

April 23, 1929.

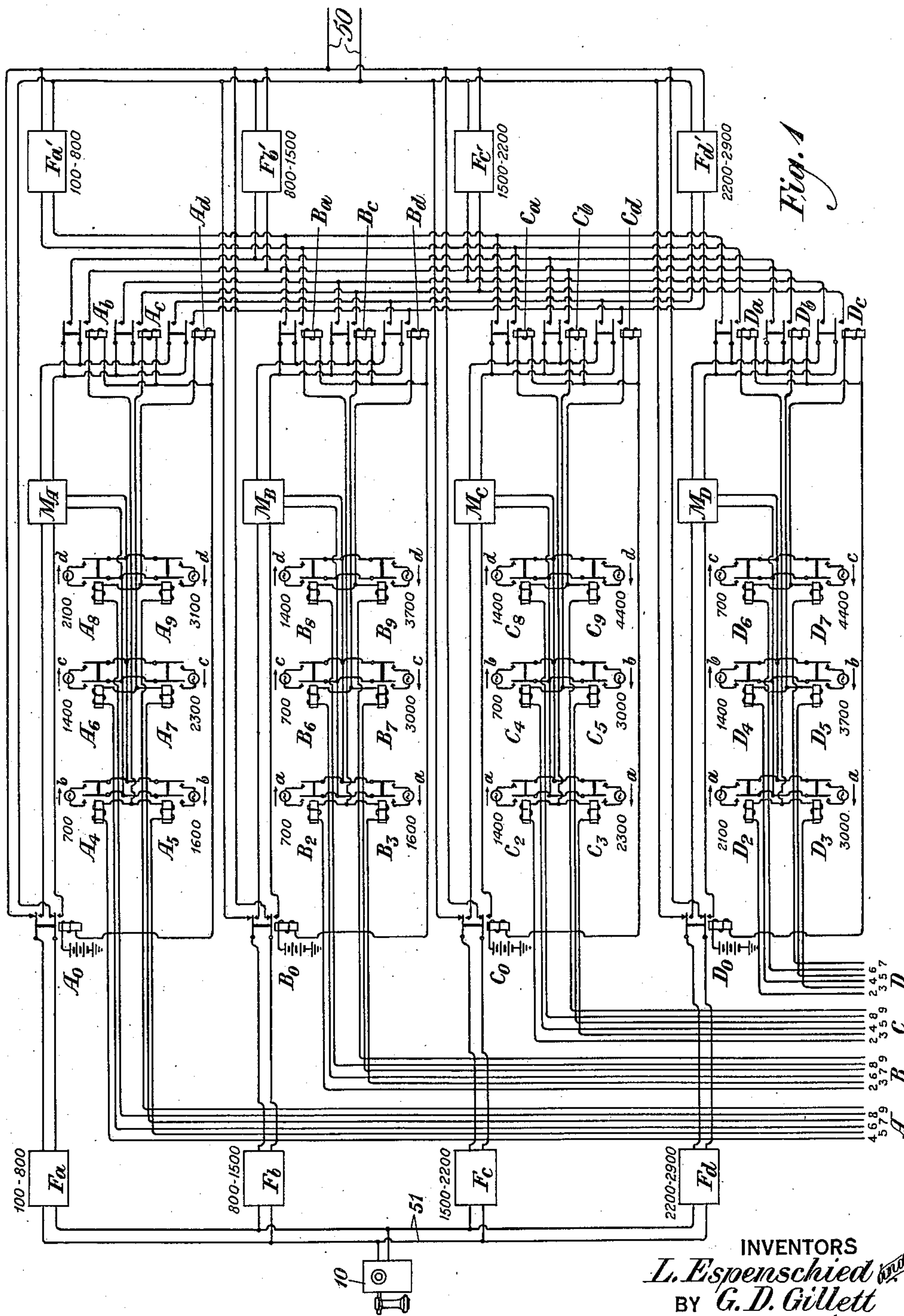
L. ESPENSCHIED ET AL

1,709,901

SECRET SIGNALING SYSTEM

Filed Oct. 8, 1925

4 Sheets-Sheet 1



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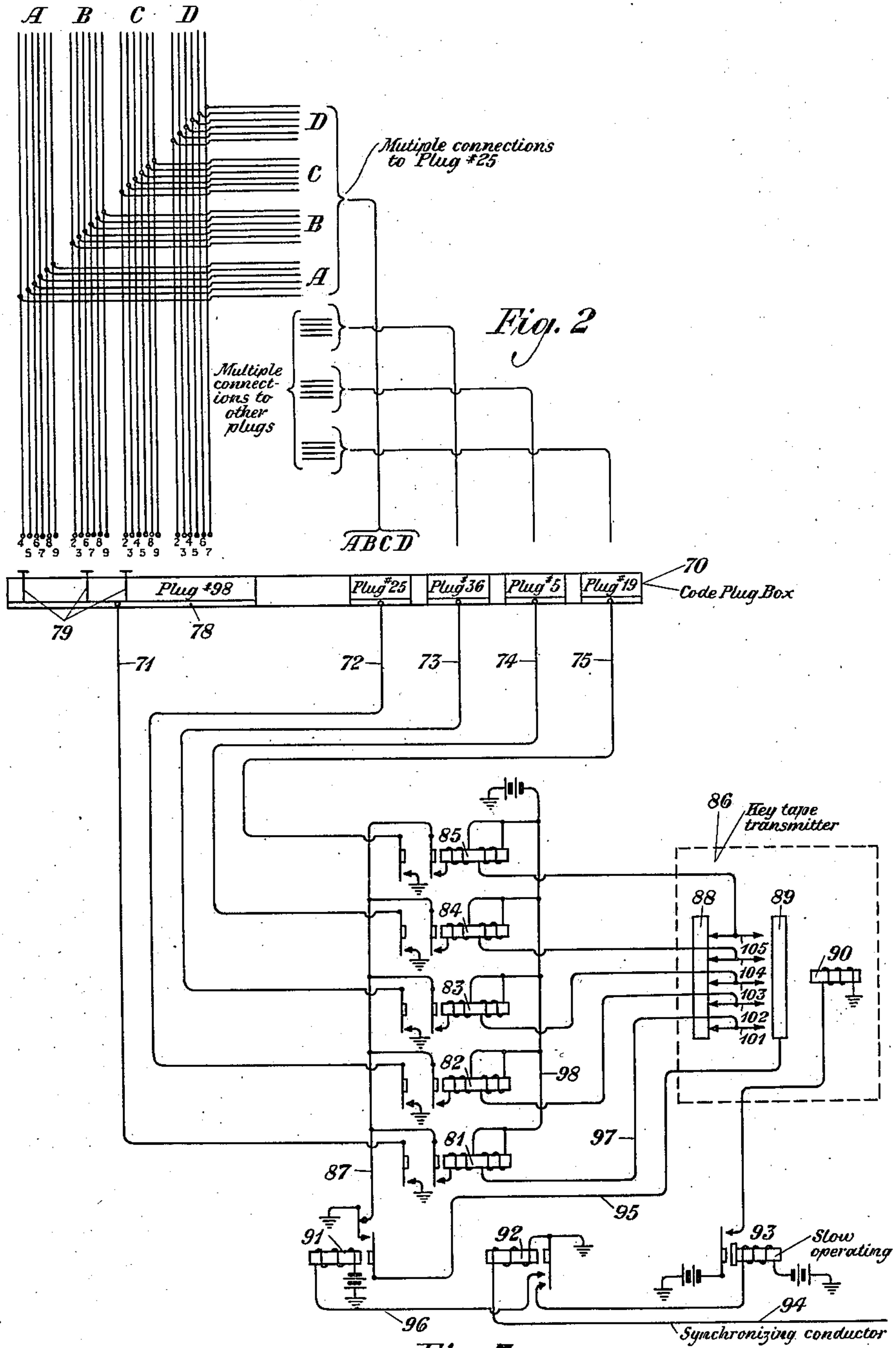
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4 Sheets-Sheet 2



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SECRET SIGNALING SYSTEM

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4 Sheets-Sheet 3

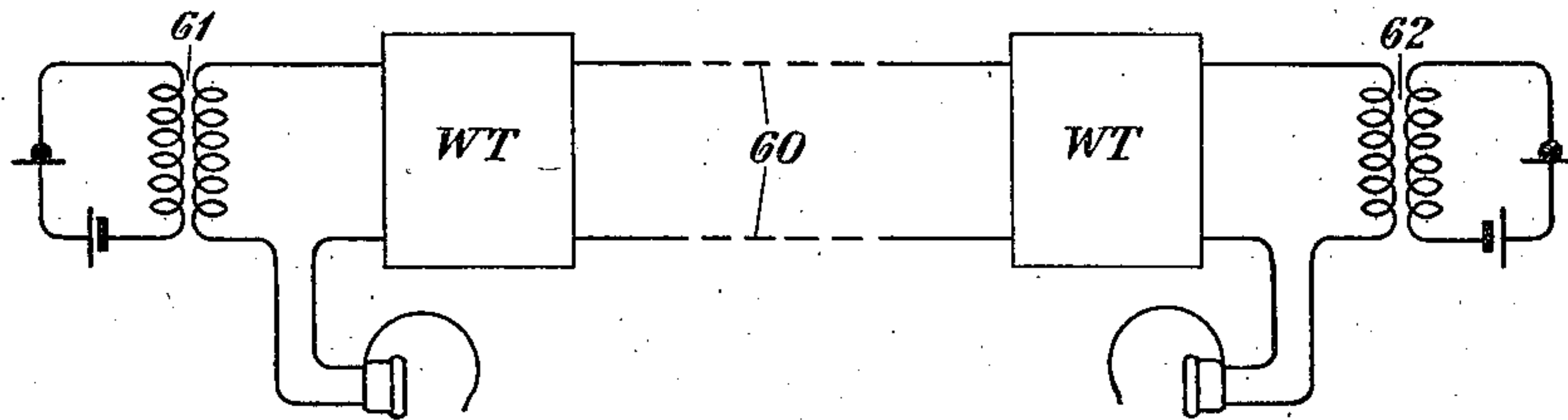


Fig. 4

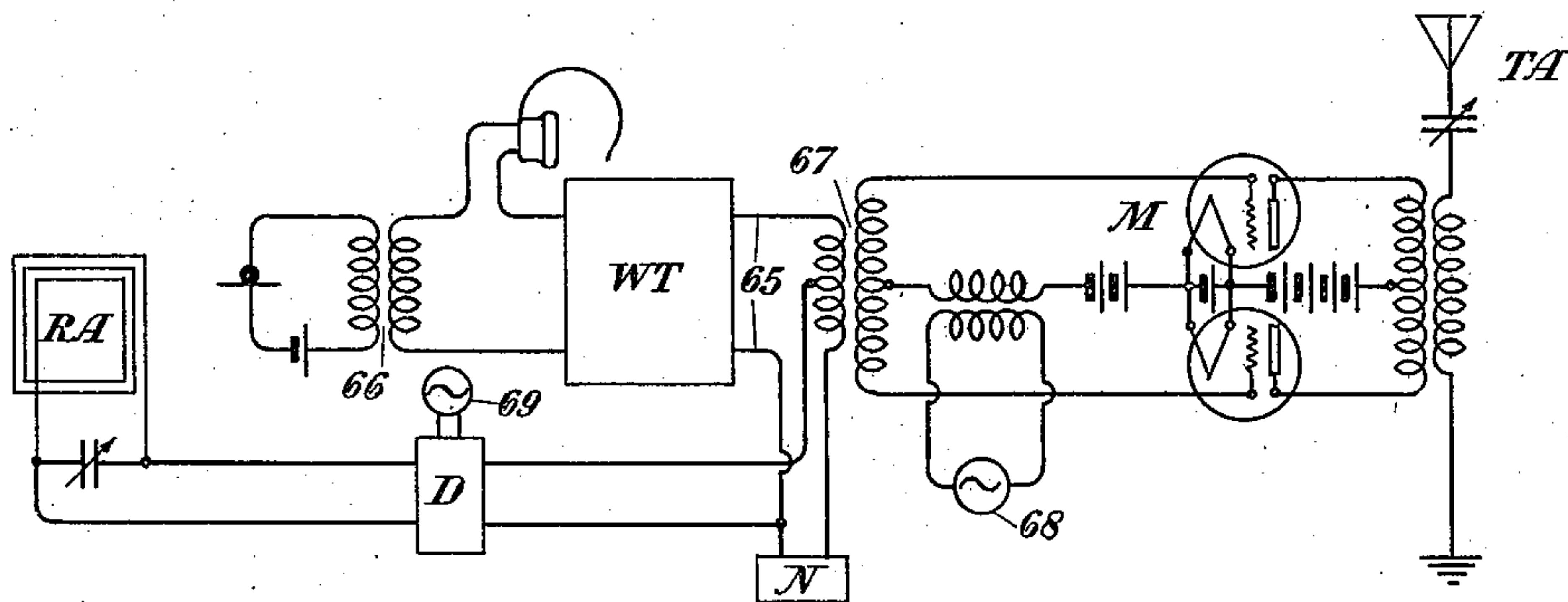


Fig. 5

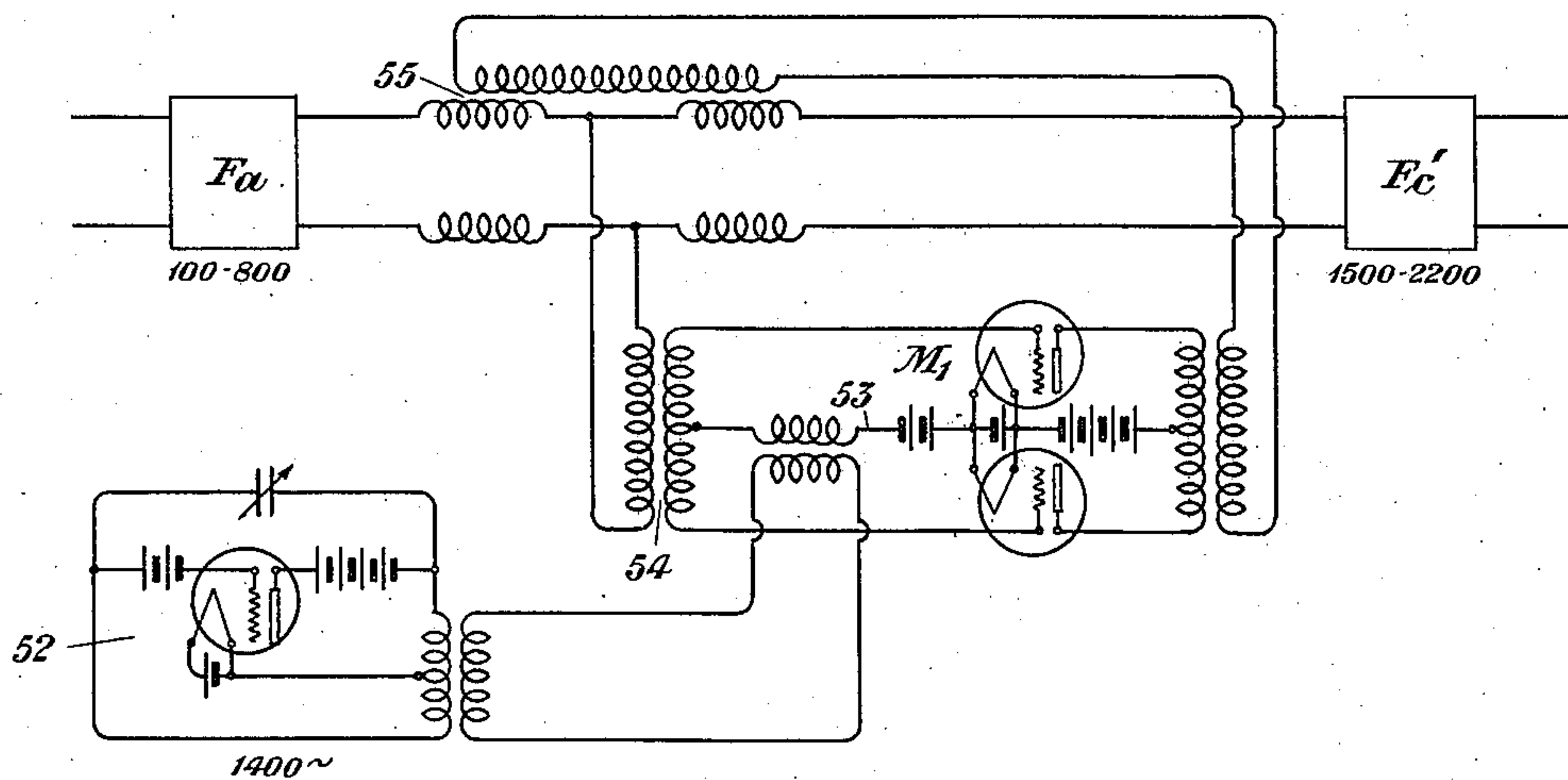


Fig. 6

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4 Sheets-Sheet 4

	a	b	c	d		a	b	c	d		a	b	c	d
	b	a	d	c	25	b	d	a	c		d	c	b	a
	b	a	d	c	26	b	d	a	c		d	c	b	a
	b	a	d	c	27	b	d	a	c		d	c	b	a
	b	a	d	c	28	b	d	a	c		d	c	b	a
	b	a	d	c	29	b	d	a	c		d	c	b	a
1	b	a	d	c	30	b	d	a	c	71	a	c	d	b
	b	a	d	c	31	b	d	a	c	72	a	c	d	b
	b	a	d	c	32	b	d	a	c	73	a	c	d	b
2	b	a	d	c	33	b	d	a	c		a	c	d	b
	b	a	d	c	34	b	d	a	c	74	a	c	d	b
	b	a	d	c	35	b	d	a	c	75	a	c	d	b
	b	a	d	c		d	a	b	c	76	a	c	d	b
	b	a	d	c		d	a	b	c		c	a	b	d
	b	a	d	c		d	a	b	c	77	c	a	b	d
	b	a	d	c		d	a	b	c	78	c	a	b	d
	b	a	d	c	36	d	a	b	c	79	c	a	b	d
	b	a	d	c		d	a	b	c	80	c	a	b	d
	b	a	d	c		d	a	b	c	81	c	a	b	d
	b	a	d	c		d	a	b	c	82	c	a	b	d
	b	a	d	c		d	a	b	c		a	d	b	c
3	c	d	a	b	37	d	a	b	c	83	a	d	b	c
	c	d	a	b	38	d	a	b	c	84	a	d	b	c
	c	d	a	b	39	d	a	b	c	85	a	d	b	c
	c	d	a	b		d	a	b	c	86	a	d	b	c
4	c	d	a	b	40	d	a	b	c	87	a	d	b	c
	c	d	a	b		d	a	b	c	88	a	d	b	c
	c	d	a	b		d	a	b	c	89	a	d	b	c
	c	d	a	b		d	a	b	c	90	a	d	b	c
	c	d	a	b	41	c	a	d	b	91	a	d	b	c
	c	d	a	b	42	c	a	d	b	92	a	d	b	c
	c	d	a	b	43	c	a	d	b	93	a	d	b	c
5	d	a	b	c	44	c	a	d	b	94	a	d	b	c
	d	a	b	c	45	c	a	d	b	95	a	d	b	c
	d	a	b	c	46	c	a	d	b	96	a	d	b	c
	d	a	b	c	47	c	a	d	b		b	c	a	d
	d	a	b	c	48	c	a	d	b	97	b	c	a	d
6	d	a	b	c	49	c	a	d	b	98	b	c	a	d
	d	a	b	c	50	c	a	d	b	99	b	c	a	d
7	d	a	b	c	51	c	a	d	b		b	c	a	d
8	d	a	b	c	52	c	a	d	b	100	b	c	a	d
9	d	a	b	c	53	c	a	d	b	101	b	c	a	d
	d	a	b	c	54	c	a	d	b	102	b	c	a	d
	d	a	b	c	55	c	a	d	b	103	b	c	a	d
	d	a	b	c	56	c	a	d	b	104	b	c	a	d
	d	a	b	c		d	c	a	b	105	d	a	c	b
10	b	c	d	a		d	c	a	b	106	d	a	c	b
	b	c	d	a		d	c	a	b	107	d	a	c	b
	b	c	d	a	57	d	c	a	b	108	d	a	c	b
	b	c	d	a	58	d	c	a	b	109	d	a	c	b
11	c	d	a	b	59	d	c	a	b	110	d	a	c	b
12	c	d	a	b		d	c	a	b	111	b	c	a	d
13	c	d	a	b	60	d	c	a	b	112	b	c	a	d
	c	d	a	b	61	d	c	a	b	113	b	c	a	d
14	c	d	a	b	62	d	c	a	b	114	b	c	a	d
15	c	d	a	b		d	c	a	b	115	b	c	a	d
16	c	d	a	b		d	c	a	b	116	b	c	a	d
	c	d	a	b	63	d	c	a	b	117	b	c	a	d
17	c	d	a	b	64	d	c	a	b	118	b	c	a	d
18	c	d	a	b	65	d	c	a	b	119	b	c	a	d
19	c	d	a	b		d	c	a	b	120	d	b	a	c
	c	d	a	b	66	d	c	a	b	121	d	b	a	c
	c	d	a	b	67	d	c	a	b	122	d	b	a	c
	c	d	a	b	68	d	c	a	b	123	d	b	a	c
	c	d	a	b		d	c	a	b	124	d	b	a	c
20	b	d	a	c	69	d	c	a	b	125	d	b	a	c
21	b	d	a	c		d	c	a	b		c	d	a	b
22	b	d	a	c		d	c	a	b					
23	b	d	a	c	70	d	c	a	b					
24	b	d	a	c		d	c	a	b					

Fig. 7

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SECRET-SIGNALING SYSTEM.

Application filed October 8, 1925. Serial No. 61,327.

The present invention relates to wave transmission and reception and more particularly has to do with the securing of secrecy, or privacy, in the transmission of waves for any purpose, such as signaling.

It has been proposed to secure secrecy, or privacy, of wave transmission by sub-dividing the waves, such for example, as signaling waves, into sub-bands of relatively narrow frequency ranges and displacing the individual bands or inverting the frequency order within the individual sub-bands or otherwise operating on the sub-bands to render very difficult the restoration of the transmitted waves to their original form. Such systems rely for privacy on the fact that it is impossible to restore the waves to their original form by means of the ordinary types of receivers even if the privacy scheme be known. Special apparatus, such as wave filters, designed to have the proper frequency transmission characteristics together with wave combining circuits, are generally required. If the scheme of transforming the waves to their unrecognizable condition were known and if this scheme were invariably used, it is conceivable that an unauthorized person of sufficient patience and resourcefulness might in time be able to construct a receiver that would produce the waves in intelligible form.

It is an object of the present invention to increase the secrecy in wave transmission of the type referred to by changing from time to time the scheme of transformation of the waves to be secretly transmitted.

It is a further object of the invention to provide a large number of highly secret schemes of transformation and to facilitate shifting from one scheme to a different scheme of transformation by automatic means operating in accordance with a fortuitous code.

Other objects and features of the invention will appear more fully from the detailed description hereinafter given.

Briefly and specifically described, the invention may take the form of a wire or wireless transmission system in which the waves to be transmitted are first sub-divided by filters into sub-bands of frequency components, after which the sub-bands may be variously treated preparatory to transmission. For example, in a system in which the waves

are divided into four sub-bands, four modulating or wave-combining circuits are provided together with appropriate wave sources and filters for obtaining any desired one of a large number of waves possessing a high degree of secrecy, 126 such highly secret combinations being provided by the invention. By simply causing the operation of certain combinations of switching arrangements, a change may readily be made from one secrecy scheme to another. Circuit arrangements are provided for operating these combinations of switching arrangements, these circuit arrangements being initially controlled by individual code plugs. A different code plug is provided for each one of the 126 secrecy combinations. An arbitrary number of these code plugs will be picked out and inserted in a code plug box. The aforementioned circuit arrangements will be multiplied so as to be associated with each one of the code plugs in the box. In other words an arbitrary number of secrecy schemes will be picked out by the choosing of these plugs under which the system is to be operated for a certain period. Associated with each of the chosen code plugs are circuits leading to printing telegraph apparatus controlled by a key tape. By this arrangement different ones of the plugs in the code plug box may be operatively associated with the aforementioned circuits from time to time in a fortuitous manner in accordance with the perforations in the key tape. In other words with this arrangement the various secrecy schemes may be changed by the choice of the code plugs and then their separate association with the circuits controlling the system may automatically be varied in a continuously changing and random manner by the key tape and printing telegraph apparatus. Arrangements are also provided for maintaining synchronism between the sending and receiving station with regard to the shifting from one secrecy scheme to another. This arrangement makes it practically an impossible task for an unauthorized person to decipher the message being sent, since the order of variation from one secrecy combination to another may be varied to an almost infinite degree.

A more detailed description of the invention will now be given in connection with the

accompanying drawings in which Figure 1 is a circuit diagram showing the arrangements of the various elements of a wave transforming system capable of use both in transmitting and receiving with secrecy; Fig. 2 is a circuit diagram to be used with Fig. 1 to show the multiple connections of the control circuits to the code plugs in the code plug box; Fig. 3 is a circuit diagram to be used with Fig. 2 showing printing telegraph equipment and the manner of its connection to the various code plugs to pick out different ones of said plugs for operatively connecting them with the control circuits; Fig. 4 shows a two-way two-station system employing the arrangements of the invention; Fig. 5 shows its application to a radio system; Fig. 6 shows details of the modulating or wave combining circuit, and Fig. 7 is a table showing in symbolic form the secrecy combination according to the invention.

In Fig. 1 there is shown a wave transforming circuit leading on the left to the telephone instrument 10 and terminating on the right in the leads 50, which may be connected to any desired type of transmission system as will be explained hereinafter. This wave transforming circuit may serve both for detecting waves originating in the telephone 10 and for incoming waves to be received at 10, on the assumption that the leads 50 are connected to a two-way system.

The speech currents originating in the telephone 10 pass into the leads 51 to which are connected the sub-dividing or analyzing filters F_a , F_b , F_c and F_d which are designed to transmit the respective frequency ranges 100 to 800, 800 to 1500, 1500 to 2200 and 2200 to 2900 cycles, respectively, on the assumption that the total range of 100 to 2900 cycles is to be transmitted. Any other desired range of frequency components may be transmitted and received and any desired number of sub-dividing filters may be used. Furthermore the signaling currents utilized are not limited to those transmitting speech as other currents such as those transmitting pictures may be applied to this system. It will be obvious to proportion the transmission ranges of the respective filters in accordance with the number of filters and the total frequency range covered.

Four wave combining or modulating circuits designated M_a , M_b , M_c and M_d are associated with the respective analyzing filters. These wave combining or modulating circuits are for the purpose of shifting the sub-bands transmitted through the respective analyzing filters so that they will occupy a different range in the outgoing wave. This will be described more fully hereinafter.

A plurality of filters F_a' , F_b' , F_c' and F_d' , similar to those heretofore mentioned, are provided connected to the circuit 50. The filters may be associated with various ones

of the modulators M_a , M_b , M_c and M_d by the operation of certain of the switching means A_b , A_c , A_d , B_a , B_c , B_d , C_a , C_b , C_d , D_a , D_b and D_c as will be pointed out more fully hereinafter.

Associated with each modulating circuit are a number of wave sources for supplying to the modulating circuits the waves of the proper frequencies for introducing the required frequency shift in the sub-bands.

Each of the filters above referred to, as well as those shown throughout the system, may be constructed in accordance with the disclosure in the patent to Campbell, No. 1,227,113, May 22, 1917. The wave sources associated with the modulating circuits may be oscillation generators of the type shown in the patent to Hartley, No. 1,356,763, October 26, 1920. The modulating circuits may all be constructed alike and are preferably of the type shown more in detail in Fig. 6.

Referring, for a moment, to Fig. 6, the modulating circuit M_1 is shown as of the balanced tube type disclosed, for example, in the patent to Carson, No. 1,343,306, June 15, 1920. The oscillator 52 is connected to the common branch 53 of the input circuit of the modulator and the individual circuits are connected by means of the transformer 54 to the midpoint of the hybrid coil 55. The outside side of the modulator is connected to the series winding of the coil 55.

Assuming the frequency of oscillator 52 to be 1400 cycles, a wave transmitted through the filter F_a is applied to the input circuit of the modulator M_a along with the 1400 cycle wave and the modulator acts in the well known manner to produce an upper side band of 1500 to 2200 cycles and a lower side band of 600 to 1300 cycles. These side bands are applied from the output of the modulator to the series winding of the repeating coil 55. It will be seen that the upper side band only comprising frequencies of 1500 to 2200 cycles will be transmitted from the filter F_c' to the outgoing circuit. It is a well known property of the balanced tube modulator that it balances out and suppresses the unmodulated carrier component so that none of the 1400 cycles wave from the oscillator 52 is impressed on the transmission circuit. However, in case some of the unmodulated carrier component is present in the output due to slight unbalance, it is suppressed by the filter F_c' . Waves received through the filter F_c' and having frequencies of 1500 to 2200 cycles are impressed on the input circuit of the modulator M_a where they combine with the 1400 cycle wave to give an upper side band having frequencies extending from 2900 to 3600 cycles and a lower side band having frequencies extending from 100 to 800 cycles. These side bands are transmitted through the repeating coil 55 and only the lower side band is transmitted through the filter F_a to the

circuit lying to the left in the figure. The modulating circuit serves, therefore, for transmission in both directions.

Returning now to Fig. 1 it will be seen that by grounding a certain one of the control circuits a circuit condition may be caused to exist between filter F_a and filter F_c' similar to that just described in connection with Fig. 6. It will be seen that if ground is applied to conductor 6 of group A of control circuits that a circuit will be closed over conductor 6, winding of relay A_6 , then through winding of relay A_c , and thence through winding of relay A_o , to battery and ground. The operation of relay A_o will connect filter F_a to the modulator M_A . The operation of relay A_6 will apply to modulator M_A a carrier frequency of 1400 cycles and the operation of relay A_c will connect the filter F_c' to the modulator M_A . This will set up a condition similar to that of Fig. 6 in which the sub-band of 100-800 cycles will be stepped up in the frequency scale so as to occupy a position of 1500-2200 cycles. The sub-band transmitted through the filter F_a may be shifted in frequency so as to be sent out through any one of the filters F_b , F_c , or F_d . The frequency order of the sub-band may also be either normal or inverted. That is, the 100 to 800 cycle sub-band may be stepped up as a whole in the frequency range in such a manner that a constant frequency is added to each of the frequency components, or, if desired, the 100 cycle component may be shifted so as to occupy the highest frequency position of the resultant sub-band and the 800 cycle component, the lowest frequency position. These various shiftings of the sub-band into different positions and conditions in the frequency scale may be accomplished simply by grounding different ones of the conductors of group A of control circuits. For example, if the band transmitted through the filter F_a is to be inverted and stepped up in frequency so as to pass through the outgoing filter F_c' , the 800 cycle component of the incoming sub-band will be shifted upward in frequency 700 cycles and the incoming 100 cycle component will be shifted upward in frequency 2100 cycles. This is accomplished by modulating a 2300 cycle wave by the incoming sub-band and selecting the lower side band of the resultant modulated wave or in other words by grounding conductor 7 of group A of control circuits and hence causing the operation of relays A_7 , A_c and A_o . Similar frequency transformations may be made in each of the other sub-bands by means of the modulators M_B , M_C and M_D and their associated wave sources and filters by simply grounding certain of the conductors of the groups B, C and D of control circuits.

Referring now to Fig. 7, the four sub-bands derived by the respective filters F_a to F_d of Fig. 1, are designated, for convenience, by

the letters, a , b , c , and d respectively. The heavy letters at the top of the column indicate the normal frequency position of the sub-bands in the wave that is to be analyzed. The letters with the accompanying arrow indicate in each horizontal row of the column a different combination which is obtainable by merely certain various combinations of the conductors of the groups A, B, C and D of control circuits. An arrow following a letter and pointing to the right indicates that the particular sub-band has a normal frequency order and a letter followed by an arrow pointing to the left means that the corresponding sub-band has an inverted frequency order. For example, in the uppermost row of the left-hand column of Fig. 7, the " b " sub-band is stepped down in frequency so that it occupies the normal " a " sub-band position and the " a " sub-band is stepped upward in frequency so that it occupies the normal " b " sub-band position. Also, the " c " and " d " sub-bands are interchanged in position, all of the frequency orders being left normal in each of the sub-bands. In the second horizontal row of the left-hand column, the same frequency shifts are made as in the case of the first row but in addition the " b " sub-band is inverted in frequency.

For purposes of illustration let it be assumed that it is desired to obtain an output wave having the combination indicated in the first horizontal row of Fig. 7. To accomplish this conductor 4 of group A of control circuits will be grounded. This will cause the " a " band to be stepped up in frequency 700 cycles. Conductor 2 of group B will be grounded and cause the " b " band to be stepped down in frequency one position. Conductor 8 of group C will be grounded and cause the " c " band to be stepped upward one position and conductor 6 of group D will be grounded and cause the " d " band to be stepped downward one position.

To obtain an output wave having the combination represented in the second row of Fig. 7 the only change that is necessary from the set-up described for the first combination is that conductor 5 of group A be grounded instead of conductor 4 of that group. The effect of this is to modulate 1600 cycles by the " a " band producing a lower side band extending from 1500 to 800 cycles.

The two illustrations given above will serve to show that by grounding certain of the conductors of the groups A, B, C and D of control circuits that it will be possible to readily set up any of the secrecy combinations illustrated in Fig. 7. The nomenclature of the various filters, switches, and conductors of the groups of control circuits has been arranged so that it is comparatively easy to determine what conductors in the various groups of control circuits must be grounded and what conductors must be left

open in order to set up any combination. Thus, if all the conductors of the A group are left open the "a" band will go through in the normal manner. However, if conductor 4 of the A group is grounded the "a" band goes through in the "b" band position. If conductor 5 of group A is grounded the "a" band goes through in the "b" band position in inverted frequency order. Also, if
 10 conductor 6 of group A is grounded it goes through in the "c" band position. Thus, the grounding of any even numbered conductor in the groups of control circuits passes the band for that group right side up and the
 15 grounding of an odd numbered conductor passes the band in inverted condition. Also the number will indicate into what filter group it will go. In addition, the circuits have been so arranged that in case of failure
 20 of battery or in case of failure of the tape transmitter to put ground on any combination, the relays A₀, B₀, C₀ and D₀ would be released and the speech band would go through in the normal fashion so that the
 25 failure would be quickly noticed at the other end of the circuit and the change made so that the circuit could still be used until the trouble was remedied by merely opening the battery circuit at the receiving end. As a
 30 further aid to clearness on each oscillator of all the modulator there has been placed a small letter with an arrow which designated the band produced by that oscillator in accordance with the arrangement shown in Fig.
 35 7 so that the relation between both figures of the drawing may be more clearly understood.

As stated above, the wave transforming circuit serves both for transmitting and receiving. For example, waves coming in on
 40 the line 50 will be divided into their respective sub-bands by the filters that are connected in circuit at the time between the leads 50 and the modulators M₁ to M₄. These sub-bands will be impressed on the respective
 45 modulators in the manner described in connection with Fig. 6, and will be combined with the appropriate waves from the associate wave sources so as to produce and transmit through the filters F_a to F_d to the tele-
 50 phone 10 a wave representing intelligible speech. The circuit 50, therefore, carries only waves which occupy speech range but which do not represent normal speech.

If an unauthorized person attempts to intercept the message being transmitted over
 55 the leads 50 to any point in the system, he will find any one of the combinations represented in Fig. 7 unintelligible. However, by using a heterodyne method of reception and filtering arrangements to suppress portions of
 60 the wave, he would, with some difficulty be able to receive at least portions of the message in the case of some of the combinations indicated in Fig. 7. For example, in the case of
 65 the first combination indicated in this figure,

if the observer should set a heterodyne oscillator frequency so as to receive the "a" sub-band correctly he would also receive the "c" sub-band correctly. Of course, the "c" sub-band would have superposed on it the "b" sub-band which would be inverted, and there would be included between the normally received "a" and "c" sub-bands the "d" sub-band as noise.

Since it is conceivable that the reception of
 75 the two sub-bands "a" and "c" in their normal position might possibly permit the chance understanding of some slight portions of the message being transmitted, this combination is not counted as one of the most highly secret
 80 combinations. In a similar manner, in the case of the second combination indicated in this figure, the "a" and "c" sub-bands could be received normal by the heterodyne method, and in the third combination, the "b" and "d" sub-bands could be similarly received. It will
 85 be seen by inspection that each of the combinations numbered 1 to 125, however, is incapable of yielding more than a single one of the sub-bands in its normal form for any one
 90 heterodyning frequency and these combinations are, therefore highly secret. As pointed out above, even in the case of those combinations which yield two sub-bands normally, the presence of the other sub-bands as noise
 95 will greatly reduce the chances of understanding the message, so that all of the combinations are secret to a very considerable degree.

Figs. 4 and 5 show application of the invention to an ordinary telephone line and to a
 100 radio system, respectively. The rectangles WT indicate that the wave transforming system of Fig. 1 connected between the leads 50 and the telephone 10 is to be inserted at this
 105 point of the circuit. The telephone line 60 terminates at each of the two stations shown, in a wave transforming circuit and in the subscribers' sets 61 and 62, respectively. Conversations in both directions may be carried
 110 on between these subscribers' stations with secrecy since any one listening on the line 60 will receive only unintelligible waves.

In Fig. 5, a transmitting antenna TA and a receiving antenna RA are connected through
 11 radio transmitting and receiving apparatus to the telephone line 65 which has included between it and the subscriber's set 66, a wave transforming circuit WT. The usual two-
 115 way connection including a balancing network N for the telephone line and the conjugate transformer 67 is employed. The waves originating in the subscriber's set 66 and transformed into a secrecy combination, are transmitted through the repeating coil 67
 120 to the input of the modulator M which is supplied also by radio frequency waves from the source 68. Due to the balanced type modulator, the unmodulated carrier component is suppressed and only the two side bands of the unmodulated wave are impressed by the

antenna TA. This antenna is preferably tuned to transmit only one side band of the modulated wave in order to economize in the transmitted energy. The receiving antenna RA is connected to a detector D of any suitable type supplied by a wave of the carrier frequency from the source 69 and the detected waves are applied from the detector to the bridged circuit of the conjugate repeating coil. These waves pass over the line 65 through the wave transforming device where they are rendered intelligible and are impressed on the subscriber's set 66.

In Fig. 2 is shown a continuation of the conductors of the groups A, B, C and D of control circuits. These conductors will lead directly to one of the plugs in the code plug box 70. These conductors will also be multiplied as many times as desired to lead to each of the other code plugs in the box. For purposes of illustration the box has been shown as containing five plugs. Accordingly five sets of multiple connections have been shown. However, it is pointed out that the circuits might be arranged so that a greater or smaller number of code plugs might be utilized. As has been previously pointed out 126 different code plugs, one for each of the secrecy combinations shown in Fig. 7 will be provided. Each of these code plugs will have the proper number of contacts strapped across them at the proper positions to ground the correct conductors of the control circuits to set up the various secrecy combinations they represent. For example, the plug #98, which represents secrecy scheme 98 of Fig. 7, will have contacts, such as 79, strapped across it so as to ground conductors 6 of group A, conductors 2 of group B, and conductor 5 of group C. This in accordance with the arrangements heretofore described will set up scheme 98 which is $b \rightarrow, c \leftarrow, a \rightarrow, d \rightarrow$. The code plug box will comprise a separate bus bar, such as 78, for each plug with which the strapped contacts, such as 79, will be engaged. The bus bars will be connected to the leads 71, 72, 73, 74 and 75 to which ground will be applied in accordance with a fortuitous code by the key tape mechanism of Fig. 3. Ground may be applied to the conductors 71, 72, 73, 74 and 75 of Fig. 3 by the operation of the relays 81, 82, 83, 84 and 85 respectively. These relays in turn are controlled by the contacts 101, 102, 103, 104 and 105 respectively of a key tape transmitter 86, of a type well known in the printing telegraph art. The contacts of the tape transmitter operate between the busbars 88 and 89 in accordance with the perforations in the key tape. The advancing of the key tape to set up new combinations of the contacts is controlled by a magnet 90. Associated with the above mechanism for purposes of control are the relays 91, 92 and 93. Connected to the winding of relay 92 would be a synchronizing

conductor 94. This conductor would extend to a distant station comprising apparatus similar to that shown in Figs. 1, 2 and 3. Mechanism (not shown) would be associated with this conductor for applying thereto impulses of current at any rate at which it is desirable to set up a new combination of the key tape. In more detail, an impulse coming in over conductor 94 would operate the relay 92. This would apply ground over the contact of relay 92, conductor 96, winding of relay 91, to battery, thus operating relay 91. Ground would also be applied over the lower contact of relay 92, through the winding of relay 93, to battery. However, relay 93 is slow-operating and will not operate at this instant. The operation of relay 91 will open at its contact a locking circuit over conductor 87 through any of the relays 81, 82, 83, 84 and 85 that may have been operated, thereby releasing them. Ground will also be applied from the contact of relay 91, over conductor 95, to the busbar 89. For purposes of illustration let it be assumed that the perforations on the key tape at that instant will allow only the contact 101 to come into contact against the busbar 89. Accordingly, at this instant ground will be applied from busbar 89, contact 101, conductor 97, right-hand winding of relay 81, conductor 98, to battery, and relay 81 will be operated. Relay 81 will become locked over its left-hand winding and contact and conductor 87 as soon as relay 91 releases, so that when ground is taken off the busbar 89 relay 81 will nevertheless, remain locked up. The operation of relay 81 will apply ground to conductor 71 and thence to the code plug, such as the code plug numbered 98, thereby operating the wave transforming device of Figs. 1 and 2 in accordance with the secrecy combination individual to plug 98. By this time the slow-operating relay 93 will have become energized and will close a circuit through the magnet 90. This will cause magnet 90 to operate and to release the tape transmitter contacts and to step the tape ahead one step to set up a new combination of the contacts. Accordingly, when a new synchronizing impulse comes in over conductor 94 the above operation will again take place and other of the relays 81 to 85 may be operated to apply ground to other of the conductors and thus to apply ground to other of the code plugs in the code plug box 70.

With the above described arrangements it will be seen that a certain number of code plugs such as those illustrated may be picked out at each station and inserted in the code plug box. Then by means of identical key tapes operating in synchronism at each station, the wave transforming device may be made to operate in a continually changing manner in accordance with any of the secrecy schemes represented by the plugs in the code

box. If desired, the key tape mechanism may switch from one plug to another in a comparatively rapid manner, say, for example, once every second. Furthermore, after the
5 set of plugs such as the five plugs illustrated have been used for a certain length of time, say, for example, an hour, word may be sent to the distant station to pull out all of these
10 plugs and to insert an entirely new set of plugs so that other of the secrecy schemes of Fig. 7 may be utilized. Accordingly, the secrecy of the arrangements of the invention may be made to depend both on the choice and changing of the sets of plugs and also
15 upon the automatic choice of the selected plugs by means of the key tape mechanism.

While this invention has been disclosed as embodied in certain arrangements it is to be understood that it is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a secret signaling system, an incoming
25 circuit, an outgoing circuit, filters for selecting bands of frequency components from waves in the incoming circuit, means to shift the frequencies of the bands to cause each shifted band to occupy the frequency range
30 occupied by a different band of components of the incoming wave and to invert the frequency order of the components within certain of the shifted bands, switching means for changing the scheme of shifting and in-
35 verting of the several bands, automatic means for controlling said switching means in accordance with a code, and means to impress the bands on the outgoing circuit.

2. In a secret signaling system, an incoming
40 circuit, an outgoing circuit, filters con-

nected to said incoming circuit for selectively transmitting different bands of frequency components from the incoming wave, a plurality of sources of waves of different frequencies, wave combining circuits adapted to
45 be associated with said filters and with said sources for combining said waves and said bands, other filters between said wave combining circuits and said outgoing circuit for separating the combined waves into bands
50 of frequency components, switching means for selecting and associating with said outgoing circuit various combinations of the first mentioned filters, said wave combining circuits and said other filters, to produce dif-
55 ferent desired combinations of frequency bands to make up the waves transmitted into the outgoing circuit, and automatic means for operating said switches in accordance with a
60 code.

3. The method of secretly transmitting waves having a band of frequency components normally occurring in a characteristic order, comprising shifting the frequency components in said band to an abnormal frequency order, transmitting said waves of
65 shifted frequency order, shifting the frequency components in said band to a different abnormal frequency order, transmitting said waves in said different abnormally shifted
70 frequency order, and automatically controlling the method of shifting said components in accordance with a code.

In testimony whereof, we have signed our names to this specification this 13th day of
75 August, 1925, and 7th day of October, 1925, respectively.

LLOYD ESPENSCHIED.
GLENN D. GILLET.