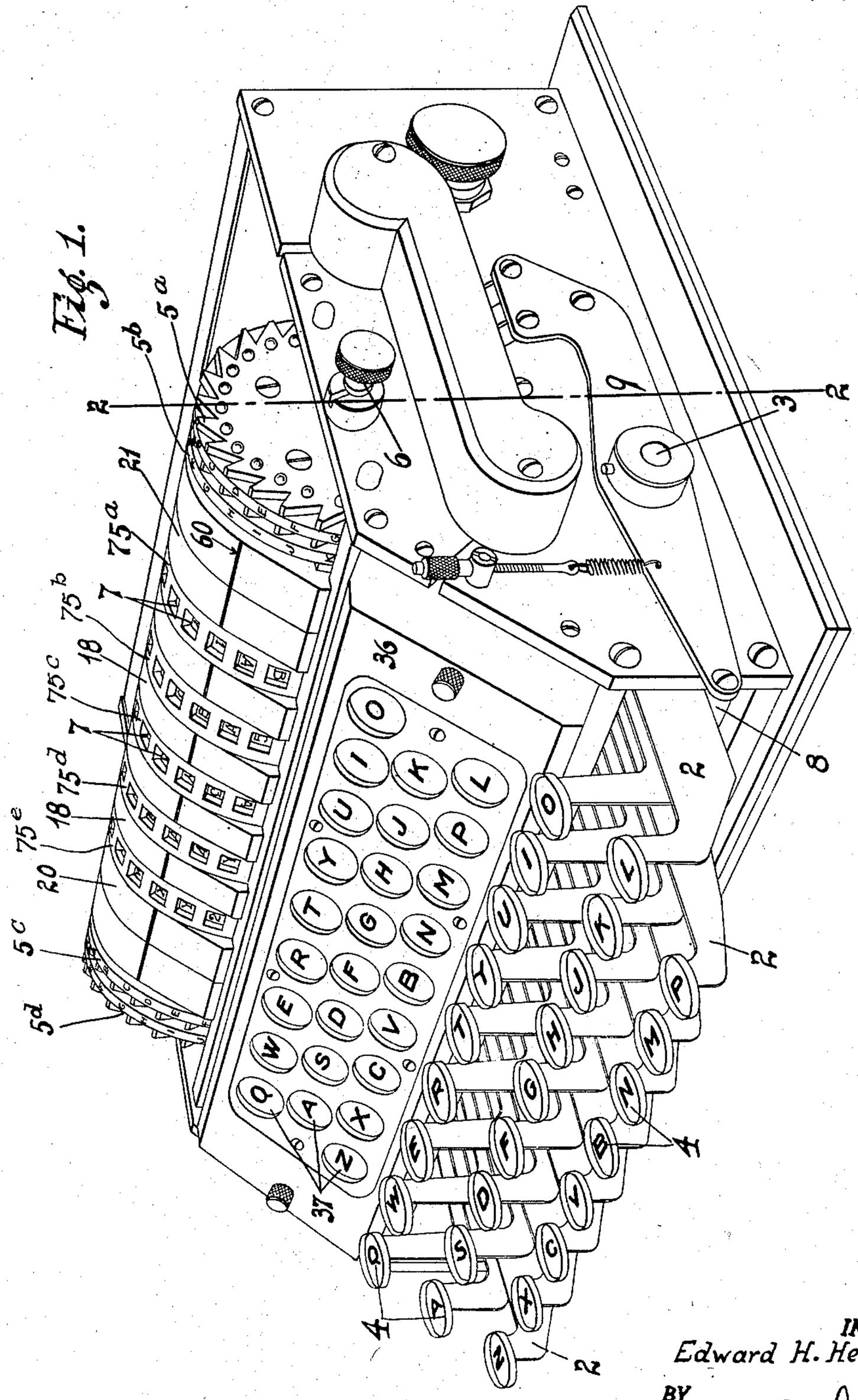
Sept. 4, 1928. 1,683,072

E. H. HEBERN

ELECTRIC CODE MACHINE

Original Filed Nov. 20, 1923 4 Sheets-Sheet 1

Fig. 1.



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Original Filed Nov. 20, 1923 4 Sheets-Sheet 2

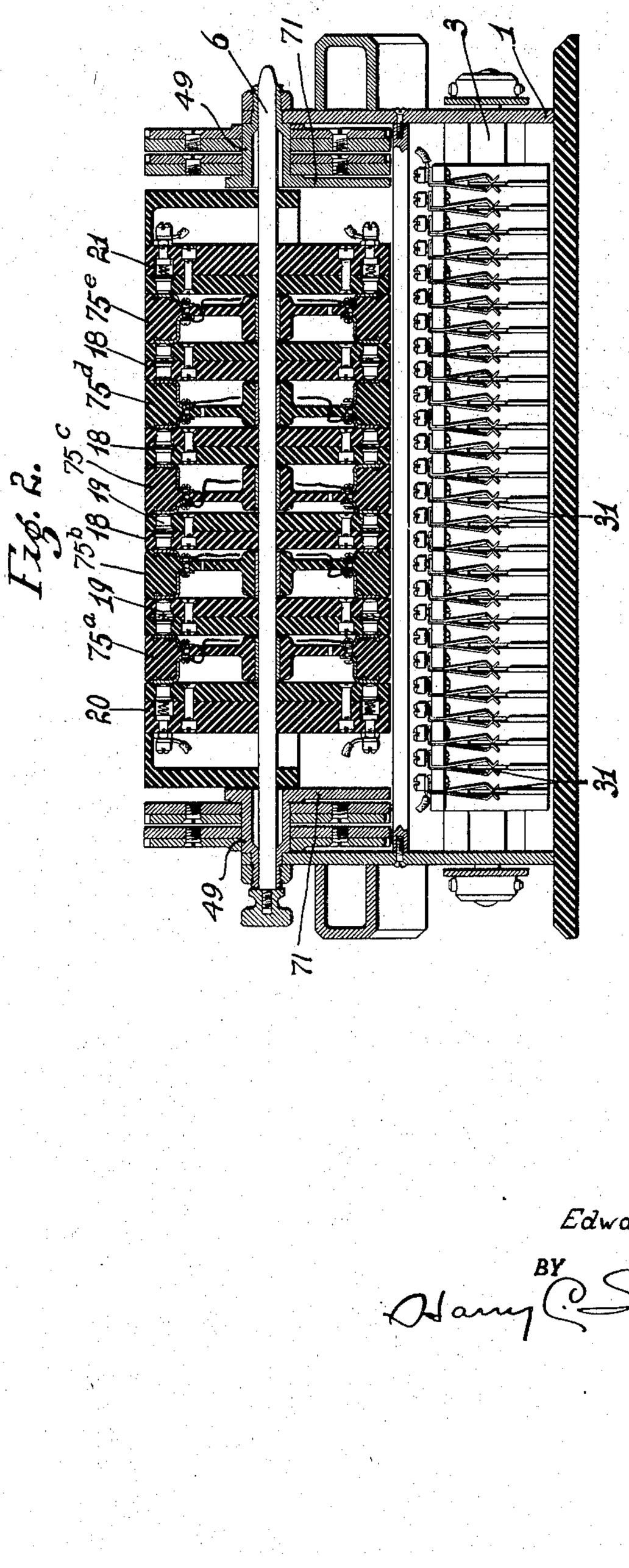

Fig. 2.

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Original Filed Nov. 20, 1923 4 Sheets-Sheet 3

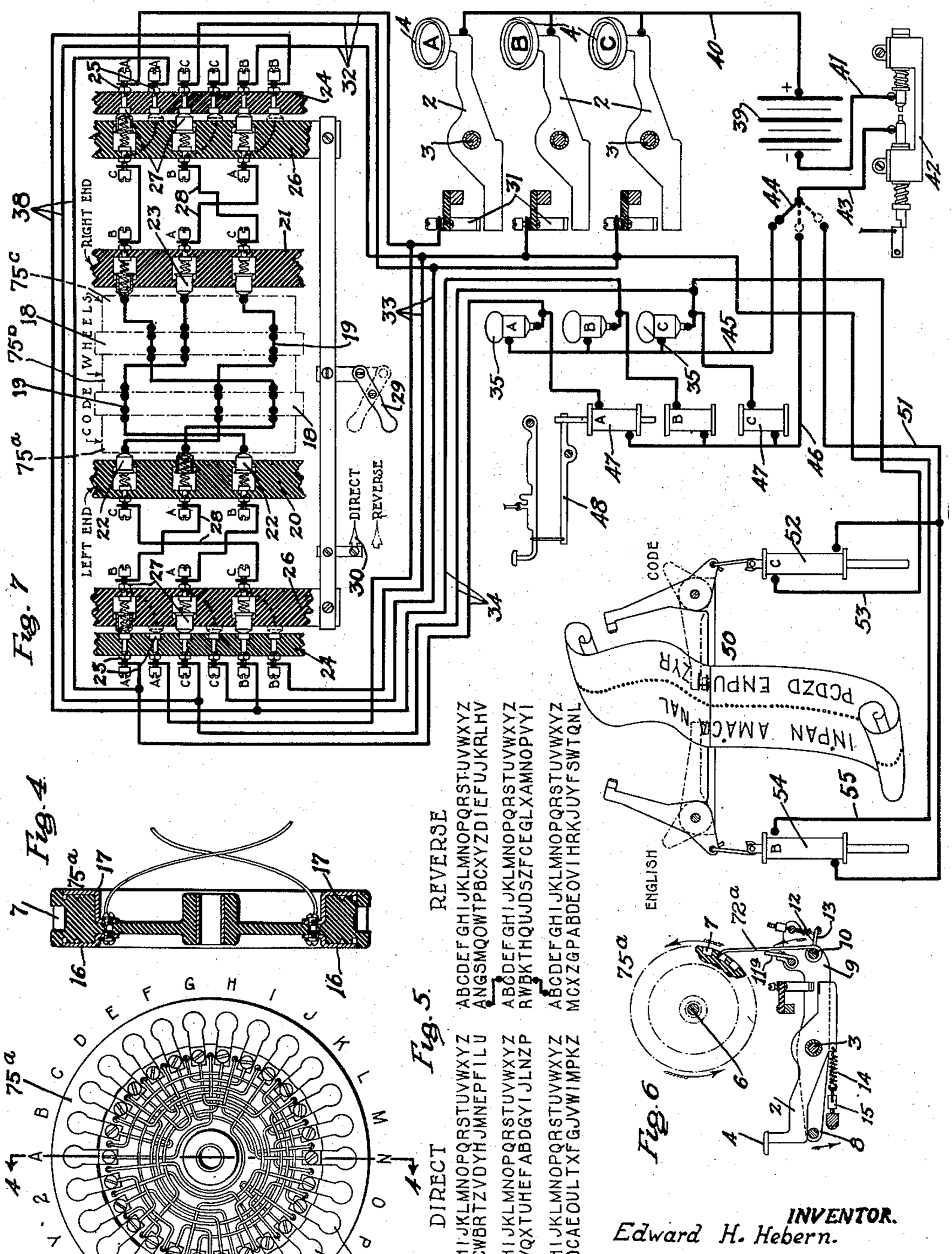

Fig. 7

Fig. 3

Fig. 4

DIRECT

ABCDEFGHIJKLMNOPQRSTUVWXYZ
AXQGOKSCWBRTZVDYHJMNEPFILU

ABCDEFGHIJKLMNOPQRSTUVWXYZ
WCROKSMVQXTUHEFABDGYIJLNZP

ABCDEFGHIJKLMNOPQRSTUVWXYZ
HQBNSRYDCAEOULTXFGJVWIMPKZ

REVERSE

ABCDEFGHIJKLMNOPQRSTUVWXYZ
ANGSMQOWTPBCXYZDIEFUJKRLHV

ABCDEFGHIJKLMNOPQRSTUVWXYZ
RWBKTHQUJDSZFCEGLXAMNOPVYI

ABCDEFGHIJKLMNOPQRSTUVWXYZ
MCXZGPABDEOVIHRKJUYFSWTQNL

Fig. 5.

Fig. 6

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Original Filed Nov. 20, 1923 4 Sheets-Sheet 4

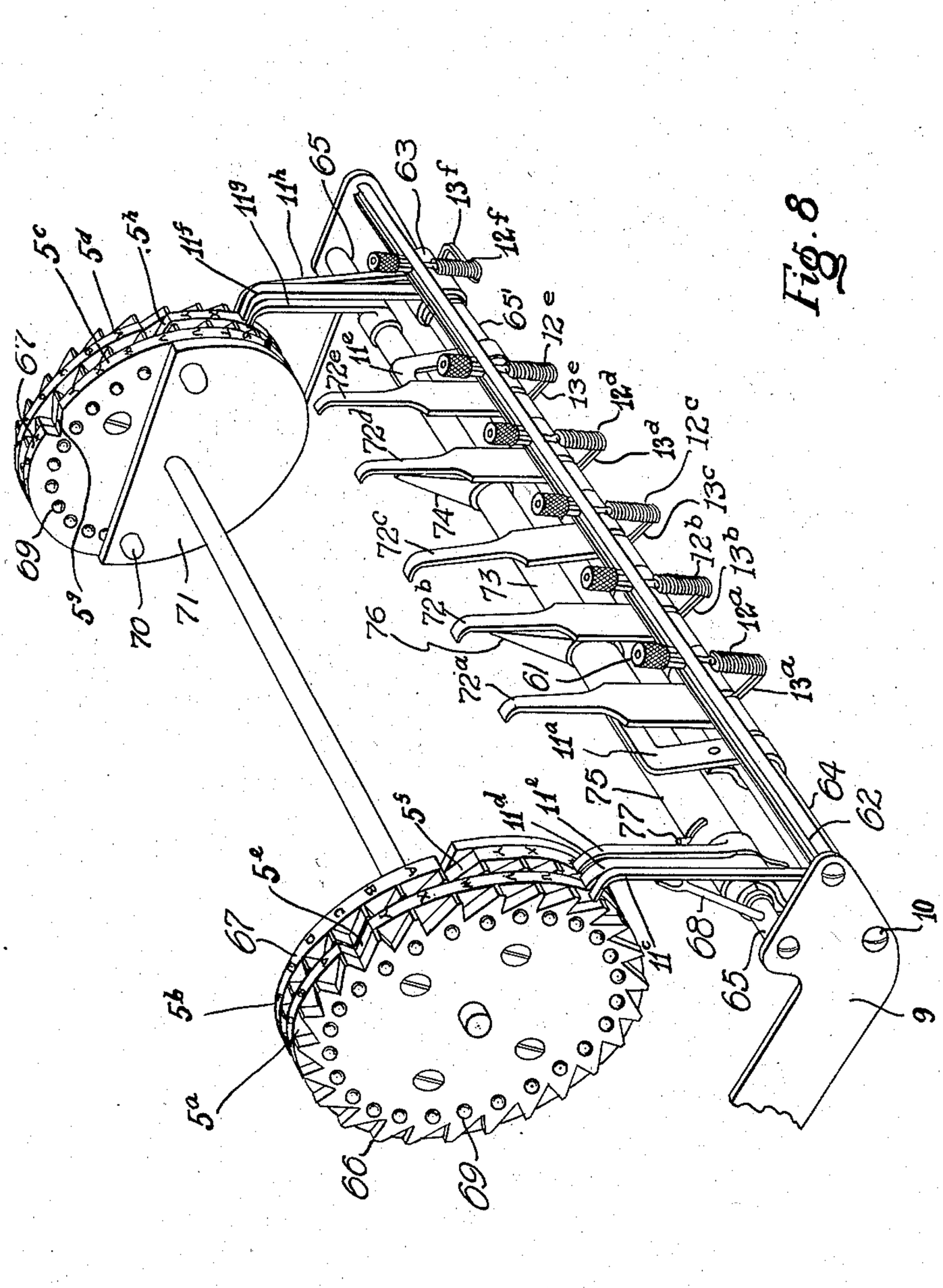

Fig. 8

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Patented Sept. 4, 1928. 1,683,072

UNITED STATES PATENT OFFICE.

EDWARD H. HEBERN, OF OAKLAND, CALIFORNIA, ASSIGNOR, BY MESNE ASSIGNMENTS, TO INTERNATIONAL CODE MACHINE COMPANY, OF RENO, NEVADA, A CORPORATION OF NEVADA.

ELECTRIC CODE MACHINE.

Application filed November 20, 1923, Serial No. 675,898. Renewed May 17, 1927.

My invention relates to an electric coding and decoding machine having a plurality of keys adapted to close a plurality of circuits and having a plurality of rotatable circuit changers adapted to divert the current in said circuits to some form of indicating means, upon which the coded or decoded message is to appear.

One of the objects of the invention is to provide a machine in which return circuits are provided and used in to the decoding of a code message.

Another object of my invention is to provide a machine in which the original and cipher letters are not in complementary pairs.

Another object is to provide a machine in which a visible code or original message indicating means is used.

Another object is to provide a machine with a plurality of rotatable wheels adapted to be moved at predetermined intervals incident to each operation of the machine to change the code each time they are moved, which wheels will decode the message when the decoding circuits are used.

Another object is to provide a new and improved coding system.

Further advantages and objects will be apparent upon consideration of the detail description in connection with the accompanying drawings, in which one modification of my invention is illustrated in its preferred form, it being understood, however, that the invention may be embodied in other forms, and that I desire to cover the same broadly in any of its modifications.

Referring to the drawings, in which corresponding reference numerals indicate like parts throughout:

Figure 1 is a perspective view of my code machine;

Figure 2 is a sectional view taken on line 2—2 of Fig. 1;

Figure 3 is a side elevation of one of the code wheels;

Figure 4 is a sectional view taken on line 4—4 of Fig. 3;

Figure 5 shows a number of English and code alphabets for both positions of the control switch;

Figure 6 is a diagrammatic view illustrating the means for operating the code wheels;

Figure 7 is a wiring diagram of my machine showing three code wheels; and

Figure 8 is a perspective view showing the ratchet operating means and the cooperation of the ratchets with the code wheel operating fingers.

Figure 9 is a perspective view of my code machine.

My code machine comprises a casing 1 in which the various parts are enclosed. A plurality of key levers 2 project from the front of the casing 1 and are journaled upon a key rod 3, which is secured in the sides of the casing. Finger keys 4 are secured to the levers 2, upon which the letters of the alphabet are formed in the arrangement ordinarily employed on typewriters.

A plurality of code wheels 75^a, 75^b, 75^c, 75^d, and 75^e are journaled upon a shaft 6, which is removably secured in the bearings 49 supported by the sides of the casing 1. The construction of these wheels is substantially similar to the wheel described in my co-pending application Serial No. 457,419, filed March 31, 1921, (Patent 1,510,441, Sept. 30, 1924). Journaled on the bearings 49 are the ratchet wheels 5^a, 5^b, 5^c, and 5^d; each of which is provided with twenty-six ratchet teeth 66 and a circular cam-forming flange 67 having the major portion of its outer periphery even with the outer parts of the teeth 66, and having the cam depressions 5^e, 5^f, 5^g, and 5^h formed therein. These wheels cooperate with the code wheels in a manner hereinafter to be explained. The letters of the alphabet appear in regular order upon the peripheral portion of each ratchet wheel, one letter being written by each notch between the teeth 66. In place of the letter "Z" on each ratchet wheel, a notch 5^e, 5^f, 5^g, and 5^h is provided, which notch is the same size as the remaining notches, but extends across the entire width of the ratchet wheel so that each of the flanges 67 is thereby provided with one notch. Each of the ratchet wheels is provided with twenty-six counter-sunk round notches 69 adapted to receive a portion of a spring pressed ball (not shown) carried in housing

70 carried in the side walls of the casing 1, and by the stationary plates 71 mounted on the inner ends of the stationary bearings 49. The object of this arrangement is to hold the ratchet wheels in the exact positions desired.

A plurality of pockets 7, twenty-six in number, are formed in the periphery of the wheels 75^a, 75^b, 75^c, 75^d, and 75^e, in which appear the letters of the alphabet from "a" to "y", and a number in the last pocket, which is the number of the wheel, as diagrammatically shown in Fig. 3.

Certain of the code and ratchet wheels may be rotated as the keys are successively depressed in the following manner:

A bar 8 extends across the front of the machine under the keys 2 and is secured at both ends to levers 9—9 which are journaled on the rod 3. Thus, as each key is depressed, it will engage the bar 8 and rock the forward ends of the levers 9 downwardly and the rearward ends upwardly. A rod 10 extends between the levers 9 and ratchet dogs or fingers 72^a, 72^b, 72^c, 72^d, and 72^e are loosely mounted upon the rod. These fingers are adapted to engage pockets 7, and as the levers 9 are rocked by the actuation of the keys 2, the wheels 75^a, 75^b, 75^c, 75^d and 75^e will be rotated step by step but at widely different intervals.

Each of springs 12^a, 12^b, 12^c, 12^d, and 12^e is secured at one end to an adjusting screw 61 carried by bar 62 extending between levers 9—9, and at its other end to an arm 13^a, 13^b, 13^c, 13^d, and 13^e of the fingers 72^a, 72^b, 72^c, 72^d, and 72^e, which springs urge the said fingers 72^a, 72^b, 72^c, 72^d, and 72^e forwardly into the pocket 7.

The finger 11^h is loosely mounted on the rod 10, and is at all times pushed forwardly by the spring 12^f pulling upwardly on the lever 13^f, forming a part of the finger 11^h. Each time any key is depressed, the finger 11^h rotates the ratchet wheel 5^d for one notch. The finger 72^c likewise rotates the code wheel 75^c a similar distance, being pressed forwardly into the notches 7 of the code wheel 75^c by the spring 12^c pulling upwardly on the lever 13^c secured to the finger 72^c. Each time a key is depressed, therefore, the code wheel 75^c and the ratchet wheel 5^d rotate one notch and make one complete revolution when twenty-six keys have been successively depressed.

As soon as the finger 11^f, which extends over the flange of the ratchet wheel 5^d and over the teeth of the ratchet wheel 5^c, is adjacent the notch 5^h of the ratchet wheel 5^d, the finger enters the notch 5^h, and one of the twenty-six notches of the ratchet wheel 5^c. The fingers 11^f and 11^e are rigidly mounted on a common sleeve 65'. The spring 12^e pulls the lever 13^e upwardly, moving the finger 72^e into engagement with one of the notches 7 on the code wheel 75^e, which finger presses the detent 11^e forwardly, rocking the sleeve 63 on the rod 10, and moving the upper end of the finger 11^f, carried by said sleeve, into the notch 5^h. Upon the depression of any key when the parts are in this position, the ratchet wheels 5^c and 5^d are rotated one step by the finger 11^f and the code wheels 75^c and 75^e are moved forwardly a similar distance, being actuated by the fingers 72^c and 72^e, respectively. It would, therefore, appear that the code wheel 75^e and the ratchet wheel 5^c rotate one complete revolution while the code wheel 75^c and the ratchet wheel 5^d make twenty-six complete revolutions.

The fingers 11^g and 68 are rigidly mounted on the rod 65 extending between the levers 9—9 and located above the rod 10. The finger 11^g is normally engaged by the flange 67 of the ratchet wheel 5^c, which holds the finger 11^c out of the notches on the ratchet wheel 5^a. As long, therefore, as the flange 67 of the ratchet wheel 5^c is in engagement with the finger 11^g, there is nothing to actuate the ratchet wheel 5^a, and the same is held stationary by the spring-pressed balls engaging the notches 69. The fingers 11^c and 11^a are rigidly mounted on a common sleeve 64. As soon as the finger 11^g is adjacent the notch 5^g, being the only notch in the flange, the finger 11^g moves forwardly by means of the spring 12^a pulling the arm 13^a upwardly, thereby moving the finger 72^a into the pocket 7 of the code wheel 75^a. The finger 72^a presses against and moves the detent 11^a forwardly, rocking the sleeve 64 on the bar 10 in a clockwise direction. As the finger 11^c is secured to the sleeve 64, the former is likewise moved forwardly and engages the finger 68, rocking the same, together with the shaft 65 and finger 11^g. The finger 11^g now enters the notch 5^g and the finger 11^c enters one of the notches between the teeth 66 on the ratchet wheel 5^a. The finger 72^c is always pressed forwardly against the middle code wheel 75^c. When the finger 11^g is in the notch 5^g, the finger 11^c is in one of the notches on the ratchet wheel 5^a, and the finger 72^c is in position to actuate the middle code wheel 75^c. When the parts are in this position, if the operator presses any key 4, the ratchet wheels 5^a, 5^c, and 5^d, together with the code wheels 75^a, 75^e, and 75^c are actuated for the distance of one notch. It is, therefore, apparent that the ratchet wheel 5^a and code wheel 75^a are rotated only one notch while the ratchet wheel 5^c is being rotated for twenty-six notches or one complete revolution. Since, therefore, the ratchet wheel 5^c moves only one notch while the ratchet wheel 5^d moves twenty-six notches, and since the ratchet wheel 5^a moves only one notch while the ratchet wheel 5^c moves twenty-six notches, the ratchet wheel 5^a moves only one notch while the ratchet wheel 5^d makes 676 revolutions, which represents the successive depression of 17,576 keys.

The finger 11^d is secured to a rotatable sleeve 73 mounted on the shaft 65, which sleeve likewise carries an arm 74 normally pressed forward by the finger 72^d. When the notch 5^e is adjacent the upper end of the finger 11^d, the finger enters the notch, being pressed into it by means of the spring 12^d, lever 13^d, finger 72^d, arm 74, and rotatable sleeve 73. When the parts are in this position, and any key is depressed, the code wheels 75^c, 75^e, 75^a, and 75^d, will move one notch in unison with the ratchet wheels 5^a, 5^b, 5^c, and 5^d, it being understood that the upper end of finger 11^d extends over the flange 67 of the ratchet wheel 5^a and over the teeth of the ratchet wheel 5^b, so that when the finger 11^d is in the notch 5^c, the said finger actuates both of the ratchet wheels 5^a and 5^b. The ratchet wheel 5^b is, therefore, rotated only one notch while the ratchet wheel 5^a makes a complete revolution or while the ratchet wheel 5^d makes 17,576 complete revolutions, which represents the successive depression of 456,976 keys.

The finger 11^e is secured on a sleeve 75 rotatable on the sleeve 73. The sleeve also carries an arm 76, which is normally pressed forward by the finger 72^b, the upper end of the finger 11^e normally resting against the periphery of the flange 67 of the ratchet wheel 5^b. When, however, it is adjacent the notch 5^f on the said flange, it is pressed into it by means of the spring 12^b, lever 13^b, finger 72^b, arm 76, and sleeve 75. The upper end of finger 72^b now enters the notch 7 in the code wheel 75^b. If, when the parts are in this position, any key is depressed, the ratchet wheels 5^b, 5^a, 5^c, and 5^d, together with the code wheels 75^b, 75^a, 75^e and 75^c will move one notch. The parts can, however, be in this position only once upon a complete revolution of the ratchet wheel 5^b, which would represent 456,976 revolutions of the ratchet wheel 5^d or the depression of 11,881,376 keys.

The five code wheels are thus moved progressively in non-recurrent succession to exhaust the possible relative rotative positions of the code wheels.

As heretofore stated, any of the code wheels may be removed, and as they are all of the same size, they may be replaced in any order or with the letters inverted. When some are inverted as are wheels 75^a and 75^c shown in Figure 1, the reversed wheels give an entirely new alphabet, and not a reversed primary alphabet. Hence, we have $10\times8\times6\times4\times2$, or 3,840 possible locations of the code wheels, each of which gives a different coding plan, thereby providing 11,881,376 alphabets times 3840, or 45,624,483,840 alphabets for the machine. In using both the direct and reverse currents, hereinafter to be explained, for sending as well as receiving, there would be a range of $2\times45{,}624{,}483{,}840$ alphabets, which is equal to 91,248,967,680 complete alphabets, which is the possible range of my machine for one set of wires. Of course the code wheels may be moved by hand to any one of 11,881,376 starting positions for the continued five code wheels.

Of course, this arrangement can be varied in any suitable manner by a proper arrangement of fingers, and cooperation between the various fingers and detents. Of course, a more or less number of code wheels and ratchets could be used as desired without departing from the spirit of my invention.

A spring 14 is secured to each of the levers 2 and to an adjusting screw 15, which extends into the casing 1 and which holds said levers in their normal raised position. The code wheels 75^a, 75^b, 75^c, 75^d and 75^e are all identical to one another in their constructional details and are similar in construction, to the code wheel described in my prior Patent 1,510,441, but are free of one important limitation imposed upon the wiring details of the code wheel in this early patent; viz, that the contacts be connected invertedly in pairs so that if the "H" contact on one side of the code wheel were connected to the Y contact on the other side thereof, the Y contact on said one side was required to be connected to the "H" contact on said other side. In the code wheel of the present invention this inverted relation is unnecessary, and inspection of Fig. 3 discloses the random character of the interconnections. A further slight distinction resides in the placing, in the present invention, of the opposed contacts on opposite sides of the code wheel in axial alignment; the contacts being insulated from each other. Just as in the code wheel of the said prior patent however, there are 26 contacts 16 and 17 positioned on each side of the code wheel. A separate wire extends from each of the contacts 16, which may be termed the incoming contacts, through the wheel and each to a (any one) contact 17 on the opposite or outgoing side of the code wheel. The contact 17 (ordinarily) represents a different letter from the contact 16, as is clearly shown in Fig. 3. Ordinarily no two code wheels in any one machine will be wired exactly alike.

The similarity of the code wheel to an electric commutator is at once apparent. In fact each code wheel is a commutator, and will be so-termed at times.

Between each pair of revolvable code wheels 5, is a stationary disk 18, which has 26 contacts on each face thereof which touch the wheel contacts 16 and 17. The contacts 19 in the disk 18 extend therethrough and conduct the current from one code wheel to the next. End plates 20 and 21 are positioned at the left and right ends respectively of the code wheels 5, through which the current is conducted to said code wheels. 26 contacts 22 extend through the plate 20, and contacts 23 extend through the plate 21 and bear against the contacts 16 and 17. A sta-

tionary contact board 24, Fig. 7 is positioned in the casing 1 in any suitable manner and a plurality of contacts 25 are positioned therein. These contacts are formed in pairs, one set being in use while the other is idle, the object of the two sets being to reverse the direction of the current through the code wheels, (from left to right or right to left) as will be described.

A movable contact board 26 is juxtapositioned to the board 24, and has one set of contacts therein adapted to cooperate with either of the two sets of contacts. Leads 28 extend from the various contacts 27 to the contacts 22 and 23. The board 26 is moved relative to the board 24 by means of a suitable handle 29, which may project through the casing 1 and the position of the contacts therein may be indicated by a pointer 30, which also may project through the casing and which points to the legend "Direct" or "Reverse", which may be marked on the casing.

Each of the key levers 2 is adapted to enter a knife switch 31 as it is depressed. Leads 32 extend from the switches 31 to the corresponding contacts on the board 24 and leads 33 are tapped from the leads 32 and extend to the corresponding duplicate contacts on the board 24. That is, one lead extends to a "direct" contact and the other to a "reverse" contact. Leads 34 extend from the direct contacts 25 to the lights 35, which are set back of a panel 36, in which are positioned the transparent windows 37, upon which the letters of the alphabet appear, and behind which the light 35 is placed to illuminate the letter. Leads 38 are tapped into the leads 34 and extend to the "reverse" contacts 25. Thus, each light is connected to both a "direct" and a "reverse" contact. It is evident that the contact boards 24 and 26 cooperate to form a multipole reversing switch for inverting the relation between all the characters simultaneously. The incorporation of this compact effective electric unit constituted an important step in my invention.

A battery 39 supplies energy to the keys 2 through a lead 40. The other terminal of said battery is joined by a lead 41 to a circuit breaker 42, such as the one described in my co-pending case Serial No. 457,419, above referred to, and a lead 43 extends from said circuit breaker to a three-way switch 44, and from said switch through leads 45 to the various lamps 35, thus completing the circuit.

To carry through one operation of the machine in direct position:—

If the key "b" is depressed, thus forming contact with the switch 31 and permitting the current to flow through the lead 32 to the "B" contact 35 on the board 24, thence to the contact 27 and through the lead 28, the contact 23 on the end plate 21, the current takes a tortuous passage through the code wheels 75^a, 75^b, 75^c, 75^d, and 75^e, and disks 18 and finally arrives at the contact 22 on the plate 20. A circuit lead 28 is now energized and the current extends to a second contact 27, and thence to a C contact 25 on the stationary board 24, from which a lead 34 carries it to a C light 35. This indicates that at this particular setting the code letter of "B" is "C".

In decoding, it is necessary to place the board 26 in the other position. That is, if the message is sent in the "direct" position, it must be decoded in the "reverse" position. In the same manner, it can be followed through in "reverse" position, that is when the C key is operated, the B light will shine.

In Fig. 5 is shown a number of examples in the alphabet sent in code in both "direct" and "reverse" position of board 26. Instead of using the light board 36, the switch 44 may be operated to throw out the lights and to operate an auxiliary typewriter, as disclosed in my application Serial No. 675,951 filed November 20, 1923.

Leads 46 extend from the switch 44 to the solenoids 47, which depress the key actuating means 48. If desired, the tabulating mechanism 50 may be used. Leads 53 extend from the leads 34 to various type arm operating solenoids 52. Leads 51 extend from these solenoids to the switch 44. Thus, the type arm is caused to print the code upon the ribbon. It is sometimes advantageous to have the English immediately above the code, and this may be accomplished by a second set of solenoids 54, which actuate type arms to print the English on the ribbon. The leads 55 to these solenoids extend to various switches 31, thus producing the English message.

A line 60 is formed along the ends 21 and stationary disks 18, by which the code and ratchet wheels are set in the starting position. In starting to code certain predetermined letters on the wheels 75^a, 75^b, 75^c, 75^d, and 75^e, must be in alignment with the line 60 and the arrow 30 indicating either "direct" or "reverse" position of the board must be set. To decode, the same letters on the wheels 75^a, 75^b, 75^c, 75^d and 75^e must be brought in alignment with the line 60, and the arrow 30 must indicate the opposite position of the board 26 from that used in coding.

It is understood that the shaft 6 is removable, and that the code wheels may be removed and interchanged or inverted to change their relative positions or to change their direction of rotation. The relative rotation or the periods of rotation of the code wheels may be determined by the ratchets or certain of the wheels may be stationary at all times, depending upon the will of the operator. The wiring of the wheels may be done entirely by the operator and the corresponding wheels of all machines in the hands of parties with whom communication is carried on are necessarily of duplicate wiring and combination.

A pin 77 is carried by the bar 65, which pin projects through arcuate slots in the sleeves 73 and 75 and serves as a means to prevent displacement of the sleeves longitudinally of the shaft 65, thereby insuring the correct positioning of the fingers in relation to the ratchet wheels 5^a and 5^b.

While I have herein shown the preferred embodiment of my invention, I do not wish to limit myself to the exact form shown, but reserve the right to make all changes which may fairly fall within the scope of the appended claims.

Devices and systems in the art of cryptography may generally be divided into two classes; one relying upon such simple tricks as writing messages backward, adding dummy symbols and like confusing expedients; and the other involving some thoroughgoing plan of introducing complexity, such for example, as that of the Vigenere* Cryptography Table. As soon as the trick is discovered in the former class, the message may be deciphered in the same manner in which it would be decoded. In the latter class however, deciphering must follow a less direct plan, such as that involving letter-frequency probabilities. My invention belongs to the latter class, and it is to be emphasized that modifications thereof by such tricks as are contained within the first-mentioned class are mere permutations within the purview of my invention. Where my invention, for example, calls for a certain continuity or sequence, the introduction of some such trick to break the continuity or sequence must reasonably be interpreted as not without the scope of my invention. It is to be expected that someone may desire to complicate the device of my invention by simply combining it with some well-known device of the latter class above defined. I desire to be protected from the infringer who would thus adopt my invention and attempt to mask it behind some other cryptographic system. A thorough mastery of the matters taught by my invention and the description thereof will suggest countless such modifications within its purview, and any interpretation of the claims to my invention should therefore rest upon a similar mastery of the matters herein taught, and upon an understanding of the fact that most of the past efforts in cryptography were directed to precisely such confusing combinations and modifications of well-known systems, in an effort to outguess cryptographic experts. It is to be emphasized that, unless such confusing complications and modifications, my invention entails the production of a complex code which does not become decipherable when the details of the coding system or machine are guessed or disclosed.

In order to assist in evaluating my invention the significance of the structural elements and combinations, of the preceding specific description will be explained.

The alphabet characters on the keys 4 and on the transparent windows 37 will be referred to respectively as language characters and code symbols; it being appreciated that the distinction between them is arbitrarily made for convenience, since the characters on the keys 4 become the code symbols when the machine is used to decode a message. The symbols and characters are the essence of any cryptographic device, and the purpose of cryptography is to establish mutual relations between these characters and symbols. My invention resides in the method and means for establishing these relations; and in the present instance I employ electrical designating interconnections between the characters and symbols for this purpose. Thus, referring to Fig. 7, it is possible to trace a designating interconnection from the character "B" on finger key 4 to the character "C" illumined by a bulb 35. This designating interconnection; traced from the switch 31 to the bulb 35; is seen to include a wire 32, contacts 25 and 27 (of the reversing switch 24—26), wires 28 (leading to the code wheels), the series of stationary wires 19 between code wheels, and movable wires (not numbered) carried by the code wheels. Each of these separate elemental parts of the designating interconnections constitutes a link in a designating interconnection, and it will be noted that the links defined by the code-wheel wires are shiftable relative to each other and relative to the designating interconnections as a whole. It is these shiftable links that control the incidence of the designating interconnections relative to the characters and symbols; and it is the shiftable nature of these links which permits altering the relation between the characters and symbols.

Each code-wheel constitutes a movable support for a group of links and the links are circularly (i. e. perimetrically) arranged in these supports so that they may be shifted simultaneously to a new set of connections. The object of moving the commutators in progressive non-recurrent succession to exhaust the relative rotative positions is simply to exhaust the possible groupings of links. Thus each movable link is connected once and only once in the 11,881,376 different relative code wheel positions, to every other possible series of links for any one given arrangement of the code wheels and wiring thereof. And it is to be emphasized that there are 3840 such code wheel arrangements, and a countless number of different wiring combinations.

Reverting to the operation of the code machine: It will be recalled that one code

* See Langie "Cryptography" Constable and Co. Ltd. London.

wheel is continuously rotated, so that if any one language character is repeatedly selected, as by depressing a single finger key time-after-time, a different code letter will appear each of the first twenty six times the key is depressed. If one, and only one, code wheel were rotated (or if all were advanced together or synchronously), the code letters would begin to repeat themselves in regular order the twenty seventh time the key was depressed, and this repetition would be in identical alphabet sequences so that each twenty sixth code letter of a given language character would be the same. With only one code wheel operating, the machine of my invention would follow a certain coding system obviously, and this system might be concisely described as follows:

The language and code alphabets are related to one another definitely (in this case by designating interconnections therebetween), and this relation is periodically changed (each time the code wheel is advanced) according to a definite plan. The particular plan of change in this case, for example, being dependent upon the character of movement of the code wheel. As stated so-far, this system will be recognized as that used in the Vigenere Cryptographic Table (See Langie "Cryptography" Constable & Co. Ltd. London), in which the plan of change of code is dependent upon some key word for the table. The use of this key word has the effect of bodily moving a single code alphabet relative to the language alphabet, while retaining an invariable sequence of letters in the code alphabet. Thus the nature of change in the Vigenere table is dependent solely upon the character of this movement. In the machine of my invention however, another factor; viz, the commutator wiring, also affects the change of code, and serves to alter the sequence as well as the bodily relation of the two alphabets. In other words, the sequential relation of the language and code letters is changed according to a definite plan. Whereas the Vigenere code can be deciphered by blocking the message into columns twenty-six letters wide and applying tables of probable letter frequencies along parallel lines, the code formed by using one code wheel of my machine breaks up the parallelism of these lines and is more than twenty-six times as invulnerable to attack by tables of letter frequency. With only one code wheel however, the code does recur at regular intervals.

The effect of employing a second code wheel is to periodically change the plan of code-change according to a definite rule, or secondary plan. If the code and language letters are related in a primary sequence and this relation is changed according to a definite plan or secondary sequence by one code wheel, then the second code wheel introduces a tertiary plan or sequence affecting the secondary sequence. This second code wheel is advanced at a relative speed such that the change of secondary sequence occurs immediately prior to its exhaustion so that; on the one hand the entire secondary sequence is utilized; and on the other hand, avoiding recurrence of the secondary sequence avoids recurrence of code. It is of course possible to change the plan of code-change without affecting the sequence of this plan, (as by connecting the wires in the second code wheel in proper fan-like relation), but it is preferred to utilize the more fundamental type of change. Use of a third, fourth and fifth code wheel introduces a hierarchy of sequences each related similarly to the tertiary and secondary sequence. Each code wheel is a rotatable support for a group of links of the designating interconnections.

Since each code wheel is rotated at a different speed no two of the hierarchy of plans are identical. Since each code wheel is wired at random and differently, each of the hierarchy of sequences of these plans is random and dissimilar.

Transposing the code wheels by inverting or interchanging any of them has the effect of altering the incidence of the groups of links relative to their interconnections and so changes or interchanges the plans of code-change to others of the same order.

The combination of the hierarchy of plans forms a highly complex basic plan of change of code and, though arrived at by fairly simple mechanical rules, there is no simple formula relating the basic plan to the code produced. While it may be decoded by this simple mechanical rule, it cannot be deciphered, since there is no relation between the basic plan and the particular letters as they occur in the message. Especial emphasis is directed to the avoidance of recurrences of code in any but a random and purely accidental order within a total number of code changes measured by the number of letters in the alphabet, not merely multiplied by, but raised to the power of, the number of plans in the hierarchy.

Having described my invention, I claim:

1. In a coding and decoding machine, a plurality of code wheels, a plurality of ratchet wheels, means whereby the ratchet wheels are actuated and means operatively connecting each of the ratchet wheels with a corresponding code wheel whereby one of the code and one of the ratchet wheels is actuated only after another ratchet wheel has made a complete revolution.

2. In a coding and decoding machine, a plurality of code wheels, a plurality of ratchet wheels, means whereby the ratchet wheels are actuated step by step, and means operatively connecting each of the ratchet wheels with a corresponding code wheel whereby one of the

code and one of the ratchet wheels is moved forward one step only after another ratchet wheel has made a complete revolution.

3. In a coding and decoding machine, a plurality of code wheels, a plurality of ratchet wheels, means whereby the ratchet wheels are actuated, means whereby each of the ratchet wheels is held stationary after having been actuated, and means operatively connecting each of the ratchet wheels with a corresponding code wheel whereby one of the code and one of the ratchet wheels are actuated only once while another ratchet wheel is making a complete revolution.

4. In a coding and decoding machine a plurality of interchangeable code wheels, a plurality of ratchet wheels, means whereby the ratchet wheels are actuated and means operatively connecting each of the ratchet wheels with a corresponding code wheel whereby one of the code and one of the ratchet wheels are actuated only once while another ratchet wheel is making a complete revolution.

5. In a coding and decoding machine a plurality of code wheels, a rod on which the code wheels are mounted, said code wheels being adapted to be lifted from the machine when said rod is removed, a plurality of ratchet wheels, means whereby the ratchet wheels are actuated, and means operatively connecting each of the ratchet wheels with a corresponding code wheel whereby one of the code and one of the ratchet wheels are actuated only once while another ratchet wheel is making a complete revolution.

6. In a coding and decoding machine, a lever, means whereby said lever is actuated, coding wheels having notches on their periphery and fingers actuated by said lever and adapted to extend into said notches and rotate one of the coding wheels one step each time the lever is depressed and the remaining coding wheels at varying intervals or simultaneously.

7. In a coding and decoding machine, a plurality of levers, means whereby said levers are actuated, a rod extending between said levers, coding wheels having notches on their periphery and fingers actuated by said rod and adapted to extend into said notches and rotate one of the coding wheels one step each time said levers are depressed and the remaining coding wheels at varying intervals or simultaneously.

8. In a coding and decoding machine, a lever, a bar carried by said lever, means whereby said lever is actuated, a plurality of ratchet wheels, a finger carried by said bar and adapted to move one of the ratchet wheels one step each time said lever is depressed, a second finger carried by said bar, means whereby said second finger is held inoperative until the ratchet wheel operated by the first finger reaches a certain point in its revolution, and means whereby the second finger is then rendered operative to actuate the second ratchet wheel one step upon the depression of the latter.

9. In a coding and decoding machine, a lever, a bar carried by said lever, means whereby said lever is actuated, a plurality of ratchet wheels, a finger carried by said bar and adapted to move one of the ratchet wheels one step each time said lever is depressed, a second finger carried by said bar, means whereby said second finger is held inoperative until the ratchet wheel operated by the first finger reaches a certain point in its revolution, means whereby the second finger is then rendered operative to operate the second ratchet wheel one step upon the depression of the lever, a plurality of code wheels and means operatively connecting the first of the ratchet wheels to one of the code wheels and the second ratchet wheel to the second code wheel.

10. In a coding and decoding machine, a lever, means whereby said lever may be actuated, a ratchet wheel and a code wheel, a finger adapted to actuate the said ratchet wheel, a second finger adapted to actuate the said code wheel, means carried by said lever whereby said fingers are supported, means whereby both of said fingers are held inoperative until the ratchet wheel is in a predetermined position, and means whereby both of said fingers are then rendered operative to move the wheels one step when the lever is depressed.

11. In a coding and decoding machine, a lever, a bar carried thereby, a sleeve on said bar, a detent and a finger carried by said sleeve, a second finger, means whereby said second finger is normally pressed forward against said detent, a ratchet wheel, means whereby said first finger is held inoperative until the ratchet wheel reaches a predetermined position, and means whereby said ratchet wheel is brought into said position, said first finger being adapted to actuate the ratchet wheel one step when the parts are in said position and the lever is depressed.

12. In a coding and decoding machine, a lever, a bar carried thereby, a sleeve on said bar, a detent and a finger carried by said sleeve, a second finger, means whereby said second finger is normally pressed against said detent, a ratchet wheel and a code wheel, means where by said first finger is held inoperative until the ratachet wheel reaches a predetermined position, and means whereby said ratchet wheel is brought into said position, said first finger being adapted to actuate the ratchet wheel one step when the parts are in said position and the lever is depressed, and means whereby said code wheel is simultaneously moved forward one step.

13. In a coding and decoding machine, a lever, a bar carried thereby, a sleeve on said bar, a detent and a finger carried by said

sleeve, a second finger, means whereby said second finger is normally pressed against said detent, said means including a rearwardly extending lever forming an extension of the said second finger, means whereby the last mentioned lever is normally pulled upwardly, a ratchet wheel, means whereby said first finger is held inoperative until the ratchet wheel reaches a predetermined position, and means whereby said ratchet wheel is brought into said position, said first finger being adapted to actuate the ratchet wheel one step when the parts are in said position and the first mentioned lever is depressed.

14. In a coding and decoding machine, a lever, a bar carried thereby, a sleeve on said bar, a detent and a finger carried by said sleeve, a second finger, means whereby said second finger is normally pressed forward against said detent, said means including a rearwardly extending lever forming a part of said second finger, an adjusting screw and spring means operatively connecting said adjusting screw and said last mentioned lever, a ratchet wheel, means whereby said first mentioned finger is held inoperative until the ratchet wheel reaches a predetermined position, and means whereby said ratchet wheel is brought into said position, said first finger being adapted to actuate the ratchet wheel one step when the parts are in said position and the first mentioned lever is depressed.

15. In a coding and decoding machine, a lever, a bar carried thereby, a sleeve on said bar, a detent and a finger carried by said sleeve, a second finger, means whereby said second finger is normally pressed forward against said detent, said means including a rearwardly extending lever forming a part of the said second finger, spring means adapted to normally pull said last mentioned lever upwardly and said second finger forwardly, a code wheel adapted to be engaged by said second finger, means whereby said fingers are held inoperative until the ratchet wheel reaches a predetermined position, and means whereby said ratchet wheel is brought into said position, said first finger being adapted to actuate the ratchet wheel and the second finger to actuate the code wheel one step when the parts are in said position and the first mentioned lever is depressed.

16. In a coding and decoding machine, a plurality of code wheels, a plurality of ratchet wheels, means whereby one of the ratchet wheels and one of the code wheels are actuated in unison while the remaining code and ratchet wheels remain stationary, and means whereby the last mentioned wheels are moved one step when the first mentioned ratchet wheel is actuated after having arrived at a predetermined position.

17. In a coding and decoding machine, a plurality of ratchet and code wheels, means whereby the said wheels may be actuated step by step, each of said ratchet wheels being provided with a plurality of teeth and a peripheral portion adjacent the teeth, said peripheral portion being adapted to render inoperative the operating means for one code and one ratchet wheel until one of the ratchet wheels has reached a predetermined position.

18. In a coding and decoding machine, a plurality of ratchet and code wheels, means whereby the said wheels may be actuated step by step, each of said ratchet wheels being provided with a plurality of teeth and a peripheral portion adjacent the teeth and extending to the outer peripheral edges of said teeth, said peripheral portion being adapted to render inoperative the operative means for one of the code wheels and one of the ratchet wheels until one of the ratchet wheels has reached a predetermined position.

19. In a coding and decoding machine, a plurality of ratchet and code wheels, means whereby the said wheels may be actuated step by step, each of said ratchet wheels being provided with a plurality of teeth and a peripheral portion adjacent the teeth and extending toward the outer peripheral edges of said teeth, said peripheral portion being adapted to render inoperative the operative means for one of the code wheels and one of the ratchet wheels until one of the ratchet wheels has reached a predetermined position, said peripheral portion being provided with one notch, which notch permits the operative means for the remaining ratchet wheel and code wheel to become effective when the said operative means is adjacent the said notch.

20. In a coding and decoding machine, a plurality of ratchet and code wheels, means whereby the said wheels may be actuated step by step, means adapted to hold said ratchet wheels against movement after having been actuated, each of said ratchet wheels being provided with a plurality of teeth and a peripheral portion adjacent the teeth, said flange being adapted to render inoperative the operative means for one code wheel and one ratchet wheel until one of the ratchet wheels has reached a predetermined position.

21. In a coding and decoding machine, a plurality of ratchet and code wheels, means whereby the said wheels may be actuated step by step, each of said ratchet wheels being provided with twenty-six teeth and a peripheral portion adjacent the teeth, said peripheral portion being adapted to render inoperative the operative means for one code wheel and one ratchet wheel until one of the ratchet wheels has reached a predetermined position.

22. In a coding and decoding machine, a plurality of ratchet and code wheels, means whereby the said wheels may be actuated step by step, each of said ratchet wheels being provided with twenty-six teeth, and a peripheral

portion extending to the outer periphery of said teeth, said peripheral portion being adapted to render inoperative the operative means for one code wheel and one ratchet wheel until one of the ratchet wheels has reached a predetermined position.

23. In a coding and decoding machine, a plurality of ratchet and code wheels, means whereby the said wheels may be actuated step by step, each of said ratchet wheels being provided with a plurality of teeth, and a peripheral portion adjacent the teeth, said peripheral portion being adapted to render inoperative the operative means for one code wheel and one ratchet wheel, until one of the ratchet wheels has reached a predetermined position, and means whereby said ratchet wheels are held in position after having been actuated, said means including a spring pressed bar adapted to be resiliently seated in notches formed in the side walls of said ratchet wheels.

24. In a coding and decoding machine, a lever, means whereby said lever may be actuated, a bar and a shaft carried by said lever, a ratchet wheel provided with teeth and a peripheral portion, said peripheral portion having a notch therein, a finger carried by said bar and adapted to engage said teeth to rotate said ratchet wheel, a finger carried by said shaft and adapted to normally rest against said peripheral portion until said notch engages a point adjacent said finger carried by the shaft, means whereby the latter finger is then forced into said notch, thereby partially turning said shaft, a sleeve on said bar a finger and a detent carried by said sleeve, a second finger carried by said shaft, and adapted to normally press against the finger on said sleeve, but to relieve the pressure when the said shaft is turned, a code wheel, a second finger on the bar and means whereby said second finger on the bar is pressed against the periphery of said wheel when the second finger on the shaft moves away from and relieves the pressure on the finger of the sleeve, said second finger on the bar being adapted to actuate the said code wheel when the parts are in this position and the lever is actuated.

25. A coding and decoding machine comprising a plurality of code wheels, a plurality of electrical conductors passing through each code wheel, a plurality of circuits operatively connected with each conductor passing through the code wheel, one of said circuits being used when coding and the other of said circuits being employed when decoding.

26. A coding and decoding machine comprising a plurality of keys, switch means actuated by said keys, a plurality of code wheels, a plurality of electrical conductors passing through each code wheel, a plurality of circuits operatively connected with said switch means and with each conductor passing through the code wheels, one of said circuits being used when coding and the other of said circuits being employed when decoding, and means whereby the operator may selectively bring either of said circuits into operation.

27. A coding and decoding machine comprising a plurality of keys, switch means actuated by said keys, a plurality of code wheels, a plurality of electrical conductors passing through each code wheel, a plurality of circuits operatively connected with said switch means and with each conductor passing through the code wheels, one of said circuits being used when coding and the other of said circuits being employed when decoding, and means whereby the operator may selectively bring either of said circuits into operation, said last mentioned means consisting of terminals in a fixed plate and terminals in a slidable plate, and means whereby the last-mentioned terminals may be brought into contact with either of two terminals on the fixed plate.

28. In a coding and decoding machine, a plurality of code wheels having electric conductors extending therethrough, a slidable plate having electrical conductors extending therethrough, a movable plate having electrical conductors extending therethrough, means whereby said movable plate may be shifted to either of two contact positions, one of said positions being the coding position and the other being the decoding position.

29. In a coding and decoding machine, a plurality of code wheels having electrical conductors extending therethrough, a slidable plate having electrical conductors extending therethrough, a movable plate having electrical conductors extending therethrough, means whereby said movable plate may be shifted to either of two contact positions, one of said positions being the coding position and the other being the decoding position, the conductors in the coding wheel forming a part of the electric circuits when the movable plate is in coding position and a part of the other electric circuits when in decoding position.

30. A coding and decoding machine comprising a series of keys, switch means actuated by said keys, a plurality of code wheels adapted to be traversed by an electric current, means whereby a code wheel is actuated one step incident to the operation of any of said keys, means whereby a second code wheel is rotated one step only after the first-mentioned code wheel has made a complete revolution, and means to conduct the current from said switch to said code wheel.

31. A coding and decoding means comprising a series of keys, switch means controlled by said keys, a plurality of code wheels having conductors extending therethrough, means for operating a code wheel incident

to the operation of said keys, means to conduct the current from said switches to said code wheels, and means whereby each of said conductors form a part of a circuit when the message is being coded and a part of another circuit when the message is being decoded.

32. A coding and decoding machine comprising a series of keys, switch means actuated by said keys, a plurality of code wheels adapted to be traversed by an electrical current, means to conduct the current from said switches to said code wheels, and means to rotate a code wheel one step incident to the operation of any key, a second code wheel being rotated one notch only after the first code wheel has made a complete revolution, a third code wheel being rotated one notch only after the second wheel has made a complete revolution, and so on for as many code wheels as may be employed.

33. A coding and decoding machine comprising a series of keys, switch means actuated by said keys, a plurality of code wheels adapted to be traversed by an electrical current, means for conducting the current from said switches to said code wheels when the machine is being used for coding a message and other means for conducting the current from said switches to said code wheels when the message is being decoded, key levers actuated by the said keys, means actuated by said key levers to actuate the code wheels step by step so that said means will cause the said code wheels to assume their initial position only after one of said code wheels has rotated as many times as the number of steps necessary to make a complete revolution thereof raised to the power equal to the number of code wheels employed.

34. A coding and decoding machine comprising a series of keys, switch means actuated by said keys, a plurality of code wheels adapted to be traversed by an electric current, means to conduct the current from said switches to said code wheels, and a core-indicating means adapted to be controlled by said code wheels.

35. A coding machine comprising a series of keys, switch means operated by said keys, a plurality of code wheels, a stationary board, a plurality of direct conditioned contacts on said board, a plurality of reverse conditioned contacts on said board, a movable contact board having contacts thereon and being adapted to contact with either said direct contacts or said reverse contacts.

36. A code machine comprising a series of keys, switch means operated by said keys, a plurality of code wheels adapted to be traversed by an electrical current, means to conduct a current from said switches to said code wheels, means to reverse the direction of the current through said code wheels, a bar under said keys adapted to be depressed when the keys are depressed, levers secured to said bar, fingers mounted on said levers, said fingers being adapted to engage said code wheel to rotate the same.

37. A coding and decoding machine comprising a series of keys, levers actuated by said keys, switch means actuated by said levers, a series of rotatable code wheels adapted to be traversed by an electric current, means to conduct the current from said switches to said code wheels, code wheel operating means adapted to be operated by each of said keys comprising a plurality of means adapted to cause rotation step by step of the code wheels so that said means will cause the said code wheels to assume their initial position only after one of the code wheels has rotated as many times as the number of steps necessary to make a complete revolution thereof raised to the power equal to the number of code wheels employed.

38. A coding and decoding machine comprising a series of keys, switches operated by said keys, a plurality of code wheels having electrical conductors extending therethrough, each of said conductors forming a part of an electrical circuit when a message is being coded and a part of another electrical circuit when the message is being decoded, and means operated by said keys for rotating a code wheel step by step incident to each operation of the keys, and other code wheels at predetermined longer intervals.

39. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged in groups; movable supports for said groups; means for moving each of said supports at relative speeds such that after each support has carried its members past not less than half nor more than all said interconnections, the support of next lower speed moves one of its members past one interconnection.

40. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged in groups; movable supports for said groups; means for moving each of said supports at relative speeds such that each member is brought into series with substantially all possible combinations of members shiftable relative thereto.

41. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged in dissimilar groups; movable supports for said groups; means for moving each of said supports at relative speeds such that after each support

has carried its members past not less than half nor more than all said interconnections, the support of next lower speed moves one of its members past one interconnection.

42. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged in random groups; movable supports for said groups; means for moving each of said supports at relative speeds such that after each support has carried its members past not less than half nor more than all said interconnections, the support of next lower speed moves one of its members past one interconnection.

43. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged in groups; movable supports for said groups; said supports being transposable; means for moving each of said supports at relative speeds such that after each support has carried its members past not less than half nor more than all said interconnections, the support of next lower speed moves one of its members past one interconnection.

44. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged in groups; movable supports for said groups; said supports being invertible; means for moving each of said supports at relative speeds such that after each support has carried its members past not less than half nor more than all said interconnections, the support of next lower speed moves one of its members past one interconnection.

45. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged in groups; movable supports for said groups; said supports being interchangeable; means for moving each of said supports at relative speeds such that after each support has carried its members past not less than half nor more than all said interconnections, the support of next lower speed moves one of its members past one interconnection.

46. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged in groups; movable supports for said groups; said supports being invertible and interchangeable; means for moving each of said supports at relative speeds such that after each support has carried its members past not less than half nor more than all said interconnections, the support of next lower speed moves one of its members past one interconnection.

47. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged in groups; relatively movable supports for said groups, and means for moving said supports at definite relative speeds; said last included means being adapted to permit independent movement of a support to adjust the phase relation between said supports.

48. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged in groups; relatively movable supports for said groups, and means for moving said supports at definite relative speeds; said last included means being adapted to permit independent movement of any said supports to adjust the phase relation between said supports.

49. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged in groups; relatively movable supports for said groups, said supports being transposable; and means for moving said supports at definite relative speeds; said last included means being adapted to permit independent movement of a support to adjust the phase relation between said supports.

50. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged perimetrically in groups of one member from each interconnection, revolvable supports for said groups, and means including ratchet mechanisms for revolving said supports.

51. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged perimetrically in groups of one member from each interconnection, revolvable supports for said groups, and means including cam-controlled means for revolving said supports.

52. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged perimetrically in groups of one member from each interconnection, revolvable supports for said groups, and means including cam-controlled ratchet mechanism for revolving said supports.

53. In a cryptographic device comprising a plurality of language and code characters, and designating interconnections between said characters; said interconnections being each divided up into a series of relatively shiftable members arranged perimetrically in dissimilar groups of one member from each interconnection, revolvable supports for said groups; said supports being symmetrical and alike to permit inversion and interchange thereof; and cam-controlled ratchet mechanism adjusted to move said supports at relative speeds such that any given support moves only one step while the support of next higher speed makes one revolution.

54. In a cryptographic machine, a plurality of code-changing code wheels, means for rotating said wheels at definite relative speeds, and means for independently moving of said wheels to adjust their phase relation.

55. In a cryptographic machine, a plurality of code-changing code wheels and means for rotating said code wheels at determinedly different speeds such that each code wheel is advanced one step after the code wheel of next higher speed has completed not less than a half nor more than a full revolution.

56. In a cryptographic machine, a plurality of code-changing code wheels, means for rotating one of said code wheels, means for rotating a second code wheel one step per full revolution of said one code wheel, and means for rotating a third code wheel one step per full revolution of said second code wheel.

57. In a cryptographic machine, a plurality of code-changing code wheels, driving means for rotating one of said code wheels, driving means controlled by said one wheel for rotating a second code wheel one step per full revolution of said one wheel, and driving means controlled by said second wheel for rotating a third code wheel one step per full revolution of said second wheel.

In testimony whereof I affix my signature.

EDWARD H. HEBERN.