May 11, 1926. 1,584,660

A. SCHERBIUS

CIPHERING DEVICE

Filed Dec. 7, 1922 2 Sheets-Sheet 1

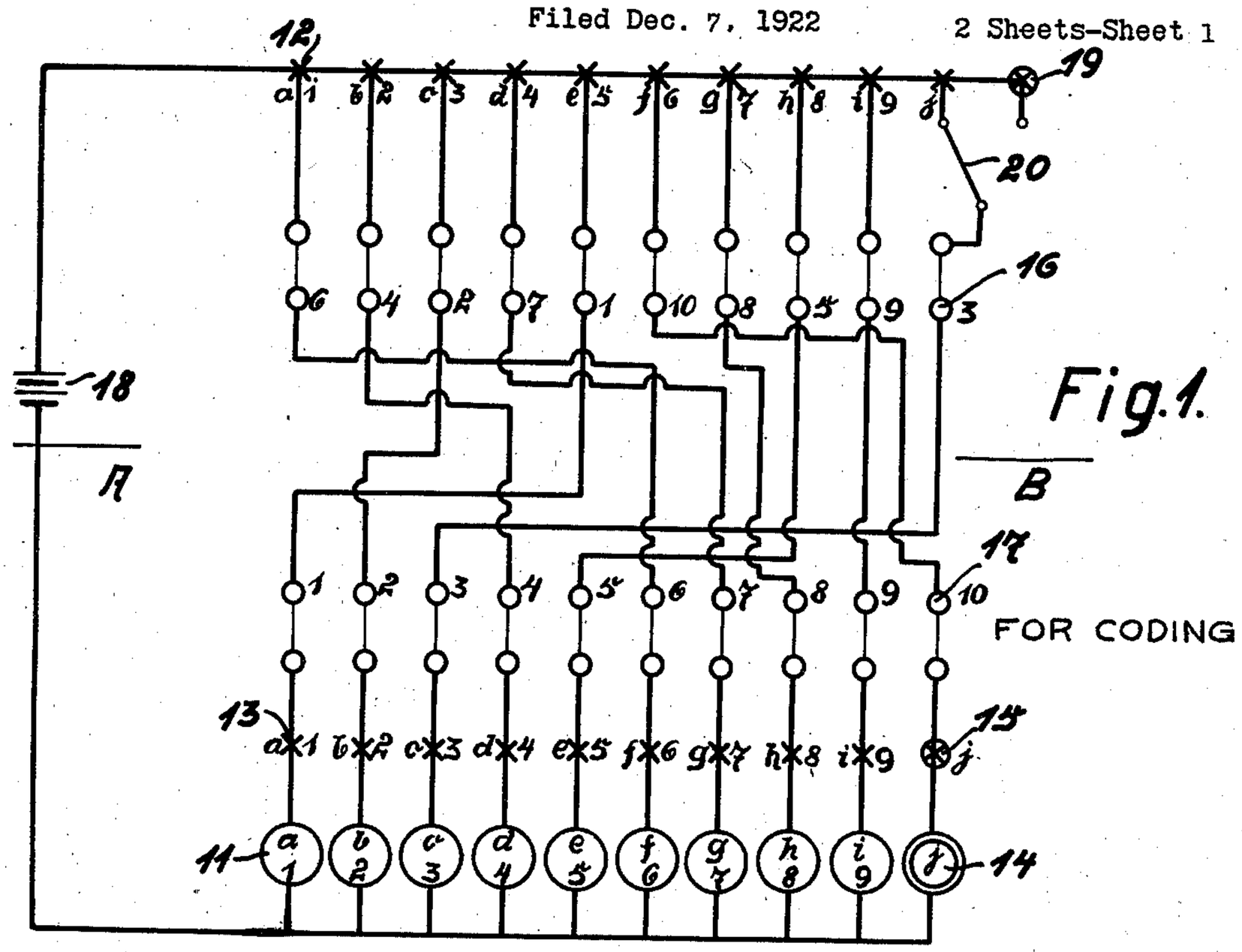

Fig.1.

Fig.2.

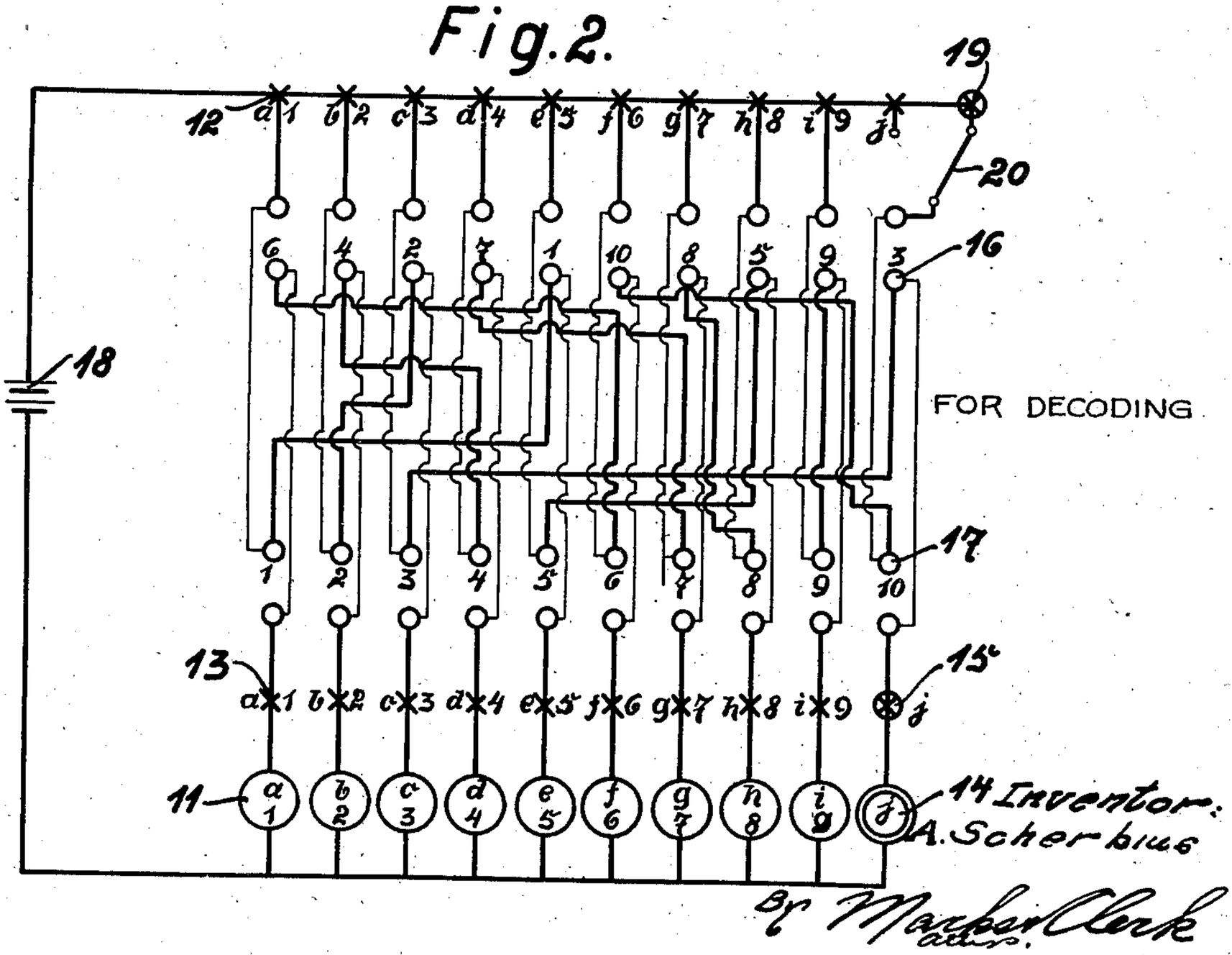

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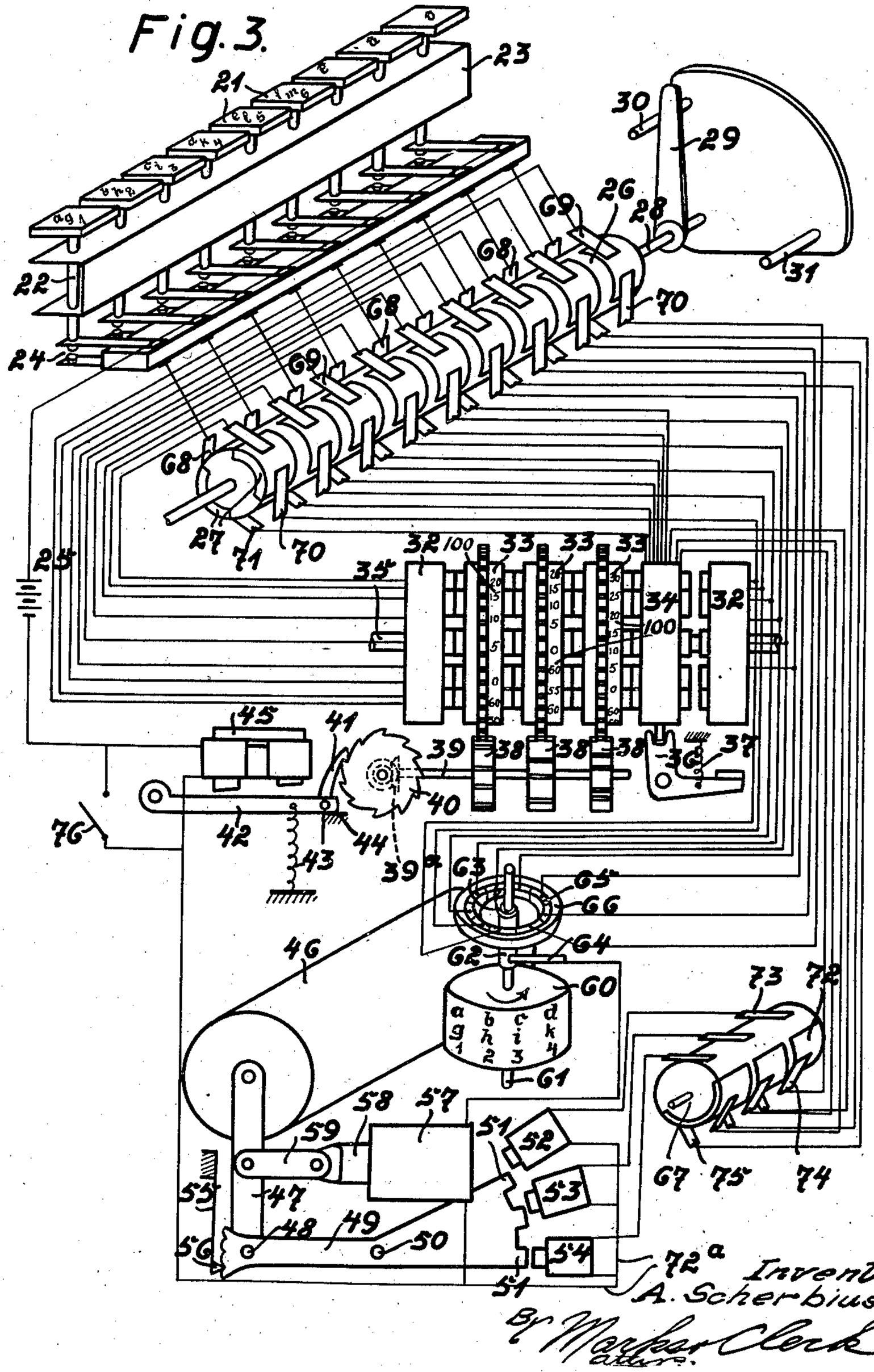
Fig. 3.



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Patented May 11, 1926. 1,584,660

UNITED STATES PATENT OFFICE.

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CIPHERING DEVICE.

Application filed December 7, 1922. Serial No. 605,473.

This invention relates to devices for ciphering or coding a clear text and for deciphering or decoding the ciphered text. Such devices usually consist of keys and indicating points of the same number as there are signs which are to be ciphered and of a similar number of interchangeable connecting elements between the keys and indicating points. For deciphering, the connecting elements are reversed or rearranged. Further, provisions are made that the interchanging of the connecting elements starting from the same point takes place in exactly the same succession and at the same distances as in the ciphering.

According to the present invention, a ciphering device of this type has a smaller number of indicating points than signs to be ciphered. In order to render this reduction of indicating points possible, the signs of the clear text are subdivided into several rows and the keys for each sign of each row are connected by the same connecting element with the same indicating point, so that this indicating point is excited indifferently in whatever row the sign to be ciphered stands. In order to render discernible in the ciphered text the row to which the ciphered sign belongs, separate keys are arranged in one of these rows to be used to indicate changes from one row to another. These keys are also connected with indicating points by interchangeable intermediary elements, for which, however, no corresponding keys are provided in the other rows. For these changing keys, signs must also be provided in the ciphered text. As ciphering signs for instance, the small letters of the alphabet and numerals will be preferably used, and as changing signs, such letters as need not be used in the alphabet, for instance *â ô* and *ê*. These shift marks or signs are arranged on special keys. The number of the changing or shift keys can be selected at will, for instance, only one changing key may be used if only two rows of signs are in the clear text, so that each time a change is made from the characters in one row to the characters in the other row, the change may be indicated by the changing or shift key. It is preferable to provide as many shift marks as there are rows of signs, in order to clearly indicate to which row the signs belong which are directly after a changing sign. As the changing signs are connected with the indicating points by means of the interchangeable connecting elements in the same manner as all of the other signs, they are also ciphered and no longer recognizable in the ciphered text as changing signs.

Two forms of the invention are shown by way of example on the accompanying drawing, wherein:

Figs. 1 and 2 show a switch diagram for a very simple ciphering apparatus explanatory of the diagram shown in Fig. 3. Figs. 1 and 2 having but one changing sign, the sign senders being formed by keys, each of which is provided with a number and a letter, while the indicating signals or points are illustrated by incandescent lamps, each illuminating a number and a letter.

Fig. 3 on the contrary, shows a ciphering machine with three changing signs, which is constructed in the form of a typewriting machine, and in which the interchange of the conductors between the keys and the writing elements is constantly modified irregularly during the ciphering.

In Figures 1 and 2, a ciphering device is diagrammatically shown which comprises two rows each of nine clear text signs and one reversing sign. In the embodiments in Figs. 1 to 3, keys for only a part of the alphabet are represented while punctuation and spacing keys are omitted. It will be evident that a complete alphabet and keys for punctuation and spacing will be provided in the device when in use. It is to be understood, however, that the machine diagrammatically illustrated by these figures will in actual practice have say three rows of keys, each carrying one or more signs. Fig. 1 shows the parts in position for ciphering, while Fig. 2 shows the same machine in position for deciphering. In these figures, 11 designates the contact keys carrying the letters *a* to *i* inclusive and the numerals 1 to 9 inclusive. 12 are incandescent lamps marked with the same letters *a* to *i* and numerals 1 to 9 to accord with the marking on the keys. Directly behind the contact keys 11, incandescent lamps 13 are arranged, and these lamps are marked with signs cor-

responding to the signs of the contact keys. The key 14 is the one used to indicate a change in the ciphered text, for instance from letters to numerals and vice versa. This key is marked with the letter *j* and is mounted in series with an incandescent lamp 15, which is preferably colored red to distinguish the same from the other lamps 13. A lamp in the row 12 corresponding with the key *j* is also marked with the letter *j*. At the side of this lamp a red lamp 19 is arranged in such manner that by a switch 20 the lamps *j* and 19 can be cut into or out of the circuit. The switch 20 serves to connect the circuit at this point with either the lamp *j* or the lamp 19, the purpose being, on deciphering, to indicate that the signs following the actuation of the lamp 19, belong to a different class or species. For instance, if the signs previous to the lighting of the red lamp 19 were letters, then the operator will be notified that the signs following the lighting of the red lamp 19 are numbers. Between the lamps 12 and the contacts 11, contact rows 16 and 17 are arranged, and these contact rows are connected with one another in an irregular manner, so that each of the contacts 16 is connected with one of the contacts 17. The wiring between the rows of contacts is indicated by lines. The connected contacts of the two rows are marked with the same figures to facilitate reading the drawing, and the manner of connection between the contacts 16 and 17 forms the ciphering key.

As one pole of the contact keys 11 and one pole of the incandescent lamps 12 are under voltage, one of the lamps in row 13 and one of the lamps in row 12 will light up upon the depression of either of the keys 11. To explain the connection, the method of ciphering the signs *a*, *b*, *c*, *d*, 1, 2, 3, 4, *e*, *f*, *g* will be hereinafter described. In order to cipher or code the first four letters of this succession of signs, the keys of row 11 corresponding to these signs are successively depressed, whereby in row 12 the incandescent lamps *e*, *c*, *j* and *b* will be successively illuminated. As the numeral 1 follows after *d*, the changing key *j* is depressed so that the change from letters to numerals will be indicated in the row 12 by the illumination of the lamp marked *f*. Then the depression of the keys 11 marked 1, 2, 3 and 4, cause the illumination of the lamps bearing the letters *e*, *c*, *j* and *b*. As a letter follows after the numeral 4, another changing sign is necessary, so that key *j* is depressed again to light up the lamp *f* in the row 12. Then the depression of the keys 11 bearing the letters *e*, *f*, *g* will produce on the indicating lamps 12, the successive illumination of the lamps bearing the letters *h*, *a* and *d*. Thus the clear text *a*, *b*, *c*, *d*, 1, 2, 3, 4, *e*, *f*, *g*, is transformed into the ciphered text *e*, *c*, *j*, *b*, *f*, *e*, *c*, *j*, *b*, *f*, *h*, *a*, *d*. It will be noted that simultaneously with the illumination of the lamps in row 12, the lamps in row 13 are lighted up to facilitate the observation of the operation of the apparatus.

The clear text thus ciphered may be deciphered by the same machine by simply rearranging or reversing the contacts 16 and 17. To facilitate this these contacts are preferably arranged on a cylinder and for deciphering purposes this cylinder is turned 180° upon the axis AB, so that the row of contacts 16 will now be directly connected to the leads from the keys 11—14, while the row of contacts 17 will be in direct connection with the leads from the lamps 12—19. The heavy wiring connected to the contacts 16 and 17 in Fig. 2 is arranged the same as that shown in Fig. 1, and the light wiring connected to these contacts illustrates the connections of the contacts with the lamps 12 and 13 when the cylinder carrying the contacts is rotated 180° for the purpose of deciphering. The arrangement of the contacts 16 and 17 for deciphering purposes may also be understood from Fig. 1 when it is considered that the heavy wiring between the contacts 16 and 17 is turned up side down so that the contacts 17 occupy the upper position while the contacts 16 occupy the lower position.

For deciphering, the switch 20 should be shifted from the lamp *j* of row 12 to the lamp 19. If now the letters *e*, *c*, *j*, *b* of the ciphered text are depressed with the keys 11 carrying the same, the letters *a*, *b*, *c*, *d* will successively appear in the row 12 of incandescent lamps. If the contact key *f* is then depressed, the red lamp 19 will light up and indicate to the observer that the following signs are numerals. Then if the letters *e*, *c*, *j*, *b* of the keys 11 are successively depressed, the lamps 1, 2, 3, 4 of row 12 will light up successively. It is obvious that on deciphering, the lamp 19 is illuminated, for letters as well as for numbers. If letters are shown first, it is obvious, by the illumination of lamp 19 that numerals will follow and vice versa. At the depression of the key *f* during deciphering, the lamp 19 will light up again indicating the transition from the numerals to the letters, and when the contact keys *h*, *a*, *d* are depressed the incandescent lamps *e*, *f*, *g* will light up, showing that the ciphering has been translated into the clear text.

The machine diagrammatically illustrated in Fig. 3, employs the same principle as that described in connection with Figs. 1 and 2, but the construction of the apparatus in Fig. 3 is different from the construction shown in Figs. 1 and 2. Fig. 3 shows a ciphering apparatus having three rows of signs in clear text and corresponding with these three rows, three reversing keys. 21

designates several of the contact keys of a typewriter for instance, of which six are marked, each with three signs of the clear text, three other keys being marked with the changing signs *ê*, *â* and *ô*. The stems 22 of the keys are guided in a U-shaped support 23 and bear upon the upper contact springs of switches 24. 26 designates an oscillatable cylinder formed of insulating material and carrying nine pairs of electricity-conducting sectors 27, which are fixed to the cylinder. The sectors of each pair are always situated one opposite the other and for each two sectors, four contact springs 68, 69, 70 and 71 are provided, and these contact springs are relatively displaced at approximately 90°. The cylinder is mounted on a shaft 28 carrying a fixed arm 29 adapted to be moved between the abutments 30 and 31 in order to shift the cylinder 26 and its sectors 27 into different positions. 32, 33 and 34 designate a device designed to interchange the electric connections between the striking keys and indicating points or typing characters. It consists of cylinders of insulating material mounted upon an axle 35. The cylinders 32 are stationary, the cylinders 33 are rotatable, and the cylinder 34 is non-rotatable but axially movable along the shaft 35. Each of the cylinders 33 has upon its opposite faces nine contacts arranged in a circle. These contacts are connected with each other in such manner that one contact on one side is always connected with one contact on the other side, and the arrangement is as confused as possible to prevent coding or decoding by unauthorized persons. The cylinders 33 are each provided with toothed crowns by means of which they may be revolved around the axle 35. The cylinder 34 is constructed similar to the cylinders 33 but with the difference that the opposite contacts on its two end faces are connected with one another in a regular manner and that the said cylinder is axially movable along the axle 35. With the aid of a lever 36 and of a spring 37, cylinder 34 presses the cylinders 33 against the right side of the left hand stationary cylinder 32. The cylinder 34 can, however, be pressed by hand in opposition to the tension of the spring, against the right cylinder 32. 38 designates three toothed wheels in gear with the toothed crowns upon the cylinders 33. The wheels 38 are keyed upon the shaft 39 and their teeth are arranged as irregularly as possible, so that by a rotation of shaft 39, the several cylinders 33 are turned different degrees about the axis of the shaft 35. A transfer wheel 40 is either arranged directly upon the shaft 39 or is connected to said shaft by a driving gear 39^a, and a pawl 41 engages with the teeth of the transfer wheel. This pawl is pivotally mounted upon an armature 42, which is pulled by a spring 43 against a stop 44. The armature may be raised by a relay 45, so that the pawl comes into engagement with the different teeth of the wheel 40 for turning the latter.

46 designates the platen of a typewriting device, and this platen is oscillatably mounted by means of two levers 47 pivoted at 48. The pivots 48 are carried by lever arms 49 which rotate about the fixed pivots 50. One of these lever arms has at its outer end three large teeth 51 of soft iron arranged opposite to three relays 52, 53 and 54. 55 designates a blade spring which has a nose 56 adapted to engage with one or the other of the three notches of the lever 49, so that this lever may be retained in any one of three positions. 57 is a solenoid coil having a movable core 58 connected by a link 59 with the lever 47 of the platen. 60 is a type cylinder which has upon its circumference three rows of signs, the upper row corresponding with the signs marked at the top upon the first six keys 21 of the typewriter, the middle row corresponding to the middle row of signs upon the same keys of the typewriter, and the lower row corresponding with the lower row of signs upon the same keys of the typewriter. The drum 60 is keyed upon the shaft 61. Said shaft may be revolved at uniform speed by any suitable motor, not shown on the drawing. Mounted on and turning with the shaft 61 is a tube 62 of conducting material which is insulated from the shaft and carries a brush collector 63, which turns with the tube. A stationary brush 64 slidably engages the other end of the tube. The outer end of the brush collector 63 slides upon the inner surface of a stationary collector composed of nine sectors 65 which are insulated from one another and are held together by an insulating ring 66. 67 is a cylinder with three sectors 72 extending approximately over half the circumference of the cylinder and cooperating with three rows of brush collectors 73, 74 and 75, displaced about 120° relatively to one another.

The several parts of the machine are connected by wires in the following manner:

The upper springs of the contacts or switches 24 are connected with one pole of a source of current 25. The lower nine members of the contacts 24 are connected with nine brush collectors 68 forming one row of contacts cooperating with the cylinder 26. The brush collectors 69 of this cylinder are connected with the nine contacts of the left hand interchanging cylinder 32. The brush collectors 70 are connected with the nine sectors 65 of the collector and certain of these brush collectors are also connected with the right hand interchanging cylinder 32. Regarding the brush collectors 71, the six situated toward the left are each connected with two opposite contact pins of cylinder 34. The three right hand

brush collectors 71 are connected with the brush collectors 75 of the cylinder 67. The brushes 74 are connected with three pairs of contacts of cylinder 34, and the brushes 73 are each connected with a respective one of the magnet coils 52, 53 and 54. The other three terminals of these magnet coils are connected with the wire 72ª to which the brush collector is also connected across the magnet coil 57. The lead 72ª is guided across the coils of the relay 45 to the other pole of the source of current 25, and the relay 45 may be short circuited by means of a switch 76.

The operation of the apparatus shown in Fig. 3 is as follows:

In the ciphering or coding, the lever 29 of the reversing cylinder 26, the axially movable cylinder 34, the feeding cylinder 67 and the switch 76 are in the positions shown. If now for instance the key marked with *a*, *g*, 1, is depressed, the current from the source of current 25 flows across the left hand end contact 24, the left hand brush collector 68, one of the sectors 27 to the left hand end brush collectors 71. From there the current flows to the axially movable changing or reversing cylinder 34 and then through the three revoluble cylinders 33 to the left hand cylinder 32, and from there to the left hand end brush collector 69, across the uppermost left hand end sector 27 to the left hand end contact brush 70 and from there to one of the sectors 65 of the collector. If now the contact spring 63 fixed upon the continuously rotating shaft 61 comes in contact with this sector, the circuit is closed. The current continues to flow across the contact brush 64, the magnet coil 57, the relay coils 45 and back to the source of current 25. The core 58 of the magnet is thus pulled into the coil 57 and the platen 46 carrying the paper is instantaneously thrown against the type drum 60, the letter of the cylinder which corresponds to the determined sector in 65 being thus typed. At the same time the armature 42 is raised by the relay 45 so that the pawl 41 engages with the next following tooth of the feed wheel 40. If now the depressed key is released, the coil 45 of the relay becomes deenergized, so that the armature 42 is pulled by the spring 43 against the stop 44 and consequently the shaft 39, wheels 38 and the interchanging cylinders 33 are turned. Owing to the different arrangement of the teeth upon the wheels 38 the interchanging cylinders 33 execute movements of different amplitudes, which must be calculated so that the contacts of adjacent cylinders stand always exactly opposite one another. After the typing of each letter a new interchanging alphabet is therefore adjusted. The course of the current remains the same if a reversing or changing key is depressed. These changing keys are the three right hand ones of the keys 21. Merely the direction of the current between the brushes 71 and the interchanging cylinder 34 varies, because the current first flows across the cylinder 67. On pressure of a changing key, the current flows as follows: battery 25, contact 24, brush 68, contact 27, brush 71, through the conductor 75, contact member 72, brush 74, non-rotatable disk 34, through the disks 33 to the left hand stationary drum 32, through the conductor to brush 69, over contact 27 to brush 70, through the conductor to a segment of the type wheel 60 corresponding to the changing key depressed, through electro-magnet 57, electro-magnet 45 and again back to the battery 25.

As an example, suppose in starting the operator depresses the right hand changing key to cause a certain character to be typed. This in the ciphered text will inform the receiver that all characters typed and following this changing sign will relate for instance to the upper row of characters on the six left hand keys 21, until say, the middle one of the changing keys is depressed, to type the second changing sign, and the receiver will thus be informed that typed characters following this second changing sign will correspond with the second row of characters on the six left hand keys 21 etc.

In order to decipher or decode with this apparatus, the wheels 33 must be returned to the same position which they occupy when the message was ciphered or coded, and the lever 29 has to be reversed or moved so that it comes in contact with the stop 31. The cylinder 67 must be also brought into such a position that the rows of brushes 73 and 74 are in electrical connection. The cylinders 33 may be brought to their original position for decoding purposes by turning back the shaft 39 until a determined initial position of the disks is reached, and this may be facilitated by placing marks or indications 100 on the disks and bringing these indications into alignment by turning the disks 33.

In decoding the apparatus functions as follows:

If for instance the letter *a* from the ciphered text is depressed; (which might have been typed in consequence of the depression of the changing or reversing key *â*, the current from the source of current 25 takes the following course. Across the contact 24, the brush 68 situated at the left hand end of the cylinder 26 to the left hand end brush 69, and from there to the left hand stationary cylinder 32, through the interchanging cylinders 33, the non-rotatable cylinder 34 to the middle brush 74 of the cylinder 67 and from the central one of

the three brushes 73 across the magnet coil 53 and relay 45 back to the source of current. Consequently the magnet 53 attracts the middle tooth 51 of the lever 49 which stands partly opposite said magnet, whereby the paper cylinder or platen 46 is lowered so far that the nose 56 engages with the middle notch of the lever 49, so that at the next following depression of the keys 21, the signs are typed by the middle row of type on the drum 60. If letters are depressed in the ciphered text which correspond not to reversing or changing signs, but to signs of the clear text, the operation is exactly as at the deciphering with the only difference that the interchanging cylinders 33 are traversed in opposite direction by current flowing from the keys to the typing device. The letters of the ciphered text, however, which have been produced by the depression of the reversing signs at the typing of the clear text, cause each time a corresponding adjustment of the paper cylinder or platen 46.

It is not always necessary to cipher the entire text. The apparatus described permits clear text to be inserted between the ciphered text. With this object in view, the cylinder 34 is pressed at the ciphering, by placing the hand on the lever 36, to cause the cylinder 34 to contact with the right hand cylinder 32, so that the current flows no longer across the interchanging cylinders 33, but directly from the keys across the cylinders 34 and 32 to the point where the typing is to be effected. The cylinder 67, must furthermore be brought into the same position as at the deciphering. The brush row 73 must therefore be connected with the brush row 75, so that at the contact of the interchanging cylinders the magnets 52 to 54 are excited and the platen raised or lowered correspondingly. The switch 76 must be closed during the typing of the clear text so that the interchanging device is not adjusted during the operation on the clear text but is in position to properly function as soon as the machine is again used for ciphering. The clear text inserted in the ciphered text can evidently be also typed at the deciphering. With this object in view the apparatus must be brought in exactly the same position as at the typing of a clear text inserted between the ciphered text.

From the foregoing, it may be seen that the present invention involves a ciphering machine, and all the elements in Fig. 3 belong to one and the same machine. A machine of this type is located at the sending station and an identical one is located at the receiving station. The manner in which the ciphered or coded message is transmitted from the sending to the receiving station is entirely immaterial. It may be transmitted by letter, postal card, telegraph or by radio. In transmitting a message by wire or wireless, the three shift or changing signs will, of course, be such as can be sent by telegraph or wireless. For instance, we will assume that the middle horizontal row of letters on the type cylinder 60 contains nine different small letters. If the platen 46 does not shift up and down during coding or ciphering, it is possible that the message typed will only consist of the nine letters on the second horizontal row of keys on the drum 60. Therefore the coded message will consist only of these same nine letters and as the receiver of the message will be familiar with the machine and code he will understand that three of these letters indicate changing or shift signs. Therefore when the receiver uses an identical machine for deciphering, he will strike the changing or shift keys at the proper time.

It is, of course, understood that a complete ciphering machine includes all the letters of the alphabet, and not as shown on the drawing, only the letters *a* to *m* which are merely shown so as not to complicate the drawing. Before the ciphering is begun at the sending station and the deciphering begun at the receiving station, the cylinder 33 must be set at a predetermined initial position, and the definite initial position selected is expressly noted at the beginning of the message and transmitted to the receiving station, so that the machine at the latter station may be adjusted to the same position. For this purpose any desired marks may be inscribed or marked on the periphery of the disks or cylinders 33.

By the invention it is possible to reduce very much the number of the signs used in the ciphered text. Consequently the unauthorized deciphering of the ciphered text is rendered very difficult. The deciphering with the aid of the machine, is, however, facilitated considerably, as at the deciphering only one row of signs need be depressed.

In the apparatus shown in Figures 1 and 2 the lamps 12 and 19 form visual indicators while in Figure 3 the type letters, for instance, placed on the papers will function as indicators, so for the purpose of claiming the present invention I have used the word "indicators" in the claims and intend that word to cover lamps, typed matter and the like.

I claim:—

1. In a coding and de-coding machine, a series of contact keys each bearing one each of one or more sets of characters, a shift key for each set of characters and bearing a shift indicating character, indicating means having elements corresponding to the sets of characters and shift indicating characters, operating means for the indicating means, a source of current, a conductor connecting the source of current to the contact

keys, a second conductor connecting the source of current to the operating means, and conducting means for placing the indicating means in circuit with the contact keys when the said keys are depressed, whereby each of said keys will operate the corresponding element of the indicating means, and a code reversing element interposed in said conductor means for changing the circuits between the contact keys and the indicating means, each of said shift keys being effective to operate its corresponding shift indicating element.

2. A machine as claimed in claim 1 in which said operating means includes a plurality of contact discs, and means for shifting said discs relatively varying distances each time one of the keys is depressed.

3. A machine as claimed in claim 1 in which said operating means includes a rotatable type drum, a circular series of contacts arranged adjacent the drum and electrically connected keys, a brush rotatable with the drum and adapted to slide over the contacts for completing a circuit throughout one of the contacts when a key is depressed, a platen adapted to carry paper to be typed, and means electrically connected to said brush for shifting the platen toward the type drum each time a key is depressed.

In testimony whereof I affix my signature.

ARTHUR SCHERBIUS.