April 22, 1969 K. C. ALLEN 3,439,760

AUTOMATIC PRINTING PRICE SCALE WITH PHOTOELECTRIC ENCODER INCLUDING RANGE AND MOTION DETECTORS

Filed Oct. 15, 1963

FIG-1

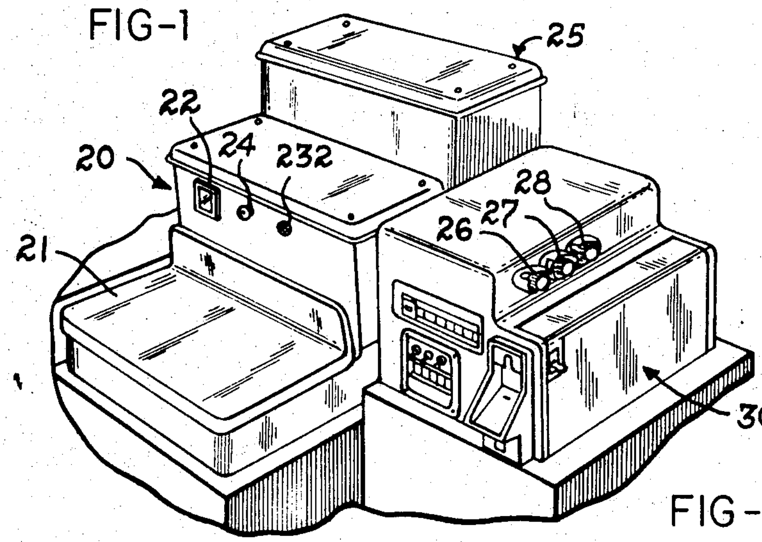

FIG-3

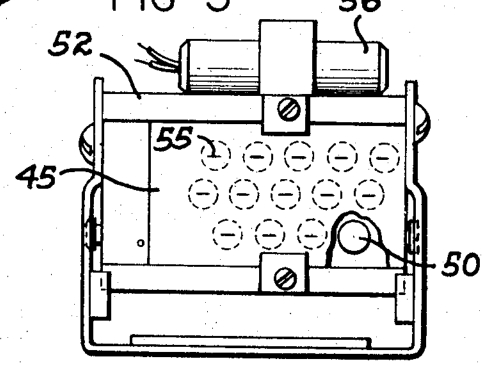

FIG-2

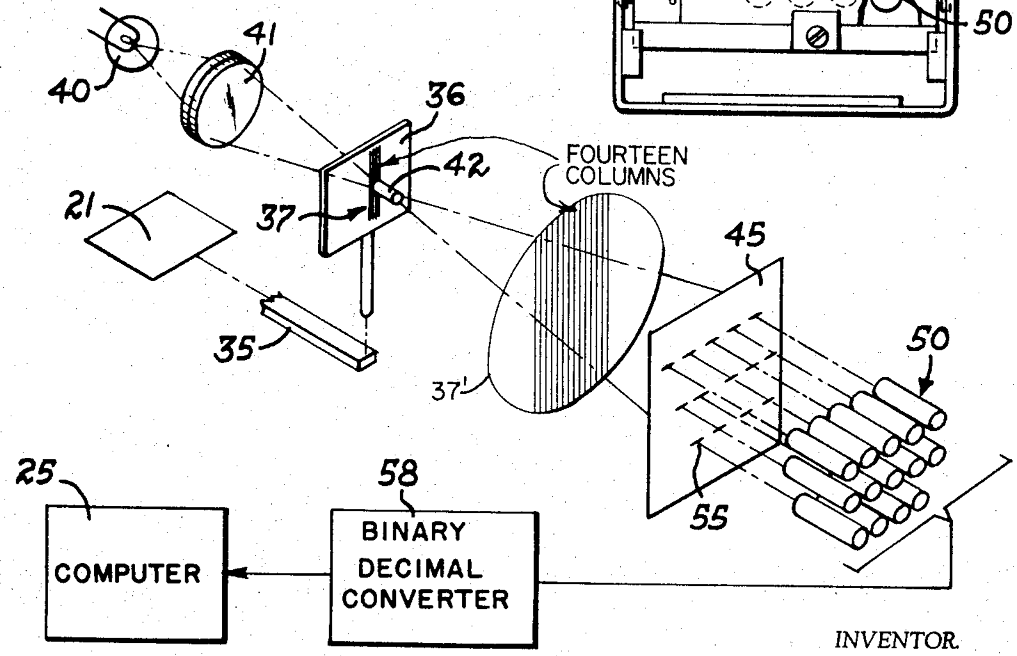

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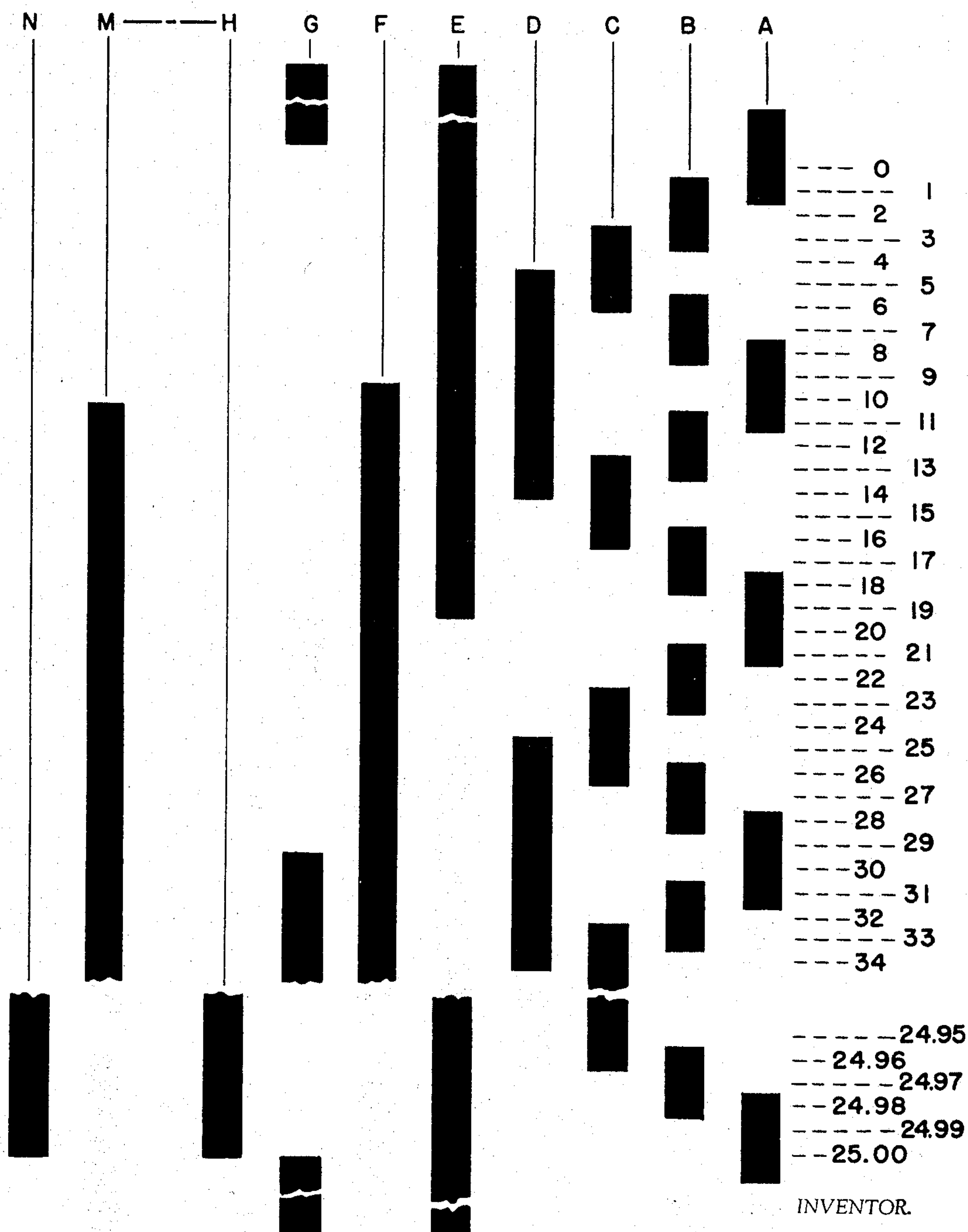
FIG-4



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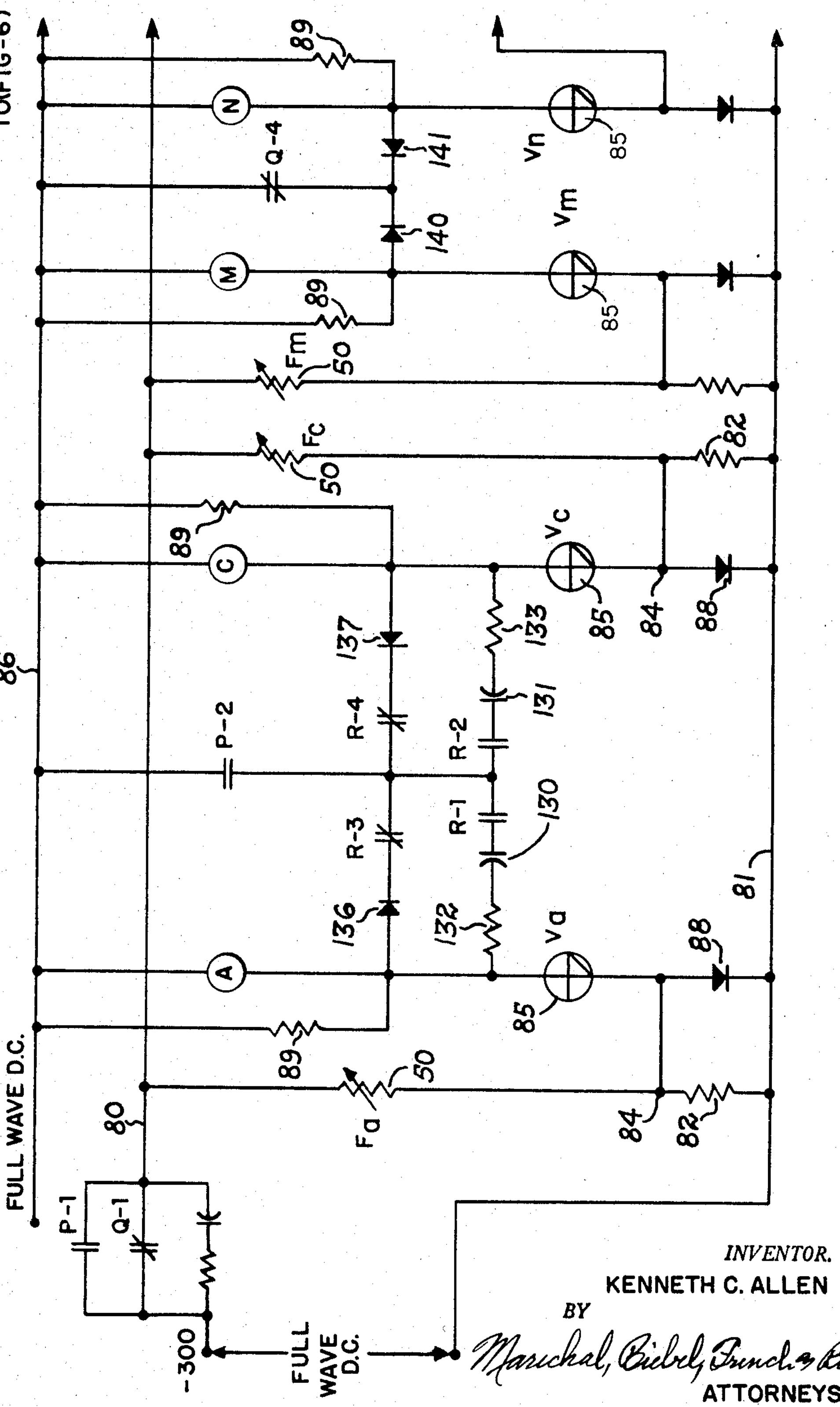

FIG-5

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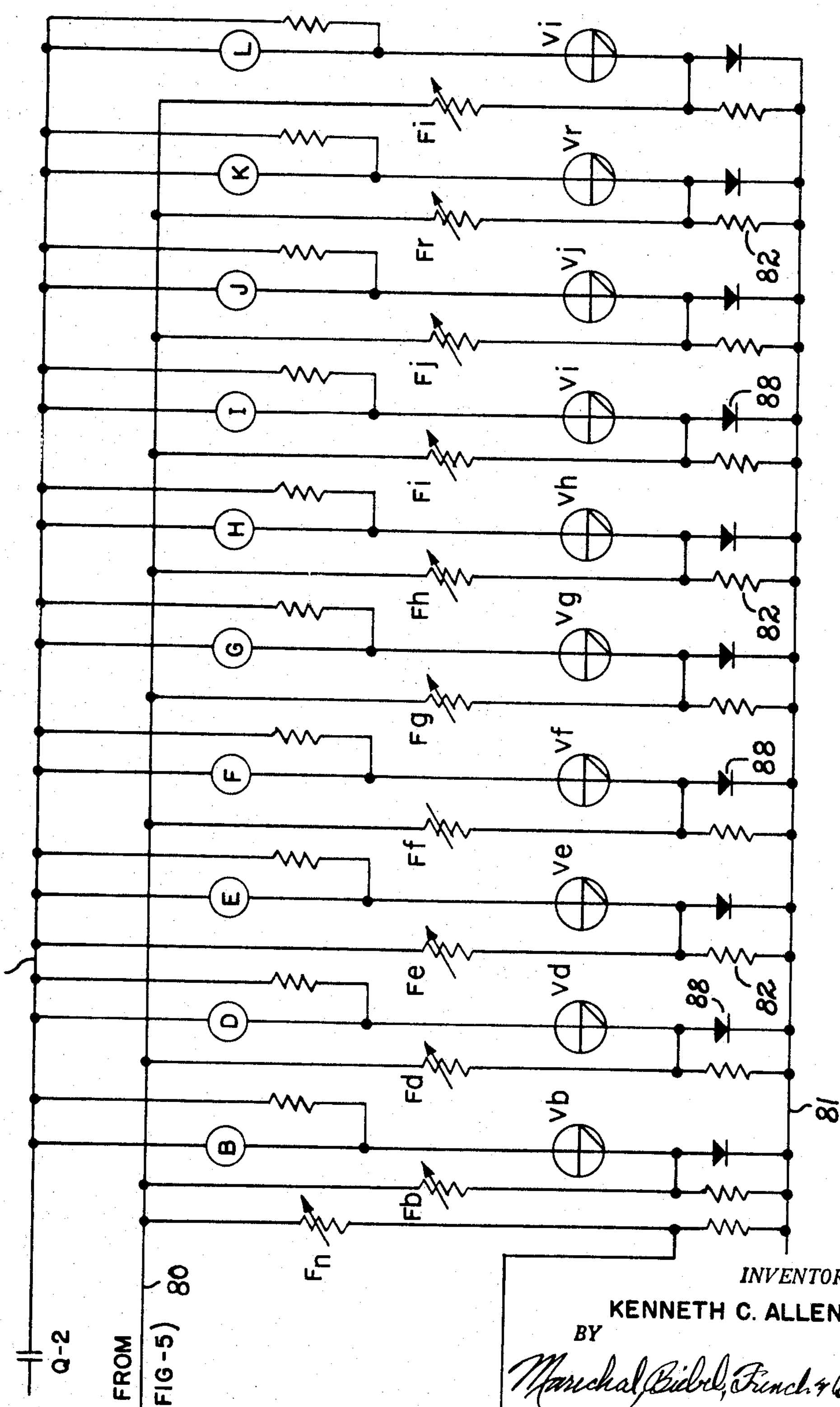

FIG-6

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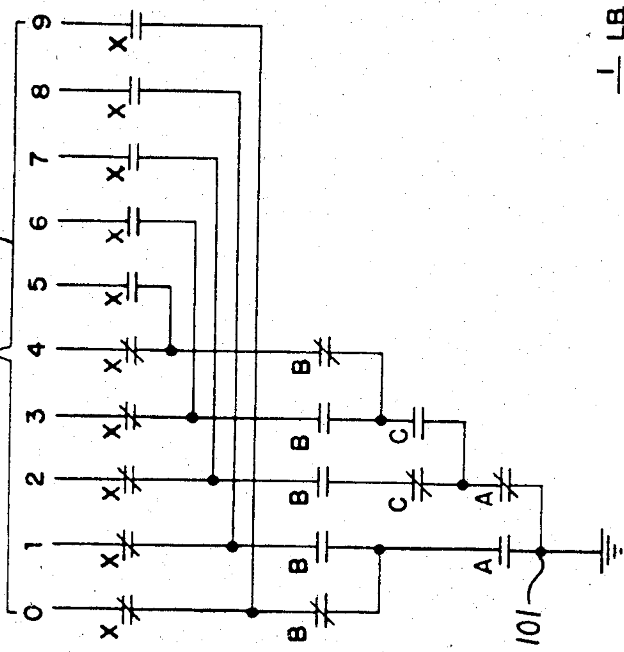

FIG-8

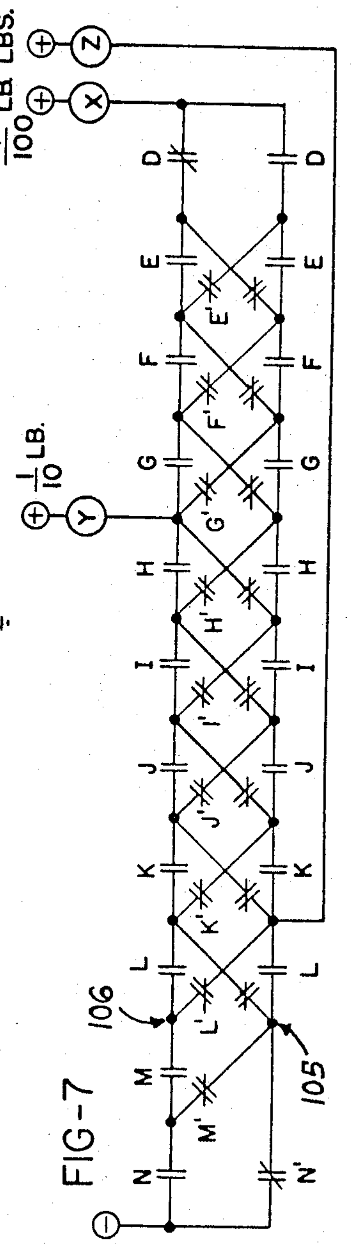

FIG-7

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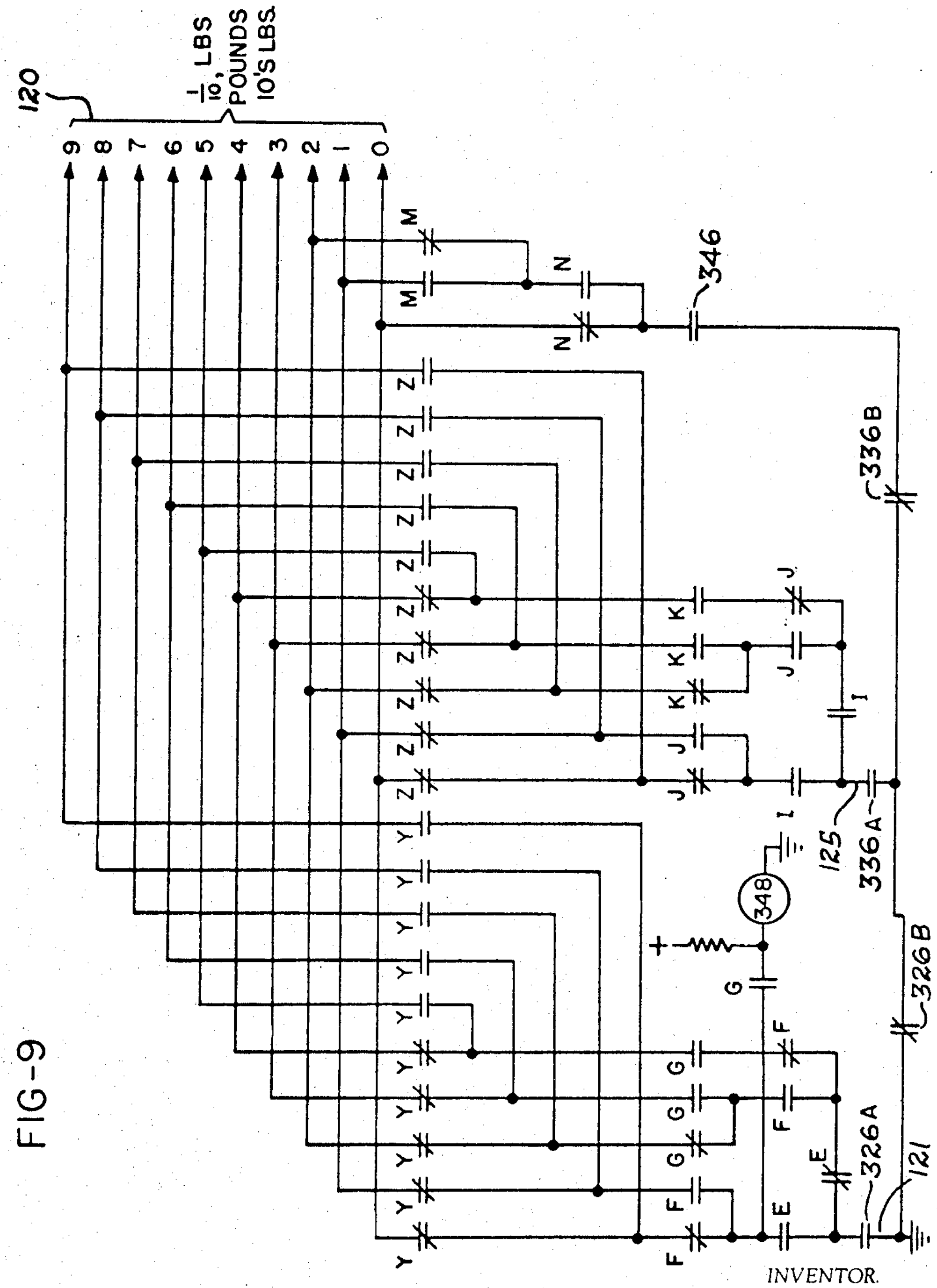

FIG-9

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FIG-10

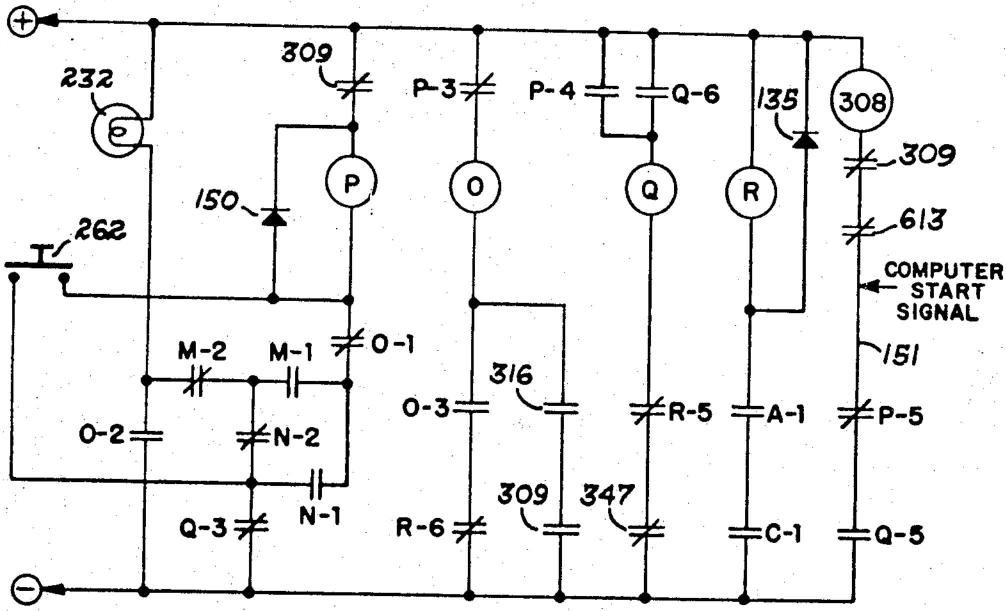
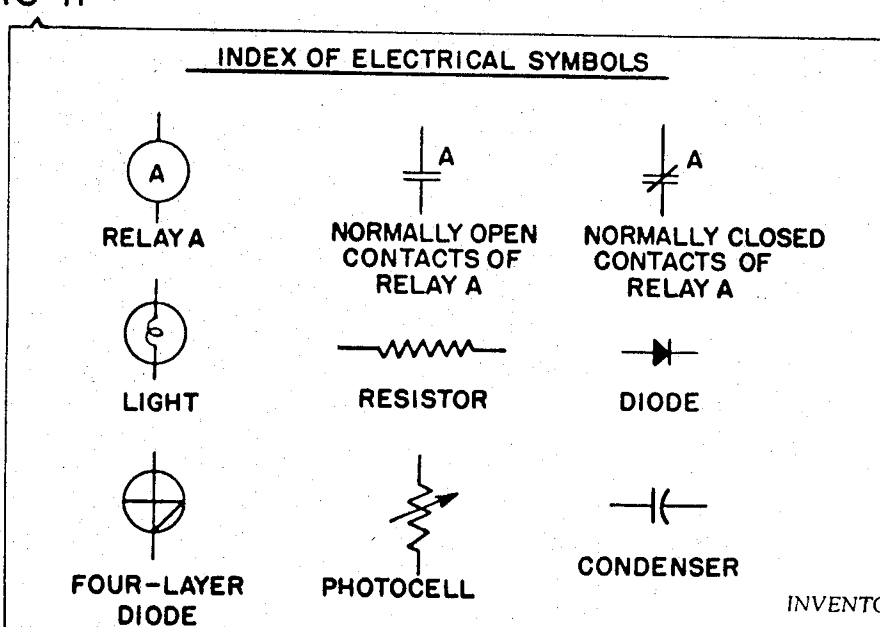


FIG-11



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United States Patent Office

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AUTOMATIC PRINTING PRICE SCALE WITH PHOTOELECTRIC ENCODER INCLUDING RANGE AND MOTION DETECTORS

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Continuation-in-part of application Ser. No. 220,765, Aug. 31, 1962. This application Oct. 15, 1963, Ser. No. 316,290

Int. Cl. G01g *23/28*

U.S. Cl. 177—3 **13 Claims**

ABSTRACT OF THE DISCLOSURE

An automatic weighing scale comprising photoelectric digital encoding means and computing means with print-out means for computing the price of a commodity and issuing a printed ticket. The price is based upon the weight of the commodity multiplied by the price per unit of weight. The digital encoding means comprises a chart bearing a pattern of translucent and opaque binary markings. Weight magnitudes are converted into binary electrical signals by photoelectric transducers clustered in the path of light projected through the chart and through a slitted mask. Certain of said same photoelectric transducers are also utilized in an out-of-range control system and in a motion detection system, both of which systems act to prevent the automatic operation of the overall system unless proper conditions obtain.

This application is a continuation-in-part of my application Ser. No. 220,765, filed Aug. 31, 1962.

This invention relates to weighing scales for automatic weighing and computing scale systems.

The invention more particularly relates to a weighing scale including a weight readout system which provides an electrical digital signal corresponding to the weight of an article placed on a platter. The weight signal which is formed is such that it may then be combined with the cost per unit weight of the commodity weighed in a computer to produce a value of the article, and a ticket printed and issued of such values.

The scale of this invention provides rapid analogue to digital conversion and is read out by the employment of photoelectric transducers which are arranged to respond to a projected portion of a movable chart carried by the scale balance mechanism. The weight represented by different chart positions is encoded on the chart in a pattern of translucent and opaque binary markings which control the energization of the transducers.

One of the principal problems in reading out any continuous encoded indicating device concerns the necessity for making distinctions between adjacent numbers, such as between 19.99 and 20.00. As the scale moves from the lower number to the higher number, or vice versa, four digits in the above example must change simultaneously. If the device responding to the encoded chart responds to less than four of the digit changes in this example, an error results.

This difficulty is eliminated in this invention by the employment on the chart of a pattern formed in a cyclic binary code which represents a range of weight. This code is read along paths or columns of binary markings by transducers after the platter has come to rest with a weight thereon falling within the weight range of the scale.

The binary code of the chart is preferably cyclic in form representing decimal equivalents. The code of this invention is a special derivation of Gray's reflected code. However, the cycle variation is based on five rather than ten, and from this a binary-cyclic-biquinary code has been derived. A principal feature of this code is that only one bit of information changes with any incremental change in weight. The readout system of this invention provides an output which is compatible with the computer described and claimed in applicant's United States Patent No. 3,045,229, assigned to the same assignee as this invention.

The mechanical portion of the weighing mechanism of the scale may be constructed according to the projecting scale shown in the United States patent to Meeker et al., 2,723,113, assigned to the same assignee as this application, wherein a chart is supported for movement according to the weight on the platter. In this invention a lens system projects an enlarged image of the encoded chart onto a mask positioned adjacent the transducers. Apparatus may also be employed to project an image of the weight in arabic numerals for viewing by the operator.

The digital readout portion of this invention includes switches or relays which are operated according to the illumination of selected ones of the transducers. The transducers are preferably photocells which undergo a decrease in resistance upon the incidence of light. The circuits further include a motion detector for signaling when the scale has come to rest with a load on the platter. The balance position of the chart is read and stored in the readout circuits with such speed that there is no need to lock the scale at balance. The transducers are made insensitive to any further movement of the scale following the readout of the chart to prevent the possible input of erroneous information.

Provision is also included for preventing automatic computer operation when there is less than a predetermined minimum weight on the scale platter. Another circuit senses a balance position of the scale and chart either above or below a given range of weights for the system and prevents an automatic start under such conditions. A nonrepeat circuit assures that only one weighing and readout cycle occurs for each separate weighing operation.

The readout circuits of this invention provide direct conversion from the binary-cyclic-biquinary code into the corresponding decimal equivalent representing the weight of an article placed on the scale platter. This results in the simplification and increased reliability of the weight readout circuit.

It is therefore a principal object of this invention to provide a weighing scale as outlined above incorporating apparatus for the digital readout into decimal equivalents of a weight represented by a binary cyclic code.

A further important object of this invention is to provide a weighing scale as outlined above having a cyclic digital system with direct decimal readout employment in a value computer.

Another object of this invention is the provision of a weighing scale as outlined above characterized by a minimum of moving mechanical components and the elimination of the motors, scanners, mechanical readout switches, the platter switch, and the like.

A still further object of this invention is the provision of an electrical digital readout weighing scale characterized by high speed.

A still further object of this invention is the provision of an automatic weighing scale as outlined above which reads out weight information sufficiently fast so that there is no need for any separate provision for holding or locking the scale to prevent error due to motion during readout.

Another object of this invention is the provision of a load sensing circuit operating by means of a signal from the binary code on a chart to sense when more than a minimum weight is on the scale platter and prevent automatic operation with less than such minimum weight.

A further object of this invention is the provision of an error interlocking operating through the code on the chart to prevent automatic operation when the scale is at balance below zero or above a predetermined weight.

Another object of this invention is the provision of an automatic weighing scale utilizing a binary-cyclic-biquinary encoded counting or weight indicating and translating system.

Further objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

In the drawings—

FIG. 1 is a perspective view of a computing scale system which may have a scale made according to this invention;

FIG. 2 is a diagrammatic view of a portion of the weighing scale of the invention;

FIG. 3 is an elevational view of the photocell block and mask;

FIG. 4 is a fragmentary view of a portion of the binary code of this invention;

FIGS. 5 and 6 together form the photocell and relay circuits for each of the rows or columns of binary markings on the chart;

FIG. 7 is a circuit diagram showing the ladder arrangement of the relay contacts for determining the "evenness" or "oddness" of a translated true number and for operating a complements indicating relay accordingly;

FIGS. 8 and 9 are wiring diagrams of the output contacts of the read out relays and complements indicating relays providing direct decimal indications of weight;

FIG. 10 is a wiring diagram of some of the control circuits of this invention; and

FIG. 11 illustrates the electrical symbols employed in FIGS. 7–10.

Referring to the figures of the drawings which illustrate a preferred embodiment of the invention, an automatic computing scale system is shown in FIG. 1 as including a weighing scale **20** having a scale platform **21**. The scale **20** is shown as including a window **22** for reading the weight, and the usual tare adjustment **24**.

The computer **25** is shown as mounted adjacent the scale **20** and receives the weight information from the scale for combining with a price per unit of weight to compute the value of a weighed article. The computer is preferably constructed according to the teachings of the United States patent to Allen, No. 3,045,229 of July 17, 1962, which will be referred to herein as the Allen computer patent. A series of price input knobs **26**, **27** and **28** are mounted on a printer **30** and provide the means by which the unit price may be set into the computer **25**. The printer **30** may be constructed according to the teachings of the United States patents to Allen, No. 2,948,465, and to Allen et al., No. 2,948,466, and operates to print and issue a label showing the unit price, weight and computed value.

The mechanical weighing mechanism of the scale **20** may be constructed according to the teachings of United States patent to Meeker et al., 2,723,113, assigned to the same assignee as this application. Referring to the diagram of FIG. 2, it will be seen that the scale **20** includes the usual lever **35** connected for movement with the platter **21**. An optical chart **36** is supported for unidirectional movement in a vertical plane by the lever **35** according to the balance position of the scale platform **21**. Weight information, i.e., a range of weights, is encoded on the chart **36** into closely spaced rows **37** of binary marks shown with exaggerated spacing in FIG. 2 and comprising patterns of alternating opaque and transparent areas. As described hereinafter, there are fourteen rows or columns **37** employed in the illustrated embodiment of the invention, and the chart **36** forms a part of an optical projection system shown as including a fixed projection lamp **40** and a lens **41** to concentrate the light of the lamp filament on the chart **36**. A projection lens **42** projects an enlarged image **37'** of a small vertical extent of the chart rows **37** onto the surface of a photocell mask **45**, and in each balance position of the scale, the transparent and opaque portions of the columns **37** form a unique pattern indicative of the corresponding particular weight.

The invention includes photoelectric means for reading out the portion of a code on the chart **36** corresponding to the weight on the platter, consisting of a plurality of photocells **50**, one for each of the rows **37**. Each photocell **50** is positioned immediately behind a slit **55** in the mask **45**. However, for the purpose of illustration, the photocells **50** are shown in FIG. 2 as being spaced away from the mask. The photocells **50** undergo a decrease in resistance with light falling on the photocell window, to operate as current gates or valves. A particularly useful photocell for this purpose is designated type CL 604, manufactured by Clairex Corporation, 19 W. Twenty-Sixth St., New York 10, N.Y.

The photocells **50** are retained in a cell block **52**, as shown in FIG. 3. There are provided as many of the cells **50** as there are rows of binary information on the chart **36**, and in this embodiment, fourteen photocells are employed. In order to conserve space within the optical system, and to position the cells **50** as closely to the center of the optical axis as practicable, the photocells are arranged in clustered relation as shown, with five in each of two rows and four in the third row, with each of the cells **50** being spaced laterally from the adjacent cells and from the cells in the adjacent rows.

The mask **45** is secured to the front face of the cell block **52** and includes image-defining openings or slits **55**, one for each of the photocells **50**. The slits **55** may be approximately ten thousandths of an inch wide and are accurately positioned in relation to the rows **37** of the projected image of the chart **36**, as indicated by the representation of the projected image **37'** of the columns **37** in FIG. 2 and as also shown in FIG. 3. Accordingly, the relative positions of each of the rows on the chart **36** are staggered vertically in order to conform to the position of the slits **55** on the mask **45**. Preferably, to provide tolerance in the physical alignment in positioning of the photocells, the effective width of the slits is smaller than the smallest division of the projected image of the code formed on the chart **36** and accurately aligned with respect to the projected image. The slits **55** obviate the necessity for accurate positioning of the photocells with respect to the projected pattern, and since each slit is smaller in effective area than the smallest division of the projected pattern, it restricts the chart image which is projected onto its associated photocell to a small and clearly defined portion of the projected image.

The cell block **52** may be provided with heater means for maintaining a constant temperature of the photocells **50** in order to eliminate the effects of drift due to variations in temperature. For this purpose, a low wattage heater **56** may be attached to one surface of the cell block **52** for the purpose of maintaining the photocells **50** at such a constant temperature.

The output of the photocells **50** is applied to circuits for converting the binary coded information into its decimal equivalents, as represented by the block **58** in FIG. 2, and as shown in FIGS. 5–10. The binary equivalent of the weight to the closest one hundredth of a pound is then applied to the computer **25**.

The code

In the patent to Gray, 2,632,058 of 1953, there is described a cyclic or reflected binary counting system wherein one can count to infinity by changing only one bit of information for each numerical change in the common decimal system. An example of this system is shown in Table I, wherein there is a column of decimal numbers on the left and a column of cyclic decimal numbers on the right. It will be noted from an examination of Table I that as one moves from 9 to 10 in the decimal system, the cyclic decimal changes from 9 to 19 and counts downwardly to the cyclic decimal 10, which, in turn, corresponds to 19 in the decimal system. In changing from 19 to 20 in the decimal system, both digits must be switched. But, in the corresponding change in the cyclic system, the digits change from 10 to 20 and only one digit is switched, that of a 1 to a 2 in the second column. Obviously, such a counting system can be extended indefinitely.

The rule for translating cyclic decimals into natural decimals can be stated as follows: Examining the cyclic decimal columns, the farthest left number is always a correct decimal number. If this number is even, the succeeding number to the right is also a correct decimal number. However, if the farthest left number is odd, then the 9's complement of the succeeding number must be used. The correct meaning of the third digit from the left is determined in the same manner, depending upon whether or not the translated true decimal number of the previous digit is odd or even. Thus, the use of the natural number or its 9's complement is dependent upon the oddness or the evenness of the translated true number that appears to its left.

The cyclic biquinary numbering system shown in Table II, has been derived from the above system. Here, a pair of digits are employed to represent a single decimal number wherein the digits 0 to 4 are used in the lower order of the pair and a 0 or a 1 in the higher order of the pair. The occurrence of a 0 or 1 in the higher order of the pair directs whether the lower order represents a true number or whether it represents the 9's complement.

The significance of the 0 or the 1 in the higher order of the pair of numbers is dependent upon whether the translated true number of the next higher order pair of digits is odd or even. If the next higher decimal number is even, the 0 directs the use of the significant number and the 1 directs the use of its 9's complement. The meaning of 0 or 1 is reversed if the higher order translated true number is odd. For example, in Table II, the cyclic biquinary number 13 dictates that the true decimal number is 6, the 9's complement of 3. In this example, the higher order decimal is an "even" 0 so that the 1 in the second column directs the use of the 9's complement of 3. By contrast, the cyclic biquinary number 01 13 calls first for a true decimal 1 in the higher order. This being odd, the significance of the 1 in the lower order pair is reversed and the true decimal number is therefore 13. Table II shows additional examples of this system of counting.

Table III represents the cyclic biquinary code of Table II in binary form. In Table III, four columns or rows of binary indications are employed to indicate a single decimal column. The first three rows of each grouping of four rows represent whole decimal numbers of 0 through 4, and the fourth row indicates whether or not the 9's complement of the number represented by the first three rows is intended.

The arrangement of binary indications representing 0 through 4 may take any one of several forms, but once this is determined, it is maintained uniformly throughout the counting system. In Table III, the numeral 1 is employed to indicate the occurrence or presence of a binary indication or digit, and the 0 is used to indicate the absence of a binary indication. Preferably, some form of indication is employed to represent a true zero rather than the lack of indication as is commonly employed in binary systems. Therefore, 0001 represents the whole decimal number of 0 in each of the groups of rows or columns.

A further examination of Table III shows that the reflective repetition of the binary indications in the first three rows occurs in five digit increments. In other words, one counts from 0 to 4 in the first three columns, and then a 1 indication is added to the fourth or complements indicating column while the binary indications of 5 through 9 represent a "reflection" or reversal of the indications of 0 through 4.

The preferred embodiment of this invention consists of an automatic weighing scale which is particularly adapted for use as the automatic weighing scale in a computing scale system such as described and claimed in the above Allen computer patent. In this patent there is described a scale system having a maximum weighing capacity of 24.99 pounds. Thus, the scale described herein uses three groups of four columns of binary markings which represent respectively the hundredths of pounds, tenths of pounds, and pounds of weight on the scale platter. Only two binary rows are required to represent the tens of pounds since this will either be 0, 1 or 2 for a scale of the given capacity of 25.00 pounds. In Table III, fourteen columns of binary indications are employed to count to 25.00 (which are, in fact, sufficient to count to 29.99) by changing only one binary indication for each successive change in digital value of the weight.

The A through N indicated in Table II above the several columns designate these columns and also designate relays A through N which are individually operated in accordance with the binary indication at any particular balance position within the columns. An examination of Table III indicates that particular groups of the relays A through N will be operated for each decimal position. The tabulation shown in Table IV illustrates the operation of the relays A, B, C and the complements indicator D in the column through the digits 0–9.

TABLE I

Decimal:	Cyclic decimal
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	19
11	18
12	17
13	16
14	15
15	14
16	13
17	12
18	11
19	10
20	20

TABLE II

Decmal:	Cyclic biquinary
0	00 00
1	00 01
2	00 02
3	00 03
4	00 04
5	00 14
6	00 13
7	00 12
8	00 11
9	00 10
10	01 10
11	01 11
12	01 12
13	01 13
14	01 14

TABLE II—Continued

Decimal:	Cyclic biquinary
15	01 04
16	01 03
17	01 02
18	01 01
19	01 00
20	02 00

TABLE III.—BINARY-CYCLIC-BIQUINARY

	NM	LKJI	HGFE	DCBA
0	01	0001	0001	0001
1	01	0001	0001	0011
2	01	0001	0001	0010
3	01	0001	0001	0110
4	01	0001	0001	0100
5	01	0001	0001	1100
6	01	0001	0001	1110
7	01	0001	0001	1010
8	01	0001	0001	1011
9	01	0001	0001	1001
10	01	0001	0011	1001
11	01	0001	0011	1011
12	01	0001	0011	1010
13	01	0001	0011	1110
14	01	0001	0011	1100
15	01	0001	0011	0100
16	01	0001	0011	0110
17	01	0001	0011	0010
18	01	0001	0011	0011
19	01	0001	0011	0001
20	01	0001	0010	0001

TABLE IV

0=A
1=AB
2=B
3=BC
4=C
5=CD
6=BCD
7=BD
8=ABD
9=AD

The above-described cyclic biquinary code is applied in binary form to the chart **36** in fourteen vertically arranged columns A through N. A fragment of columns A through D on chart **36** is illustrated in FIG. 4, beginning at zero pounds and extending through twenty-eight hundreths of a pound (0.28 pound in one hundredths of a pound increments. The dark binary indications of the code as shown in FIG. 4 are actually formed on the chart as clear or transparent areas wherein light is permitted to fall on the photocells thus effecting a decrease in the resistance, signalling the coincidence of the associated slit **55** with the projected image of the chart at one of the "1" binary indications. The "0" binary bits comprise the opaque areas on the chart **36**.

The physical arrangement of the rows A through N of binary indications may be varied on the chart **36** within wide limits, as long as the associated photocell **50** and slit **55** reading the particular column are correspondingly located to receive the projected image of the particular column which it is to scan. Thus, the columns A–N may be formed concentrically on a disk, or wrapped about a drum. Preferably, they are arranged linearly side-by-side in a plane on a photographic plate. The binary indications of the columns are stagged vertically one in relation to another to correspond to the physical placement or grouping of the corresponding cells **50** within the block **52**, but for convenience of understanding the principles of the invention, they are represented in FIG. 4 as if the fourteen photocells were all arranged in alphabetical order and in a single horizontal line.

Referring to FIG. 4, the A column comprises dark areas each having a vertical extent of four units and spaced six units apart, and since as already noted, these dark areas represent transparent portions of the chart, it follows that light will be transmitted to the A photocell only when the digit in the hundredths of a pound column is 8, 9, 0 or 1.

The C column is identical with the A column except that it is displaced with respect thereto so that light falls on the C photocell only when the digit in the hundredths column is 3, 4, 5 or 6. The B column contains sections of dark areas each three units in vertical extent and spaced two units apart, while the D column comprises alternating light and dark units each of a vertical extent of ten units.

The four columns E, F, G and H are similar to the columns A, B, C and D respectively except that the light and dark areas therein are each ten times the vertical extent of the corresponding column for the hundredths of a pound digits because they represent the next higher decimal order. It will also be noted that the E and G columns include dark areas extending below zero and above the indicated capacity of 25.00 pounds, so that the E and G photocells both receive light whenever the balance position of the scale is below zero or above 25 pounds, for a reason pointed out hereinafter. It will be apparent that the I, J, K and L columns are also similar to the columns A, B, C and D, respectively, but have the light and dark area therein each one hundred times the vertical extent of the corresponding A, B, C or D column. The M and N columns correspond in relative arrangement to the A and B columns, but each area therein is one thousand times the vertical extent of the corresponding area in the A or B column, with the exception that the dark area of the M column is removed below .11 pound for a reason pointed out hereinafter.

Chart reading and converting circuits

In the following description, reference may be had first to FIGS. 5 and 6 of the electrical wiring diagram wherein respective photocells **50** associated with the code columns A through N are shown in conjunction with their associated relays A through N. In the following description, the photocells **50** are designated individually as F_a, F_b, F_c, et cetera, according to the binary column A, B or C with which they are associated. Similarly, the relays controlled by the photocells are correspondingly designated as relays A, B and C, et cetera.

Each of the photocells **50** is connected to a common power lead **80** which has applied thereto, through either normally open contacts **P–1** or normally closed contacts **Q–1** of control relays P or Q, a negative full wave rectified and unfiltered DC voltage which may be in the order of −300 volts. The photocells are each similarly connected to a common return lead **81** through load resistors **82**. Accordingly, when one of the photocells F_a–F_n, at the balance position of the weighing mechanism, is coincident with a projected binary marking on the chart **36**, the impedence of the photocell may drop in the order of 5:1, such as from .5 megohm to .1 megohm, thereby developing a more negative voltage at the junction **84** between the photocell **50** and the load resistor **82**.

Relay operating means for the relays A–N may include thyratron tubes which are grid controlled by the photocells, but preferably include four-layer diodes **85** which are identified by the identifications V_a–V_n, in conformance with the above-established notations. The four-layer diodes may be of the Shockley type 4E–200 which have the characteristic of thyratrons in that a negative pulse at the base of the diode will set the diode into a state of conduction, and it will continue to conduct until the voltage is removed from the anode.

It will be seen from an examination of FIGS. 5 and 6 that the four-layer diodes **85** are connected in series with the associated relays A–N between a lead **86** and the common lead **81**. A full wave unfiltered DC voltage for operating the relays A–N is applied to the lead **86**, and may be in the order of 24 volts. It will also be noted that a conventional diode **88** extends between the junction of the cathode of the four-layer diodes **85** and the load resistor **82** to ground, for each of the circuits associated with the photocells F_a through F_n. The diodes **88** provide a low impedence conducting path for the four-layer diodes **85** while blocking the dissipation of the load signal effected by the photocells **50**. Additionally, each of the relays A through N is provided with a resistor **89** connected effectively in parallel with the relay coil between the line **86** carrying the power for the relays, and the junction of each relay and its diode **85**. The purpose of the resistors **89** is to provide an instantaneous current for the four-layer diodes V_a–V_n in order to hold the diodes conducting while the current is building in the associated relay coils.

The circuit components described above apply to each of the circuits for reading out the columns A–N. In addition, the circuits associated with the photocells F_a, F_c and F_m, F_n are provided with additional components since these photocells are also used as motion detectors and weight presence indicators, and their functions will be described in greater detail below.

The contacts of the relays A–N are combined with those of three complements indicating relays X, Y and Z as shown in FIGS. 7, 8 and 9 to provide direct binary to decimal readout circuit means for the binary code on the chart **36**. Referring to FIG. 8, it will be seen that the contacts of relays A, B and C are arranged in a matrix to apply a ground signal selectively to the digits 0–4 in the one-hundredths of a pound leads indicated generally at **100**. The 9's complements are applied through normally open contacts of the complement relay X.

Referring to FIG. 8 and comparing the circuit with the relay operating sequence shown in Table IV, if a zero in the one-hundredths of a pound column is indicated, then only relay A is operated by photocell F_a, thus closing a line through a pair of normally closed contacts of the relay B to the zero lead. If the numeral "1" is indicated in this column, then both relays A and B are operated according to the code, resulting in the application of ground to the number "1" lead, through front contacts of relays A and B. The circuit may easily be traced for the numerals 2, 3 and 4 according to the schedule of operation for the relays as shown in Table IV.

For the numerals 5, 6, 7, 8 and 9, the complements relay X is operated by the circuit shown in FIG. 7. Thus, in order to indicate a 5 in the one-hundredths of a pound column $(C+D)$, a ground is applied to the number **5** terminal through a closed contact of the complements indicator relay X and a closed contact of relay C. The circuits may easily be traced for the numerals 6, 7, 8 and 9 as outlined in Table IV.

The complements indicator relays X, Y and Z, respectively, representing the complements of the hundedths of a pound, tenths of pound and pounds, are operated by a signal applied through the ladder circuit of FIG. 7. This circuit electrically determines the "evenness" or "oddness" of the preceding translated binary number and determines whether the significant number or the 9's complement of the next lower order number is to be used.

The ladder circuit includes both normally open and normally closed contacts of the relays D through N. The arrangement of contacts is not unlike that of an electric circuit where a light is controlled by a plurality of switches. The full complement of M and N relay contacts is not needed since, in this example, the maximum tens of pounds column digit is limited at two. Only a pair of contacts of the D complement indicator relay is needed, since it will control only the X complement relay for the hundredths of pound column. Also, no contacts of the A, B or C relays are needed, since these represent the lowest order and cannot have any effect upon any further complements. Otherwise, for each of the relays E through L, two normally open relay contacts are cross connected by two normally closed contacts of the same relay so that a ground signal will be applied on one side of the ladder or carried across to the opposite side depending upon whether any particular relay D through N is operated or open.

The complements relay Z for the pounds column is connected with the ladder for operation just below the indicator relay L for the pounds column. The complements relay Y for the tenths of pounds column is connected just below the H indicator relay in the tenths of pound column. The complements relay X for the hundredths of pounds column is connected at the bottom of the ladder just below the indicator relay D.

An examination of the circuit of FIG. 7 will reveal that the complements indicating relay Z for the pounds column will be operated or not operated depending upon whether relays for the tens of pounds columns N and M are operating, and whether the indicator relay L for the pounds column is operated. The connection of these relay contacts is such that any one of them can direct whether the relay Z is operated or not. In further explanation, if the highest order number (10's of pounds) is an even number, then it is either a zero or a 2, the output or the ground is applied by the ladder at position **105** in FIG. 7, through the normally closed contact N. Now, if relay L is not energized, the next lower order number is a true one and the complements indicator relay Z would not be energized.

If on the other hand, the highest order number is an odd number, then a ground is applied at position **106** on the ladder. The higher order number being an odd number indicates that the 9's complement of the lower order number must be used, and the complements relay Z is operated. If relay L is operated and the highest order number is an even number, relay Z is operated. But, if relay L is operated and the highest order number is an odd number then, according to the rule for translating the cyclic code, the two odds make an even and the complements relay ZZ will not be operated since the number indicated by the relay I, J and K would then be a true number.

The same description applies to the operation of the complements indicating relays Y and X. In this manner, the evenness or oddness of the preceding higher order number is determined, and it directs whether the 9's complement below is used depending upon whether the indicator relay (D, H, or L, depending on the column) for the particular column is operated or not operated.

FIG. 9 shows the additional contact connections for indicating the tenths of a pound, pounds, and tens of pounds of weight and for application of a weighting scale computer. The circuits of FIGS. 8 and 9 are particularly adapted for use with the computer of the Allen computer patent. In this patent, the computer includes a programmer for selecting, in sequence, the hundredths of a pound, tenths of a pound, pounds and tens of pounds stored weight information. The outputs **100** in FIG. 8 correspond to, and be electrically connected to, the contacts **185** in FIG. 16 of the Allen computer patent. The wiper **190** of that patent would not be used, but the ground common lead **101** of the hundredths of a pound contacts corresponds to that wiper. The combined output leads **120** of FIG. 9, which are sequentially applied to the tenths of pounds, pounds and tens of pounds circuits, correspond to, and may be electrically connected to, the fixed contacts **205** in FIG. 17 of the Allen computer patent.

A relay **316** in the Allen computer patent is operated to apply the information stored in the matrix corresponding to the closed contacts of the relays A, B, C or X to the Allen computer patent's weight storage relay **310–315** for hundredths of a pound. When one of these relays is operated, indicating that this weight information has been received, the computer relay **316** is released and, in doing so, applies power to the relays **320–325** of the Allen computer patent. Up to this time during the computing cycle, relay **326** has been operated, and thus a ground is supplied through contact **326A** in lead **121** of the tenths of a pound matrix (FIG. 9). The weight information thus stored in the matrix comprising the closed contacts of relays E, F, G and Y is then applied to the computer and stored by the tenth of a pound storage relays **320–325** in the Allen computer patent.

Similarly, when one of these tenth of a pound storage relays has operated, signaling that the weight information has been received, the holding circuit to the relay **326** is broken, and the ground is applied through contact **326B** and closed contact 336A to the lead 125 of the pounds storage matrix. The release of relay 326 also applies power to computer relays 330–335. The input of weight information represented by the matrix of the relay contacts I, J, K and Z is then stored by computer relays 330–335 following which the holding circuit for the relay 336 is broken. This applies the ground through contacts 336B to the tens of pounds matrix. In this manner, the stored weight information of FIGS. 8 and 9 is applied sequentially to the computer for utilization.

In this manner, a computer may receive the directly converted numerical outputs of this invention and use them to combine with unit price for computing the value of the article which has been weighed. It is obvious that the invention is not limited to sequential read out, since all of the closed ones of the contact groups of FIGS. 8 and 9 may be sensed simultaneously and used directly, or the information stored.

Control circuits and operation

In the automatic weighing system of the Allen computer patent, there are provided controls and interlocks which initiate or permit certain automatic operations and prevents or block others under various circumstances. For example, that system included control circuits for indicating that a weight had been placed on the platter, and that the scale had come to balance, and the system of this invention also includes weight detecting means which must be operated, or be bypassed manually in order to initiate the automatic scale and computer operation. The weight detecting circuit in the Allen computer patent included a platter switch, namely the switch 55, but in the apparatus of this invention, a signal is taken or generated from the chart itself to indicate that more than a small weight is on the platter, such as one tenth of a pound or more. Provision is also included for manually overriding the weight detecting means so that weighing, computing and printing operation may be completed when the weight is less than the small predetermined weight, such as less than one tenth of a pound, and the circuits for accomplishing this result include the relays in the M and N columns (tens of pounds), as now explained.

The binary code from zero to two in the tens of pounds column is as follows: $0=M$, $1=MN$ and $2=N$. However, zero is also equal to "no M," and a small portion of the M column on chart 36 adjacent zero is accordingly removed for a distance corresponding to approximately the first one tenth of a pound, so that zero to .10 pound in the M and N column gives no output or signal to the photocells. This causes M to come in only above a tenth of a pound, and thus a signal in either the M column or the N column will indicate that a weight is on the scale in excess of .10 pound. The control circuit for the readout includes the start relay P, and as shown in FIG. 10 this circuit includes a pair of normally open contacts M–1 and N–1 of the N and M relays connected in parallel so that either one of these contacts can operate relay P through a normally closed contact Q–3 of the power control relay Q and a closed contact O–1 of the nonrepeat relay O. If neither of relays M or N is operated, this indicates that there is less than a minimum weight on the scale, and relay P does not operate.

The balance or scale motion detecting circuit may be as described and claimed in the copending application of Allen, Ser. No. 220,765, filed Aug. 31, 1962, and assigned to the same assignee as this invention. In that application, there is described a portion of the circuit including the relays A and C employed as motion sensors or detectors. Only so much of the motion sensing control circuits is described herein as necessary to an understanding of the operation of this portion of the control circuit.

Referring to FIG. 4, it will be seen that two of the columns of binary marking, A and C, have markings which do not mutually coincide. The motion detection circuit uses a portion of the photocell readout circuit of relays A and C during scale movement, and includes a circuit for sensing the dropout of either relay A or C for signaling that the platter has come to rest. Since the binary markings of columns A and C are mutually exclusive in the sense that relays A or C will never be operated simultaneously at any balance position of the scale, then it follows that when either of relays A or C is released following a delayed dropout, the scale is at balance, regardless of the state of the other relay. A feature of this arrangement, which is described and claimed in the application Ser. No. 220,765, is that the photocell motion detecting circuit, using two photocells, is not adversely affected by small vibrations, since the arrangements of the photocells and the binary markings are such that at any balance position, at least one of the photocells A or C will be at a steady state condition.

In the following description of an operating cycle, it is assumed that the scale and readout system are connected as noted above with the computing and printing circuits of the Allen patent. In addition to the relay contacts already listed which are identified by the same reference characters as in that patent, it should be noted that certain of the components shown in FIGS. 9 and 10 similarly correspond to components in the same patent. Thus relay O corresponds to relay NR in the Allen computer patent, and any part bearing a reference character above 200 corresponds to the similarly numbered part in the same patent.

Referring to FIGS. 5, 6 and 10, when the scale is in balance with no load on the platter, relays 308, O, P. Q and R and all of relays A to N will be released, as well as the relays having the contacts 309, 316, 326, 336, 346, 347 and 613, and the signal light 232 will be lighted. When a load is applied to the platter, the chart will begin to move and cause the photocell F_a to operate its associated four-layer diode V_a, causing relay A to close and to be locked in this position for the reason that the inductive currents in photocell F_a are not bypassed in any manner, and these currents hold the four-layer diode operated across the null point of the full-wave unfiltered power supply. Immediately thereafter, relay C will operate and similarly be held by the memory function of its four-layer diode V_c.

The simultaneous operation of relays A and C will now operate relay R. If the weight exceeds .10 lb., then simultaneously with the operation of relays A and C, either or both of relays M and N will operate, and this will cause the operation of relay P and the extinguishing of the ready light 232. The closing of contacts P–2 now establishes a shunt path around relays A and C, and since relay R is already closed, these two relays are shunted by condensers 130 and 131 and their associated current limiting resistors 132 and 133.

As the scale proceeds towards its balance point, photocells F_a and F_c will be alternately operated by the coded chart 36 at slower and slower speeds, and when the balance point is nearly reached, one or both of photocells F_a and F_c will remain unlit. Since contacts P–2 and contacts R–1 and R–2 are now bypassing the inductive currents of relays A and C, these relays are completely under the control of their associated photocells, because the four-layer diodes V_a and V_c will no longer be receiving current during the null period of the DC power supply. Therefore, one of these four-layer diodes will stop conducting, and the associated relay A or C will remain operated only sufficiently long to discharge its associated condenser 130 or 131.

When one of relays A or C does release, this causes the release of relay R, after a very short time delay, duirng which the inductive current of relay R recirculates through diode 135. The resulting opening of the contacts R–1 and R–2 removes the time-delay condenser from the other of relays A and C, thus permitting it to drop out immediately if its associated photocell is not calling for it to be operated. With the release of relay R and the closing of contacts R–3 and R–4, relays A and C are now bypassed by diodes **136** and **137** so that the operation of relays A and C is still under the full control of the associated photocells, due to the continued bypassing of the inductive currents of the relay coils.

The release of relay R closes contacts R–5, and since contacts P–4 are already closed, relay Q will operate and set up its own holding circuit through contacts Q–6. Closing of relay Q will also close its contacts Q–5 as one of the conditions for starting the computer and will open contacts Q–4 and thereby remove the bypass through diodes **140** and **141** from relays M and N, and this will establish the holding conditions for the four-layer diodes V_m and V_n. At the same time, closing of contacts Q–2 will provide power to the relays B and D through line **86**, and the opening of contacts Q–1 will eliminate one of the sources of power for line **80**.

The opening of contacts Q–3 will remove power from relay P, and after a very short period of time, during which the inductive current of relay P recirculates through diode **150**, relay P will release and thereby cut off power through line **80** to the photocells. The release of relay P opens contacts P–2, thus removing the bypass circuits from relays A and C and thereby establishing the memory functions of their associated four-layer diodes V_a and V_c. More specifically, this action renders the system insensitive to any further scale motion, since all of the four-layer diodes were fired or not according to the position of the chart **36**, and those which were fired remain in that condition after power was removed from the photocells. The firing of the four-layer diodes during the short period of concurrent operation of relays P and Q is so fast that there is no need for mechanically locking or holding the weighing mechanism in balance, but the removal of power to the photocells as described, in combination with the self-locking action of the fired four-layer diodes, provides in effect an electronic lock preventing the readout system from responding to further scale motion until the cycle is completed as now described.

The closing of contacts P–5 applies a ground on the computer start line **151** to close relay **308** and thereby to start the readout cycle of the computer, provided the other conditions with respect to relays **309** and **613** of the Allen computer patent are satisfied as described therein. At the start of the computing cycle, the relays having the contacts **309** and **316** in FIG. 10 will close as described in the Allen computer patent. This will operate relay O, which will lock itself in through its contacts O–3, and light **232** will be operated through contacts O–2 to indicate that a new load may now be placed on the scale. Closing of relay **309** will also release relay **308**, and this will in turn close the relays having the contacts **326**, **336**, and **346** as described in the Allen computer patent. At the conclusion of the read out cycle as described in the Allen computer patent, a relay **347** in the computer operates, thus opening the holding circuit to relay Q as shown in FIG. 10. Relay Q releases, and conditions are now identical with those which existed at the start of this description with the exception that relay O has been operated, and this prevents any further computer operation through the opening of contacts O–1 which prevent any operation of relay P.

As soon as the load is changed after operation of light **232**, relays A and C will close in the manner previously described and cause the operation of relay R, which in turn will cause the release of relay O. When the scale arrives at a new balance point in the weighing range above .10 pound, a new cycle of readout will take place, initiated as already described by closing of relays R and P, provided the cycle for the previous load has been completed and the label has been removed as indicated by closure of the relay contacts **309** and **613** respectively. If, on the other hand, the scale has come to balance at the zero point, a second operation would not take place because with neither of relays M nor N operated, relay P could

not be operated. Under these conditions, signal light **232** will be lighted through contacts Q–3, N–2 and M–2.

Provision is made for causing the computer to function in the low weight range of .10 pound or less, or when relay O has not been operated by movement of the scale, as at zero or to print duplicate labels without removing the load from the scale. In such cases, neither of relays M and N is operated, or relay O is not released, and there is therefore no energizing circuit available for relay P. A manual switching **262** is accordingly connected in the circuit as shown in FIG. 10 to bypass the M, N and O contacts and thereby to provide for manual closing of relay P. This will initiate operation of the complete cycle as already described following the closing of relay P.

The scale further includes means for automatically sensing if the scale mechanism is in a position less than zero, or if the mechanism is in a position which exceeds the weighing capacity of the scale. Referring to Table IV, it will be seen that relays E and G are never operated simultaneously in accordance with the code. Therefore, the chart is formed arbitrarily below zero, and above a maximum weight (such as above 25 pounds) in such a manner that E and G are caused to operate together, as already noted in connection with FIG. 4. Thus, a weight of −00.01 provides a signal of A, E̲, G̲, I. A weight of 25.01 pound arbitrarily provides a signal of N, L, K, H, G̲, E̲, A. It will be seen that in each case G and E are operated together, and this may be used to indicate error and prevent automatic operation. A circuit for utilizing this condition is shown in FIG. 9 as including a contact G–1 connected to receive a signal through a contact E–1 on the E relay. This signal, provided both the G and E relays are energized, is applied to shunt down the error detecting relay **348** of the Allen computer patent when relay **326** is closed as the result of the reopening of relay **308** as noted above and described in the Allen computer patent, thereby preventing completion of the computing cycle.

It will therefore be seen that this invention provides an automatic scale system in which a chart and associated reading transducers are used to determine when a weight has been placed on the platform, to sense motion, and to sense conditions of over and below capacity situations. The invention further provides direct readout and cyclic binary to decimal conversion of the binary chart. A unique cyclic biquinary code is employed which reduces the number of binary columns or paths which are required and therefore reduces the number of readout components required. Also, a unique converting circuit is employed for translating the cyclic biquinary into true decimal numbers.

What is claimed is:

1. A computing scale system comprising, a weighing mechanism, a chart operatively connected with said mechanism having formed thereon a binary pattern representing a range of decimal weights, a mask having means forming a plurality of openings therein, a projecting system including a light source arranged to project an image of said chart onto said mask, each of said openings being smaller in effective area than the smallest division of said projected pattern, a separate photocell positioned adjacent each of said openings to receive light therethrough, and converter circuit means connected to said photocells and operative to provide an output of the decimal value of the pattern intercepted at said openings.

2. A computing scale system as defined in claim **1** wherein said pattern comprises a plurality of rows, there being one of said photocells for each of said rows, and comprising means maintaining said photocells in clustered relation about the optical axis of said projecting system, said rows being staggered in the direction of movement of said chart to conform with said clustered placement of the corresponding said photocells.

3. An automatic weighing and price computing system having maximum and minimum weight limits, comprising a scale mechanism, a chart operatively connected with said mechanism having a binary code formed thereon representing a range of weights which extend beyond said limits, photoelectric transducers positioned to respond to a portion of the code on said chart representing weight on the scale, electric circuit means connected to said transducers for translating the observed portion of said code into output signals representing a digital value of said weight, and means responsive to the occurrence of a characteristic combination of transducer outputs signaling the movement of said scale mechanism to a balance position outside of said system limits.

4. An automatic system as defined in claim **3** comprising means responsive to the occurrence of a different characteristic output of said transducers signaling motion of said scale and blocking operation of said electric circuit means.

5. In an automatic weighing and computing scale system including a platter on a balance mechanism, a projection system including a chart operatively connected with said mechanism and a plurality of photocells positioned to be responsive to the balance position of said chart, and a computer, the improvement comprising a plurality of indicia on said chart representing a range of weights arranged in a binary code, said indicia and the range represented thereby extending to a maximum weight above the range of said balance mechanism, read out means connected to receive the output from said photocells and operable to translate said output into electrical signals for employment in the computer representing the weight on said platter, and circuit means responsive to a characteristic output of at least two of said photocells when said balance mechanism is in a stationary position above the range thereof and connected to prevent automatic operation of said system.

6. In an automatic weighing and computing scale system including a platter on a balance mechanism, a projection system including a chart operatively connected with said mechanism and a plurality of photocells positioned to be responsive to the balance position of said chart, and a computer the improvement comprising a plurality of indicia on said chart representing a range of weights arranged in a binary code, said indicia and the range represented thereby extending from the minimum weight below zero to a maximum weight above the range of said balance mechanism, read out means connected to receive the output from said photocells and operable to translate said output into electrical signals for employment in the computer representing the weight on said platter, first circuit means responsive to a characteristic output of at least one of said photocells when said mechanism is in a stationary condition at a position with less than zero weight for preventing automatic operation of said system, and further circuit means responsive to a further characteristic output of at least two of said photocells when said balance mechanism is in a stationary position above the range thereof and connected to prevent automatic operation of said system.

7. A weighing scale comprising a balance mechanism, a projection system including a chart operatively connected with said mechanism and having formed thereon a binary code representing weight, photocells positioned to intercept the projected image of a portion of said chart, a converter circuit connected to receive the output of said photocells, and circuit blocking means including one of said photocells responsive to a balance position of said chart with less than a minimum weight on said scale for preventing the operation of said converter circuit.

8. An automatic computing scale system including a weighing scale and a computer, comprising a projection system in said scale including a movable chart having formed thereon a binary code effectively arranged in rows and representing a range of weight, a plurality of photocells positioned to respond to a portion of the projected image of said chart, there being one of said photocells for each of said rows, converter circuit responsive to whether each said photocell is illuminated or not by said projection system, and means including a pair of said photocells energized simultaneously by movement of said scale to a balance position outside of said weight range and connected to block automatic operation of said computer when said scale is outside of said range of weight.

9. An automatic system as defined in claim **8** wherein said computer includes motion detector means sensing a change in the output of at least one of said photocells and providing a signal blocking operation of said computer.

10. In an automatic weighing scale including a balance mechanism, the improvement comprising a projection system, a chart in said system movable in proportion to the weight of an article on said scale and having formed thereon a binary code arranged effectively into rows representing a range of weight, a plurality of photocells positioned to respond to a portion of the projected image of said chart corresponding to the balance position of said mechanism representing the weight of an article on said scale, there being one of said photocells for each of said rows, a converter circuit including a circuit responsive to the operation of each said photocell, circuit means including a pair of said photocells operable upon motion of said weighing mechanism and connected to block the operation of said converter circuit during the time when said scale mechanism is in motion and thereafter to energize said converter circuit, and means including another said photocell repsonsive to the movement of said scale a predetermined small amount above zero indicating the presence of a weight on said scale and connected to prevent the operation of said converter circuit when said scale is in a range below said small amount.

11. In an automatic weighing and computing scale including a balance mechanism and a projection system including a relatively movable chart and a plurality of photocells positioned to be responsive to the projected indicia on said chart, the improvement comprising indicia on said chart arranged in a binary code, controllable readout means for said photocells, and circuit means including at least one of said photocells and responsive to a characteristic output of said one photocell when there is less than a small minimum weight on said scale for blocking the operation of said readout means.

12. The weighing and computing scale of claim **11** further including manually operable means for overriding said blocking means to provide for operation of said readout means with said small weight on said scale.

13. In an automatic weighing and computing scale system including a platter on a balance mechanism, and a projection system including a chart operatively connected with said mechanism and a plurality of photocells positioned to respond to an image of said chart, the improvement comprising a plurality of indicia on said chart arranged in a binary code, readout means connected to receive the output from said photocells and operable to translate said output into an electrical digital signal representing the weight on said platter at balance, and circuit means including at least one of said photocells and responsive to a characteristic output thereof at balance with less than a predetermined minimum weight on said platter for preventing the automatic operation of said readout means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,439,760 Dated April 22, 1969

Inventor(s) Kenneth C. Allen

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 24 "Table II" should read -- Table III--. Column 10, line 40 "of a weighting scale" should read --to a weighing scale--; lines 46 and 47, "and be" should read -- and may be --. Column 18, line 5 "355,963 France" should read 355,963 Swiss --; line 6 insert -- 1,231,229 France --.

SIGNED AND
SEALED

OCT 21 1969

(SEAL)
Attest:

Edward M. Fletcher, Jr.
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Commissioner of Patents