Aug. 25, 1953 S. D. BROWNING 2,650,266

DUAL CHANNEL TELEGRAPH SYSTEM

Filed July 3, 1948 2 Sheets-Sheet 1

Fig. 1.

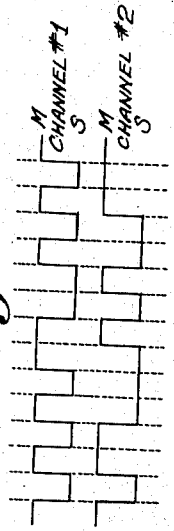

Fig. 4.

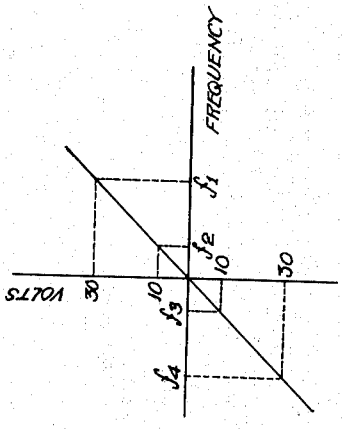

Fig. 2.

1 CONDITION	2 TRANS.-1	TRANS.-2	3 E_1	4 E_2	5 E_1+E_2	6 f TRANS.
1	S	S	0	0	0	f_1
2	M	S	5	0	5	f_2
3	S	M	0	10	10	f_3
4	M	M	5	10	15	f_4

Fig. 5.

7 f REC.	8 E_3	9 E_4	10 TUBE 22	11 TUBE 52	12 KEYER & PRINTER 2	13 TUBE 24	14 TUBE 25	15 TUBES 24+25	16 TUBE 36	17 TUBE 23	18 TUBE 52	19 TUBES 53+56	20 KEYER 1 PRINTER 1
f_1	-15	+15	S	M	SPACE	S	M	M	S	S	M	M	SPACE
f_2	-5	+5	S	M	SPACE	S	M	M	S	M	S	S	MARK
f_3	+5	-5	M	S	MARK	S	S	S	M	M	S	M	SPACE
f_4	+15	-15	M	S	MARK	M	S	M	S	M	S	S	MARK

M = CURRENT FLOW S = NO CURRENT $\Delta f = f_1 - f_2 = f_2 - f_3 = f_3 - f_4$

INVENTOR.
SAMUEL D. BROWNING

BY R. P. Morris

ATTORNEY

Aug. 25, 1953 S. D. BROWNING 2,650,266

DUAL CHANNEL TELEGRAPH SYSTEM

Filed July 3, 1948

2 Sheets-Sheet 2

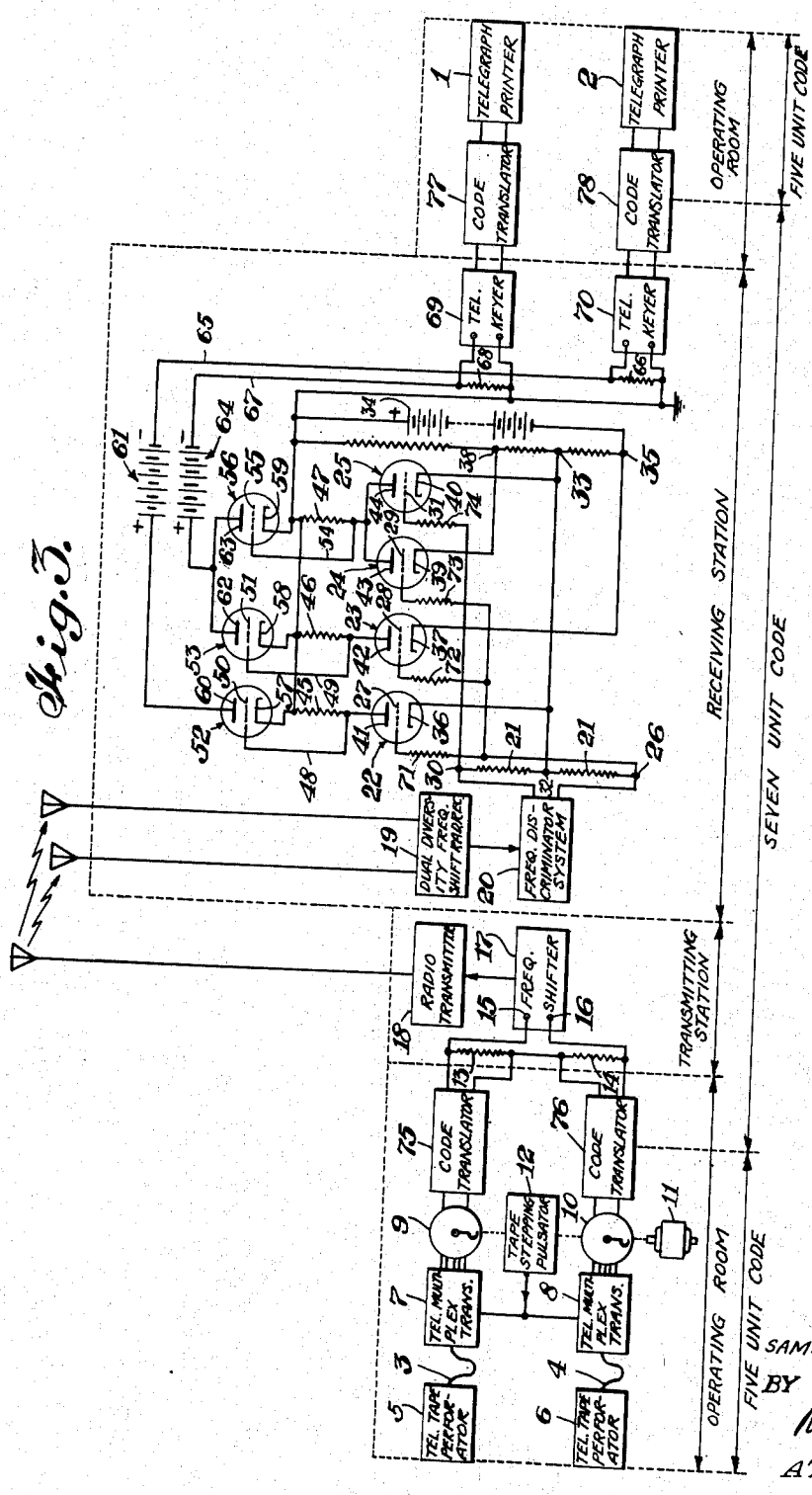

Fig. 3.

INVENTOR.
SAMUEL D. BROWNING
BY
R. P. Morris
ATTORNEY

Patented Aug. 25, 1953

2,650,266

UNITED STATES PATENT OFFICE

2,650,266

DUAL CHANNEL TELEGRAPH SYSTEM

Samuel D. Browning, Baldwin, N. Y., assignor to Mackay Radio and Telegraph Company, New York, N. Y., a corporation of Delaware

Application July 3, 1948, Serial No. 36,841

7 Claims. (Cl. 178—61)

1

This invention relates to telegraph systems, and more particularly to systems for transmitting signals having certain characteristics, over a transmission channel designed for transmission of signals of different characteristics.

A principal object of the invention is to provide a novel arrangement and organization of apparatus for enabling a single intelligence channel, e. g., a radio channel, to be used to convey intelligence signals arising at a pair of separate channels each of which is adapted to transmit intelligence signals by means of two elements, e. g., mark and space telegraph conditions.

Another object is to provide a novel arrangement for enabling two separate 2-element signal channels, to be connected to a single 4-element transmitting channel, so that at any given instant a single element in said transmitting channel represents intelligence from both the 2-element channels. A typical example of such a transmitting channel is a carrier frequency shift channel.

Another object is to provide a novel arrangement for receiving a single intelligence signal element which arises in two separate 2-unit channels, e. g., mark and space units, and automatically reproducing, under control of said single element, the original 2-element signal conditions in said two channels for the purpose of operating respective telegraph printers or the like.

Another object is to provide a novel method of transmitting intelligence from two separate mark and space telegraph channels over a frequency shift transmission channel, whereby at any given instant the frequency represents intelligence from both said telegraph channels.

Another object is to provide a frequency shift of the mark and space signals from a pair of telegraph channels, and the respective output frequencies and their control voltages.

Fig. 1 is a graph showing the synchronized transition characteristic between the two telegraph channels. Fig. 2 is a chart showing the relation between the four output shifted frequencies and the four space-mark combination or conditions in the two channels to a transmitting channel.

Fig. 3 is a schematic diagram, partly in block form, of a complete system according to the invention.

Fig. 4 is a graph of a typical characteristic curve of the frequency discriminator shown in Fig. 3.

Fig. 5 is a chart showing the relations between

2

the received frequencies and the segregated mark and space signals and their respective control voltages.

Referring to Fig. 1, there are represented the current conditions arising in two separate telegraph channels of the mark and space type. Merely for purposes of explanation, it will be assumed that the space condition is represented by zero current, and the mark condition is represented by current of a certain minimum amplitude. It will be understood however, that the invention is equally useful where the mark and space conditions are represented by current reversals. It is apparent that there will be only four possible combinations between the mark and space elements of the two channels. These combinations can be represented by the elements of a single 4-element channel as follows:

2-Element Channel #1	2-Element Channel #2	4-Element Circuit
Space	Space	f_1, I_1, etc.
Mark	do	f_2, I_2, etc.
Space	Mark	f_3, I_3, etc.
Mark	do	f_4, I_4, etc.

In accordance with the invention, it will be assumed that the signals from the two channels (Fig. 1) are to operate respective telegraph printers 1, 2 (Fig. 3) which operate on the 5-unit or Baudot code principle. It will also be assumed that the originating signals from the two channels are to be transmitted over a radio or carrier channel of the frequency shift kind. In accordance with one phase of the invention, each of the above listed four conditions of the combined pair of 2-unit channels is represented by one of four different frequencies, f_1, f_2, f_3, f_4, only one of which is transmitted at a time over the radio channel.

If the two originating channels are keyed at random, the keying speed of the combined channels will be variable, because some of the combinations listed above may exist for very short periods of time. If, however, the two channels employ the same code, e. g., the 5-unit printer code, and the two channels are synchronized so that the transitions between mark and space occur simultaneously in both channels as illustrated in Fig. 1, then the keying speed of the combined channels will be the same as that of either of the single channels. Preferably, therefore, although not necessarily, automatic tape transmission is employed, although any other known method of synchronization may be employed.

Thus as shown in Fig. 3, the tapes 3, 4, from two separate tape perforators 5, 6, are fed into respective multiplex tape transmitters 7, 8. The 5-unit code signals from transmitter 7 are taken off by a distributor 9, and the 5-unit code signals from transmitter 8 are taken off by a distributor 10, both distributors being synchronously driven from the common driving motor 11. In accordance with well-known mechanism 12, after each complete rotation of the distributors, a stepping impulse is delivered to the transmitters 7, 8, to step the tapes ahead to the next character.

The signal output current from distributor 9 is applied across a resistor 13, and the signal output current from distributor 10 is applied across a resistor 14, both resistors being connected in series across a pair of frequency shift input control terminals 15, 16. The resistors 13, 14 are respectively proportioned or adjusted so that for a given mark signal in each channel, the voltage developed across resistor 14 is, for example, twice that developed across resistor 13. Thus the above listed four possible combinations of mark and space elements will result in four respective values of voltage. For example, if a mark signal in channel #1 is represented by five volts across resistor 13, a mark signal in channel #2 will be represented by 10 volts across resistor 14. Consequently the four possible combinations will be represented respectively by four voltages, namely 0, 5, 10 and 15 volts at the terminals 15, 16. These four voltage conditions can be transmitted by any well-known means to a receiving point for selective segregation purposes.

These four voltages, for example, are applied to the linear input of any well-known kind of frequency shifter 17 which produces four distinct frequencies f_1, f_2, f_3, f_4, in accordance with the said four voltages. Fig. 2 shows in chart form, the relation between the original four conditions of the pair of 2-element channels and the output frequencies from the shifter 17. Thus the pair of 2-element telegraph channels are combined into a single 4-element channel by the process of converting the mark elements of the two telegraph channels into a form of energy so that the energy representing one channel is twice the energy representing the other channel, and then combining these energies in series and using the combined energy to key the 4-element channel. The simplicity of this process results from the representation of the four combinations of the 2-element channels by the respective frequency of the single 4-element channel in the following sequence:

S1S2=f_1 (or f_4)
M1S2=f_2 (or f_3)
S1M2=f_3 (or f_2)
M1M2=f_4 (or f_1)

Preferably, although not necessarily, the signals from shifter 17 are transmitted over a dual diversity radio channel, the radio transmitter being schematically represented by the block 18, and the dual diversity receiver being represented by the block 19. The output of receiver 19 is applied to any well-known frequency discrimination system 20 by means of which the frequencies f_1, f_2, f_3, f_4 are converted into corresponding D. C. voltages as illustrated for example by the graph of Fig. 4. These voltages are applied across a center-tapped resistor 21, so that there are produced across this resistor four pairs of oppositely polarized voltage values E3, E4, as indicated in columns 8, 9 (Fig. 5).

Associated with resistor 21 are four grid-controlled tubes 22, 23, 24, 25. The terminal 26 of resistor 21 is connected in parallel to the control grids 27, 28, 29, of respective tubes 22, 23, 24, while the terminal 30 is connected only to the control grid 31 of tube 25. It will be understood that the particular voltage values above mentioned, are arbitrarily chosen merely for explanatory purposes and are not necessarily the optimum values that may be used.

The center tap 32 of resistor 21 is connected to a point 33 in a voltage divider resistor which is bridged across the D. C. power supply represented by the 100 volt battery 34. The point 33 is chosen, under the above-mentioned voltage ranges, so that it is 10 volts removed from the —100 volt terminal 35. The point 33 is connected to cathode 36, and point 35 is connected to cathode 37. Another point 38 on the voltage divider which is 20 volts positive with respect to point 35, and therefore 10 volts positive with respect to point 33, is connected to cathode 39. The point 33 is also connected to cathode 40. The points 35 and 38 are therefore chosen so as to represent approximately ⅔ the maximum value of E3+E4 so that the valves E3 and E4 will fall equally distant on either side of the three points 33, 35, 38.

The cathodes 36, 37, 39, 40, are connected to the taps adjacent the negative end of the D. C. power supply, while their respective plates 41, 42, 43, 44, are connected through suitable series resistors 45, 46, 47, to the positive end of the D. C. power supply 34. The plates 41, 42, of tubes 22, 23, are directly connected by conductors 48, 49, to the control grids 50, 51, of associated tubes 52, 53. Likewise, the plates 43, 44, are connected in parallel and directly by conductor 54 to the control grid 55 of an associated tube 56. Thus, when no signals are being received from the discriminator 20, the grid of tube 22 is at zero bias with respect to its cathode; the grid of tube 23 is biased 10 volts positive with respect to its cathode; the grid of tube 24 is 10 volts negative with respect to its cathode; and the grid of tube 25 is at zero bias with respect to its cathode. It will also be observed that the tube 25 is controlled only by the E4 voltage. The cathodes 57, 58, 59, of tubes 52, 53, 56, are connected to the grounded positive terminal of the power supply 34. However, the plate 60 of tube 52 is supplied by a separate D. C. power supply 61, and the plates 62, 63, are connected in parallel to another separate D. C. power supply 64.

Connected in the negative lead 65 of power supply 61 is a resistor 66. Likewise, connected in the negative lead 67 of power supply 64 is a resistor 68. Any well-known tone keyer 69 is connected across resistor 68, and a similar tone keyer 70 is connected across resistor 66. The keyers are so arranged that a negative voltage across their respective resistors 66, 68, place these keyers on space, while a positive voltage places them on mark.

Consider now, tube 22 whose cathode 36 is connected to the —90 volt point 33, and whose grid is driven by the voltage E3. When frequencies f_1 or f_2 are being received, the grid voltage at grid 27 falls at points 35 and 38, namely sufficiently negative to keep tube 22 at plate current cutoff, representing a space signal as indicated in columns 7, 8 and 10 (Fig. 5) for frequencies f_1, f_2. However, when frequency f_3 or f_4 is being received, the grid 27 is driven positive and plate current flows through tube 22 to represent a mark signal. This is indicated in Fig. 5 in the columns 8, 9, 10, adjacent the frequencies f_3, f_4. Prefer-

ably, the grid of each of the tubes 22—25 has a resistance 71—74 in series with it, to prevent excessive positive excursions of the grid.

Considering now the tube 52, it will be seen that when tube 22 is at cut off (i. e. on space), there is no current drawn thru anode load resistor 45 and consequently no voltage drop is developed thereacross and no bias is applied to grid 50 and therefore tube 52 is plate current conductive. Likewise, when tube 22 is conductive, tube 52 is at cut off. In other words, tubes 22 and 52 are conductive in opposite phase as indicated in columns 10 and 11 (Fig. 5). In a similar manner, when tube 52 is at cut off there is no bias applied to keyer 70 and both keyer 70 and printer 2 are on mark. On the other hand when tube 22 is on space (i. e. at cut off), tube 52 is conductive and a bias is applied through resistor 66 to drive the keyer 70 and the printer to space. By a comparison of columns 12 and 2, it will be seen that channel #2 has been effectively separated so as to control only the printer 2.

By the same process it will be seen that tube 24 is on space (i. e. at cut off) for frequencies f_1, f_2, f_3, so long as E3 is at the voltage of points 37, 35, 38. Similarly tube 25, whose grid is fed by E4, is on space for frequencies f_3, f_4, while E4 is at the voltage of 33 or 35. These values of mark and space are indicated in columns 13, 14, of Fig. 5.

The plates of tubes 24, 25, being in parallel, it will be seen that should both be on space, then a mark condition on grid of tube 31 will cause a current to flow through their common plate resistor 47. Therefore, tube 56 will go to mark only when both tubes 24, 25, are on space. Likewise, when either tube 24 or 25, or both tube 24 and 25, are on mark, tube 56 will be on space. This is indicated in columns 15, 16 (Fig. 5) wherein column 15 shows a mark condition when either tube 24 or 25 is at mark.

Now considering tube 23, it will be seen from column 17 that it will be on space only for frequency f_1, and it will be on mark only for frequencies f_2, f_3, f_4. As a result, tube 53 will be in opposite phase as indicated in column 18. The plates of tubes 53 and 56 being in parallel, operate in combination similarly to the pair of tubes 24, 25. In other words, both tubes 53, 56, must be on space, in order to remove the bias across keyer 69 so as to drive it to mark. The combination of tubes 53, 56, is indicated in column 19 and the resultant condition of keyer 69 and printer 1 are indicated in column 20. It will be noted that the conditions in column 20 correspond to those of channel #1 (column 1, Fig. 2), and thus the 2-element channel #1 has been reformed and the signals arising in that channel are reproduced only on printer 1. Instead of a printer, any other signal reproducing device responsive to a 2-element code can be used.

Any of the well-known means may be employed to prevent false operation by reason of "hits" or "drop outs" affecting the radio link due to static or other interference and to fading. To minimize the printing of erroneous characters as a result of these effects, the radio circuit can be operated in the well-known manner on a 7-unit code basis by inserting any well-known 5 to 7 unit translators at the transmitting end as represented by the dotted rectangle 75, 76; and corresponding 7 to 5 unit translators 77, 78, at the receiving end.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention. For example, while the four voltage conditions represented in columns 3 and 4 (Fig. 2) have been described as being transmitted over a radio channel by corresponding frequencies, they may be transmitted as respective amplitude modulations whether of voltage or current so long as they are received and reproduced as the corresponding pairs of opposite polarity voltages as represented for example in columns 8 and 9 (Fig. 5).

What is claimed is:

1. An electron switch arrangement for converting four selectively received frequencies into separate mark and space signals for use in two separate channels, comprising a frequency discriminator circuit, a first set of four grid-controlled tubes coupled to said circuit, each of said tubes differently biassed to be responsive to the output of said circuit, a second set of three grid-controlled tubes, each of the tubes of said sets having a grid, a cathode and a plate, a first signal reproducer channel connected to the plate circuit of the first tube in the second set, another signal reproducer channel connected in parallel to the plate circuit of the second and third tubes of the second set, the plates of the first and second tubes of said first set each respectively connected to said first and second tubes of said second set to vary the grid bias thereof, the plates of said third and fourth tubes of said first set connected to the third tube of said second set to vary the grid bias thereof so that the receipt by said discriminator circuit of one frequency causes both reproducer channels to go to space, a second frequency causes both reproducer channels to go to mark, a third frequency causes the first reproducer channel to go to mark and the second reproducer channel to go to space, and a fourth frequency causes the first reproducer channel to go to space and the second reproducer channel to go to mark.

2. A telegraph transmitter comprising means to set up signal voltages in two separate mark and space telegraph channels, means to synchronize the transitions between mark and space conditions in each of said channels, means to combine said voltages each of a respective different amplitude to set up four different control voltages representing respectively the four possible combinations of mark and space conditions in said two channels, means to generate a carrier frequency and means to apply said control voltages to said channel, means to shift the carrier frequency to any one of four distinct frequencies each representing one of said four combinations.

3. A telegraph transmitter according to claim 2 in which each of said telegraph channels includes a multiplex tape controlled transmitter each having an output distributor, and a common motor for driving said distributors in synchronism.

4. A telegraph transmitter according to claim 2 in which the means to combine said voltages comprises a pair of resistors each connected respectively across the output of a corresponding one of said telegraph channels, said resistors being connected in series and being mutually proportioned in value so that a mark signal from one channel produces twice the voltage across its respective resistor as is produced by a mark

signal across the resistor for the other channel.

5. A telegraph transmitter according to claim 2 in which said means to combine said voltages comprises a pair of resistors each individually connected across the output of one of said channels, said resistors being connected in series, and a frequency shifter connected across the terminals of said series connected resistors and whose output controls the carrier shift of said radio transmitter.

6. A telegraph receiver comprising in combination, a frequency shift radio receiver arranged to respond to four different receiver carrier shifts to produce two sets of four different voltages, a set of four grid-controlled electron tubes, means to apply the voltages of one set to selectively control the conductivity of three of the tubes of said set of four tubes, means to apply the voltages of the other set to selectively control the conductivity only of the fourth tube of said set of four tubes, another set of three grid controlled tubes, means connecting the plate of the first tube of said three tubes of the first set to one signal reproducing channel, means connecting the plates of the remaining two tubes of the other set in parallel to a second signal reproducing channel, means connecting the plates of the first and second tubes of the first set respectively to the grids of the first and second tubes of the other set, and means connecting the plates of the third and fourth tubes of the first set in parallel to the grid of the third tube of the other set.

7. A system of telegraph communication comprising in combination a radio transmitter of the frequency shift kind, a pair of telegraph transmitters each arranged to transmit respective mark and space signals from a pair of channels, means to synchronize the transition between mark and space conditions in said channels, a first voltage developing network for coupling the signals from said channels to said radio transmitter to produce four different carrier frequency shifts corresponding respectively to the four possible combinations of simultaneous space and mark signals from said two channels, a radio receiver, a pair of telegraph signal reproducers, coupling means for coupling said reproducers to the output of said receiver comprising a resistance network to produce two sets of four different voltages, a frequency discriminator coupled between the output of said receiver and said resistance network, a bank of four grid-controlled electron tubes, means to apply the voltages of one of said two sets to selectively control the conductivity of three of the tubes of said tube bank, means to apply the voltages of the other set to selectively control the conductivity only of the fourth tube of said tube bank, an additional bank of three grid-controlled electron tubes, means connecting the plate of the first tube of said additional banks to a first of said signal reproducers, means connecting the plates of the remaining two tubes of said additional bank in parallel to the other of said signal reproducers, means connecting the plates of the first and second tubes of the first-mentioned bank respectively to the grids of the first and second tubes of said additional bank, and means connecting the plates of the third and fourth tubes of said first bank in parallel to the grid of the third tube of said additional bank, whereby said reproducers are automatically operated in accordance with signals only from a respective one of said telegraph transmitters.

SAMUEL D. BROWNING.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,631,976	Mathes	June 14, 1927
1,661,962	Robinson	Mar. 6, 1928
1,886,263	Ilberg	Nov. 1, 1932
2,301,373	Cox	Nov. 10, 1942
2,464,837	Werthmann	Mar. 22, 1949