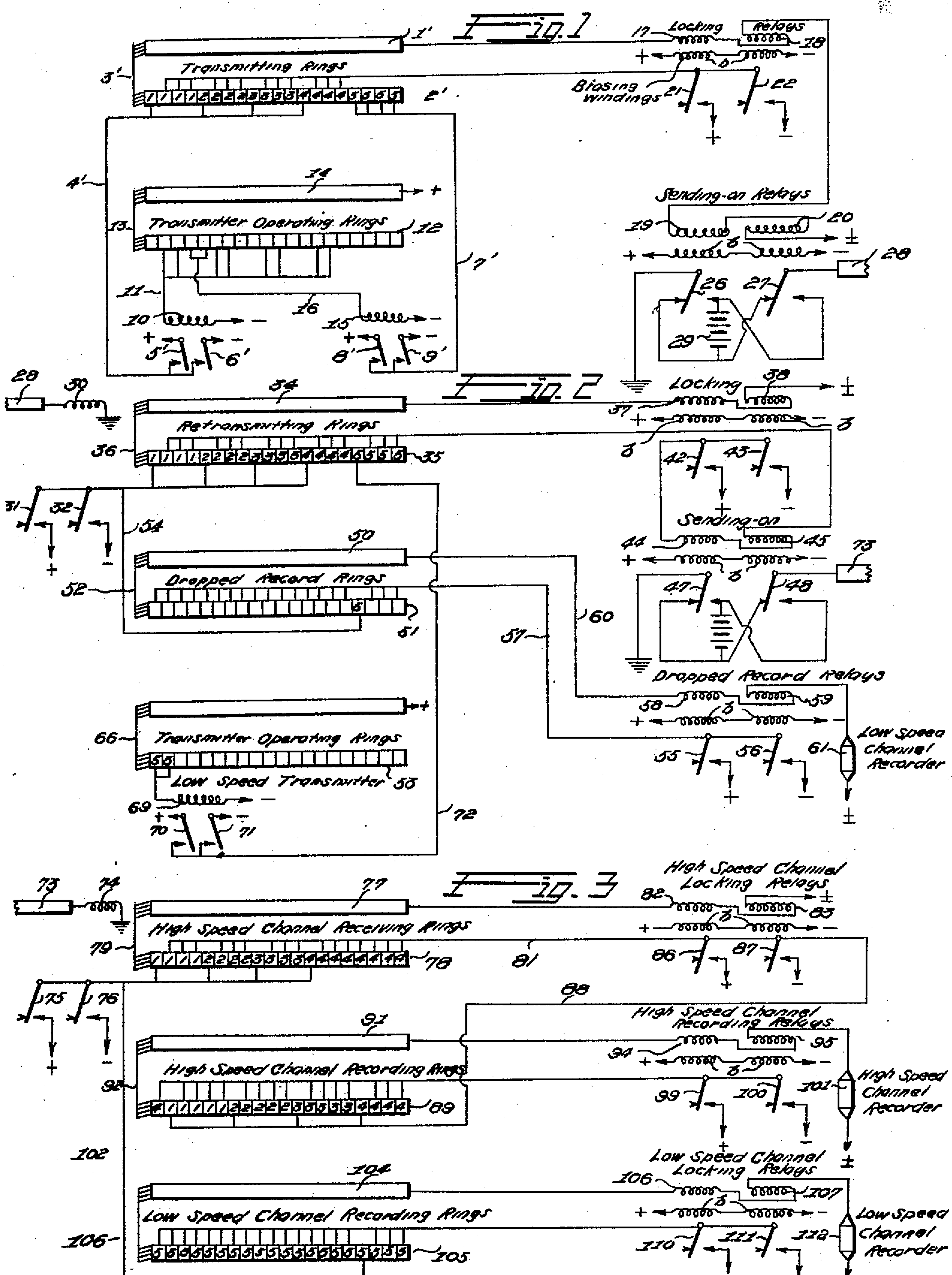

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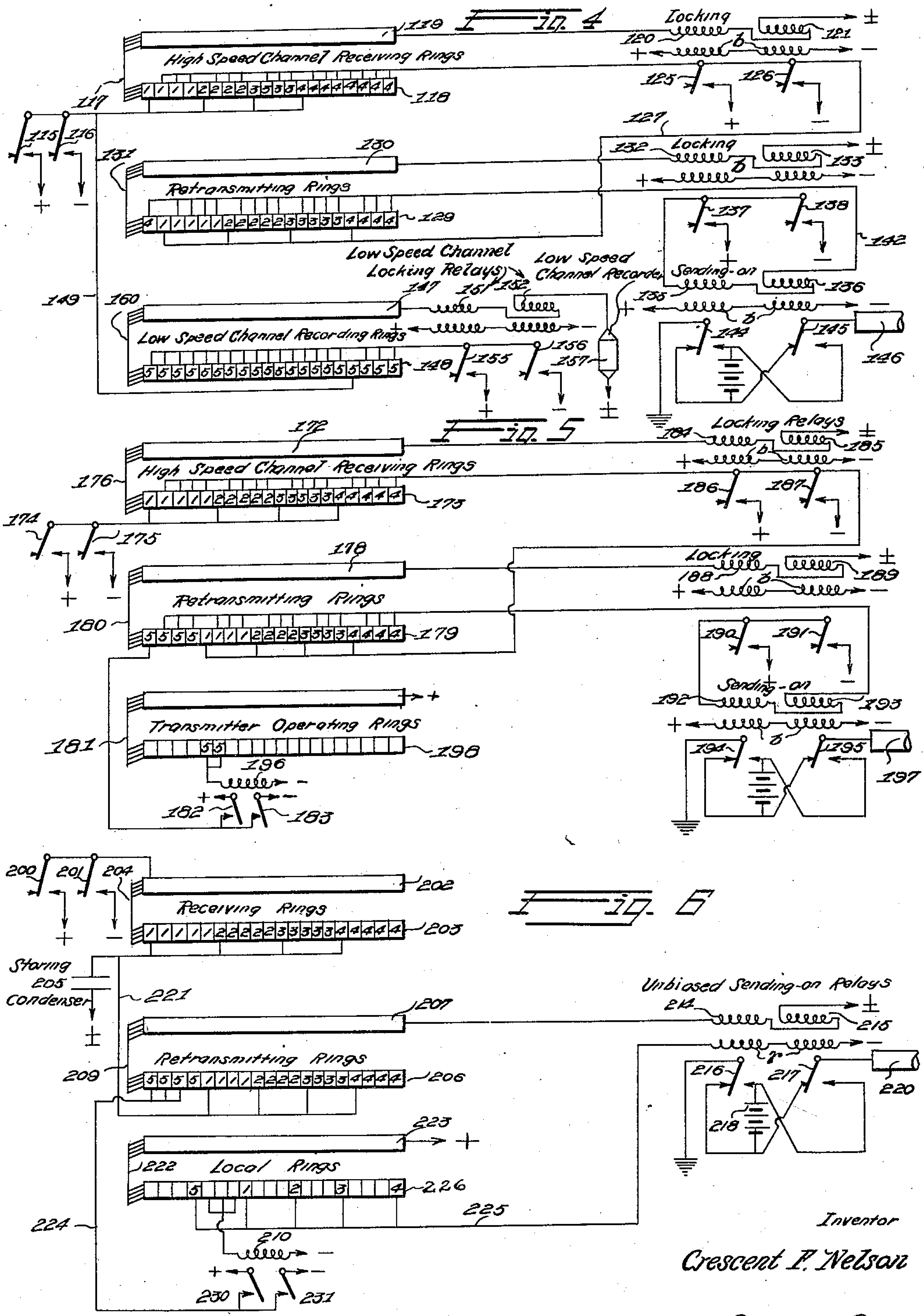

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UNITED STATES PATENT OFFICE

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MULTICHANNEL TELEGRAPH CABLE SYSTEM

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My invention relates to improvements in automatic telegraph systems, and more particularly to multi-channel systems.

The standard two channel telegraph system is divided into two equal parts, each channel being apportioned one half of the traffic capacity of the system. While such an arrangement is ordinarily satisfactory, conditions sometimes exist in which the traffic load of one channel is often considerably greater than the load of the other channel. Under such circumstances, if each channel is assigned an equal portion of the signaling capacity of the system, the channel with the heavy traffic would be overtaxed while the other channel would be operating below the normal line capacity.

In systems including a repeater station, the signal traffic between the repeater station and either terminal station is often considerably less than that between the terminal stations. Nevertheless, in the standard system the repeater station signals over one of the two equal channels and thus takes one half of the total traffic handling capacity of the system. In such a case, the same difficulty occurs, the one channel between the terminal stations being overtaxed and the second channel operating below its capacity. A further illustration is found in the case where a repeater station is connected to one terminal station by a high speed cable and to the second terminal station by a slow speed cable. In such a case, the high speed cable is operated below its capacity even when the slow speed cable is operating at its maximum capacity by reason of the greater signaling capacity of the former.

It is desirable however, to distribute the signaling traffic evenly over the entire signaling period in order that the maximum signaling capacity of the system may be utilized.

An object of my invention, therefore, is to provide means for allotting unequal proportions of the total traffic capacity to the different channels of a telegraph system.

Another object of my invention is to provide a multiplex telegraph system in which each channel is allotted a portion of the total signaling capacity of the system, the portion assigned to each channel being dependent on the signaling traffic requirements of that particular channel.

Another object of my invention is to provide a telegraph system in which a greater percentage of the total capacity of the system is allotted to one channel over which there is comparatively more traffic and a smaller percentage of the total capacity of the system is allotted to a second channel over which there is comparatively less traffic.

Still another object of my invention is to provide means for operating each of two cables connected at a repeater station and having different signaling speeds at maximum capacity.

Where a multi-channel system is employed which is incapable of signaling with a separate recorder for each channel, there is a zero period on each recorder, during the time the other recorder is receiving its signal. This is confusing to the receiving operator.

Another object of the invention is to provide in a multi-channel system, means whereby more unit impulses are transmitted and received over each of one or more channels during any period of time than over the remaining channel or channels.

An object of my invention is to provide means for operating a recorder which receives a signal during only part of the signal period for the full length of time assigned to each signaling impulse so as to eliminate all zero intervals except those which are transmitted by the terminal station.

There are other objects of my invention which together with the foregoing will appear in the following description with reference to the accompanying drawings, in which:—

Figure 1 is a diagram of the circuit connections and apparatus at a transmitting station, illustrating one application of my invention in which a high speed channel from a transmitting station to a receiving station is connected through at an intermediate station, a low speed channel is connected from the transmitting station to the intermediate station and a low speed channel is connected from the intermediate station to the receiving station.

Figure 2 is a diagram of the circuit connections and apparatus at the intermediate or repeating station.

Figure 3 is a diagram of the circuit connections and apparatus at the receiving station.

Figure 4 is a diagram of the circuit connections and apparatus at the repeating station illustrating another application of my invention in which a high speed channel operates from a transmitting station to a receiving station, repeating through a repeating station and a low speed channel operates from a transmitting station to the intermediate station.

Figure 5 is a diagram of the circuit connections and apparatus at the repeating station illustrating another application of my invention in which a high speed channel operates from a transmitting station to a receiving station, repeating through a repeating station and a low speed channel operating from the repeating to the receiving station.

Figure 6 is a diagram of the circuit connections and apparatus at the repeating station illustrating another application of my invention in which a high speed channel operates from a transmitting station to a receiving station, repeating through a repeating station, with a modified form of locking circuit.

Referring now more particularly to Figure 1, a transmitting distributor comprising a solid ring 1′ and a segmented ring 2′ bridged by a rotating brush 3′, is divided into two channels.

Since the signaling traffic in a high speed channel is greater than that of the low speed channel, a larger number of impulses will be transmitted over the former than over the latter. Obviously the ratio of the capacity of the high speed channel to the low speed channel may be any value, depending on the respective traffic to be handled over each channel. For purposes of illustration, I have chosen, however, to disclose a system in which the ratio between the two channels is four to one, that is the high speed channel transmits four signals to each low speed channel signal. For this ratio, the high speed channel will be assigned eighty per cent of the total capacity of the system and the low speed channel will be assigned twenty per cent of the total capacity.

Since, as pointed out above, the high speed channel transmitter transmits four impulses for each impulse of the low speed channel transmitter, the first four sections 1 to 4, of the transmitting ring comprising the high speed channel are connected in multiple over the conductor 4′ to tape controlled contacts 5′ and 6′ of the high speed transmitter. The second channel on the transmitting ring comprising the last group of segments 5 is connected over the conductors 7′ to the tape controlled contacts 8′ and 9′ of the low speed transmitter.

The magnet 10 controls the feelers of the tape (not shown) for withdrawing the feelers from the tape between signaling impulses and steps the tape to a succeeding perforation in the manner shown in detail in the patent to Benjamin No. 1,298,440, dated March 25, 1919. The magnet 10 is connected over the conductor 11 to the segmented ring 12 and periodically energized from the positive side of battery over the rotating brush 13, which bridges the ring 12 and the solid ring 14. The brushes 13 and 3′ are mechanically joined and rotate over their respective rings in synchronism. Similarly, the low speed transmitter tape is controlled by the magnet 15 which functions in a similar manner to remove the feelers from the tape (not shown) so as to permit the tape to be moved to each succeeding perforation of the code characters. The magnet 15 is controlled over a conductor 16 connected to the segments on the segmented distributor 12 in the manner already described in connection with the magnet 10. Since I am illustrating my invention in connection with cable code signaling, I disclose only two tape controlled contacts for positive and negative respectively. It will be evident however, to those skilled in the art that my invention is also applicable to systems employing the five unit code.

Associated with the solid transmitting ring 1′ are a pair of locking relays 17, 18 and a pair of sending relays 19, 20 connected in series. Each of these relays is provided with a biasing winding *b* which normally urges the armature against its left hand or spacing contact. The main windings of the relays 17, 18 and 19, 20 are oppositely poled so that a pulse of one polarity which moves the armature of one winding to its marking contact in opposition to the biasing winding will maintain the armature of the other winding on its spacing contact. A cable 28 is thus normally grounded over the left hand contacts of armatures 26 and 27. With no current flowing through the main windings of relays 17 and 18, the biasing windings *b* will maintain their armatures 21 and 22 normally in engagement with their left hand contacts, and similarly the biasing windings of the sending relays 19 and 20 will maintain their armatures 26 and 27 normally in engagement with their left hand contacts.

As will be evident from the description which follows, the stepping magnet 10 of the high speed distributor functions to step its tape to the succeeding perforation, preceding the connection of the contacts 5 or 6 to the locking relays 17 and 18. It will be assumed for purposes of illustration, that the tape controlled feelers (not shown) have been operated by the perforated tape (not shown) and that the perforation was such as to cause dot contactor 5′ to engage its contact. It will be assumed that the brush 3′ at this time engaged the first or pick-up segment of the transmitting ring 2′.

A circuit is completed from the positive side of battery over the contact arm 5′ and its contact, conductor 4′, the first or pick-up segment of group 1, of ring 2, through brush 3′, solid ring 1′, through the windings of the locking relays 17 and 18, and the windings of the sending relays 19 and 20 to the mid-point or "split" of the battery. As a result of this circuit the winding 17 is energized and moves its armature 21 into engagement with its right hand contact while the energization of the winding 18, by reason of its opposite poling from the winding 17, will add to the force produced by the biasing winding *b* to maintain the armature 22 in engagement with its left hand contact. In a like manner, the winding 19 is energized and moves its armature 26 into engagement with its right hand contact while the energization of the winding 20, by reason of its opposite poling from the winding 19 will add to the force produced by the biasing winding *b* to maintain the armature 27 in engagement with its left hand contact.

When now the brush 3′ is moved into engagement with the second segment of group 1, a locking circuit is completed from positive battery over the right hand contact and armature 21 to said second segment of the segmented ring 2. over brush 3′, and solid ring 1′, through the main windings of relays 17, 18 and 19, 20 in series to the mid-point of the battery.

At the sending relays, the energization of the winding of relay 19 functions to hold its armature 26 into engagement with its right hand contact and the energization of the relay 20 functions by reason of its opposite poling to aid the holding effect of the biasing winding *b* to maintain the armature 27 in engagement with its left hand contact. As a result, a circuit is completed from ground, over the armature 26 and its right hand contact, through the battery 29, the left hand contact and armature 27 of relay 20, to the cable 28.

Simultaneously, as the brush 13 engages its second segment, an energizing circuit is completed for the magnet 10 of the high speed channel transmitter from positive battery, through solid ring 14, brush 13, the second segment of ring 12, and winding of magnet 10 to negative battery. The energization of the winding 10 removes the feelers of the transmitter from the tape in the well known manner shown in the patent referred to above and permits the tape to be stepped to its succeeding perforation for the transmission of a second impulse. A locking circuit is maintained as shown above for the impulse impressed on the cable in accordance with the preceding tape perforation while the tape is being stepped forward to the succeeding perforation. When the brush 13 engages its fourth segment, a similar circuit is completed for the magnet 15 of the low speed transmitter from positive battery, through solid ring 14, brush 13, through the fourth segment of the ring 12, conductor 16 and magnet 15 to negative battery. The energization of the magnet 15 functions to remove the feelers from the tape of the slow speed transmitter and permits the tape to be stepped to the next succeeding perforation, to thereby prepare the slow speed transmitter for the transmission of the next impulse on this channel.

When the brush 3′ of the transmitting ring engages the fifth segment of ring 2′, the locking circuit for the sending relays 17 and 18 traced above, is opened and the relays 17, 18 and 19, 20 are deenergized, permitting their armatures to be moved to their left hand or spacing contacts under the operation of their biasing windings *b*.

At the same time, a second transmitting impulse is impressed on the conductor 4′ in accordance with the new perforation of the tape. It will be recalled that the tape was stepped to a new position while the brushes 3′ and 13 were passing over the second and third segments. Contractors 5′ or 6′ have now been operated in accordance with the new tape perforation. In a manner as described above, armatures 21 or 22 and 26 or 27 are again operated, depending upon the polarity of the impulse transmitted and as the brush 3′ moves into engagement with the locking segments of the second group on the segmented ring 2′, a locking circuit is then completed for maintaining the operated armature of the transmitting or sending-on relay in engagement with the contact it has assumed.

In this manner, four impulses are transmitted over the first channel of the system. After an impulse is started, a locking circuit is completed therefor while the tape is stepped to the next perforation. The high speed channel operation is thus obtained.

When the brush 3′ engages the first of the group marked 5, which is the seventeenth segment of the ring 2′, a circuit is completed for the sending-on relays 19 and 20 as described above, except that it is completed from the low speed tape transmitter contacts 8′ or 9′ of the second channel. The circuit is completed from positive or negative battery to either the contactor 8 or 9, depending upon whether the perforation in the tape of the low speed transmitter corresponded to a positive feeler or to a negative feeler, then through conductor 7′ to the seventeenth segment and through brush 3′, and the windings of relays 17, 18 and 19, 20 in series to the mid-point of the battery.

Let it be assumed that the contactor 8′ is caused to engage its contact, and an impulse of positive polarity is impressed upon the circuit last described. The energization of relay winding 19 causes its armature 26 to move over its right hand contact while the oppositely poled winding 20 holds its armature 27 against its left hand or spacing contact. An impulse of negative polarity is therefore transmitted into the cable from ground through armature 26, right hand contact, battery 29, left hand contact and armature 27 to cable 28. Since but a single impulse is to be transmitted over the low speed channel, it is unnecessary to step the tape for transmitting a second impulse at this time since a long interval will elapse during the operation of the high speed channel during which the tape can be stepped. Hence no locking circuit is provided for the low speed channel transmitter. For this reason, all of the four segments assigned to the second channel and designated 5, 5, 5, 5, on the segmented ring 2′, are connected in multiple to the contact to the low speed tape transmitter, since the tape transmitter in this case will remain in position until the end of the impulse. In this manner, four impulses are transmitted over the high speed channel and a single impulse transmitted over the low speed channel.

Referring now to Figure 2, showing an intermediate or repeater station, the impulses received over the transmitting cable 28 function to energize the relay 30 which in turn, through the usual local circuits (not shown) operates the armatures 31 and 32 of repeating relays. These relays repeat the four impulses from the high speed channel to the corresponding pick-up segments of the segmented ring 35 of the retransmitting rings. This ring is divided into five sections or groups of four segments each. The first four sections or groups, comprise the four transmitting portions of the first channel and the fifth section or group of segments constitutes the second channel.

The solid ring 34 is connected serially with the windings of the locking relays 37 and 38. The armatures 42 and 43 are connected to the windings of the sending-on relays 44 and 45 and to the locking segments of the ring 35.

Attention is directed to the circuit connections of the locking relays as compared with those at the transmitting station. The windings of the sending-on relays 19 and 20, at the transmitting station, are connected directly in series with the windings of the locking relays which are therefore energized simultaneously when the wiper 3 engages the first segment. At the repeating station, on the other hand, the locking relays are actuated when the brush 36 passes over the pick-up segment, but the sending-on relays are not actuated until the brush is in engagement with the succeeding distributor segment. Consequently the retransmitted impulses are all of a uniform length and are not dependent upon the amount of the received signal utilized to operate the locking relays.

In addition to the retransmitting rings 34, 35 for repeating the code signals of the high speed channel, the distributor at the intermediate station comprises "dropped record" rings 50, 51 for transferring the incoming signals of the low speed channel to a recording instrument, and transmitter operating rings 52, 53 for transmitting signals from a local tape transmitter over the low speed channel from the repeater station to the distant terminal station.

Only two of the segments 5, 5, of the transmitter ring 53 are connected to the actuating magnet 69 of the tape transmitter. The contactor arms 70, 71, one of which is actuated whenever the tape is stepped to a new position, are connected by conductor 72, to the pick-up segment of the group of segments 5, 5, of the retransmitting ring 35, assigned to the low speed channel.

As the impulses are received over the cable 28, the cable relay 30 is energized in accordance with the signal impulses and causes the local dot and dash relays to move their armatures 31 or 32 in accordance with the received impulses.

As it was assumed that the first signal transmitted over the cable 28 was an impulse of a positive polarity, it will be assumed that the armature 31 is operated thereby into engagement with its right hand contact. An impulse is thereupon impressed from the positive side of battery over the right hand contact and armature 31 to the first or pick-up segment of the retransmitting segmented ring 35, through brush 36, and solid ring 34, through the windings 37 and 38 of the locking relays in series and to the mid-point or "split" of the battery. The winding 37 overpowers the effect of the biasing winding *b* and moves the armature 42 into engagement with its right hand contact. Since the winding 38 is oppositely poled from that of the winding 37, it assists the biasing winding to maintain the armature 43 in engagement with its left hand or spacing contact.

A locking circuit is completed for relay 37 when brush 36 passes over the second segment, from positive battery over the right hand contact and armature 42, through the windings of sending-on relays 44 and 45 in series and over the second segment of ring 35, brush 36, ring 34, the windings of locking relays 37 and 38 in series to the mid-point of battery.

The energization of relay winding 44, overpowers the biasing winding and causes the armature 47 to engage its right hand contact, thereby completing a circuit from ground over the armature 47 and its right hand contact, through the battery, the left hand contact and armature 48 and sending an impulse to the cable 73. By reason of the locking circuit described above, this impulse continues to be impressed upon the cable 73 as long as the brush wipes over the three locking segments 1. When the brush leaves the group of segments 1, the locking circuit traced above is broken and the biasing winding *b* returns the armature 47 to its left hand or spacing contact thereby grounding the cable.

During this period the brushes 52 and 66 of the distributor have been passing over their rings in synchronism with the brush 36. The brush 52 has been maintaining a locking circuit through the dropped record locking relays 58 and 59. As the brush 66 passed over the two segments of ring 53, marked 5, 5, the actuating magnet 69 of the local tape transmitter was energized, causing the tape to be stepped to the next position. The feelers moved one or the other of the contactor arms 70, 71 into engagement with its battery contact, setting up the corresponding positive or negative polarity on the first or pick-up segment of group 5, 5 of the transmitting ring 35.

The signals received over the low speed channel are not to be retransmitted but are to be recorded at the repeater station. For this purpose the armatures 31 and 32 of the local receiving dot and dash relays which are connected in multiple to the pick-up segments of the four groups of segments of ring 35, assigned to the high speed channel, are also connected by conductor 54, with a segment designated 5 of "dropped record" ring 51. The brush 52 moves onto this segment while the signal impulse of the low speed channel is being received by the cable relay 30. If this is a negative impulse the local relay armature 32 will move against its right hand or "marking" contact closing a circuit from negative battery through armature 32, conductor 54, segment 5 of ring 51, brush 73, solid ring 50, conductor 60, windings of "dropped record" relays 58, 59 and low speed channel recorder 61 to the mid-point or "split" of the battery. As the brush 52 moves from the pick-up segment to the next segment a locking circuit is closed from negative battery through armature 56, conductor 57, said first locking segment, brush 52, solid ring 50, conductor 60, the windings 58, 59 and recorder 61 to the split of the battery. This locking circuit is maintained as the brush is passing over all of the remaining segments which are multipled to conductor 57, so that there may be no break or zero mark except those transmitted by a terminal station on the record tape of recorder 61 between received signals which would be confusing or make the record unintelligible.

Simultaneously with the separation and recording of the low speed channel signal on the recorder 61, the brush 36 passed onto the first or "pick-up" segment of the group of segments marked "5" on the transmitting ring 35, thereby causing a new signal impulse from the local tape transmitter to be sent into the cable 73, in the manner previously described.

Thus it has been shown how the four impulses received at the repeater station over the high speed channel are retransmitted to the distant terminal station over the cable section 73 while the signal impulse received over the low speed channel is separated or terminated and recorded at the intermediate repeater station, and a new signal impulse from the local tape transmitter is transmitted to the distant station over the low speed channel of the cable 73.

At the distant terminal station, illustrated in Figure 3, the impulses received over the cable 73, operate a receiving relay 74, which in the usual manner, controls a pair of local receiving relays indicated by the armatures 75, 76. These armatures are connected in multiple to the first or pick-up segments of each of the four sections or groups of segments comprising the high speed channel receiving ring of the rotary distributor. Since it was assumed that the first impulse sent into the cable at the transmitting station and repeated at the intermediate or repeater station was of positive polarity, the armature 75 will be moved against its marking contact. A circuit will thus be completed from positive battery through armature 75, pick-up segment 1, brush 79, solid ring 77, and the oppositely poled windings of the locking relays 82 and 83 to the mid-point or "split" of the battery. The pull of winding 82 will overpower the effect of biasing winding *b* and move the armatures 86 against its marking contact. As the brush passes from the pick-up segment onto the first locking segment, ' circuit is completed from positive battery, through armature 86, conductor 81, said locking segment, brush 79, solid ring 77, and locking relays 82 and 83 to the split of battery. Simultaneously a multiple circuit is completed from positive battery, armature 86, conductor 88, the first or pick-up segment of the group marked 1, of the high speed channel recording ring 89, through brush 92, solid ring 91, the oppositely poled windings of the high speed recording relays 94 and 95, to the high speed channel recording instrument 101 to the mid-point or split of battery. As brush 92 passes on to the second segment marked 1, which is the third segment on the high speed channel recording ring 89, a circuit is established from positive battery right hand contact and armature 99 through the second segment marked 1, ring 89, brush 92, ring 91, windings 94 and 95, recording instrument 101 to the split of the battery. This circuit locks the impulse previously received on recording instrument 101. In like manner each of the impulses received over the high speed channel of the cable is recorded by the instrument 101.

The impulse of the low speed channel is received by the cable relay 74 and one or the other armature 75 or 76 immediately after the fourth impulse of the high speed channel and is transmitted over conductor 102 to a segment of the low speed recording distributor ring 105, corresponding to the segment of ring 89 which receives the fourth impulse of the high speed channel from the locking relay. Assuming that a positive impulse was received over the low speed channel, when the brush 106 moves onto said segment of ring 105, a circuit is completed from positive battery over armature 75, conductor 102, said segment 5, brush 106, solid ring 104, oppositely poled windings of the low speed locking relays 106, 107, and low speed channel recorder 112 to the mid-point or split of battery. The relays are maintained in locked position while the brush 106 is passing over all of the other segments which are multipled together in order that the record strip of the recorder shall not show any zero mark between the signaling impulses, except those which are transmitted from the transmitting station.

Since there is always an impulse in the low speed channel interposed between each four impulses in the high speed channel, the high speed channel occupies only four fifths of the total receiving period. There would therefore be a zero period between every four impulses in the high speed channel record which would render the record tape of the recorder unintelligible. In order to overcome this difficulty, provision is made whereby each received impulse is increased to one fourth of the total low channel period so that the entire signaling period is consumed in the operation of the high speed channel recorder. This is accomplished by receiving the impulses of the high speed channel on one distributor ring and storing them in succession on locking relays. The impulses are then transferred in succession to another ring in which the segments covering the entire signaling period are divided equally between the four signaling impulses and from this ring they are transmitted to the recorder. Thus the signals of the high speed channel are received from the receiving relay armatures 75 and 76 upon ring 78 in which four segments are assigned to each impulse and after being stored successively upon the locking relays 82, 83, they are transferred to the recording ring 89, as the brush 92 moves thereover, in which five segments are assigned to each impulse so that the recording of the four high speed channel impulses on the instrument 101 occupies the entire signaling period.

From the foregoing it will be evident that the entire system is operated at all times at full capacity by transmitting four impulses over the high speed channel and a single impulse over the low speed channel in the system illustrated, allotting proportional time for each of the two channels in accordance with the demands of traffic. It will be noted also that although the impulses received over the low speed channel are properly separated from the impulses over the high speed channel and neither takes the full operating period of the distributor, the recorders are so arranged that no zero periods except those transmitted from the transmitting station occur on the record tapes of the recording instruments, and the copyist may thus very easily read the record taken. It will be understood of course, that the distributors at these three stations in the above described system are maintained in synchronism in the well known manner.

Although I have illustrated my invention as applied to a system in which there is a high speed channel between the two terminal stations, which operate through a repeater station with low speed channel from each terminal station to the repeater station, it is obvious that my system may be applied to many other systems where there is unequal signal traffic over the various channels.

Thus, for example, one system may be arranged in which there is a high and a low speed channel between the two terminal stations, operating through the repeater station, or a low speed channel may be operated between the two terminal stations through a repeater station with a high speed channel between each terminal station and the repeater station. The invention may also be applied to a system in which a high speed channel operates between the terminal station operating through a repeater station with a low speed channel between one terminal and the repeater station or between the other terminal and the repeater station; or there may be a low speed channel between the terminal stations with a high speed channel between one terminal and the intermediate station or the other terminal and the intermediate station. And in fact, my invention can be applied to any number of similar combinations of systems.

Figure 4 illustrates one of such modifications of my invention in which a high speed channel operates between the two terminal stations through a repeater station, and a low speed channel operates from the first transmitting station to the repeater station. The circuits in this figure are those at the repeater station.

Impulses received from the transmitting station to the repeater station operate the receiving relays, indicated by the armatures 115 and 116, in accordance with the received impulses. The armatures 115 and 116 are connected in multiple to the first or pick-up segment of each of the four groups of segments assigned to the high speed channel receiving ring 118 of the rotary distributor. The solid ring 119 is connected to the oppositely poled windings of the locking relays 120 and 121. The armatures 125, 126, which are normally held against their spacing contacts by the constantly energized biasing windings *b*, are connected in multiple to all of the locking segments of ring 118, and are also multipled through the conductor 127 to the first or pick-up segment of each of the four groups of segments of the high speed channel retransmitting ring 129.

The solid ring 130, is connected to the oppositely poled windings 132, 133 of the retransmitting locking relays in series and to the split of battery. The armatures 137, 138, normally held against their spacing contacts by their biasing windings *b* are connected in parallel to the series-connected oppositely poled windings 135, 136 of the sending-on relays and through conductor 142 to all of the locking segments of ring 129 in multiple.

The signal impulse received over the low speed channel of the cable, following the reception of the four impulses over the high speed channel, is transmitted over conductor 149, to the pick-up segment of the low channel recording ring 148. All of the other segments of this ring are connected in multiple to the armatures 155, 156 of the low speed channel locking rings. The solid ring 147 is connected in series to the oppositely poled windings 151, 152 of the low speed channel locking relays and to the recording instrument 157 and the split of battery.

As the impulses are received from the transmitting station to the intermediate repeating station disclosed in Figure 4, the armature 115 or the armature 116 is operated to its right hand contact in accordance with the received impulses. It will be assumed for illustration that the first impulse is of positive polarity and moves the armature 115 into engagement with its right hand or marking contact. At this instant the brush 117 is in engagement with the pick-up segment of the first group, marked 1, and completes a circuit from the positive battery over said first segment through brush 117, solid ring 119, windings of locking relays 120 and 121 to the mid-point of the battery. The energization of the winding 120 operates the armature 125 into engagement with its right hand contact, in opposition to the pull of its biasing winding *b*. The energization of the oppositely poled relay 121 assists its biasing winding to maintain the armature 126 in engagement with its left hand or spacing contact. A circuit is thus completed, when the brush 117 engages the second segment, from positive side of battery through armature 125, over said second segment of the ring 118, brush 117, solid ring 119, and the winding of the locking relays 120 and 121 to the mid-point of the battery.

Simultaneously as the brush 131 engages the second segment of ring 129, which is the pick-up segment of the group of segments marked 1, a circuit is completed from the positive side of battery over the armature 125, conductor 127, said pick-up segment of group 1, of ring 129, brush 131, solid ring 130, the windings of locking relays 132 and 133 to the mid-point of the battery. The energization of the winding 132 operates the armature 137 into engagement with its right hand or marking contact in a manner already described above in connection with other relays. A circuit is thereby completed from the positive side of battery over armature 137 to the windings 135 and 136 of the sending-on relays through the third segment of ring 129, which is the first locking segment of group 1, through brush 131, solid ring 130 and the windings of the locking relays 132 and 133 to the mid-point of the battery. The energization of the relay 135 moves its armature 144 into engagement with its right hand contact while its armature 144 into engagement with its right hand contact while the armature 145 is maintained in engagement with its left hand contact. An impulse of predetermined polarity is thereby impressed upon the cable 146.

It will be observed that while the four impulses of the high speed channel received at the intermediate station were each assigned a length of four segments on the distributor ring, the remaining period being used by the impulse of the low speed channel, the impulses retransmitted to the cable 146 are each assigned five segments on the ring 129, the four impulses thus occupying the entire signaling period of the cable.

When the brush 160 engages the segment of the low speed channel recording ring 148, to which the conductor 149 is connected, the impulse received over the low speed channel is transmitted over either armature 115 or armature 116 to operate the low speed channel recorder 157 in a manner which has already been described in detail in connection with recorders 61 and 112. It will be noted that the segments of the low speed recording channel are all multipled together except the segment to which the conductor 149 is connected so that when the impulse is received it is locked up and a record is made during the entire signaling period until the next impulse on the low channel is received. In this manner no idle period except those transmitted from the transmitting station appears either on the high or the low speed channel.

Figure 5 illustrates the apparatus and circuit arrangements at a repeating station in a system wherein a high speed channel is operated between the two terminal stations through the repeating station and a low speed channel is operated from the repeating station to the distant terminal station. Since the low speed channel exists only between the intermediate or repeating station and the distant terminal station, it is obvious that the high speed channel will employ all of the line signaling period between the transmitting station and the intermediate station, but between the intermedate or repeating station and the distant terminal station the high speed channel can only be assigned four-fifths of the signaling time leaving the remaining fifth for the low speed channel.

By comparing the relative positions of the numbers assigned to the segments of the high speed receiving ring 173 with those of the retransmitting ring 179, it will be observed that the first impulse locked up on one of the locking relays 184, 185, is not relayed from battery through the armature 186 or 187 to the pick-up segment 1 of the retransmitting ring until just before the second impulse is received by the receiving relays 174, 175. The four impulses of the high speed channel are then relayed and equally spaced, being each assigned four segments on the retransmitting ring 179. The time or period thus gained is employed for operating the impulse over the low speed channel, in the manner already described, over the first four segments marked 5, on the ring 179. The low speed channel transmitter is controlled by the magnet winding 196 which operates to remove the fingers from the perforated tape and steps the tape forward to the succeeding perforation in preparation for transmitting the next code signal impulse over the low speed channel transmitter in the manner previously described.

The tape transmitter operating magnet 196 is operated when the brush 181 moves across the two segments marked 5, 5 on the ring 198, at which time the brush 180 is on the pick-up segment of the group 1, on the ring 179 to transmit the first impulse of the preceding set of impulses on the high speed channel to the cable 197. The new impulse set up by the low speed channel tape transmitter upon said pick-up segment 5 of ring 179 by contactor 182 or 183, as above described, will not be transmitted however, until the brush 180 passes over the remaining segments of the ring 179 and again begins to traverse the ring 179. The operation of the locking relays 188, 189 and their armatures 190, 191 energizes the sending-on relays 192, 193 and transmits the signal impulses into the cable 197 as will be clear from the previous detailed description in connection with the preceding figures.

In the arrangements previously described the signal impulses have been stored momentarily in succession in locking relays. An alternative method of storing the impulses is disclosed in Figure 6, in which a condenser is employed in lieu of storing or locking relays. This figure shows an arrangement of circuits for an intermediate or repeating station similar to the arrangement in Figure 5. The signal impulses coming in over the cable actuate one or the other receiving relay, indicated by the armatures 200, 201, in accordance with the polarity of the impulses. A high speed channel occupies the full signaling period of the incoming cable and consequently the high speed channel receiving ring 203 of the rotary distributor is divided into four equal groups of five segments each.

As in the arrangement shown in Figure 5, the outgoing cable between the repeating station and the distant terminal station is divided between a high speed channel and a low speed channel. Consequently the retransmitting ring 206 is divided into five groups of four segments each, the four groups marked 1, 2, 3, 4, being allotted to the high speed channel and the group marked 5, being allotted to the low speed channel. At the instant brush 209 is on the first segment of ring 206, as shown in Figure 6, a signal impulse is being transmitted to the low speed channel of the cable 220 from the low speed channel tape transmitter 210, through conductor 224, segments marked 5 of ring 206, brush 209, solid ring 207 and the oppositely poled windings of sending-on relays 214 and 215 to the mid-point of battery. Either the armature 216 or the armature 217 will be moved over against its marking contact, thereby sending an impulse from battery 218 into the cable 220. The relays 214 and 215 are unbiased and hence the armatures 216 and 217 remain in the position to which they were last moved. All of the other relays shown in Figures 1 to 5, are provided with biasing windings *b* which are constantly energized to return the armatures to their back or spacing contact as soon as the main operating windings are deenergized.

At the instant the brush 204 engages the first segment on the ring 203, a signal impulse is received over the cable from the transmitting or first station which operates either the armature 200 or the armature 201 of the local receiving relays against its marking contact, thereby closing a circuit from positive or negative battery through said armature, solid ring 202, brush 204, segment 1 of ring 203, to one plate of condenser 205, the other plate being connected to the mid-point or split of the battery. A charge is thus stored on the condenser. When the brush 209 engages the fifth segment of ring 206, marked 1, which is the first segment of the high speed channel, the condenser 205 discharges over a path through conductor 221, said segment 1 of ring 206, through brush 209, solid ring 207 and the windings of sending-on relays 214 and 215, causing armature 216 to move to its right hand or marking contact and thereby sending an impulse from battery into cable

220. Simultaneously a circuit is closed from positive battery through solid ring 223, brush 222, and the magnet 210 of the low speed tape transmitter, which sets up a new code signal from battery through contact 230 or contact 231, through conductor 224 upon the segments marked 5 on the ring 206, in readiness to be transmitted over the low speed channel of cable 220 when the brush 209 has completed the transmission of the four impulses of the high speed channel and starts upon another revolution.

Immediately after the condenser 205 has discharged over the path above traced, the brush 204 engages the first segment marked 2 on this ring and at this instant another signal impulse is received on the receiving relays, thereby causing armature 200 or 201 to engage its marking contact, a corresponding charge being stored on condenser 205. The impulses coming in over the cable from the distant transmitting station and received on the relays 200, 201 are in this manner charged successively upon condenser 205 and retransmitted into cable 220.

The armatures of the dot and dash sending-on relays 214, 215 being unbiased, remain against the contacts to which they were moved. After each impulse is transmitted to the cable, the armature 216 or 217 is restored to its spacing or back contact by an impulse through restoring windings *r*, from plus battery through solid ring 223, brush 222, one of the segments marked 1, 2, 3, 4 or 5 of ring 226, conductor 225, and restoring windings *r*, to negative battery.

Although I have disclosed my invention in connection with a two channel system it is obvious that the invention may be applied to any multi-channel system, either operating between two terminal stations with an intermediate repeating station or between terminal stations and two or more repeating stations, or in fact, in any multi-channel system.

My system may also be applied to a system in which one section of the cable has a higher operating speed than the other section. In this case, the through channel may be operated at the maximum speed of the slower section and in addition another channel may be applied in the manner described in the various illustrations, to the higher speed sections so that both cable sections will be operated at their maximum speed. Thus for example, if the cable between the main transmitting station and the repeating station is capable of operating at one fourth of the speed of the cable connecting the repeater to the remote receiving station, a single channel system can be operated between the main transmitting station and the repeating station and a two-channel system from the intermediate station to the remote receiving station. The single channel impulses received from the transmitting station being retransmitted through the repeater in the manner disclosed in the drawings.

It is obvious from the above that my invention has many applications and may take on many forms and hence I do not intend it to be limited to the special application which I have employed to illustrate the invention but only in so far as set forth in the appended claims, in which:—

I claim:

1. A multi-channel telegraph system comprising a telegraph line or cable connecting two remote stations, the amount of signaling traffic in one channel being different from that in the other channel in the same direction, and means for apportioning said telegraph line to each of said channels for periods of time proportional to the traffic in said channels.

2. In a telegraph system, a first station, a remote station, a multi-channel telegraph system including a signaling line connecting said stations, the traffic in said channels being unequal, and means for apportioning said signaling line time to each of said channels in the same direction in accordance with the traffic of said channels.

3. In a multi-channel telegraph system a first station, a second station, transmitters for the several channels at each of said stations, the traffic carried by the respective transmitters in the same direction being unequal and means for apportioning said signaling line time to each of said transmitters in accordance with the proportion of traffic carried by it.

4. The method of telegraphy which comprises associating a plurality of transmitters to a signaling conductor successively in the same direction for different periods of time dependent upon the traffic carried by the respective transmitters.

5. In a multi-channel telegraph system, a first station, a remote station, a signaling line connecting said stations, transmitters for the different channels at said first station, means for associating said transmitters to the channels of said signaling line successively for traffic in the same direction and means for maintaining said transmitters associated with said signaling line for periods of time proportional to the traffic load of said respective transmitters.

6. In a telegraph system, a first station, a second station, a multi-channel telegraph system connecting said stations, and means for varying the operating period of each of said channels in accordance with the traffic in the same direction of said respective channels.

7. In a telegraph system, a first station, a second station, a multi-channel telegraph system connecting said stations, each of said channels operating over different portions of the entire signaling period in one direction, said portions being of different lengths

respectively, in accordance with the traffic of said channels, a receiver at said second station associated with each of said channels and means whereby the receiver in each of said channels is operated over the entire signaling period.

8. In a telegraph system, a first station, a second station, a multi-channel system connecting said stations, each of said channels being operated during a portion only of the signaling period in one direction, the operating time of the respective channels differing from each other, a receiver for each of said channels operating in response to impulses transmitted over its individual channel, and means comprising a synchronously operating repeating device whereby each of said receivers is operated during the entire signaling period of said line.

9. In a telegraph system, a first station, a remote station, a multi-channel system including a signaling line connecting said stations, a receiver at said second station for each of said channels, means for apportioning a predetermined portion of said signaling line period to each of said channels, the operating time of the respective channels in the same direction differing from each other, and means comprising a synchronously operating repeating device whereby the receiver individual to each of said channels is operated during the full signaling period of said signaling line.

10. In a telegraph system, a first station, a repeating station, a remote station, a single channel system, connecting said first station and said repeating station, a multi-channel system connecting said repeating and said remote station, said multi-channel system including as one of its channels the channel connecting said first station and said repeating station and synchronously operating means comprising a repeating device for apportioning the signals between the channels in accordance with the traffic of said channels and proportioning the length of the impulses so that said single channel system connecting said first and second stations and said system connecting said second and said remote stations are operated at maximum capacity.

11. In a telegraph system, a first station, a second station, a signaling line connecting said stations, a transmitter at said first station, a receiver at said second station, means for associating said transmitter with said signaling line only for a portion of the signaling period sufficient to transmit signaling impulses to operate said receiver and means for lengthening said impulses to operate said receiver continuously.

12. In a telegraph system, a first station, a second station, a signaling line connecting said stations, a transmitter at said first station, a receiver at said second station, means whereby said transmitter impresses impulses of predetermined length on said signaling line less than the signaling period, means comprising a synchronously operating repeating device for increasing the signal length of said signaling impulses at said second station and means for transmitting said impulses of increased length to operate said receiver.

13. In a telegraph system, comprising a first station, a second station, a transmitter at said first station and a receiver at said second station, the method of signaling which comprises transmitting impulses over said line for fractions of the signaling line period of a channel, increasing the length of the impulses to consume the entire signaling line period of a channel and operating said receiver by said increased impulses.

14. In a telegraph system, a first station, a second station, a multi-channel telegraph system including a signaling line associating said stations, a high speed channel transmitter associated with one of said channels, a low speed channel transmitter associated with the other of said channels, and means for associating said channels with said signaling line for periods of time proportionate to the signaling traffic of said respective channels.

15. In a telegraph system, a first station, a second station, a multi-channel telegraph system including a signaling line connecting said stations, a high speed channel transmitter associated with one of said channels, a low speed channel transmitter associated with the other of said channels, means for associating said channels with said signaling line for periods of time proportionate to the signaling traffic of said channels, a high speed channel receiver at said second station associated with the same channel as said high speed channel transmitter, a low speed channel receiver at said second station associated with said low speed channel transmitter and means whereby said receivers are operated to produce a continuous record in response to impulses transmitted by their respective high and low speed channel transmitters.

16. In a telegraph system, a first station, a second station, a third station, a multi-channel telegraph system including signaling lines connecting said first and said second stations and said second and said third stations, a high speed channel transmitter at said first station, a low speed channel transmitter at said first station, each of said transmitters being associated with a different channel, means for associating said transmitters with said signaling line for periods of time dependent upon the signaling traffic of said respective transmitters, means at said second station for repeating the signaling impulses of said high speed transmitter to said signaling line connecting said second and third stations, a low

speed recorder at said second station, means for isolating said impulses from said low speed channel transmitter to operate said low speed channel recorder at said second station, a transmitter at said second station for transmitting impulses from said second to said third stations over said low speed channel, and high and low speed channel recorders at said third station associated with said high and low speed channels respectively and operated by impulses received over said channels to produce continuous records.

17. In a telegraph system, a first station, a second station, a third station, a multi-channel telegraph system including signaling lines connecting said first and said second stations, and said second and said third stations, a high speed channel transmitter at said first station, a low speed channel transmitter at said first station, each of said transmitters being associated with a different channel, means for associating said transmitters with said signaling line for periods of time dependent upon the signaling traffic of said transmitters, means at said second station for repeating the impulses of said high speed channel transmitter to said signaling line connecting said second and third stations, a low speed channel recorder at said second station, means for isolating said impulses from said low speed channel transmitter to operate said low speed channel recorder at said second station, a transmitter at said second station for transmitting impulses from said second station to said third station over said low speed channel, and high and low speed channel recorders at said third station associated with said high and low speed channels respectively and operated by impulses received over said channels, and means whereby said recorders produce continuous records.

18. In a multi-channel telegraph system, a first station, a second station, a signaling line connecting said stations in which different channels thereof have different signaling speeds, transmitters at said first station equal to the number of channels, and automatic means for connecting said transmitters successively to said line for portions of the signaling period corresponding to said signaling speeds.

19. In a multi-channel telegraph system, a first station, a second station, a signaling line connecting said stations in which different channels thereof have different signaling speeds, a plurality of transmitters at said first station, and a rotary distributor provided with a segmented transmitting ring having its segments divided into a plurality of groups, said groups being operatively connected to said transmitters in accordance with the proportion of line signaling time allotted to the respective transmitters, whereby the transmitters will be successively connected to the line each for the period of time allotted to its channel.

20. In a multi-channel telegraph system, a plurality of stations, a signaling line connecting said stations in which the channels thereof are operable at unequal signaling speeds, a rotary distributor at one station provided with a segmented transmitting ring having its segments divided into a plurality of groups, said groups being divided into unequal sets which are allotted to the respective channels of the signaling line, and means for impressing the code signals for the respective channels upon said sets of the distributor in succession.

In testimony whereof I affix my signature.

CRESCENT F. NELSON.