Feb. 16, 1960 M. M. LEVY 2,925,586

METHOD OF, AND APPARATUS FOR, ELECTRONICALLY INTERPRETING A PATTERN CODE

Filed June 9, 1953 6 Sheets-Sheet 1

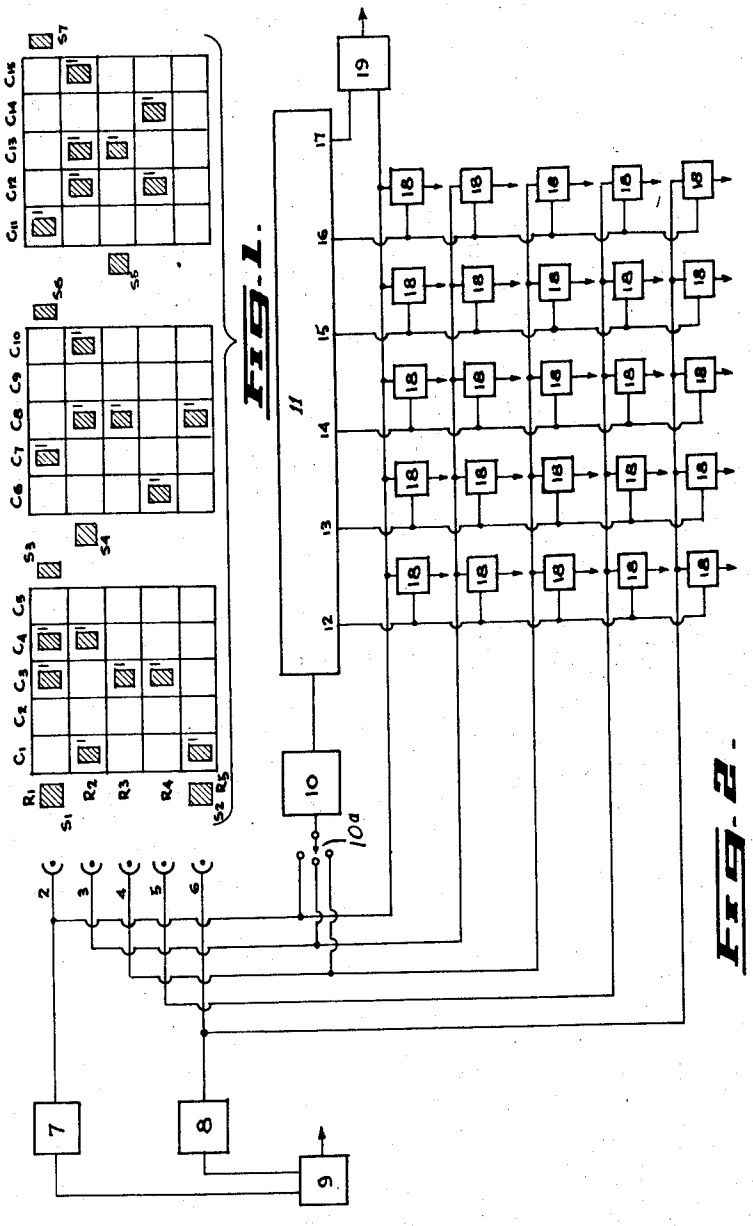


Fig. 1.

Fig. 2.

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METHOD OF, AND APPARATUS FOR, ELECTRONICALLY INTERPRETING A PATTERN CODE
Filed June 9, 1953 6 Sheets-Sheet 2

Fig. 3.

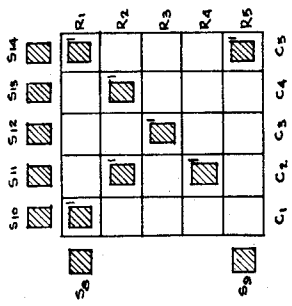


Fig. 4.

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METHOD OF, AND APPARATUS FOR, ELECTRONICALLY INTERPRETING A PATTERN CODE

Filed June 9, 1953 6 Sheets-Sheet 3

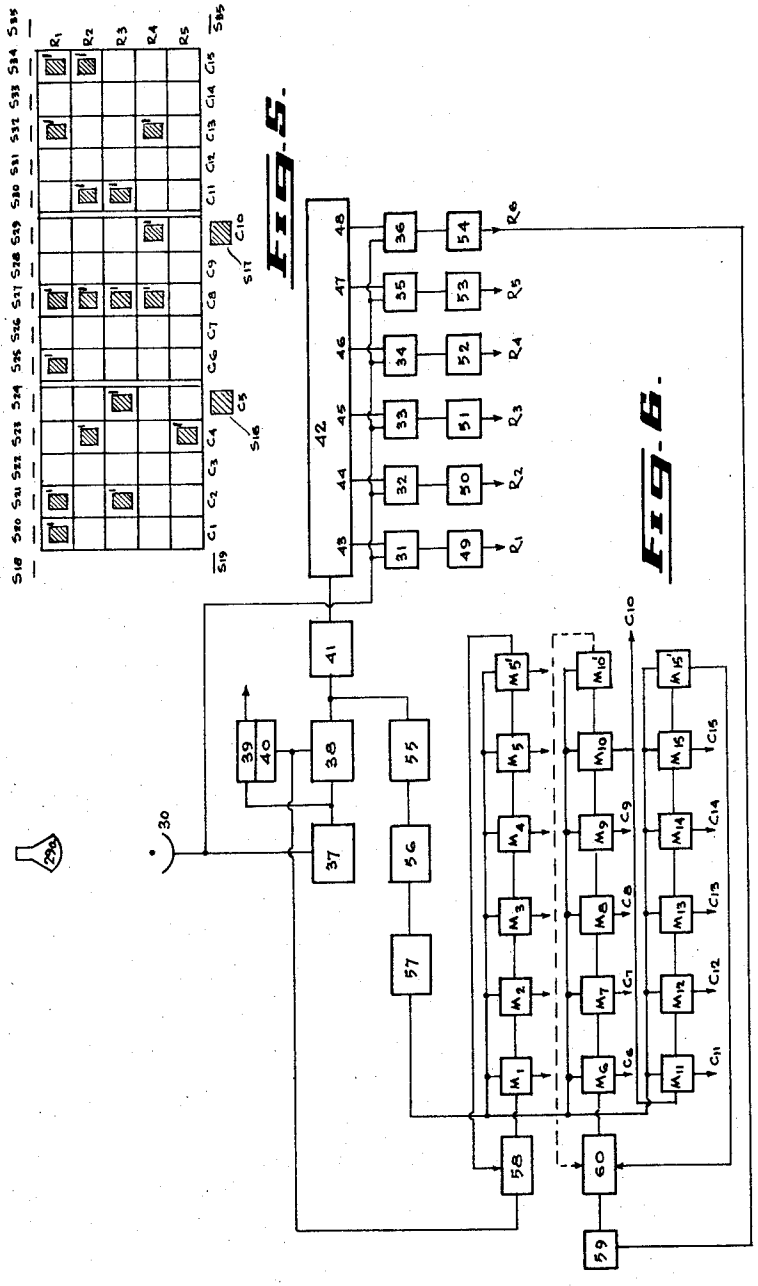


Fig. 5.

Fig. 6.

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METHOD OF, AND APPARATUS FOR, ELECTRONICALLY INTERPRETING A PATTERN CODE

Filed June 9, 1953 6 Sheets--Sheet 4

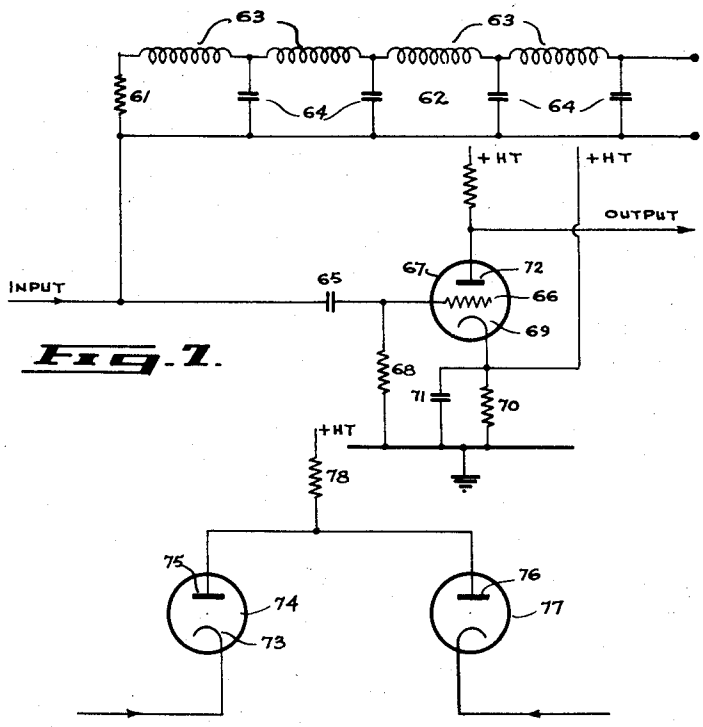


Fig. 1.

Fig. 9.

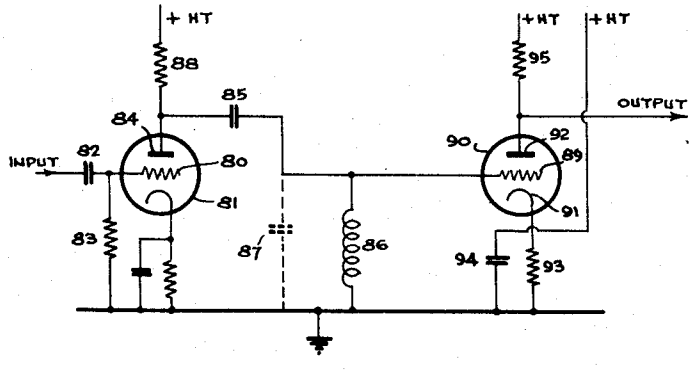


Fig. 10.

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Feb. 16, 1960 M. M. LEVY 2,925,586
METHOD OF, AND APPARATUS FOR, ELECTRONICALLY INTERPRETING A PATTERN CODE
Filed June 9, 1953 6 Sheets-Sheet 5

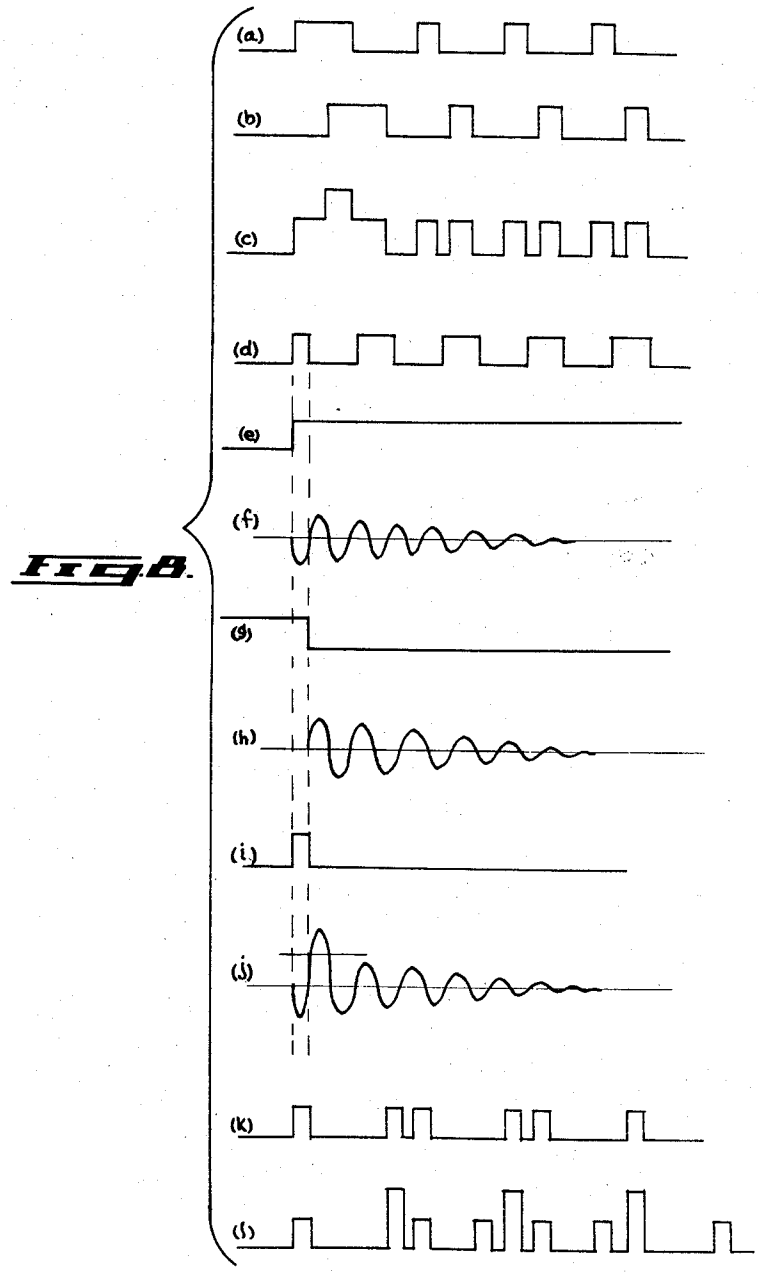


Fig 8.

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Feb. 16, 1960 M. M. LEVY 2,925,586

METHOD OF, AND APPARATUS FOR, ELECTRONICALLY INTERPRETING A PATTERN CODE

Filed June 9, 1953 6 Sheets-Sheet 6

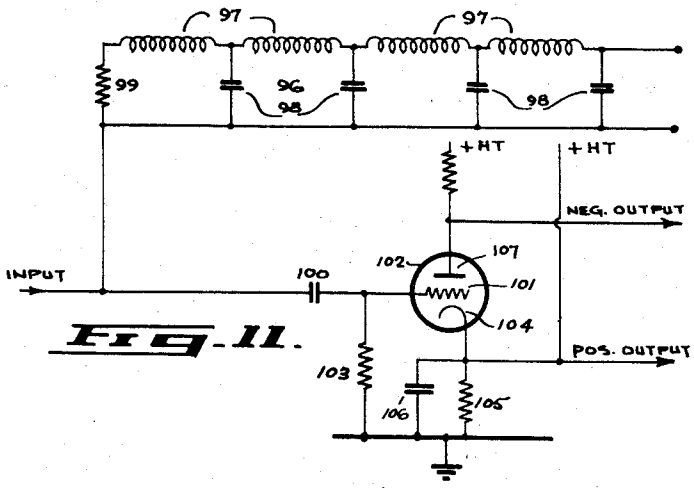


Fig. 11.

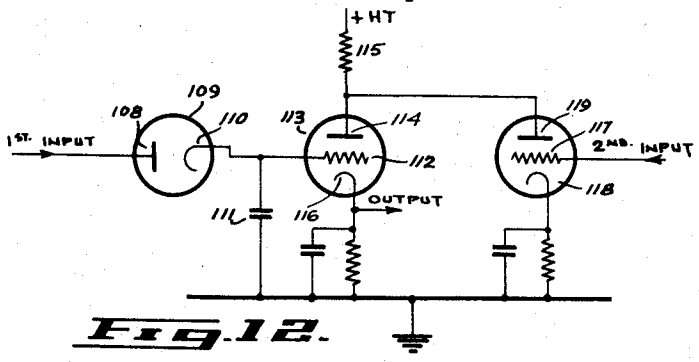


Fig. 12.

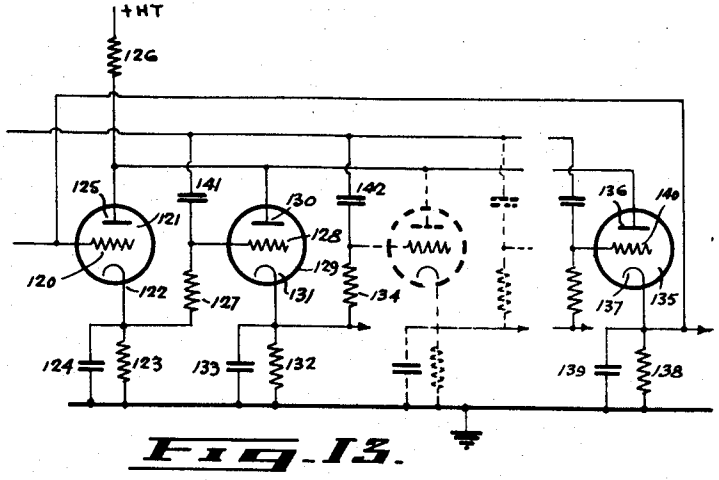


Fig. 13.

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United States Patent Office 2,925,586
Patented Feb. 16, 1960

2,925,586

METHOD OF, AND APPARATUS FOR, ELECTRONICALLY INTERPRETING A PATTERN CODE

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

Application June 9, 1953, Serial No. 360,540

Claims priority, application Canada April 29, 1953

9 Claims. (Cl. 340—174)

This invention relates to codes and apparatus for electrically identifying articles having imposed thereon a pattern code, and more particularly to such methods and apparatus suitable for use in identifying letter mail for purposes of sortation.

It has long been considered desirable to have automatic systems for sorting mail. There are a number of mechanical systems designed to assist in the sorting of mail. However, these are merely mechanical aids to the actual handling of the mail, the actual sorting of which is still being effected by human beings.

The real difficulty in producing an automatic mail sortation system is the replacement of the human eye, i.e. the provision of a device which is able to read and reproduce in usable form any one of the untold thousands of addressed letters which pass through any large post office.

The first step needed to overcome this difficulty is the provision of a uniform code sufficiently compact to be imposed upon an envelope in a position so as not to be obscured by the hand-writing on the envelope, and yet which is capable of conveying virtually any address in the world. The need of a code which could convey so many countless combinations immediately eliminated single line codes such as have been used in the past in other coding systems. It has been mainly for this reason that previous sensing devices have been unsuitable for use in mail sorting systems. Another and most important reason why prior sensing devices have not been suitable for this field is that they have been designed merely to compare codes against a predetermined standard and to produce a "yes"-or-"no" output according to whether the codes scanned thereby do conform with the predetermined standard or not. This, of course, is quite unsuitable for the present field where it is necessary to know exactly what is contained in any one of innumerable codes.

Having decided that single line codes were unsuitable due to the limited number of combinations conveyed thereby, a multi-lined, or what may be called a two-dimensional, pattern code was evolved. In such a code, information is not only conveyed by the position of marks in any one row of the code but it is also conveyed by the inter-relationship of code marks in any number of several associated rows. Thus a code frame-work of a given number of rows and a given number of columns, as will be described later in detail, was chosen. In such a code frame-work, information could be conveyed by the placing of marks in appropriate positions within such a framework.

The next requirement is the provision of a sensing device capable of reading such a pattern code and reproducing in usable form exactly the information conveyed in any one such code, i.e. in the form of electric signals. To do this it was necessary to add to the code frame-work a certain number of marks in a given pattern extraneous of the frame-work itself. These latter marks are referred to in this specification as synchronization

marks as opposed to those marks which convey information and which have been termed classification marks. For purposes of clarity it may be mentioned that the term "code marks" shall be construed as being generic to both classification marks and synchronization marks.

Of course, having provided a device which is capable of reading and converting into the electric signals the information conveyed in a pattern code capable of expressing virtually any postal address in the world, such electric signals can then be adapted to actuate suitable equipment for affecting the actual mechanical sortation of mail.

According to the present invention, a method of identifying articles for purposes of subsequent sortation comprises imposing upon an article a pattern code in the form of rows and columns of classification marks and then scanning said pattern code with an electric sensing device to detect the individual classification marks and produce corresponding electric signals, separately identifying each such signal and applying it to the appropriate terminal of a group of terminals each corresponding to one position in the frame-work of said pattern code.

In addition to the classification marks there are spaced about the frame-work of a pattern code a number of synchronization marks. It is the signals excited by such synchronization marks which are used to enable identification of those signals excited by the classification marks.

A more specific form of the present method consists of imposing a pattern code upon an article, said pattern code including synchronization marks and classification marks, said classification marks being disposed within a frame-work of rows and columns, a first synchronization mark being disposed before a first row of said frame-work, a second synchronization mark being disposed an equal distance before a second row of said frame-work not adjacent said first row, and a series of further synchronization marks disposed at the same end of, equidistant from, and in line with each column of said frame-work, said further synchronization marks thus forming a row parallel with the rows of said frame-work, at least said first and said second synchronization marks being of different configuration than said classification marks, simultaneously scanning each row of said frame-work together with said first and said second synchronization marks and said row of further synchronization marks with an electric sensing device, applying the signals excited in said sensing devices by said first and said second synchronization marks to two synchronization signal selectors adapted one to select the signal excited by said first synchronization mark and one to select the signal excited by said second synchronization mark, applying the signals selected by said selectors to a single electronic gate, the presence of a signal at the output of said single gate indicating correct alignment of said pattern code, applying the signals excited in said sensing device by said series of further synchronization marks to a number of multi-vibrators corresponding one to each column of said frame-work and forming a cascade circuit, applying the signal selected by one of said selectors to a starter in electrical connection with the first multi-vibrator in said cascade circuit, applying the signal which appears at the output of each of said multi-vibrators to a separate group of electronic gates, the number of electronic gates in each of said groups corresponding to the number of rows in said frame-work, and applying the signals excited in said sensing devices by the classification marks in any one row of said frame-work to the electronic gate in each of said groups of electronic gates corresponding to that particular row.

The apparatus for effecting this method may comprise an electric sensing device, a group of terminals one cor-

responding to each position in the frame-work of a pattern code, and means for separately identifying each of the signals excited in said sensing device by said classification marks and applying each such signal to the appropriate terminal of said group of terminals.

It is highly desirable that means should be provided to indicate when a pattern code being scanned is incorrectly positioned in relation to the scanning device thus giving rise to incorrect reading of the code.

In the accompanying drawings which illustrate the preferred embodiments of the present invention:

Fig. 1 shows a pattern code,

Fig. 2 shows a block diagram of an electronic device for reading a code as shown in Fig. 1,

Fig. 3 shows a modification of Fig. 1,

Fig. 4 shows a block diagram of an electronic device for reading a code as shown in Fig. 3,

Fig. 5 shows a further modification of Fig. 1,

Fig. 6 shows block diagram of an electronic device for reading a code as shown in Fig. 5,

Fig. 7 shows a circuit of a synchronization pulse selector as shown by numerals **7**, **8** and **10** of Fig. 2,

Fig. 8 shows a pulse diagram,

Fig. 9 shows a circuit of an electronic gate,

Fig. 10 shows a circuit of a pulse width synchronization pulse selector,

Fig. 11 shows a circuit of a synchronization pulse selector as shown by numeral **39** of Fig. 6,

Fig. 12 shows a voltage control circuit, and

Fig. 13 shows a cold cathode tube cascade circuit.

For the purpose of describing the preferred embodiments of the present invention, pattern codes will be considered as being scanned by the various sensing devices employed. In practice, however, the codes are passed before the sensing devices.

There are at least two basic methods of scanning pattern codes; one where the code is scanned by a single sweep along its length, at a constant or at a varying speed, i.e. scanning by rows, and one where a large number of scanning sweeps are made at right angles to the direction in which the code is moving at a constant speed in relation to the sensing device, i.e. by columns. Many well-known types of sensing devices may be employed to scan pattern codes according to the present invention so to facilitate the following description an arbitrary choice of sensing devices has been made to illustrate scanning by rows and scanning by columns. These choices are; a battery of photo-electric cells in the case of scanning by rows, and a flying spot cathode ray tube in conjunction with a photo-electric cell in the case of scanning by columns.

It is to be understood that this arbitrary choice does not in any way restrict the present invention which may be adapted for use with various code imposing mediums, i.e. black and white, color, fluorescent, magnetic powder and phosphorescent codes. It will be understood, of course, that the sensing device would have to be modified according to the medium in which the code is imposed. Fluorescent codes would require illumination by ultraviolet light and phosphorescent codes would require the absence of visible light before they would excite the pulses in photo-electric cells, while a code imposed in magnetic powder would require the use of magnetic heads rather than photo-electric cells.

Referring to Fig. 1, classification marks 1 are grouped into three blocks each of five rows R and five columns C. The rows R represent the following numbers: $R1=1$; $R2=2$; $R3=4$; $R4=8$ and $R5=16$.

Any number up to and including 31 can thus be represented in any one column C by combinations of classification marks 1, i.e. the classification mark 1 in row R2 and the classification mark 1 in row R5 both in column C, represent the number 18. Similarly combinations of classification marks 1 in any one column C_1 can represent a letter of the alphabet where $1=A$; $2=B$; $3=C$ and so on, i.e. the classification marks 1 in row R2, row R3 and row R5, all in column C8 represent the letter V.

Other types of code may be used having other than 5 rows; however this 5 row type of code has proved preferable. The number of columns used may vary and other forms of grouping the classification marks 1 into blocks may be employed according to the grouping most suitable for any particular application. The grouping shown in Fig. 1 is, for example, suitable for an address where the street number is given in one block, the street or an abbreviation of same in another and the town and state or province in the remaining block.

Synchronization marks S are provided, to enable determination of the position of any classification mark in the code, to ensure correct alignment of the pattern code when being scanned and to enable all blocks together or any desired block of the code individually to be read.

A pattern code as shown in Fig. 1 is scanned from left to right at a constant speed by a battery of photo-electric cells **2–6** as shown in Fig. 2. The photo-cells **2–6** are so arranged that when the code being scanned is correctly positioned, the photo-cells **2–6** correspond each to one row of the code.

Upon the commencement of scanning a code as shown in Fig. 1, pulses in the photo-cells **2** and **6** are first excited by synchronization marks S1 and S2. It will be noted that certain of the synchronization marks S are larger than the classification marks 1 and thus excite larger pulses. The pulses excited in photo-cells **2** and **6** are applied to synchronization pulse selectors **7** and **8** which select the larger pulses excited by synchronization marks S1 and S2 and apply these pulses to an electronic gate **9**. If the code is substantially correctly aligned when scanning commences, the selected synchronization pulses will be simultaneously applied to the gate **9** and a pulse will thus appear at the output of the gate **9**.

If a pulse does not appear at the output of the gate **9** then the code is not correctly positioned. Thus if an electronic code interpretation device according to the present invention is used in conjunction with a known electrically-operated sorting system, i.e. an I.B.M. sorter, such a system could be set to divert all codes into a reject box unless a pulse appeared at the output of the gate **9**.

The pulses excited in photo-cell **2** are also applied to a further synchronization pulse selector **10** through one contact of a three-way switch **10A**. The selector **10** selects the larger pulses excited by the synchronization mark S1 and this pulse is applied to a delay line **11**. Tapping points **12** to **17** inclusive are provided along the length of the delay line **11** and since the code in this method is being scanned at a constant speed, the delay of the delay line **11** is such that the synchronization pulse applied to the delay line **11** will reach the tapping point **12** at the precise moment that any classification marks in column C1 excite pulses in the photo-cells **2** to **6** inclusive. Similarly tapping points **13** to **16** correspond to columns C2 to C5 inclusive of the first block of the pattern code.

Each of the tapping points **12** to **16** is connected one to a column of electronic gates **18** in a pattern of electronic gates corresponding to one block of the code shown in Fig. 1. The photo-cells **2–6** are connected each one to the row of gates **18** in the pattern of gates **18** which corresponds to the row R of the code which the particular photo-cell is scanning. Thus each gate **18** is electrically connected to one of the tapping points **12–16** and to one of the photo-cells **2–6**.

The synchronization pulse applied to the delay line **11** from the selector **10** will thus be applied to all the gates **18** corresponding to one column of the code at the same time as impulses are excited in the photo-cells **2** to **6** inclusive by any classification marks which might appear in that particular column C of the code. Since these impulses, if any, are instantaneously applied to the

gates 18 corresponding to the rows R of the code, and since a pulse will appear at the outlet of a gate 18 if two pulses are applied to it simultaneously, a pulse will appear at the output of any gate 18 corresponding to the intersection of a column C and a row R of the code at which a classification mark 1 appears.

For example, the pulses excited in photo cells 3 and 6 by the classification marks 1 in row R2 and row R5 of the code both falling in column C1 will be applied to the corresponding gates 18 connected to tapping point 12 at the same instant that the synchronization pulse selected by selector 10 appears at the tapping point 12 and is applied to the column of gates 18 in electrical connection therewith. Thus a pulse will appear at the output of the gate 18 which is in electrical connection with both photo-cell 3 and tapping point 12 and at the output of the gate 18 which is in electrical connection with both photo cell 6 and tapping point 12.

A precaution against a code being incorrectly read because of being scanned at an incorrect speed is provided by synchronization mark S3. The synchronization pulse applied from selector 10 to the delay line 11 should reach the tapping point 17 by the time the synchronization mark S3, which is of the same size as the classification marks 1, is scanned by, and excites an impulse in photo cell 2. If the code is being scanned at the correct speed the pulse excited in photo cell 2 will be applied to the electronic gate 19 at the same moment the pulse at the tapping point 17 is applied thereto, and a pulse will appear at the output of gate 19. This may be adapted to prevent the code being scanned from being rejected in the manner similar to that described in connection with gate 9. This is also a further check on the alignment of the code since if the code if sufficiently out of alignment to give an incorrect reading, a pulse would not be excited in photo-cell 2. This indication of a code having been incorrectly read may be used, if desired, to actuate the apparatus designed to reject the article bearing the incorrectly read code.

It will be noted that by means of the switch 10A, any single block of the code may be selected for scanning. If, for example, photo-cell 3 were in electrical connection with selector 10 through the switch 10A, no pulse would be applied to the delay line 11 except that excited by synchronization pulse S4 while the scanning of the second block of the code is in progress with the result only those classification marks appearing in the second block of the code would give rise to the appearance of pulses at the outputs of the corresponding gate 18.

Similarly the third and last block of the code may be read by the electrical connection of photo-cell 4 to the selector 10 through the switch 10A. Here the delayed pulse is that excited by the synchronization mark S5.

At the end of the second and third blocks of the code in Fig. 1, synchronization marks S6 and S7 appear in row R1. These are to ensure that the code is scanned at the correct speed and in correct alignment as was the case with synchronization mark S3.

Having now a pattern of electrical pulses, or rather of terminals at which such pulses appear, corresponding to the occurrence of classification marks 1 of the code being scanned, these pulses may be used to actuate sorting systems.

The scanning method described above requires that the speed of scanning be constant. Since it may be difficult to maintain such a constant speed of scanning, the following method of scanning by rows which does not rely on a constant speed of scanning may be employed.

Referring to Fig. 3, a pattern code is shown which is suitable for scanning by rows at non-constant speeds. For the sake of simplicity this code is shown as a single block code having an initial synchronization pulse S8 and a row of synchronization marks S10–S14 at the top of the block, one aligned with each column C. If it were desired to break down the code into a number of

blocks, the longer synchronization marks S of each block may be disposed exactly as shown by the synchronization marks S4 and S5 in Fig. 1. Alternatively, synchronization marks of different configuration could be disposed one at the beginning of each block of the code all in one row, the one photo-cell scanning that row being in electrical connection with as many synchronization pulse selectors as there are blocks, each selector selecting a synchronization pulse of a specific configuration.

In Fig. 4 the photo-cells 2 to 6 are aligned each to scan a particular row R of the code shown in Fig. 3. An additional photo-cell 20 is provided to scan the row of synchronization marks S10–S14. As in the case of Fig. 2, the photo-cells 2 to 6 are in electrical connection each with a row of electronic gates 18 forming a part of a pattern of gates 18 corresponding to the rows R and columns C of the code.

Photo-cells 2 and 6 are electrically connected to synchronization selectors 21 and 22 which select the pulses excited in photo-cells 2 and 6 by synchronization marks S8 and S9. Here again if the code is substantially correctly aligned a pulse will appear simultaneously at the outputs of selectors 21 and 22 which when applied to an electronic gate 23 will produce a pulse at the output of gate 23 which may be used, if desired, to prevent rejection of the article bearing the code being scanned.

The pulses excited by the synchronization marks S10 to S14 in photocell 20 are applied to a row of cold cathode tube counters 24 to 28 inclusive, one for each column of the code while the pulse excited in photocell 2 by synchronization mark S8 and selected by the selector 21 is applied to a starter 29. The pulse appearing at the output of the starter 29 is applied to the counter 24 preparing it for striking.

When the synchronization mark S10 excites a pulse in photo-cell 20 this pulse is instantaneously applied to the counter 24 which strikes and applies a pulse to the first column of electronic gate 18 and to the counter 25 preparing it for striking when the pulse excited in photocell 20 by synchronization pulse S11 is applied to it.

Since the synchronization mark S10 is aligned with the leading edge of column C1 of the code in Fig. 3, the pulse applied from the counter 24, when caused to strike by the pulse excited in photo-cell 20 by the synchronization mark S10, to the first column of gates 18 will coincide with the application of any pulses excited in photo-cells 2 to 6 by any classification marks 1 in column C1 of the code, to the rows of gates 18. Thus the pulse excited by the classification mark 1 in row 1 and column 1 of the code in Fig. 3 will be applied from photocell 2 to the first row of the gates 18 during the time the pulse from the counter 24 is applied to the first column of the gates 18. A pulse will then appear at the output of that gate 18 in electrical connection with both the counter 24 and photo-cell 2.

The successive synchronization marks S10 to S14 inclusive strike in turn each of the counters 24 to 28 respectively. As each counter 24 to 28 is struck it prepares the next counter 24 to 28 for striking, i.e. counter 24 when struck will prepare counter 25 for striking which when struck itself will in turn prepare counter 26 for striking. Conversely as each counter 24 to 28 is struck by the application of a pulse excited by a synchronization mark S10 to S14, it cuts off the counter immediately before it, i.e. counter 26 will cut off counter 25 which itself, when struck, cut off counter 24. It will be noted that as the synchronization marks S10 to S14 appear at the leading edge of each column, the pulses appearing at the outputs of the counters 24 to 28 will be of the same duration as the time taken for any one column to pass before photo-cells 20 and 2 to 6. Thus the speed with which the code as shown in Fig. 3 is scanned, within the limits of the mechanical means provided for moving the code in relation to the photo-cells 20 and 2 to 6, has no effect on

the accuracy of the reading of the code. The pulse appearing at the output of the counter 28 is applied to and resets the starter 29. Such a row of counters 24 to 28 will be more fully described later in this specification.

As an additional precaution against incorrect reading of a code due to incorrect alignment, the pulse appearing at the output of the last counter in the cascade circuit, counter 28, may also be used in conjunction with the pulse at the output of gate 23 to prevent rejection of the article bearing the code being scanned.

Various adaptations of the above methods which fall within the scope of the present invention are envisaged. Among these are methods whereby synchronization marks are placed above, or below, the columns in two rows, those aligned with the odd numbered columns being in one row while those in line with the even numbered columns being in a second row. Alternatively the synchronization marks S could all be in the same row, as shown in Fig. 3, but alternately large and small, or by alternately different combinations of a number of smaller marks.

It should be understood that the main characteristic of a synchronization mark is that the pulse or pulses it excites be electronically distinguishable from the pulses excited by classification marks and may therefore be of a number of configurations. These variations would allow the coded message to be divided into two parts, one part being represented by the odd numbered columns, the second part by the even numbered columns. Thus, where alternately large and small synchronization pulses are used either part of the code could be interpreted without the other by using only the pulses excited by one row of synchronization pulses in the former case or by the use of a synchronization pulse selector selecting only synchronization pulses of the desired width.

In this method the image of the spot excited on the screen of a cathode ray tube 29A of Fig. 6 is suitably focused on a code as shown in Fig. 5 and the reflection of or emission excited by the image is suitably focused on a photo-cell 30, Fig. 6. As it is desired that the columns of the code be rapidly scanned, a sawtooth wave may be applied to the cathode ray tube 29A thus causing the image of the spot continuously to travel down the columns and fly back as the code moves before the tube 29A at right angles to the direction of movement of the image.

It may be mentioned here that if the flying spot type sensing device is used in conjunction with the methods earlier described of scanning by rows a stepped wave-form voltage may be applied to the cathode ray tube causing the image to move successively from one column to the next in the same row, pausing momentarily in each column.

The second of the two broad methods of scanning defined earlier in this specification is that whereby the code is scanned by columns at a rapid rate as the code is moved from right to left, or vice versa, in relation to the sensing device, which has in this case been arbitrarily chosen as a flying spot cathode ray tube in conjunction with a photo-electric cell.

A pattern code suitable for scanning by columns is shown in Fig. 5. The synchronization pulses S are narrow in relation to the direction of scanning, i.e. by columns, with the exception of synchronization pulses S16 and S17 which are larger in size to the classification marks 1.

In this method the letter moves before the sensing device from right to left so that the scanning commences at the left hand side of the code. The first pulses excited in the photo-cell 30, see Fig. 6, are those excited by synchronization marks S18 and S19. The photo-cell 30 is in electrical connection with a series of electronic gates 31 to 36 inclusive and to a narrow pulse synchronization pulse selector 37. The narrow pulses excited by synchronization marks S18 and S19 are selected by selector 37 and applied to an electronic gate 38 and to a second synchronization pulse selector 39 which combines the two pulses excited by synchronization marks S18 and S19 in any one scan into one sharp high pulse. If the code is correctly aligned, this combined pulse will be of sufficiently high voltage to actuate selector 39 and to cause a pulse to appear at the output thereof. This pulse is applied to a voltage control 40 and may also be used to prevent the article bearing the code from being rejected as has been described earlier.

The selector 39 and voltage control 40 will be considered in detail later.

The voltage control 40, when actuated by a pulse from selector 39, applies a voltage to the gate 38 which is maintained throughout the scanning of the code. Thus as scanning continues the pulses excited by synchronization pulses S20 to S34 and selected by the selector 37 are applied to, and pass through the gate 38. These pulses are then applied through a pulse widener 41 to a high frequency delay line 42.

The speed with which the flying spot of the cathode ray tube 29A travels down the columns is constant. Thus the rate at which the five rows R are traversed, and the rate at which pulses are excited by any given classification mark 1 are constant. The delay of the line 42 is such, therefore, that tapping points 43 to 47 inclusive correspond to the rows R1 to R5 while the tapping point 48 corresponds to the row in which the synchronization marks S16 and S17 appear. For example, the pulse excited by synchronization mark S25 in any single scan of the column C6 will appear at the tapping point 45 at the same instant that a pulse is excited by the classification mark 1 at the intersection of column C6 and row R1 during the same scan of column C6.

The tapping points 43 to 48 are in electrical connection each with one of the series of electronic gates 31 to 36 inclusive to all of which the pulses excited in the photo-cell 30 are applied.

Let us here assume that in the time it takes for the width of one classification mark 1 to pass before the photo-cell 30, the column C1 in which the classification mark 1 appears is scanned five times. Referring back to the above example regarding the appearance of a pulse at tapping point 43 coinciding with the pulse excited by the classification mark in column C6, row R1, such a coincidence of pulses will occur five times while the code moves the width of a classification mark in relation to photo-cell 30. Therefore since both the tapping points 43 to 48 inclusive and photo-cell 30 are in electrical connection with the gates 31 to 36 respectively, whenever a classification mark 1 appears in a row R or a synchronization mark S16 or S17 appears in the case of tapping point 48 and gate 36, five short pulses will appear in rapid succession at the output of the gates 31 to 36 inclusive corresponding to the row in which the classification mark 1 or synchronization marks S16 and S17 appeared.

Each one of the gates 31 to 36 inclusive is in electrical connection with a low pass filter 49 to 54 at the output of which a single wide pulse appears whenever a series of narrow pulses, e.g. five, are applied thereto from the gates 31 to 36. As is well known, a low pass filter has the effect of widening and delaying each pulse passed through it. The single wide pulse is thus the result of the addition to one another of the individual pulses that have been widened in the low pass filter so as to overlap one another. Of these low pass filters, 49 to 53 inclusive are electrically connected each to a row of electronic gates 18 as in previous methods. The number of columns in the pattern of gates 18 in this case corresponds to the number of columns C in the code.

The pulses appearing at the output of the gate 38 are also applied to a low pass filter 55 which, as in the case of the low pass filters 49 to 54, supplies one large pulse whenever a series of short pulses are applied thereto. The long pulses at the output of the low pass filter 55,

each corresponding to one of the synchronization marks S20 and S21 and so on, are applied to a delay line **56**, the delay of which is such as to delay the pulses by three-quarters of the time delay between the synchronization marks S20 and S21 and so on in passing before the photo-cell **30**.

The delayed pulses at the output of the delay line **56** are then applied to a short pulse generator **57**. For every delayed pulse applied to the short pulse generator **57**, two short pulses appear at the output thereof, one positive-going and one negative-going. Since only one of these latter two pulses is desired, the negative-going pulse may be suitably suppressed. The positive-going pulse appearing at the output of the generator **57** is then applied to a row of cold cathode tube electronic counters or multi-vibrators M1 to M15 inclusive in cascade circuits, each row corresponding to one of the columns C in one block of the code as shown in Fig. 5.

The pulse at the output of the voltage control **40** and applied to the gate **38** is also applied to a starter **58** which immediately prepares the multi-vibrator M1 for striking. It will be remembered that the voltage at the output of the voltage control **40** is initiated by the combining of the pulses excited by the synchronization marks S18 and S19. Thus the multi-vibrator M1 is prepared for striking by the pulse applied from the starter **58** immediately upon the commencement of scanning.

Due to the delay of the delay line **56**, the first, or positive-going, pulse of the two short pulses generated by the generator **57** from the pulses originally excited in photo-cell **30** by the synchronization mark S18 will be applied to multi-vibrator M1 at the time the scanning of column C1 commences, the second of the two pulses having been suppressed since it is unwanted. This first short pulse, or for the sake of clarity the S18 positive-going short pulse causes the multi-vibrator M1 to strike and a voltage will appear at the output thereof. It should here be mentioned again that cold cathode tubes are used in the multi-vibrator cascades M1 to M15′ inclusive which will be considered in detail later. The voltage appearing at the output of M1 will continue until the positive-going short pulse originating from the pulses excited by synchronization mark S20 appears at the output of the generator **57**. This S20 positive going short pulse is applied to the row of multi-vibrators and will strike M2, M1 having already been struck. As soon as M2 begins to conduct, the anode voltage of multi-vibrator M1 drops and the voltage appearing at its output is cut off. It will be seen that since the first and positive-going pulse generated by the generator **57** appears at the output of the generator **57** coincidental with the time the scanning of a particular column commences, the output voltage of the multi-vibrators M1 to M15′ will have a duration each corresponding to and coinciding with the time taken to scan one column C of the code. The output voltage of the multi-vibrator M1 is applied to the first column of gates **18** in the pattern of gates **18** previously described and shown in Figs. 2 and 4, thus the gates **18** corresponding to column C1 of the code are ready to open should any classification marks appear in that column and cause the pulses to appear at the output of one of the low pass filters **49** to **53** inclusive.

The output voltage of the multi-vibrator M1 is also applied to multi-vibrator M2 thus preparing it for striking. By this time the first of the two short pulses generated from the pulse excited by synchronization mark S20 has appeared at the output of generator **57** and thus to multi-vibrator M2 causing it to strike. Thus this is repeated until M5 has been struck and cut off. This is done by an additional multi-vibrator M5′. The multi-vibrator M5′ is struck when the positive-going short pulse generated by the pulse excited by synchronization pulse S24 is applied thereto and the output pulse thereof is applied to and resets the starter **58**.

Now referring back to the high frequency delay line **42** and to tapping point **48**. The series of pulses excited by the synchronization mark S24 and widened by pulse widener will reach the tapping point **48** and be applied to the gate **36** at the same time as a series of pulses excited by the synchronization mark S16 are applied to the gate **36**. Thus a series of pulses will appear at the output of the gate **36** and will be converted into one long pulse by the low pass filter **54**. This long pulse is applied through a pulse differentiator **59** to a starter **60** which then prepares multi-vibrator M6 which corresponds to column C6 of the code, the first column of the second block of the code, for striking.

Multi-vibrators M6 to M10 inclusive, corresponding to columns C6 to C10 of the code, are prepared for striking, struck and cut off in the same manner as multi-vibrators M1 to M5 inclusive and the output pulses thereof are applied to the columns of gates **18** corresponding to the columns C6 to C10 of the code. Similarly multi-vibrator M10′ when struck, applies a pulse to, and resets starter **60**.

The synchronization marks S16 and S17 are, however, not essential, their use being simply to enable separate blocks of the code to be scanned rather than the entire code. In describing the actuation of the row of multi-vibrators M11 to M15 which correspond to columns C11 to C15 of the code it will be assumed that no synchronization mark S17 is used. In such a case multi-vibrator M10′ will also be unnecessary. Instead of the output pulse from multi-vibrator M10 being applied to multi-vibrator M10′ it is applied directly to multi-vibrator M11. The cascade of multivibrators M11 to M15 thus strike and cut off as did multi-vibrator M1 to M5 and M6 to M10, the output pulses being applied to the appropriate gates **18**. Here a multi-vibrator M15′ is used to supply a pulse to reset the starter **60**.

Thus it will be seen that in each of the methods described a series of pulses are obtained at terminals in a pattern which exactly corresponds with the pattern in which the classification marks are imposed on the code being scanned. These pulses can be adapted for use in many ways such as to operate the earlier mentioned sorting systems, to select codes having certain specific data on them as with a cataloguing system, or to actuate memory devices.

The details of the circuits will now be considered. Referring to Fig. 7 a synchronization pulse selector of the type shown by the numerals **7**, **8** and **10** in Fig. 2 is illustrated.

As pulses are excited in photo-cell **2** of Fig. 2, for example, they are applied across resistance **61** of an unterminated delay line **62** comprising inductances **63** and condensers **64**.

In the case of a white surface with black synchronization and classification marks being scanned, these pulses would be positive and it will be assumed that this is the case. The sign of the pulses if excited by a fluorescent code, thus being negative, could simply be reversed by applying the negative pulses to the grid of a triode and applying the positive output pulses appearing at the anode of the triode to the delay line **62**.

A pulse diagram representing the input of the delay line **62** is shown at (*a*) in Fig. 8. The pulses travel along the delay line **62** and are then reflected back along the delay line **62** unchanged in sign but delayed. A pulse diagram of the reflected pulses is shown at (*b*) of Fig. 8. The input pulses and the reflected pulses appear combined at the input of the delay line **62**. A pulse diagram representing the input plus reflection of the delay line **62** is shown at (*c*) of Fig. 8. It will be noted that the delay of the delay line **62** is such that only the wider pulses excited by the larger synchronization marks actually overlap to produce a high voltage pulse. In the case of the apparatus as shown in Fig. 2, this is possible since the speed of scanning is constant.

The original input pulses and the reflected, delayed

pulses combined are applied from the input of the delay line 62 through condenser 65 to the grid 66 of a triode 67. A grid bias resistance 68 is connected between the grid 66 and ground. The cathode 69 of the triode 67 is grounded through cathode resistance 70 and by-pass condenser 71. A positive H.T. voltage is applied to the cathode 69 of the triode 67 of such a value that only a positive pulse of the voltage of the high pulse created by the overlapping of the original wide pulse, excited by the synchronization mark S1 of Fig. 1, and its delayed reflection will be sufficient to overcome the positive bias of the cathode 69 and cause it to conduct thus producing a negative pulse on the anode 72 of the triode 67. This negative pulse corresponds to the pulse originally excited in photo-cell 2 of Fig. 2 by the synchronization mark S1 of Fig. 1. If desired, of course, the sign of this pulse may be changed by applying it to the grid of a second triode and tapping off the positive pulse which would appear in the anode circuit of this second triode.

A number of different types of electronic gates may be employed in the three preferred embodiments of the present invention.

The preferred form of gate shown in Fig. 9, may be used in all instances in any of the circuits illustrated in Figs. 2, 4 and 6. Here again the apparatus illustrated in Fig. 2 will be used as an example. The pulse appearing at tapping point 12 of the delay line 11 in Fig. 2 is applied to the cathode 73 of diode 74 in Fig. 10. The anode 75 of the diode 74 is electrically connected to a plate voltage source in parallel with the anode 76 of a second diode 77 through a common plate resistance 78. The cathode 79 of the diode 77 is in direct electrical connection with the photo-cell 2 through a suitable amplifier. For the sake of clarity such amplifiers, which are well-known in the art, have not been shown.

Since the cathodes 73 and 79 are originally at zero potential and since the anodes 75 and 76 will follow the lowest cathode potential, a pulse will only appear across the plate resistance 78 when pulses are simultaneously applied to both the cathodes 73 and 79. Therefore the pulse excited by a synchronization mark appearing at tapping point 12 of delay line 11 in Fig. 2 and applied to the cathode 73 of diode 74 will not cause a pulse to appear across resistance 78, Fig. 10, unless a pulse excited in photo-cell 2 by a classification mark is simultaneously applied to the cathode 79 of diode 77.

Fig. 10 illustrates the detailed circuit of a pulse width synchronization pulse selector as shown by the numeral 37 in Fig. 6.

Let us, for example, consider the pulses excited in photo-cell 30 of Fig. 6 during one scan of column C8 of Fig. 5. Here a narrow pulse will first be excited by the synchronization mark S27 which will be followed by wide pulses excited by the four classification marks 1 in column C8. A diagram of pulses excited in the photo-cell 30 is shown at (*d*) of Fig. 8.

These pulses are all applied to the grid 80 of a tube 81 (this may be a triode or pentode) through a condenser 82 and across a grid bias resistance 83. The anode 84 of the tube 81 is coupled through a condenser 85 to a tuned circuit comprising an inductance 86 and possibly a condenser 87, representing the inter-electrode capacity of the tube 81 which is usually of sufficient value. This tuned circuit is tuned to an oscillation frequency suited to the selection of a certain width of pulse, as will be seen below. A plate resistance 88 is provided to dampen the oscillations which are set up in the tuned circuit upon the application or withdrawal of a voltage to the grid 80.

The initial input voltage on the grid 80, i.e. the beginning of the narrow synchronization pulse excited by synchronization mark S27, is shown at (*e*) in Fig. 8. This sets up an oscillation in the tuned circuit of the inductance 86 and the condenser 87 which will be dampened by the plate resistance 88, see (*f*) of Fig. 8.

The second input on the grid 80 is a voltage drop, i.e. the end of the narrow synchronization pulse excited by synchronization mark S27, is shown at (G) of Fig. 8. Here again a damped oscillation is set up in the tuned circuit of inductance 86 and the condenser 87, delayed by the width of the narrow synchronization pulse and of reverse sign to the initial oscillation, see (*h*) of Fig. 8.

Therefore the combined initial and second inputs as shown at (*i*) of Fig. 8 will produce a combined oscillatory output as shown at (*j*) of Fig. 8. It will be seen that the first swing of the second oscillation will combine with the second swing of the initial oscillation, both being positive, to produce an extra high voltage swing. As mentioned before, the tuned circuit must be tuned so that the frequency of the oscillation corresponds to double the width of the pulse to be selected. Since the oscillations are dampened by the plate resistance 88 the combined oscillations of the larger pulses excited by the classification marks 1 in column C8 of Fig. 5, for example, the combined oscillations produced are not as great as that produced by the synchronization pulse, the initial oscillation having been considerably damped.

The output of the tuned circuit of inductance 86 and condenser 87 is then applied to the grid 89 of a triode 90 having a positive bias on its cathode 91. As is the case of the triode 67 of Fig. 7 the value of this positive bias must be such that only the positive voltage of the combined positive swing of the initial and second oscillations as shown at (*j*) of Fig. 8 will cause the triode 90 to conduct thus producing a negative pulse on the anode 92 of the triode 90. This pulse may then be converted to a positive pulse by applying it to the grid of a further triode and tapping off the positive pulse appearing at the anode of this further triode. The numerals 93, 94 and 95 show the cathode resistance, the by-pass condenser and the plates resistance respectively of the triode 90.

Referring now to Fig. 11, the details of the synchronization pulse selector 39 of Fig. 6 is shown. This selector operates on similar lines to those shown at numerals 7, 8 and 10 of Fig. 2 and shown in detail in Fig. 2. Since the speed at which the flying spot of the cathode ray tube 29*a* of Fig. 6, traverse the columns C of a code is constant, the synchronization marks S18 and S19 of the code shown in Fig. 5 will excite pulses in photo-cell 30 of Fig. 6 at regular intervals. Therefore an unterminated delay line 96 is built up of inductances 97 and condenser 98 having a total delay of half the delay between the appearance of the pulse excited by the synchronization mark S18 and that excited by synchronization mark S19 in the same scan. Thus as these pulses appear at the output of selector 37 of Fig. 6, they are, assuming them to be positive, applied directly to the input resistance 99 of the delay line 96. If the initial pulses are negative they may be applied to the grid of a triode and the positive pulses appearing in the plate circuit of the triode be applied to resistance 99. The delay line 96 being unterminated, the pulses are reflected back to the input without a change of sign and since the delay of the delay line 96 is half of the delay between the occurrence of two pulses in any one scan of the synchronization pulses S18 and S19, the pulse excited by mark S 18 will be reflected back to the input resistance 99 coincidental with the application of the pulse excited by the mark S19 thereto. Thus a series of narrow positive pulses, see (*k*), Fig. 8, applied to the delay line 96 will appear at the input of the delay line 96 as a series of narrow pulses, every second pulse being of twice the positive voltage of the others, see (*l*) of Fig. 8.

The input of the delay line 96 is then applied through condenser 100, to the grid 101 of a triode 102. The grid 101, being grounded through resistance 103, and the cathode 104 of the triode 102 being grounded through resistance 105 and by-pass condenser 106. The value of

the cathode **104** being positively biased so that only a positive voltage of the value of the larger positive pulses applied to the grid **101** will cause the triode **102** to conduct thus causing a positive pulse to appear at the cathode **104** of the triode **102** and a negative pulse to appear in the plate circuit **107** of the triode **102**. It will be seen that if the code, Fig. 5, being scanned is incorrectly aligned, the delay between the narrow synchronization pulse being applied to the delay line **96** will not correspond to the delay of the delay line **96**. Therefore a pulse will only appear in the plate circuit **107** or at the cathode **104** of triode **102** when the code is in the correct position.

When a negative pulse appears at the anode output of the synchronization pulse selector **39** of Fig. 6, it is applied to voltage control **40**. The details of voltage control **40** are shown in Fig. 12.

The negative pulses are first applied to the anode **108** of a diode **109**, the cathode **110** of which is connected to ground through a condenser **111** and to the grid **112** of a cold cathode triode **113**. As the pulses appear at the anode **108** of the diode **109** a positive charge is built up on the plate of condenser **111** remote from ground. This positive charge is applied to the grid of the triode **113** the anode **114** of which is connected to a positive H.T. source through resistance **115** and will tend to strike that tube. Since the code is being scanned by column however, and since the pulses will be excited by the synchronization marks S18 and S 19, Fig. 5, several times, for example five, as early mentioned, five pulses will appear at the output of the selector **39**, Fig. 6, if the code is correctly aligned. Should the code being scanned be only slightly out of alignment it may be possible for a single pulse to appear at the output of the selector **39**, Fig. 6, but not several. Therefore as an additional precaution against incorrect scanning the cold cathode triode **113** is biased so that several pulses are required to sufficiently charge the condenser **111** that the voltage applied to the grid **112** strike the triode **113**.

Once the triode **113** is struck, a positive voltage will appear at the cathode **116** of the triode **113** which will continue indefinitely. This voltage is applied to the gate **38**, Fig. 6, and will thus allow any synchronization pulse applied directly from the selector **37**, Fig. 6, to pass through the gate **38**.

Referring again to Fig. 5, it will be seen that an additional synchronization mark is provided at S35. The pulses which this mark S35 excites in the photo-cell **30**, Fig. 6, are applied to the grid **117** of a second cold cathode triode **118** causing it to strike. The anode **119** of the triode **118** is in parallel with the anode **114** of triode **113** thus when the triode **118** strikes a negative-going pulse appears in the combined anode circuits **114** and **119** as a result of which the triode **113** will be cut off. The triode **113** will then remain quiescent until the scanning of another code commences.

Referring to Fig. 13, a cascade of cold cathode tubes as shown by the numerals **24** to **28** in Fig. 4 and by the numerals M1 to M15 in Fig. 6. A starter pulse is applied to the grid **120** of a starter tube **121** the cathode **122** of which is grounded through resistance **123** and by-pass condenser **124**. The anode **125** of the tube **121** is connected to a positive +H.T. source through plate resistance **126**.

The cathode **122** of the tube **121** is electrically connected through a resistance **127** to the grid **128** of a second cold cathode tube **129**. The anode **130** of the tube **129** is connected to plate resistance **126** in parallel with the anode **125** of the tube **121**, the cathode **131** thereof being grounded through resistance **132** and by-pass condenser **133**. Again the cathode **131** of the tube **129** is electrically connected through a resistance **134** to the grid of the next tube and so on until tube **135** is reached which is connected as with all the other tubes, its anode **136** to the plate resistance **126** and its cathode **137** to

ground through resistance **138** and by-pass condenser **139** and its grid **140** to the cathode of the preceding tube.

In operation the pulse, let us assume it to be a selected pulse excited by a synchronization mark as in Fig. 4, is applied to the grid **120** of the starter tube **121**. A positive-going voltage appears at the cathode **122** of the tube **121** and is applied to the grid **128** of the tube **129**. The cold cathode tubes used should be such that the positive-going voltage is not sufficient to strike the tube **129** but does prepare it for striking.

Referring again to Fig. 4 we find that photo-cell **20** is connected to the counters **24** to **28**. In fact the grids **128** and **140**, and all the grids of the intermediate tubes, are connected in parallel to the photo-cell **20** through condensers **141** and **142** respectively.

As soon as the first pulse is excited in photo-cell **20** by the synchronization mark S10, this pulse is applied through condenser **141** to the grid **128** of the tube **129**. The voltage of this pulse in addition to the voltage applied to the grid **128** from the cathode of the starter tube **121** is sufficient to strike the tube **129**.

When the tube **129** strikes, a negative-going voltage appears at the anode **130** and hence at the anode **125** of tube **121** thus cutting off the starter tube **121**.

This whole process is repeated, a further cold cathode tube being struck each time a new pulse is excited in the photo-cell **20** of Fig. 4 by another synchronization mark, each tube in turn preparing the next and cutting off the one previous, until the last tube of the cascade, tube **135** is struck. This last tube **135** will cut off the preceding tube and the positive-going voltage at the cathode **137** thereof is applied back to the grid **120** of the starter tube **121** thus preparing it for striking by the next selected pulse either to begin the scanning of a new block of the code or to commence the scanning of the next code. The pulses utilized to open the gates **18** of Figs. 4 and 6 are those appearing at the cathodes of all the tubes in the cascade except that of the starter tube **121**.

Other components of the block diagrams such as low pass filters, short pulse generators and pulse wideners are well-known units in the art and need not be described in detail.

It will be understood that the form of synchronization marks used may vary greatly and that the type of code used may also vary. Similarly a number of sensing devices may be employed. The present invention is mainly concerned with an effective system of using pulses excited by synchronization marks to enable the pulses excited by classification marks to be isolated and identified in relation to the position of the classification marks in the code being read.

While no specific mention has been made of what use the pulses appearing at the outputs of the gates **18** in the various figures may be put, these pulses are identifiable and may be used in numerous manners by one skilled in the art. A use for these pulses specific to the sorting of mail will be the subject of another application.

I claim:

1. An apparatus for detecting and reproducing in the form of electric signals information conveyed in a pattern code having classification marks disposed within a frame-work of rows and columns and synchronization marks of generally similar configuration to the classification marks disposed one at the same end of, equidistant from, and aligned with each column of said frame-work to form a row substantially parallel with the rows of said frame-work together with an initial synchronization mark of different configuration than said classification marks disposed before and in alignment with a row of said frame-work, comprising a number of sensing devices so disposed as to scan each one row of said pattern code including all the rows of said frame-work and said row of synchronization marks, a cascade of multi-vibrators one corresponding to each column in said code in elec-

trical connection with the sensing device in alignment with said row of synchronization marks, a synchronization pulse selector in electrical connection with the sensing device aligned with that row of said frame-work before which said initial synchronization mark is disposed, a starter in electrical connection with the output of said synchronization pulse selector, said starter being electrically connected to the first and the last multi-vibrator of said cascade circuit, and a number of electronic gates corresponding to the number of rows in said frame-work being in electrical connection with each of said multi-vibrators, each of said sensing devices scanning a row of said frame-work being in electrical connection with the electronic gate electrically connected to each multi-vibrator and corresponding to the row being scanned by that particular sensing device.

2. An apparatus as claimed in claim 1 in which said initial synchronization mark is disposed before and aligned with a first row of the frame-work, a second initial synchronization mark of a different configuration than the classification marks is disposed an equal distance before and in alignment with a second row of said frame-work not adjacent said first row, a further synchronization pulse selector is provided in electrical connection with the sensing device scanning the said second row of said frame-work, and a single electronic gate is connected to both said synchronization pulse selectors, said separate single gate being adapted to emit a signal when the pulses selected by both said synchronization pulse selectors are applied to said single gate simultaneously, the presence of a signal at the output of said single gate indicating correct alignment of said pattern code.

3. In a method of identifying articles for purposes of sortation, comprising imposing a pattern code upon an article, said code including classification marks disposed within a framework of rows and columns, at least one starting mark disposed at one end of said framework and at least one finishing mark disposed at the other end of said framework; scanning said classification marks to detect the individual classification marks and produce corresponding classification electric signals; separately identifying each such signal for subsequent sortation of said article; the improvement of a verification procedure comprising carrying out said scanning step so as to generate a starting signal corresponding to said starting mark and a finishing signal corresponding to said finishing mark, in addition to said classification signals; calculating from the time relationship of at least said starting and finishing signals the distance between said starting and finishing marks; comparing this calculated distance with a datum distance to detect any discrepancy therebetween, and generating a rejection signal for cancellation of sortation in accordance with said classification signals whenever such a discrepancy is detected.

4. The method of claim 3 wherein said article is moved relatively to the scanning means and said scanning is effected in the direction of said travel.

5. The method of claim 3, wherein said article is moved relatively to said scanning means and said scanning is effected substantially at right-angles to said direction of travel.

6. The method of claim 3, wherein said step of calculating the distance between said starting and finishing marks includes the step of calculating from said classsification signals the number of columns of classification marks situated between said starting and finishing marks.

7. The method of claim 3, wherein said step of calculating the distance between said starting and finishing marks includes the step of determining the mean rate of scanning of said code and relating this rate to the time interval between said starting and finishing signals.

8. A method of identifying articles for purposes of sortation, comprising imposing upon an article a pattern code in the form of rows and columns of classification marks, scanning said code in a manner such as to scan each such mark a plurality of times and produce a plurality of spaced electric pulses corresponding to successive portions of each said mark, separating the pulses corresponding to each mark from the pulses corresponding to other marks and widening and delaying each of said separated pulses to such extent that said pulses overlap one another, and adding said separated pulses together to produce a unitary signal representing each such mark.

9. Apparatus for detecting and reproducing in the form of electric signals information conveyed in a pattern code on an article, said code having marks disposed within a framework of rows and columns, said apparatus comprising sensing means for detecting said marks; means for moving said article and said sensing means to cause said sensing means to scan said code in a manner such as to scan each of said marks a plurality of times to form a plurality of individual pulses each corresponding to a successive portion of said mark, means for separating the pulses produced by a selected mark and a low-pass filter for widening, delaying and adding said separated pulses to produce a signal representing said mark.

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