Aug. 27, 1963 M. M. LEVY 3,102,254

APPARATUS FOR MINIMIZING CODING ERRORS

Filed March 17, 1960 6 Sheets-Sheet 1

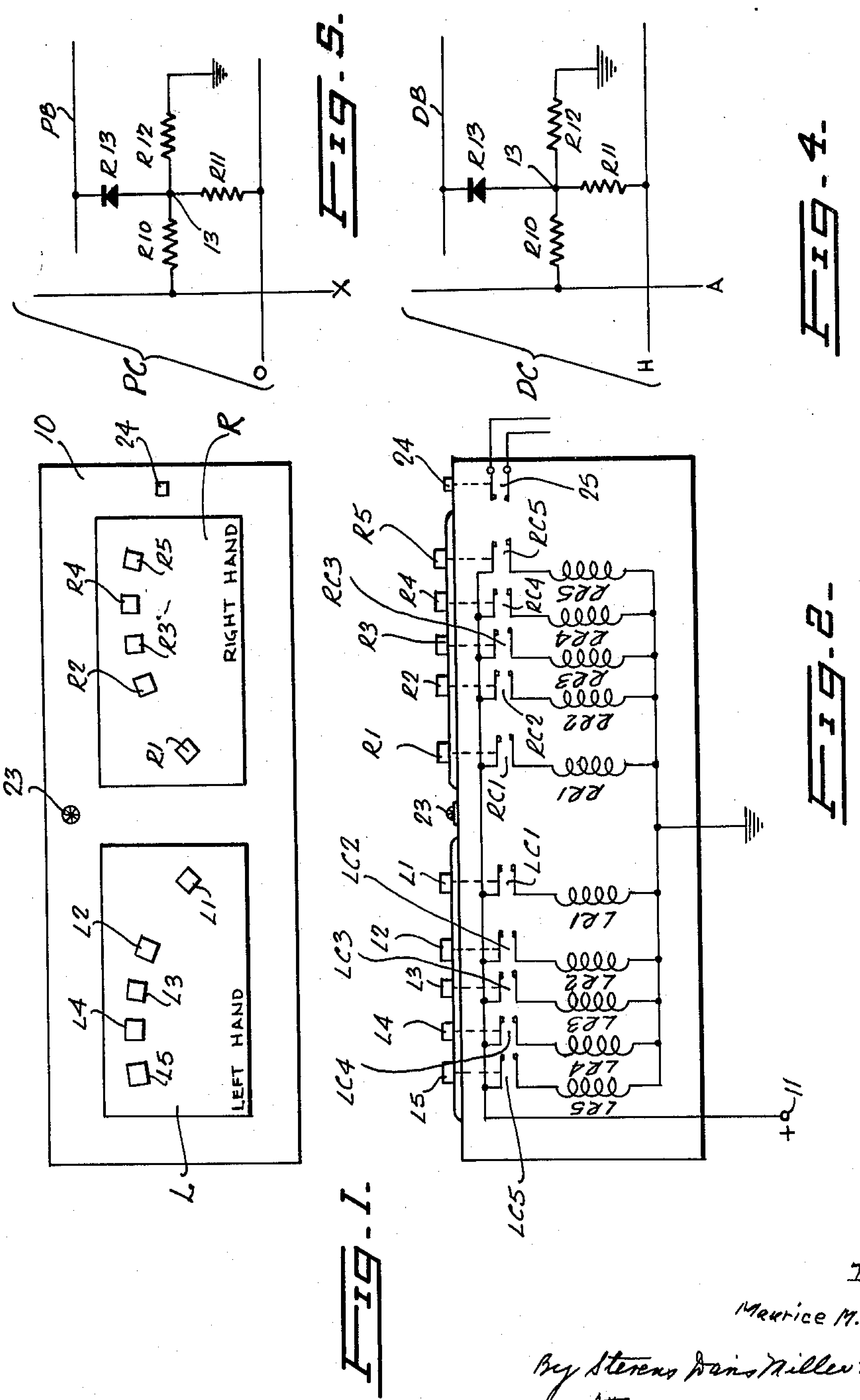

Fig. 1. Fig. 2. Fig. 4. Fig. 5.

Inventor
Maurice M. Levy
By Stevens Davis Miller & Mosher
Attorneys

APPARATUS FOR MINIMIZING CODING ERRORS

Filed March 17, 1960 6 Sheets-Sheet 2

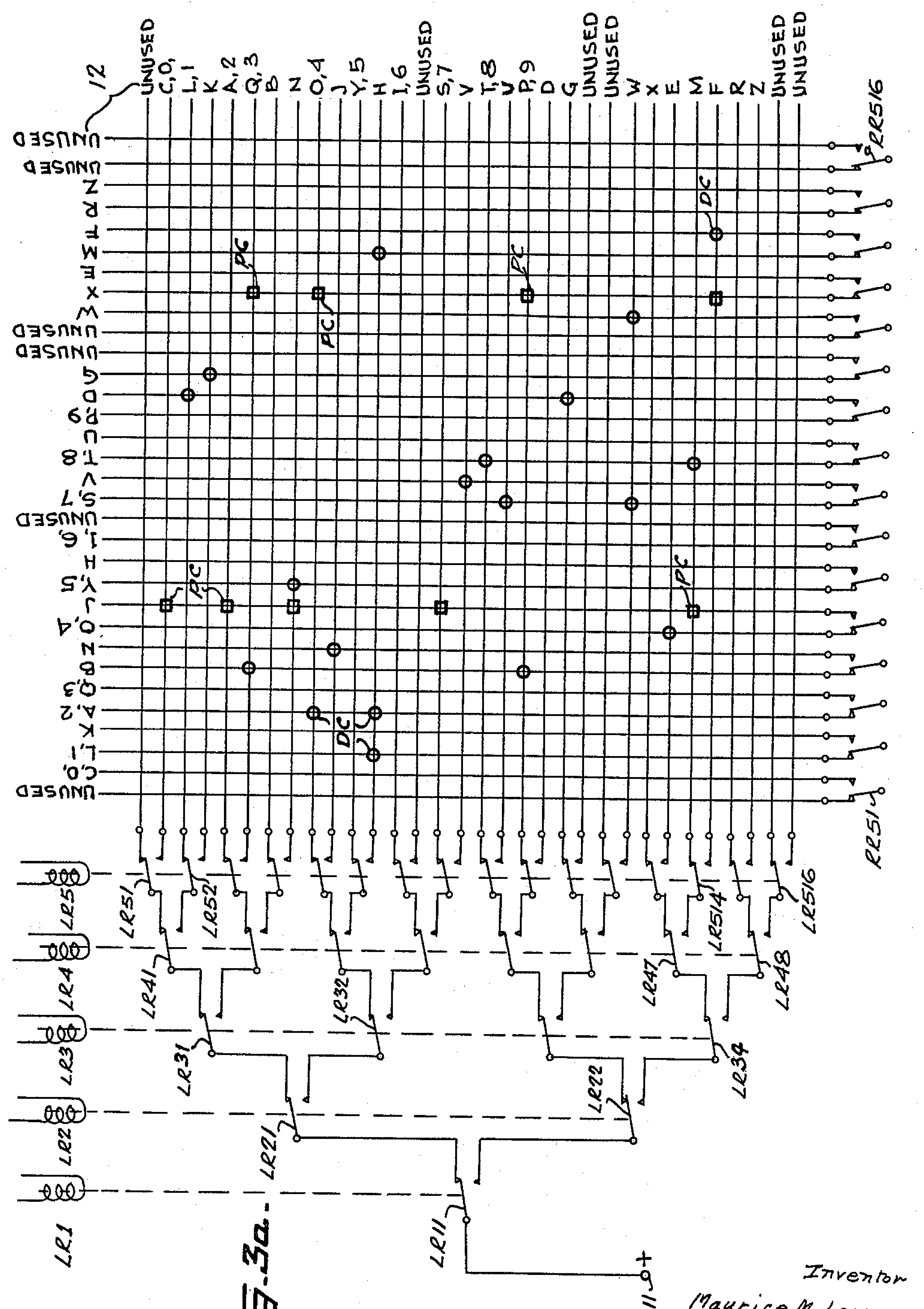

Fig. 3a.

Inventor
Maurice M. Levy
By Stevens Davis Miller & Mosher
Attorneys

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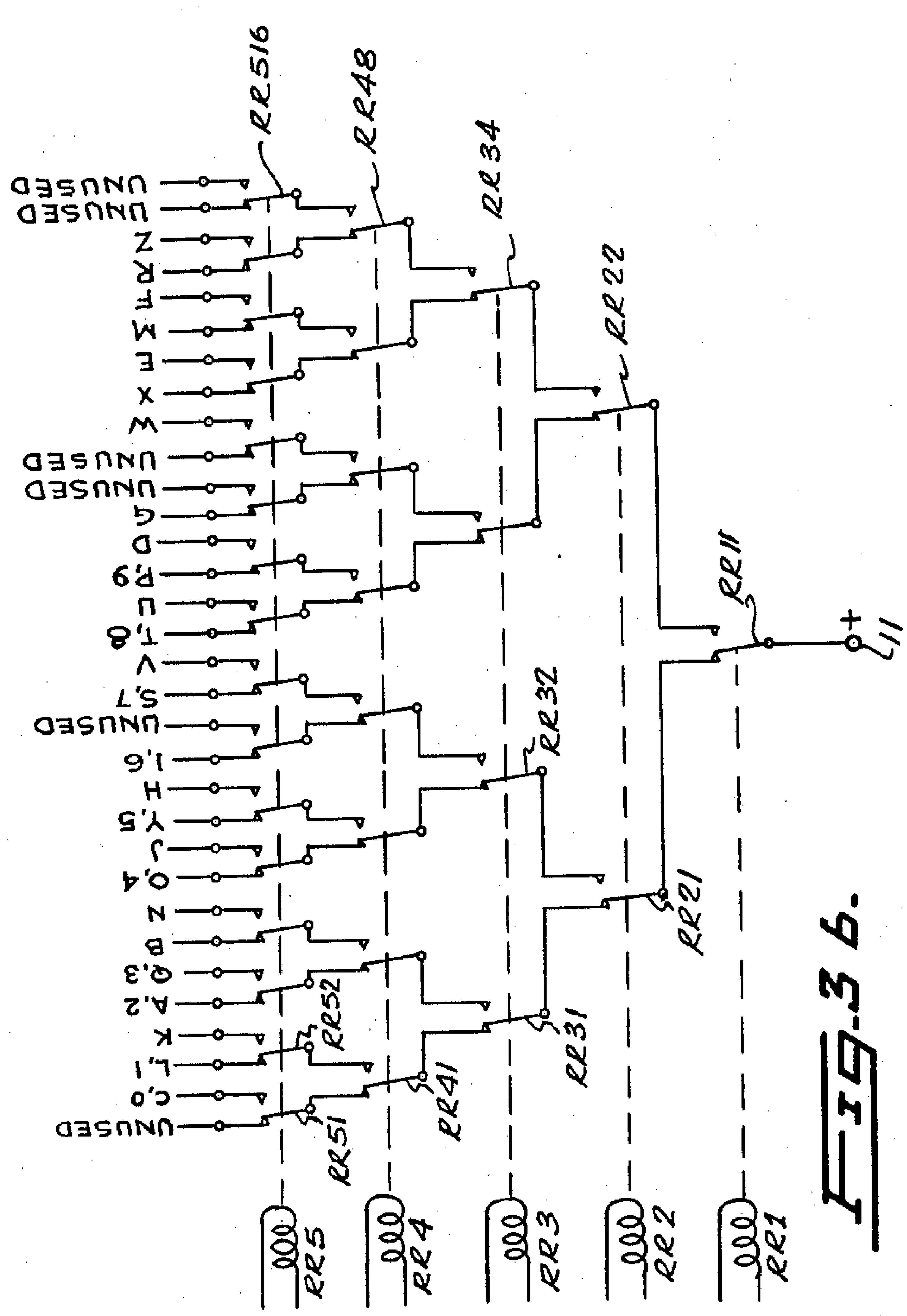

Fig. 3b

Inventor
Maurice M. Levy
By Stevens Davis Miller & Mosher
Attorneys

APPARATUS FOR MINIMIZING CODING ERRORS

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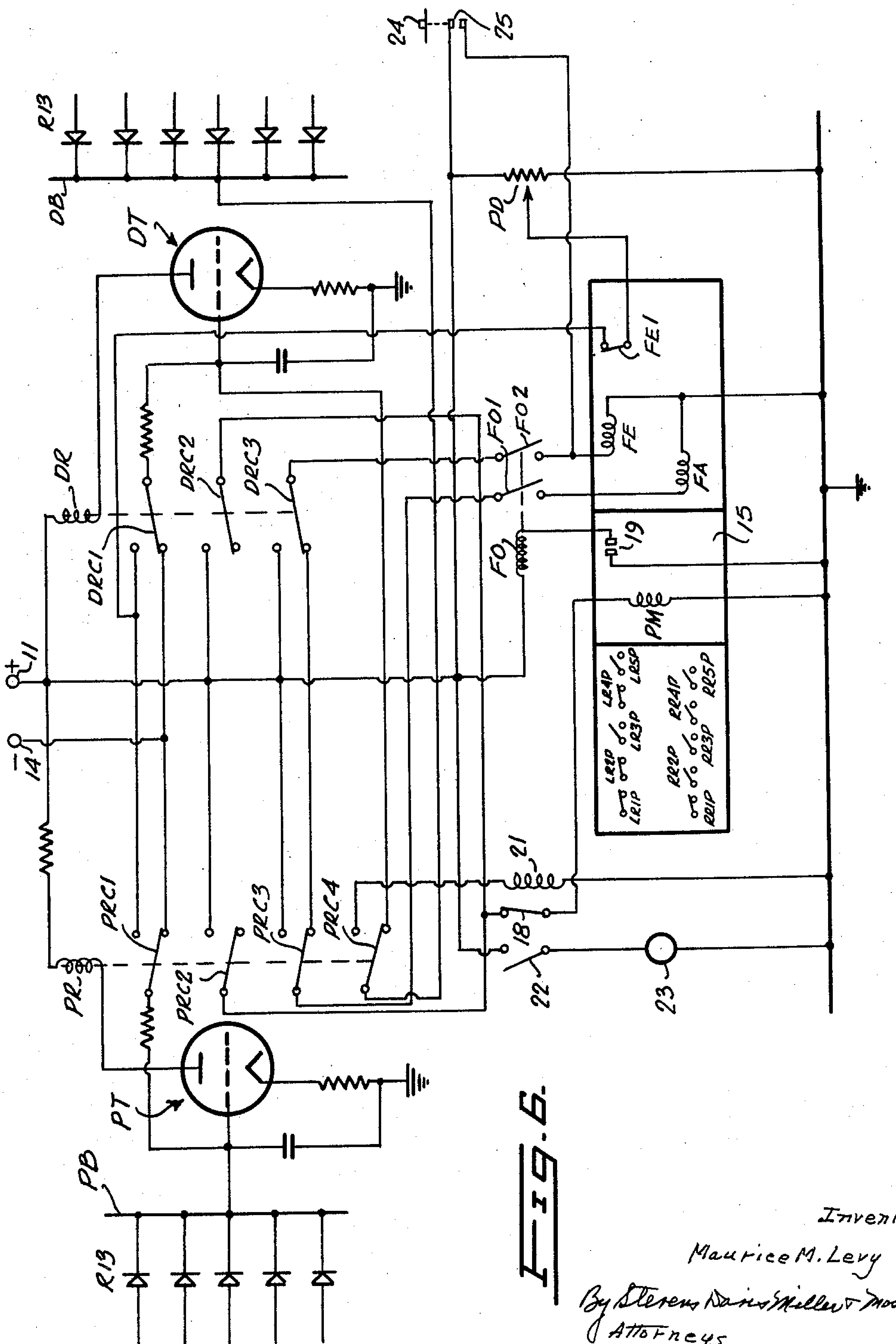

Inventor
Maurice M. Levy
By Stevens Davis Miller & Mosher
Attorneys

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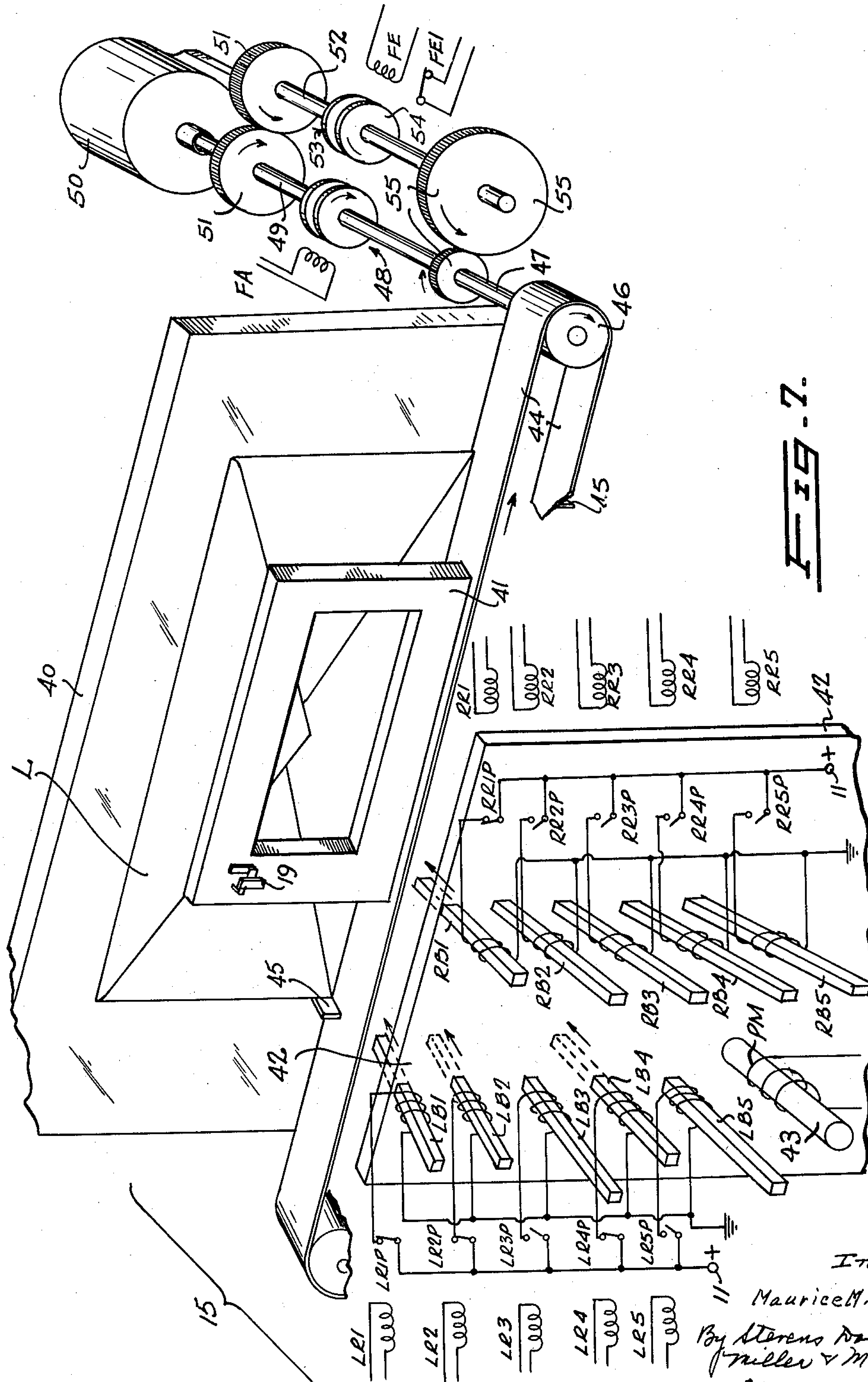

FIG. 7.

Inventor
Maurice M. Levy
By Stevens Davis Miller & Mosher
Attorneys

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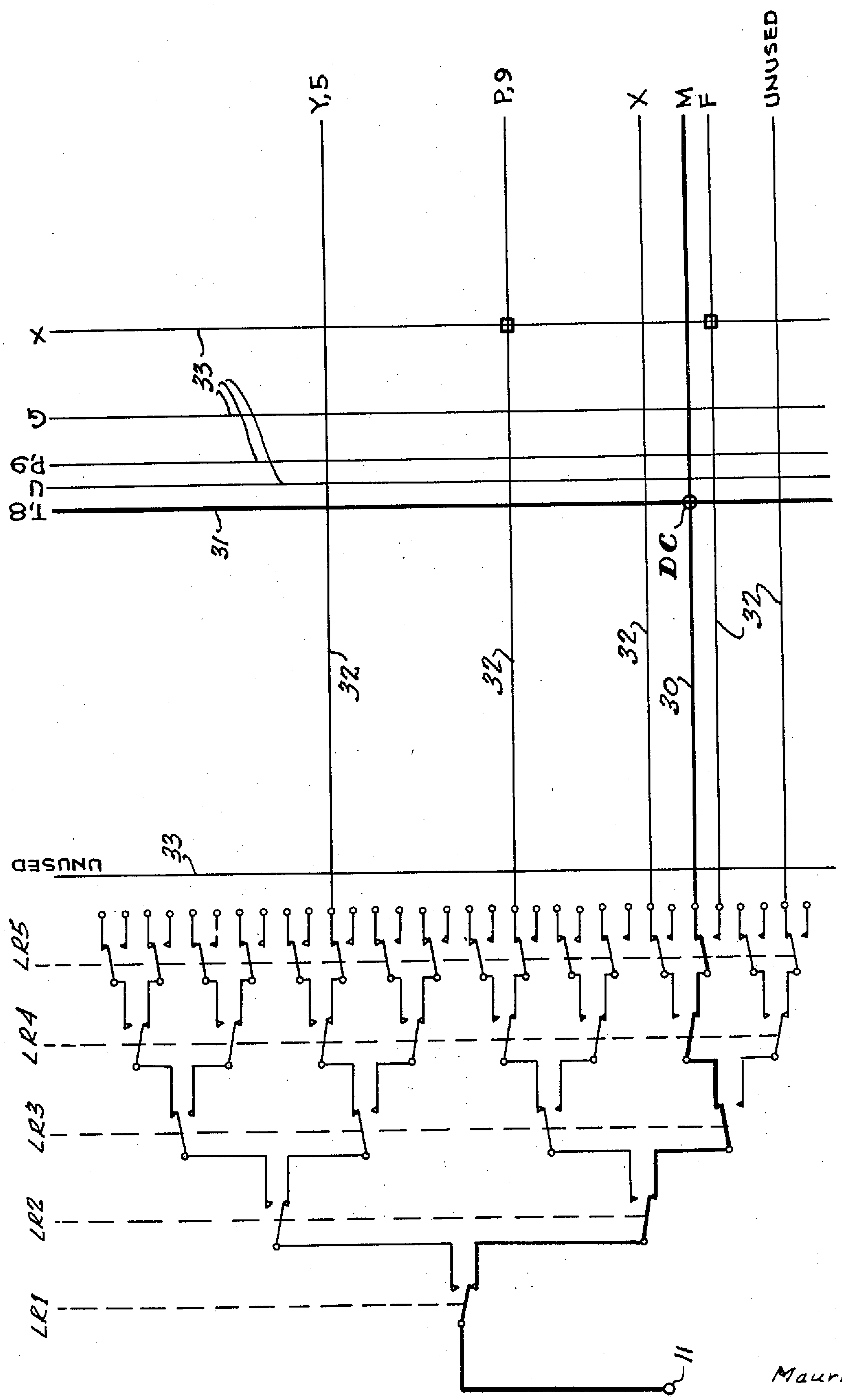

FIG. 8.

Inventor
Maurice M. Levy
By Stevens, Davis, Miller & Mosher
Attorneys

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APPARATUS FOR MINIMIZING CODING ERRORS

Maurice M. Levy, Ottawa, Ontario, Canada, assignor to Her Majesty the Queen in the Right of Canada as represented by the Postmaster General, Ottawa, Ontario, Canada

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9 Claims. (Cl. 340—146.1)

This invention relates to apparatus for minimizing the harmful effects of operators' errors in the application of coded designations to articles that are subsequently to be sorted on the basis of such imposed code designations. The invention has been principally developed in connection with the coding of letter mail, and in the specific example set out below the articles to be coded are assumed to be letters of the usual type that pass through the mails. However, as will become apparent, the essential principles of the invention are equally applicable to the handling of any other articles on which a code designation can be imposed and which are destined subsequently to be sorted in accordance with such coding.

The invention is concerned with a coding system operating in accordance with the binary system. In a typical such system, the operator has five keys for each hand, one key corresponding to each finger, and each character to be coded corresponds to a selected combination of finger operations. Thus, unlike a typewriter where each key corresponds uniquely to a given character, in the binary system each combination of keys corresponds to a given character (or, in some instances, characters, since the same combination may be used for both a letter and a numeral).

The broad object of the present invention is the reduction of operators' errors in such coding apparatus. It has been found that the majority of errors which occur in practice result from either one desired key not being quite adequately depressed, or one key that should not be depressed being accidentally touched and operated. That is, to say, the majority of errors made by an experienced operator are "one-finger errors," the combination of keys actually depressed differing only in respect of one finger (or one key) from the combination intended. It is not considered a "one-finger error" when one finger is displaced from its correct position so as to depress the wrong key. This is a "two-finger" or "two-key" error, since, not only is one key depressed which should not be, but also one key is not depressed which should be. As a practical matter, the probability of such a displaced finger type of error is low.

One important object of the present invention is the provision of apparatus for detecting one-finger errors in the operation of a keyboard. Once such errors have been detected, the detector may be employed simply to warn the operator of the erroneous coding attempted, or it may be employed automatically to block the application of the erroneous code to the article.

As will later be explained, the basic principles of the present invention may be further extended also to detect some two-finger, three-finger and more complex errors.

In its specific application to a mail coding and sorting system, the invention will normally be employed to detect all one-finger and some multiple-finger errors in the code combination applied to articles of mail in respect of the primary destination designation of such articles. In this way the number of total code combinations available is not universally restricted; it is only restricted in respect of the first code designation applied to the article. This is in keeping with practical requirements. If an occasional error causes a letter to be directed to a town within

the same geographical area as the town intended, the matter can be readily corrected with only a small delivery delay. On the other hand, if a letter destined for Vancouver from Ottawa is erroneously sorted and sent to Great Britain, the resulting delay before the error has been rectified would be very serious. The avoidance of errors in the primary destination designation (country or large geographical or political area) is thus of special importance.

It is not intended to give the impression that any form of sortation error is considered trivial. With conventional manual sorting methods errors have never been entirely avoided, and indeed with the modern improvements in mechanisation of postal sorting methods, it is believed that errors can be substantially reduced. The principal purpose of the present invention is to add still further to this improvement by providing apparatus that will automatically check the operator's first chosen code combination (which will signify the main geographical or political area of the letter's destination) and will compare this chosen code combination with a set of "acceptable" code combinations, and indicate when an error has been made. The present apparatus cannot check against all possible operator's errors, such as the substitution of an erroneous "acceptable" code combination for the correct "acceptable" code combination, but it can prevent all other errors in the initial coding step. Moreover, it can ensure that all one-finger errors (the most likely to occur) are amongst those detected during this initial coding step.

It is believed that the manner of operation of the present invention will become more readily apparent after reference has been made to the accompanying drawings which demonstrate by way of example one method of carrying the invention to practice. In the drawings:

FIGURE 1 shows a plan view of the keyboard panel of a coding desk;

FIGURE 2 shows a side view of FIGURE 1 cut away to show part of associated electrical circuits;

FIGURE 3*a* shows a portion of a matrix and an associated switching circuit controlled by the left hand keyboard;

FIGURE 3*b* shows the switching circuit operated by the right hand keyboard and controlling the same matrix;

FIGURE 4 is a fragmentary circuit diagram;

FIGURE 5 is another similar fragmentary circuit diagram;

FIGURE 6 is a general circuit diagram illustrating the manner of operation of a printing and feeding mechanism in accordance with the arrangement of the matrix;

FIGURE 7 is a more detailed view of the printer of FIGURE 6; and

FIGURE 8 is a diagram showing some only of the parts of FIGURE 3*a* arranged in a manner to demonstrate the particular choice of coding combinations adopted in accordance with the present invention.

FIGURE 1 shows the keyboard panel of a coding desk 10, such panel comprising a first binary keyboard L having five keys, L1, L2, L3, L4 and L5 for operation by the left hand and a second binary keyboard R having five keys R1, R2, R3, R4 and R5 for operation by the right hand. In both instances the thumb is considered as the first finger, so that the thumbs operate keys L1 and R1, the other fingers being numbered consecutively from the thumb towards the smallest finger. FIGURE 2 shows the manner in which each of the keys L1 to L5 and R1 to R5 is mechanically arranged to close a pair of corresponding contacts LC1 to LC5 and RC1 to RC5. Each such pair of contacts is arranged in series between a positive voltage supply 11 and ground with a corresponding relay coil LR1 to LR5 and RR1 to RR5 interposed. As will be apparent, depression of each one of the finger-operated keys, will cause energization of the correspondingly designated relay coil.

Attention is now directed to FIGURE 3*a* in which a binary switching system is illustrated for connecting the positive supply **11** to each one individually of thirty-two horizontal lines in a matrix **12**. As far as this switching system is concerned, relay coil LR1 operates only one movable contact arm LR11, while relay coil LR2 has two such arms LR21 and LR22, relay coil LR3 has four arms LR31 to LR34, relay coil LR4 has eight arms LR41 to LR48 and relay coil LR5 has sixteen arms LR51 to LR516. In this way any one of the thirty-two horizontal lines can be connected to the positive voltage supply **11** by employing a different combination of relay energization. Each such line thus corresponds uniquely to a particular combination of operated keys. The switching arms are assumed to be in their upper positions, as shown in FIGURE 3*a*, when the corresponding relay is un-energized. Energization of a relay will cause its entire bank of contact arms to move to their lower positions.

A particular combination of key operations is then chosen to correspond to each letter of the alphabet and each numeral. This is essentially an arbitrary choice. The letters required to be used most often may conveniently be made one-finger operations; the next most frequently used letters, two-finger combinations and so on. In this connection, it should be appreciated that it is the letters that will appear most commonly in the code designations, and not the letters which appear most frequently in ordinary language, that are so chosen. With a five bit binary system, that is to say using five keys, the number of combinations available is 2^5, that is 32. This number of combinations includes the one in which no keys are operated. It is inconvenient to use this combination, which reduces the number available to 31. However, since there are only twenty-six letters in the alphabet, another five combinations can be unused. As a practical coding matter, there is no disadvantage inherent in using a particular code combination to signify both a letter and a numeral, so that some of the combinations are used for this purpose. In choosing the table of code designations consideration is also given to the manual ease with which certain combinations of keys can readily be depressed by the human hand.

A typical list of code designations is shown in Table 1 which follows:

TABLE 1

Combination of keys depressed	Corresponding code designation	Combination of keys depressed	Corresponding code designation
1	T,8	5	C,0
2	O,4	5,1	U
2,1	X	5,2	J
3	A,2	5,2,1	E
3,1	G	5,3	Q,3
3,2	I,6	5,3,1	Unused
3,2,1	R	5,3,2	Unused
4	L,,1	5,3,2,1	Z
4,1	P,9	5,4	K
4,2	Y,5	5,4,1	D
4,2,1	M	5,4,2	H
4,3	B	5,4,2,1	F
4,3,1	Unused	5.4,3	N
4,3,2	S,7	5,4,3,1	W
4,3,2,1	Unused	5,4,3,2	V
		5,4,3,2,1	Unused

In the left hand column, the key combination is shown, the numerals in this column referring to the numbering of the keys shown in FIGURE 1. The same code system is conveniently used for both the left and the right hand, although there is nothing inherent in the system that demands this. The right hand column of Table 1 shows the code character that corresponds to each key combination. This table will require to be memorized by the operator and will represent the principal mental human effort involved.

Taking the binary code set out of Table 1 and applying it to the matrix lines shown in FIGURE 3*a*, it immediately becomes possible to label each of the horizontal matrix lines with a corresponding code character. For example the letter M is represented by the combination of keys 1, 2 and 4. Now, if the corresponding relay coils LR1, LR2 and LR4 of the left hand are assumed to be energized so that their banks of contact arms are moved to their lower positions (while the contact arms of relays LR3 and LR5 remain in their upper positions) the positive voltage from source **11** is conducted down through the first contact arm LR11 it encounters, down through the second contact arm LR22 it encounters, up through the next contact arm LR34, down through the fourth contact arm LR47 and finally up through the last contact arm LR514 to impose such voltage on the sixth horizontal line from the bottom of the matrix **12**. It will be observed that this line has been labeled at the extreme right hand end with the letter M, to signify this fact. All the other lines shown in the matrix **12** have been similarly labeled to agree with the key combinations to which they correspond. For symmetry of illustration, all thirty-two horizontal lines in the matrix have been shown, including those that are unused. In practice, such lines can be simply omitted, because they serve no subsequent purpose. Indeed some others of the lines may also be omitted, depending on the coding procedure adopted, as will be more fully explained below.

As shown in FIGURE 3*b*, a similar switching arrangement is adopted for control by the relay coils RR1 to RR5 that the keys of the right hand keyboard control. The switch arms RR11 to RR516 shown in FIGURE 3*b* serve similarly to connect the source of positive voltage **11** to one or other of thirty-two matrix lines. These matrix lines extend vertically so that each one crosses every one of the horizontal matrix lines. The vertical lines are shown broken in FIGURE 3*b*, but appear in full in FIGURE 3*a*. Since the same code system has been chosen for the right hand, each of the vertical matrix lines will correspond in the same sequence to the letter or numeral that is to form the code designation. These characters have been applied to each of the vertical matrix lines in the same way as to the horizontal ones.

Now, before proceeding with the description of the apparatus provided, it will be desirable to explain that, in the sorting of mail by post office authorities, it is conventional to designate a certain number of large centres as DIRECTS. Other major cities in the same country as the sorting is being carried out in, are usually designated DIRECTS, but occasionally very large cities in other countries and foreign mail generally may also be so designated. The choice of DIRECTS will be arbitrary and will depend on the volume of mail for various centres being handled by the sorting post office, and by the proportion of such mail which is destined for the major centres. Taking the Ottawa post office as an example, there are currently nineteen designated DIRECTS. Mail which is destined for a DIRECT is coded accordingly. Each DIRECT has its own individual bin in the primary sortation stage and after sorting is dispatched directly to the centre concerned without further sorting. Thus, as far as the originating station is concerned, it is unnecessary to impose any code designation on such mail beyond that of the DIRECT itself.

All mail to centres which are not designated as DIRECTS will require subsequent breakdown. For example, again assuming the Ottawa post office to be the originating point, the mail to a small town in Ontario will require firstly to be sorted under "Ontario" and then subjected to a secondary sortation in which all the "Ontario" mail is further sub-divided into individual towns or districts. In some instances, a tertiary and even a quaternary sortation may be necessary to effect the necessary fineness of breakdown. Since the post office system of Canada is being taken as an example, and since the principal areas into which non-DIRECT mail is divided are defined by provincial boundaries, non-DIRECTS are referred to as PROVINCES. In other countries, this type of mail may well be referred to as STATES or COUNTRIES or DISTRICTS. The name applied is of no consequence; what distinguishes this mail from the DIRECTS is the fact that at least one further breakdown of such mail is required to be made at the office of origin.

Each piece of mail is thus coded initially either with a DIRECT or as a PROVINCE code designation. Taking the Ottawa post office system as a further example, there is shown below in Table 2 a list of the DIRECTS proposed for use in the Ottawa post office, together with the code designations chosen for each.

TABLE 2

Directs

TT	Toronto.
VV	Vancouver.
WW	Winnipeg.
MT	Montreal.
HA	Halifax.
HM	Hamilton.
FF	British & Foreign.
US	U.S.A. (other than NYC).
OA	Ottawa (local mail).
GD	Government Departments.
LD	London, Ontario.
PB	Peterborough, Ontario.
QB	Quebec City.
JN	St. John, N.B.
EO	Edmonton.
KG	Kingston.
HL	Hull, P.Q.
NY	New York City.
WS	Windsor, Ontario.

It will be noted that some of the DIRECTS represent not a major city but a major geographical area, such as "British and Foreign" and "United States of America." Such mail will obviously require substantial subsequent breakdown, but for the purposes of the first sortation stage, these areas are treated as DIRECTS.

Table 3 shows a list of PROVINCES employed at the Ottawa post office, together with the code designation chosen for each.

TABLE 3

Provinces

OX	Ontario.
QX	Quebec.
MJ	Manitoba.
AJ	Alberta.
PX	New Brunswick and Prince Edward Is.
CJ	British Columbia & Yukon.
SJ	Saskatchewan.
FX	Newfoundland.
NJ	Nova Scotia.

It cannot be too highly stressed that the choice of the particular destinations that make up the list of DIRECTS and PROVINCES as well as the choice of the individual code designations, is entirely arbitrary. It will vary from one post office to another and may vary from time to time in the same post office, as the volume of mail varies. The code designations are chosen with a view to being comparatively easy to remember. They usually include either the initial letter of the city repeated, such as TT for Toronto, or two prominent letters from the word, such as QB for Quebec City. All the PROVINCE code designations are chosen by adopting the first letter of the PROVINCE and following this either with an X or a J. Such a system makes the task of memorizing the code somewhat easier for the operators, but the apparatus to which the present invention relates would be equally applicable if the code designations were entirely unrelated

to the names of the centres to which they apply. The tables given herein are furnished merely to facilitate an understanding of the description which follows.

Whenever an operator codes a letter, the first thing that he does is to apply the DIRECT or PROVINCE code, as appropriate. This must happen to every letter handled. When the code applied is that of a DIRECT there is no subsequent coding at this point, and that is an end to the matter. When the code applied is that of a PROVINCE, the operator goes on to code the letter further in accordance with additional code designations that have not been listed herein. It follows that the combination of code letters first applied by the operator must be chosen from one or other of Tables 2 and 3. If the operator presses any other combination of letters during the initial coding step, he has made an error. Many other combinations can be used later when in effecting a subsequent breakdown of a letter initially coded by PROVINCE it is necessary to code the town, suburb and street name and number. But initially only the few selected code combinations shown in Tables 2 and 3 are "acceptable." All other code designations are "unacceptable." In the examples chosen there are nineteen DIRECTS and nine PROVINCES, which provides a total of 28 acceptable code combinations. Each of these acceptable code combinations has been shown in FIGURE 3*a* by a circle or square placed around the point of intersection of the matrix lines corresponding to such combination. The circles represent DIRECT acceptable combinations DC, while the squares show PROVINCE acceptable combinations PC. It will be remembered that the horizontal lines always represent the first letter of the combination while the vertical lines represent the second letter.

It is necessary to distinguish in the apparatus the matrix cross-over points DC and PC, from all other matrix cross-over points, that is distinguish "acceptables" from "unacceptables." In the specific example illustrated, this is done by connecting the DC and PC cross-over points together in the manner illustrated respectively in FIGURES 4 and 5. FIGURE 4 shows on a larger scale the cross-over point of matrix lines H and A, representing the DIRECT, Halifax. The vertical matrix line is connected through resistor **R10** to a common point **13** with a second resistor **R11** which connects such point to the horizontal matrix line. The common point is also connected to ground through resistor **R12** and to one electrode of a rectifier **R13** and hence to a bus bar DB. When a voltage from source **11** is applied to the horizontal matrix line H only, the voltage at the common point **13** will rise in relation to ground by an amount determined by the relative resistances of resistors **R11** and **R12**. Similarly, this point **13** will be raised in voltage the same amount when the vertical matrix line A alone is connected to source **11**. However, when both matrix lines H and A are simultaneously connected to the source **11**, the common point **13** will be raised to a higher voltage than when either of the lines is individually energized. This voltage is transmitted through rectifier **R13** to the DIRECT bus bar DB. As will be seen later, the lower voltage resulting from energization of only one of the matrix lines is arranged to be too low to actuate the subsequent circuit, whereas the higher voltage acquired through energization of both matrix lines is sufficient to effect subsequent actuation. All the cross-over points DC are similarly interconnected, each having a rectifier **R13** which feeds to the common DIRECT bus bar DB. The rectifiers prevent a signal fed from one cross-over point being dissipated by return through the resistors **R12** of one of the other cross-over points DC. In an identical manner, the matrix lines at each of the PROVINCE cross-over points PC, of which the example for Ontario, OX, is shown in FIGURE 5, are joined together and transmit their combined signal to a PROVINCE bus bar PB separate from bus bar DB.

The effect of a signal on one or other of these bus bars will now be described in connection with FIGURE 6. This figure shows two triodes DT and PT connected for energization by bus bars DB and PB respectively. The anode circuit of triode DT includes a relay coil DR having contact arms DRC1, DRC2 and DRC3. Similarly, triode PT has in its anode circuit a relay coil PR with contact arms PRC1, PRC2, PRC3 and PRC4. All these contact arms occupy their lower positions, as shown, when the corresponding relay coils are unenergized. Under the normal, quiescent conditions prevailing in the absence of any energization from bus bars DB and PB, the control grids of both triodes are subjected to a negative bias supplied from a source of negative potential 14 through contact arms DRC1 and PRC1. These control grids are also connected to their respective bus bars, the control grid of triode PT being directly connected to bus bar PB, while the grid of triode DT is connected to bus bar DB through the normally closed contact arm PRC4.

It will be helpful to explain the operation of the system while proceeding with the description of its structure, for which purpose let it be assumed that a positive signal is supplied to bus bar PB from one or other of the PROVINCE code cross-over points PC on the matrix 12. If this is a low voltage, resulting from energization of only one of the matrix lines, it will be insufficient to overcome the negative bias on the grid and the triode will remain non-conducting. If, however, the positive potential on bus bar PB is that produced by simultaneous energization of both associated matrix lines, then this higher potentials will raise the potential of the grid of triode PT sufficiently for such triode to begin to conduct. Relay PR will accordingly be energized to change over its contact arms to the position opposite from that shown in FIGURE 6. Contact arm PRC1 acts as a holding contact, the grid of triode PT being disconnected from the negative source 14 and connected through a pair of normally closed contacts FE1 to the centre tap of a potential divider PD connected between the positive source 11 and ground. In this way a small positive bias is placed on the grid of the triode PT, which thus remains in its conducting condition until contacts FE1 are opened, regardless of subsequent changes in potential of bus bar PB. Contact arm PRC2 serves at the same time to connect the positive source 11 through normally closed contacts 18 to the operating coil PM of a printer shown generally at 15. Such printing mechanism 15 will include additional contacts LR1P to LR5P and RR1P to RR5P operated respectively by the corresponding key-controlled relay coils LR1 to LR5 and RR1 to RR5, to set the printing bars in readiness to print the chosen code on the letter which the operator is coding and which is thus currently situated in the printing mechanism. Such printing bars having been set by the key-controlled relays, the printing operation will be effected as soon as the operating coil PM is energized. The particular manner in which this printing operation is carried out is shown only diagrammatically in FIGURE 6, but is further described below in connection with FIGURE 7. The only other part of the printing mechanism shown in FIGURE 6 is a pair of contacts 19 which are closed by the movement of the frame carrying the type bars as the printing operation is effected.

The third contact arm PRC3 which is moved upwardly when the triode PT conducts, connects the positive supply 11 to a feeding advance coil FA mounted in a feeding mechanism forming part of the printer 15 and which serves to position the letter properly for such printing. More specific description of one form that the printer 15 may take will be described below with reference to FIGURE 7. Before the feed advance coil FA can be energized, the printing operation must be completed and contacts 19 closed, the latter serving to complete a circuit to a feed operating coil FO, normally open contacts FO1 of which are connected in the circuit to coil FA. Coil FA when so energized advances the letter one line in readiness for the imposition thereon of a further set of code symbols. It will be remembered that when imposing a PROVINCE coding on a letter; the letter must remain in the printer for additional subsequent coding, although advanced to a new position so that the code marks will not be superimposed.

The fourth contact arm PRC4 of the triode PT, when moved to its upper position disconnects the grid of the other diode DT from the bus bar DB, and connects such bus bar to a relay coil 21 which controls the normally closed contacts 18 already described and a pair of normally open contacts 22 which when closed energize a lamp 23 on the coding desk (see also FIGURE 1).

Before explaining in further detail the manner of operation of these latter parts, the triode DT and its operation will be described. Its holding contacts DRC1 operate in a similar manner to the holding contacts PRC1, connecting the grid of the triode initially to the negative bias, but, once the triode has started to conduct and energized is relay coil DR, connecting such grid to the positive bias so that the triode will be maintained in conducting condition so long as contacts FE1 remain closed Contact arm DRC2 serves a similar purpose to contact arm PRC2, connecting the printer operating coil PM to the positive supply when the relay coil DR is energized. Contacts DRC3, when closed, connect the positive supply 11 to a feeding-ejecting coil FE of the printer 15. Whereas coil FA advances the letter one position to be in readiness for another line of coding, the coil FE ejects the printed letter completely from the printer. This is required because no further coding is applied after a DIRECT has been coded. Coil FE, like coil FA, only becomes operative when coil FO is energized, since its supply passes through normally open contacts FO2.

The practical operation of the system is as follows:

If one of the selected DIRECT codes is correctly applied to the keyboards by the operator the bus bar DB will be energized to its full voltage. This voltage will pass through contacts PRC4 to the grid of triode DT and will be sufficient to overcome the negative bias on that tube. As a result this tube will conduct and relay coil DR will be energized to reverse the position of contacts DRC1, DRC2 and DRC3. Contacts DRC1 will hold the triode DT in its operating condition, notwithstanding the fact that the operator may immediately release the keys. Depression of the appropriate keys will also have actuated the printer contacts LR1P to LR5P and RR1P to RR5P to prepare the correct marking bars in position for printing on the letter. The printer 15 will be then operated by its coil PM which receives voltage through contacts ERC2. The printing operation will close contacts 19 thus energizing coil FO and closing contacts FO2. These latter contacts, together with contact arm DRC3 will now establish a circuit energizing the feeding-ejecting coil FE, so that the letter, after having had the DIRECT code markings imprinted on it, will be ejected from the mechanism to make room for the next letter. Energization of coil FE will also open contacts FE1 which will then break the supply of positive bias to the grid of triode DT. The latter will then cease to conduct and will revert to its quiescent condition, as will the remainder of the circuit, awaiting subsequent operation. The operator will know that a correct combination of keys has been pressed, by the fact that a printing operation has taken place and that the letter has been ejected. A new letter will then be presented for coding.

If, on the other hand, a correctly chosen PROVINCE combination of keys is depressed by the operator, full positive voltage will appear on the bus bar PR. This will overcome the standing negative bias on the grid of triode PT, causing this triode to conduct and to change over the position of its contact arms, Contact arm PRC1 will apply the holding positive grid bias; contact arm PRC2 will energize the operating coil PM of the printer

15; and contact arm PRC3 will energize the feeding advance coil FA of the printer as soon as contacts FO1 in that circuit are closed by coil FO which follows closing of contacts 19 on application of the code markings to the letter. Coil FA will advance the letter ready for a second coding operation. The operator will then proceed to code the next aspect of the address, which will normally be the town. The code combination for this town will be different from any of the PROVINCE or DIRECT code combinations and accordingly it will not energize either of the bus bars PB or DB. For example if the PROVINCE coding were OX (Ontario) the next code might be GA (for the town of Galt, Ontario). GA is an "unacceptable" combination, but this is of no consequence. The matrix is no longer effective and "acceptability" is no longer a requirement for operation of the printer, once the first coding step has been completed. This effect is achieved by reason of the triode PT remaining energized, so that the operating coil PM of the printing mechanism also remains energized. Thus, as soon as the operator presses the keys for the next code combination it will be immediately printed regardless of the nature of such combination. The contacts 19 will be closed again, so that coil FO will be energized and hence coil FA will be energized. The letter will be again advanced in readiness for yet a third coding. As soon as the operator has impressed all the desired stages of code markings on the letter, he will depress an eject button 24 (FIGURES 1, 2 and 6) which will close contacts 25 arranged to provide direct energization of the feeding-ejecting coil FE. The letter will thus be ejected from the printer, contacts FE1 opened, and the circuit returned to its quiescent condition.

Should, however, the operator depress a DIRECT combination after having coded a PROVINCE combination (a series of actions which must necessarily be erroneous), the voltage which will appear on the direct bus bar DB will pass through the raised contact arm PRC4 to energize coil 21. This will open contacts 18 supplying power to the printer operating coil PM, thus preventing the erroneous code being printed, and at the same time it will close contacts 22 energizing a warning lamp 23 which appears in front of the operator and indicates that an erroneous coding has been attempted. As soon as the operator releases the wrongly pressed keys, coil 21 will be de-energized and the circuit will be ready to receive a proper coding combination, the erroneously selected code combination having been ineffectual.

If, initially, on the first coding operation for each letter, the operator chooses any code combination which is not one of the selected PROVINCE or DIRECT "acceptable" code combinations, neither of the triodes PT and DT will be energized and the operating coil PM of the printer will not be energized. Accordingly the keys will be ineffective to impress any code upon the letter. This fact will be apparent to the operator by virtue of the fact that clearly no operation has taken place and the letter has not been fed forward. The operator will then realize that an error has been made and will select the correct code. If desired, a warning light arrangement could also be associated with this form of erroneous operation, but it will not normally be necessary, as the absence of the movement associated with a printing operation will be readily apparent to the operator.

In further support of the general method of operation described in FIGURE 6, a simplified, schematic illustration of one possible form of printer 15 is shown in FIGURE 7, although it will be understood that any other convenient form of printing mechanism may be substituted for the one shown, since the particular nature of the printing mechanism forms no part of the present invention.

FIGURE 7 shows a letter L in printing position between a glass sheet 40 and a perforated metal plate 41. The printing mechanism itself comprises a frame 42 carrying ten printing bars LB1 to LB5 and RB1 to RB5 each operable by an associated solenoid controlled by respective contacts LR1P to LR5P and RR1P to RR5P, which, in turn, are controlled by the key-operated solenoids LR1 to LR5 and RR1 to RR5 (see FIGURE 2). FIGURE 7 shows bars LB1, LB2, LB4 and RB1 extended to print the binary marks corresponding to the code designation MT. With the printing bars thus set by the keys L1 to L5 and R1 to R5, the printing operation is effected by movement of frame 42 towards the portion of the rear surface of letter L exposed through plate 41. This movement is effected by coil PM cooperating with an armature 43 connected to frame 42. As such printing operation is completed the contacts 19 which are mounted on plate 41 are closed, with the effect already described in connection with FIGURE 6.

Forward movement of the letter L is controlled by an endless belt 44 bearing projections 45 to engage the rear edge of the letter. Belt 44 is driven by roller 46 on shaft 47 which carries one part of a clutch 48, the other part of which is connected to a shaft 49 driven by a motor 50. Gearing 51 drives a further shaft 52 from shaft 49, shaft 52 carrying one part of a second clutch 53, the other part of which is mounted on shaft 54 that drives through gearing 55 to shaft 47. Clutch 48 is operated by feed advance coil FA and clutch 53 is operated by feeding-ejecting coil FE, the energization of which has already been described. Each of the clutches is of the known type that, upon energization, completes one revolution transmitting rotation and then automatically disengages itself. Thus each of clutches 48 and 53 will connect the constantly turning motor 50 to roller 46 driving belt 44 for one revolution of the clutch in question, regardless of the shortness of the duration of the impulse energizing coil FA or FE. When clutch 48 is closed by coil FA, the single revolution of shaft 47 that results, advances the letter L the required short distance for the new printing operation to take place beside the first such operation on the surface of the letter. When clutch 53 is closed by coil FE, the single revolution of shaft 54 that results, causes a number of revolutions of shaft 47, sufficient to propel letter L entirely out of the mechanism.

In a practical printer, other mechanisms, such as inking rollers and devices for feeding a fresh letter into correct initial position each time a previous letter has been ejected from the printer, will be required, but there appears to be no purpose in further describing these mechanisms, as they are entirely conventional and form no part of the present invention. Indeed neither do any of the mechanisms shown in FIGURE 7, but these have been included in order to render a complete understanding of the operation of the circuit of FIGURE 6.

As has already been explained, the twenty-eight selected code designations for DIRECTS and PROVINCES are arbitrarily chosen. However, once they have been chosen, certain other requirements must be met in accordance with the preferred form of the present invention, to avoid any possibility of one-finger errors in respect of such chosen code combinations. This feature is explained with the aid of FIGURE 8 which shows the switches of the left hand switching relays LR1 to LR5 in position for energizing the matrix line 30 corresponding to the letter M. An example is being taken of the DIRECT code combination MT for Montreal. The right hand switching relays RR1 to RR5 are not shown in FIGURE 8 but are assumed to be in position to energize the vertical matrix line 31 for T. These matrix lines are shown somewhat heavier than the other matrix lines in FIGURE 8, since they are being considered for the purposes of the present example as the "Principal" matrix lines. Now let it be assumed that the operator makes a one finger error with the left hand. This means that, keeping four of the relay coils in the proper condition corresponding to the letter

M (that is with relay coils LR1, LR2 and LR4 energized) the fifth relay coil is assumed to be in the incorrect position. That is it is assumed that one key is either erroneously operated or erroneously not operated. This is done five times, once for each key, since five such one-key errors are possible and the switching arrangements produced are such as to energize the other horizontal matrix lines designated 32 in FIGURE 8, i.e. those corresponding to the letters Y, P, X, F and one unused line near the bottom of the matrix. This group of lines 32 may be referred to as "First Order Associates" of the Principal line 30. This is because they represent lines that may be energized with a "first order" or one-finger error. If the same procedure is carried out for the vertical Principal line 31, First Order Associate lines 33 are produced. It will be apparent that, for each selected Principal line, there will be a different group of five First Order Associate lines. There will be some measure of reciprocity in this regard. For example, since the line for P is a First Order Associate for the line for T, when the latter is a Principal line, then the line for T will be a First Order Associate when the line P is chosen as a Principal line. But when the line P is chosen as a Principal line the other First Order Associates will not be the same as those which accompany the Principal line T.

In its broad purpose, the preferred form of the invention sets out to avoid First Order errors in the primary coding step. Ten possible First Order errors can arise, since ten fingers are used in the coding. These are represented on the matrix by the five points at which the horizontal Principal line crosses the First Order Associates of the vertical Principal line and the five points at which the vertical Principal line crosses the horizontal First Order Associates. It will be seen from FIGURE 8 that all these ten points are "unacceptable" points, that is to say they do not correspond to a DIRECT or PROVINCE code combination. By so selecting the set of "acceptable" code combinations that no one of them is a combination which could result from a First Order error in one of the other "acceptable" combinations, all possibility of a one-finger error in the first sortation is eliminated, because any one-finger error must necessarily produce an "unacceptable" code combination which will not operate the printer.

All the code combinations are chosen in this way. That is to say—for each combination in which the matrix lines are associated with each other in the so-called "acceptable" manner, there is an associated group of combinations of matrix lines in which said lines are associated with each other in the so-called "unacceptable" manner, this associated group including every combination of matrix lines that corresponds to a combination of key operations differing only in respect of a single key from the key combination corresponding to the Principal matrix line combination under consideration.

This requirement necessarily restricts the number of code combinations that can be made "acceptable," but not unduly. In fact, if some similarity between the "acceptable" combinations and the names of the cities etc. concerned can be sacrificed, a total of 512 "acceptable" combinations can be used. For example, with ten keys, there are 2^{10} possible combinations of operation. This is 1024. Then if all the combinations involving an odd total number of keys are chosen, there are 512 such combinations. These can then all be made "acceptable," because a one-finger error in setting up a combination involving an odd number of keys must necessarily result in the depression of an even number of keys, and all the even number combinations will have been made "unacceptable." Similarly, if all the even number key combinations are made acceptable, there can be 512 of these, the "unacceptable" combinations then being constituted by all the operations involving depression of an odd number of keys.

In practice, seldom would as many as 512 "acceptable" combinations be required. In the example given above of the Ottawa post office, only 28 "acceptable" combinations are used. In some post offices, more than 28 "acceptable" combinations may be needed, but never more than the number of bins in to which the mail is sorted on the first sortation. However, in some punched card sorting systems, the full number of available "acceptable" combinations may be employed with advantage. The need for fewer "acceptable" combinations than the theoretical maximum in post office systems permits a hybrid choice, that is a mixture of some odd number combinations and some even number combinations. This mixing of the odd and even types of combination reduces the number of "acceptable" combinations possible, but permits more latitude of choice, and hence enables combinations to be made "acceptable" that are comparatively easy for the operator to remember, by virtue of a similarity to the city concerned. Such a hybrid choice has been adopted in the examples of code combinations given in the tables above. For example "acceptable" DIRECT code combination MT (Montreal) is an even number key combination—3 keys (L1, L2 and L4) for M and 1 key (R1) for T, making a total of 4 keys while the "acceptable" DIRECT code combination NY (New York) is an odd number key combination—3 keys (L3, L4 and L5) for N and 2 keys (R2 and R4) for Y, making a total of 5 keys. Similarly PROVINCE "acceptable" combination OX (Ontario) is an odd combination (3 keys), while PROVINCE "acceptable" combination QX (Quebec) is an even combination (4 keys).

All the possible code combinations must fall into one or other of the two classifications or sets that have, for convenience, been referred to as "acceptable" and "unacceptable." In the matrix an "acceptable" combination is distinguished by the connections which extend from the corresponding matrix elements (FIGURE 4 or FIGURE 5) to the operating circuit of FIGURE 6, the "unacceptable" combinations being simply constituted by a lack of connection between the matrix elements. As will be apparent, this arrangement could be reversed with the "unacceptable" combinations connected and the "acceptable" combinations unconnected. Moreover, any suitable method of connection may be used which will provide the necessary indication. The essential feature is that there should be two different manners of connecting the matrix elements together (one of the "manners of connecting" usually being a failure to connect), and that some means should be provided for distinguishing between the simultaneous energization of a combination of matrix elements that are connected together in the first manner and the simultaneous energization of a combination of matrix elements that are connected together in the other manner.

Moreover, in the specific example given, those code combinations that are connected in the first or "acceptable" manner are further divided into two categories "DIRECT" and "PROVINCE," between which the indicating circuit can discriminate.

Furthermore, it is to be understood that "energization" is here used in the broad sense of a change of condition. Although the most convenient method of operation is to charge the selected combination of matrix elements, as in the foregoing example, it is apparent that it would be possible to maintain all the matrix elements normally charged and then to discharge the selected ones. These would then be "energized" in the sense that their condition and hence their energy state would have been made different from the remaining elements.

In the foreging description, the destinations of mail have been divided into two basic categories "DIRECT" and "PROVINCE." Additionally, if desired, a category of "SUB-DIRECT" can also be employed. Mail in this category will be destined for medium size towns too small to come under the "DIRECT" classification, but nevertheless large enough to be adapted readily for comparatively direct sorting. In coding a letter destined for a

"SUB-DIRECT" destination, the operator first codes the PROVINCE code designation. The apparatus already described checks this code and having found it correct effectively removes the matrix 12 from further action as far as this piece of mail is concerned. The next code applied to the piece of mail is the two letter code of the SUB-DIRECT. To indicate that a SUB-DIRECT code is being applied the operator presses a special operating key or bar (not shown). In this modification, for each province there will be provided a secondary matrix (considering the matrix 12 as the primary matrix), and the first two letters of the second code applied to the keyboard will be compared in the secondary matrix of the province concerned. This matrix will be set to distinguish SUB-DIRECT destinations (which require no further coding) from all other breakdowns (which do require further coding). If the specially operating subdirect key has not been depressed then the secondary matrix will have no effect. But if this key has been depressed (indicating that the operator intended to apply a SUB-DIRECT code), the matrix will be employed to indicate the comparison that it has made of such code, and specifically to indicate if such code is not in fact one of the preselected SUB-DIRECT codes. In this way the apparatus furnishes a check against a coding error at the SUB-DIRECT stage, analogously with the principal check made by matrix 12.

The discriminating mechanism that distinguishes between energization of the two different manners of matrix element combination may be, as in the example illustrated, connected to a printer so as mechanically to prevent an erroneous code marking being imposed. It should be appreciated, however, that this aspect of the apparatus could be simplified if desired, while still remaining within the ambit of the present invention. For example, the depression of a combination of keys corresponding to an "unacceptable" code combination could simply illuminate a warning light or sound a warning buzzer to advise the operator that the wrong keys have been depressed, subsequent reliance being placed on the operator to make sure that such code marking is not applied to a letter, or if it has been applied, that such letter is deflected to a reject bin for manual sorting. In such a simplified arrangement, it might be preferable to isolate the matrix elements making up each "acceptable" combination, while connecting together those of the remaining "unacceptable" combinations to enable a circuit to the warning device to be established whenever an "unacceptable" combination of keys is depressed by the operator.

Although it is believed that by far the majority of errors result from the operator making a one-finger error, it would be possible, if desired, to so select the codes as also to eliminate all Second Order errors. For example, the sixteen points of crossing of the horizontal First Order Associate lines with the vertical First Order Associate lines shown in FIGURE 8 each represents a Second Order error, that is to say a two-finger error. They represent only a particular type of two-finger error, namely one in which the two errors are distributed one to each hand. If the system is also to be designed to cover the situation arising where both errors occur on the same hand, then it will be necessary to determine the Second Order Associates of each matrix line required to be a Principal line, and to ensure that the points of crossing of such Second Order Associates with the Principal line extending in the other direction are "unacceptable." This would have to be done for every "acceptable" crossover point. The Second Order Associate lines would be constructed by changing over the position of two switches simultaneously and taking every possible combination of such a modification. There will be found to be ten Second Order Associate lines for each Principal line. They have not been illustrated.

As will be seen from FIGURE 8, no attempt has been made in the present system to eliminate all second Order errors, since the intersection points of First Order Associate lines P and F with First Order Associate line X are acceptable, both as PROVINCE code designations. Nevertheless in any particular system it could readily be done, although it will reduce somewhat the number of possible "acceptable" code combinations. Since experience has shown that by far the majority of operators' errors are First Order errors, the added complexity of also eliminating all Second Order errors would not normally be justified. It will be undestood that, in the apparatus illustrated many Second Order errors are in fact eliminated, although, unlike the First Order errors, not all the Second Order errors are necessarily eliminated. Since only 28 combinations are connected to be "acceptable," all other combinations, which will include many Second, Third and higher Order errors, will be detected and rejected.

It was mentioned earlier in this description that the UNUSED matrix lines could be omitted, as they serve no purpose. Similarly, all those matrix lines may be omitted on which no "acceptable" crossover point DC or PC appears. For example, the horziontal lines for letters C, Y, I, D, X, R and Z and the vertical lines for letters C, K, Q, H, U, P, E, M, R and Z serve no purpose and need not be provided, although, as a practical matter, it is usual to retain these lines so that changes can more readily be made later by the addition of different "acceptable" combinations.

It has been assumed throughout the foregoing description that two separate keyboards are used, one for the right hand and one for the left hand. Although this will be the convenient way to operate, the same final result could be achieved with a single, five-key keyboard. The first time this keyboard was operated, a selected combination of the left hand relay coils LR1 to LR5 would be energized and held in their energized positions, and then the second time the keyboard was used, it would energize the right hand relay coils RR1 to RR5. In other words, a single keyboard could, in this way perform at different times the respective functions of the two keyboards of FIGURE 1. A code combination representing two letters or other symbols is thus produced and fed to a matrix as in the foregoing example.

Moreover, a possible simplified coding system could, in certain instances, be used as an alternative, with only one code designation employed. This would be equivalent to the relay coils LR1 to LR5 controlled by a single, five-key keyboard L and operating switch arms feeding to the horizontal lines of the matrix. There would be no second keyboard and no vertical lines, so the matrix would no longer properly be so called. It would not have "acceptable" and "unacceptable" cross-over points, but instead "acceptable" and "unacceptable lines. Supposing all the lines corresponding to an even number of finger operations (that is those in the foregoing example representing the letters X, G, I, P, Y, B, U, J, Q, Z, K, F, W and V) were deemed "aceptable," then the remainder would be considered "unacceptable." Of course, if fewer than 14 "acceptable" lines were required, then this number could be reduced and the number of "unacceptable" lines increased correspondingly. Electrical connections to these lines could then readily distinguish the "acceptable" set from the unacceptable set. For example, each of the "unacceptable" lines could energize a warning device. Although this arrangement would be limited in its application to a coding and sorting system having a maximum of 2^x coding alternatives, where x is the number of keys (which is not necessarily five), it nevertheless will embody the important feature of the present invention, the avoidance of all one-finger errors, provided the sets of "acceptable" and "unacceptable" lines are properly chosen in the manner hereinabove indicated.

Throughout the foregoing specification and in the appended claims reference is made to binary "keys," "keyboards" and "keyboard means." Without explanation such expressions may imply direct finger operation by an operator, but it is desired to hereby define these terms as including within their scope the binary keyboard-like mechanisms that have been developed in recent years and which are operated by signals from punched tape or other storage devices to set up a binary code designation. Apparatus is, for example, known, in which the operator is provided with a keyboard like an ordinary typewriter (one key for each character), but in which the intelligence fed into the machine by the depression of a single key is automatically converted into a binary-type signal equivalent to the depression of a plurality of keys on a binary keyboard. Accordingly it is within the scope of the present invention for the binary signal to be generated indirectly in this way by any means for generating a binary signal, such means necessarily including a plurality of individually operable members, whether such members be keys for direct physical operation by the operator's fingers or whether they be other movable devices controlled indirectly by some separate selecting instrumentality.

Moreover, although the term matrix has been used herein to refer specifically to the cross-over arrangement illustrated in FIGURE 3*a*, it is to be understood that this is merely by way of example and that any suitable circuitry designed to perform the same function may be substituted for that illustrated. Basically, the essence of the invention in its broadest form is the provision of discriminating means associated with a plurality of individually operable members for generating a binary signal (one or two five-key keyboards or other apparatus as just explained), such discriminating means being adapted to determine the combination of such members operated and to distinguish among the combinations so produced those which fall into a first "acceptable" set from those which fall into a second "unacceptable" set, the sets being so predetermined that for any selected combination in the first set there is an associated group of combinations in the second set, such associated group including every combination of said members differing only in respect of a single said member (a so-called one-finger or one-key error) from the selected combinaton.

I claim:

1. Apparatus comprising means for generating binary signals including a plurality of individually operable members, a matrix having two series of elements, first switching means operated by said binary members for connecting an energization source to each one of the first series of said elements exclusively, the element so connected corresponding uniquely to the combination of operated binary members, second switching means operable by said binary members for connecting an energization source to each one of the second series of said elements exclusively, the element so connected corresponding uniquely to the combination of operated binary members, each matrix element of said first series being associated with each matrix element of said second series in a selected one of two different manners, and indicating means connected to said matrix elements for distinguishing between energization by said first and second switching means of a combination of said elements associated with each other in the first of said manners and energization by said first and second switching means of a combination of each elements associated with each other in the second of said manners, the combinations of matrix elements being so chosen that for each combination in which said elements are associated with each other in said first manner, there is an associated group of combinations of matrix elements in which said elements are associated with each other in said second manner, said associated group including every combination of matrix elements that corresponds to a combination of operated binary members differing onl yin respect of a single said member from the combination of operated binary members corresponding to the last-mentioned matrix element combination the elements of which are associated with each other in the said first manner.

2. Apparatus comprising binary keyboard means having a plurality of individually operable keys, a matrix having two series of elements, first switching means operated by said keys for connecting an energization source to each one of the first series of said elements exclusively, the element so connected corresponding uniquely to the combination of operated keys, second switching means operable by said keys for connecting an energization source to each one of the second series of said elements exclusively, the element so connected corresponding uniquely to the combination of operated keys, each matrix element of said first series being associated with each matrix element of said second series in a selected one of two different manners, and indicating means connected to said matrix elements for distinguishing between energization by said first and second switching means of a combination of said elements associated with each other in the first of said manners and energization by said first and second switching means of a combination of said elements associated with each other in the second of said manners, the combinations of matrix elements being so chosen that for each combination in which said elements are associated with each other in said first manner, there is an associated group of combinations of matrix elements in which said elements are associated with each other in said second manner, said associated group including every combination of matrix elements that corresponds to a combination of operated keys differing only in respect of a single key from the combination of operated keys corresponding to the last-mentioned matrix element combination the elements of which are associated with each other in the said first manner.

3. Apparatus comprising a first binary keyboard for operation by an operator's left hand, said keyboard comprising a plurality of individually operable keys, a second binary keyboard for operation by an operator's right hand, said keyboard comprising a plurality of individually operable keys, a matrix having two series of elements, first switching means operated by the keys of said first keyboard for connecting an energization source to each one of the first series of said elements exclusively, the element so connected corresponding uniquely to the combination of operated keys, second switching means operated by the keys of said second keyboard for connecting an energization source to each one of the second series of said elements exclusively, the element so connected corresponding uniquely to the combination of operated keys, each matrix element of said first series being associated with each matrix element of said second series in a selected one of two different manners, and indicating means connected to said matrix elements for distinguishing between simultaneous energization by said first and second switching means of a combination of said elements associated with each other in the first of said manners and simultaneous energization by said first and second switching means of a combination of said elements associated with each other in the second of said manners, the combinations of matrix elements being so chosen that for each combination in which said elements are associated with each other in said first manner, there is an associated group of combinations of matrix elements in which said elements are associated with each other in said second manner, said associated group including every combination of matrix elements that corresponds to a combination of operated keys differing only in respect of a single key from the combination of operated keys corresponding to the last-mentioned matrix element combination the elements of which are associated with each other in the said first manner.

4. Apparatus comprising a first binary keyboard for

operation by an operator's left hand, said keyboard comprising a plurality of individually operable keys, means for printing a first code pattern on each of a plurality of articles presented seriatim to said printing means, the nature of the code pattern so printed corresponding uniquely to the combination of operated keys, a second binary keyboard for operation by an operator's right hand, said second keyboard comprising a plurality of individually operable keys, means for printing a second code pattern on each of said plurality of articles, the nature of said second code pattern so printed corresponding uniquely to the combination of operated keys of said second keyboard, a matrix having two series of elements, first switching means operated by the keys of said first keyboard for connecting an energization source to each one of the first series of said elements exclusively, the element so connected corresponding uniquely to the combination of operated keys, second switching means operated by the keys of said second keyboard for connecting an energization source to each one of the second series of matrix elements exclusively, the element so connected corresponding uniquely to the combination of operated keys of said second keyboard, each matrix element of said first series being associated with each matrix element of said second series in a selected one of two different manners, and indicating means connected to said matrix elements for distinguishing between simultaneous energization by said first and second switching means of a combination of said elements associated with each other in the first of said manners and simultaneous energization by said first and second switching means of a combination of said elements associated with each other in the second of said manners, the combinations of matrix elements being so chosen that for each combination in which said elements are associated with each other in said first manner, there is an associated group of combinations of matrix elements in which said elements are associated with each other in said second manner, said associated group including every combination of matrix elements that corresponds to a combination of operated keys differing only in respect of a single key from the combination of operated keys corresponding to the last-mentioned matrix element combination the elements of which are associated with each other in the said first manner.

5. Apparatus according to claim 4 including means connecting said indicating means to said printing means for preventing operation of said printing means upon simultaneous energization by said first and second switching means of a combination of said matrix elements associated with each other in the second said manner.

6. Apparatus as claimed in claim 4, wherein the combinations of matrix elements associated with each other in said first manner are divided into two categories, said indicating means including discriminating means for distinguishing between simultaneous energization by said first and second switching means of a combination of said elements of the first such category and energization by said first and second switching means of a combination of said elements of the second such category, said apparatus further including means associated with said printing means for advancing a said article in said printing means, means connecting said discriminating means to said advancing means for operation thereof to advance a said article to receive a further code marking upon detection by said discriminating means of energization of a said combination in said first category, means associated with said printing means for ejecting a said article therefrom, means connecting said discriminating means to said ejecting means for operation thereof to eject a said article from said printing means upon detection by said discriminating means of energization of a said combination in said second category.

7. Apparatus as claimed in claim 6, including means for detecting the energization of a said combination in said second category immediately following the energization of a said combination in said first category.

8. Apparatus comprising means for generating binary signals including a plurality of individually operable members, a matrix having two series of elements, first switching means operated by said binary members for connecting an energization source to each one of the first series of said elements exclusively, the element so connected corresponding uniquely to the combination of operated binary members, second switching means operable by said binary members for connecting an energization source to each one of the second series of said elements exclusively, the element so connected corresponding uniquely to the combination of operated binary members, each matrix element of said first series being associated with each matrix element of said second series in a selected one of two different manners, the number of combinations of matrix elements associated with each other in the first said manner being small in relation to the number of combinations of matrix elements associated with each other in the second said manner, and indicating means connected to said matrix elements for distinguishing between energization by said first and second switching means of a combination of said elements associated with each other in the first of said manners and energization by said first and second switching means of a combination of said elements associated with each other in the second of said manners.

9. Apparatus according to claim 8, including printing means for printing a code pattern on each of a plurality of articles, means connecting said printing means to said signal generating means to cause the code pattern so printed to correspond uniquely to the combination of operated binary members, and means for preventing operation of said printing means upon energization by said first and second switching means of a combination of said matrix elements associated with each other in the second said manner.

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