

June 14, 1949.

R. E. BITNER

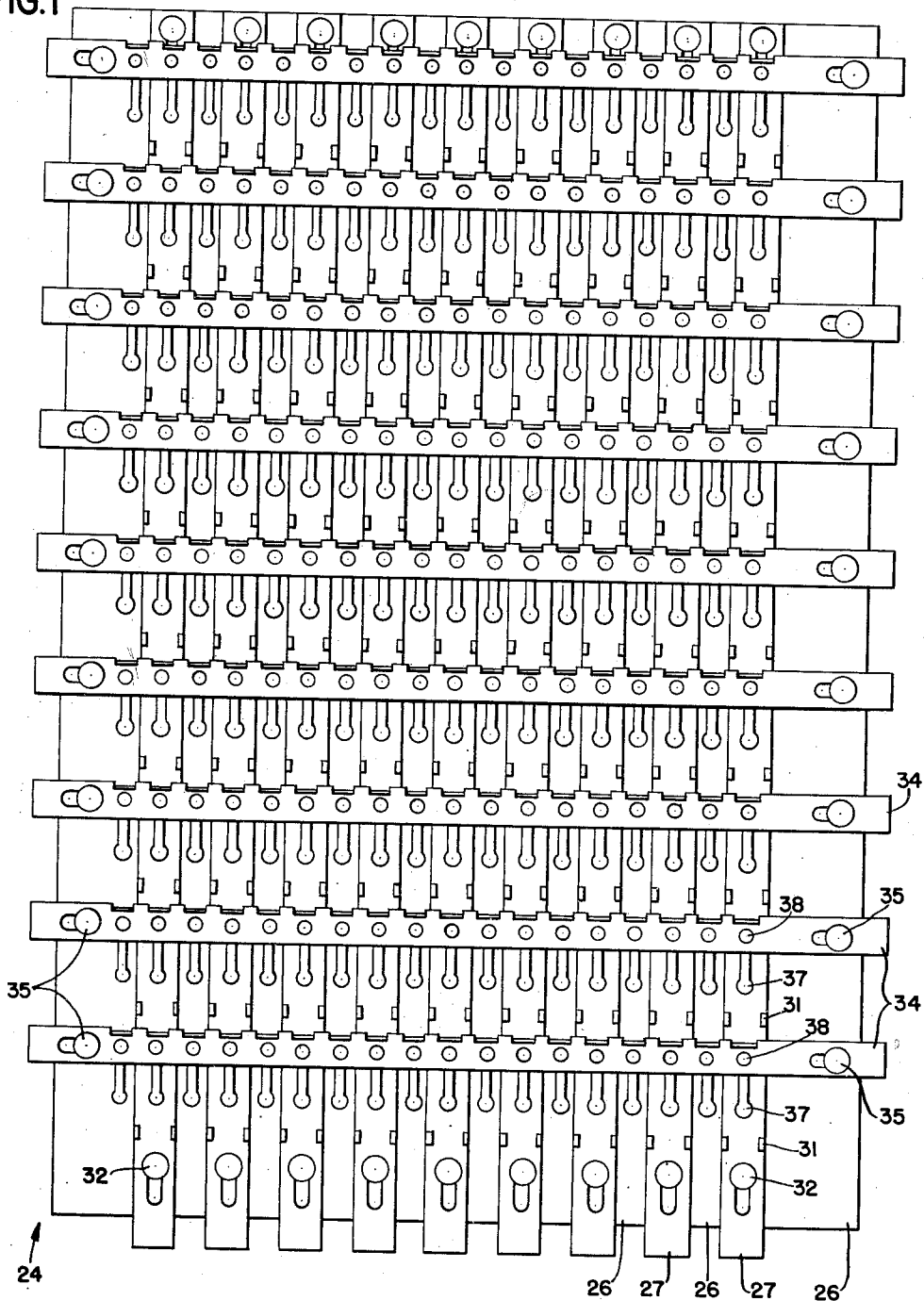
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PARTIAL PRODUCTS MECHANISM

Filed Nov. 13, 1945

7 Sheets-Sheet 1

FIG. 1



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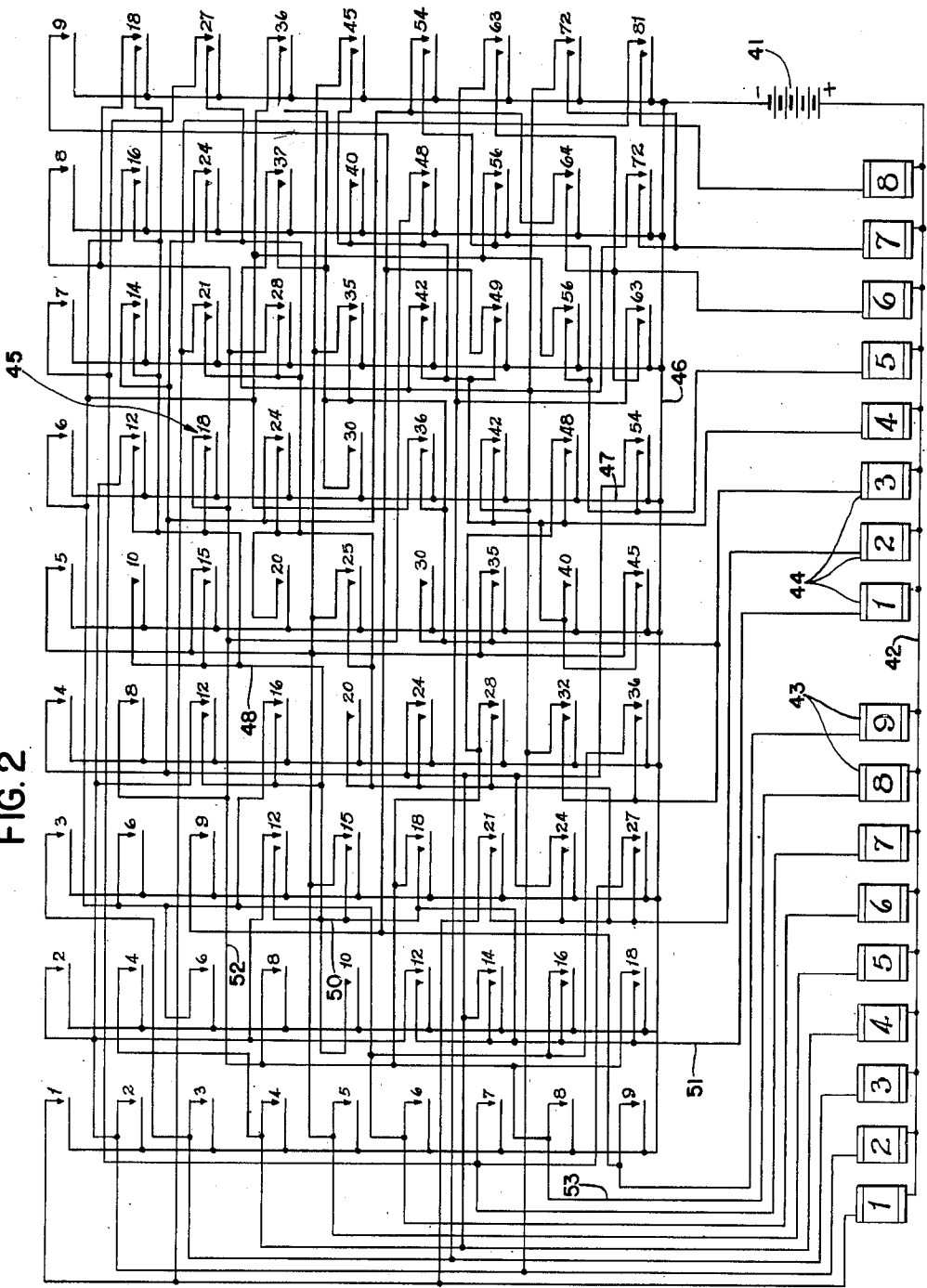
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Filed Nov. 13, 1945.

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FIG. 2



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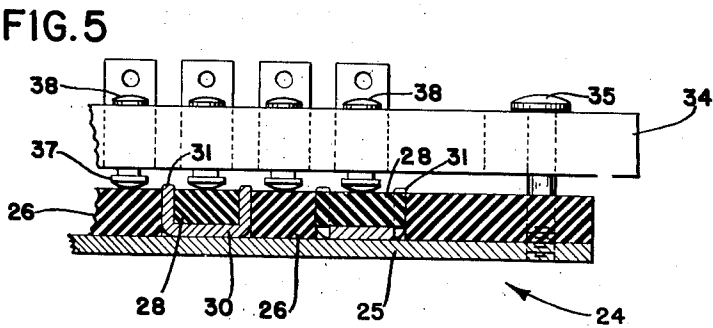
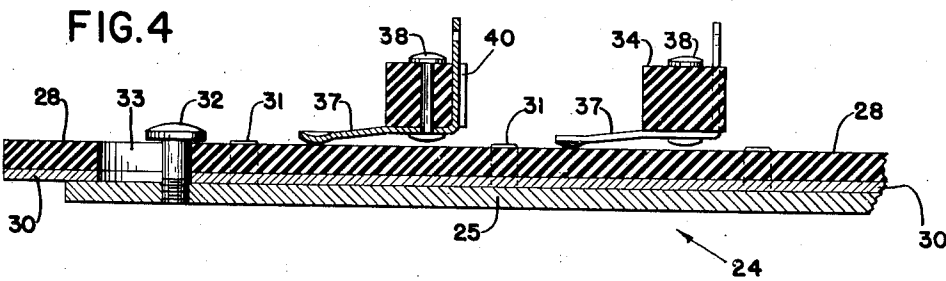
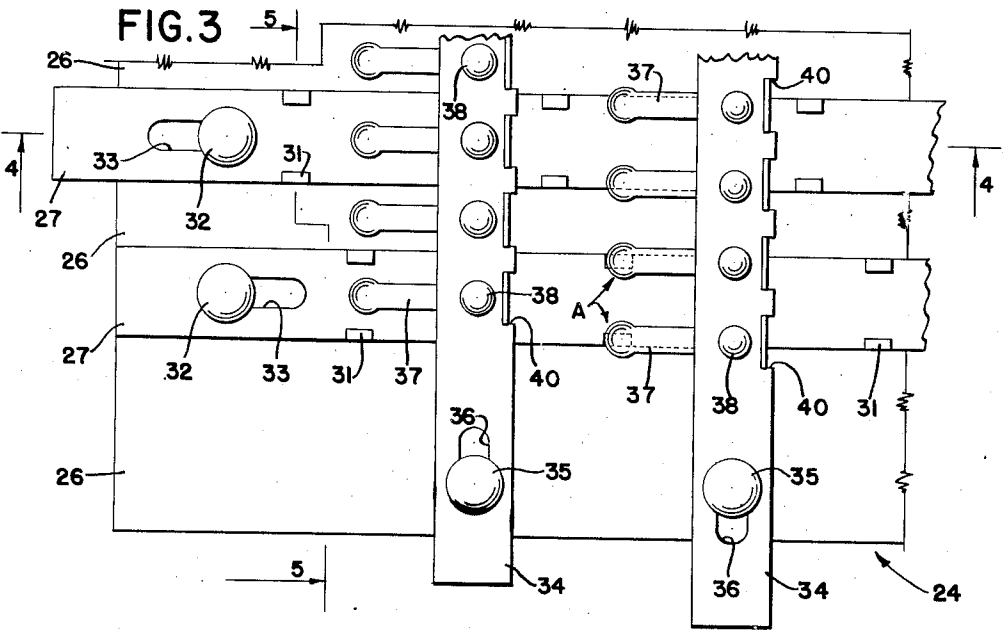
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PARTIAL PRODUCTS MECHANISM

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FIG. 6

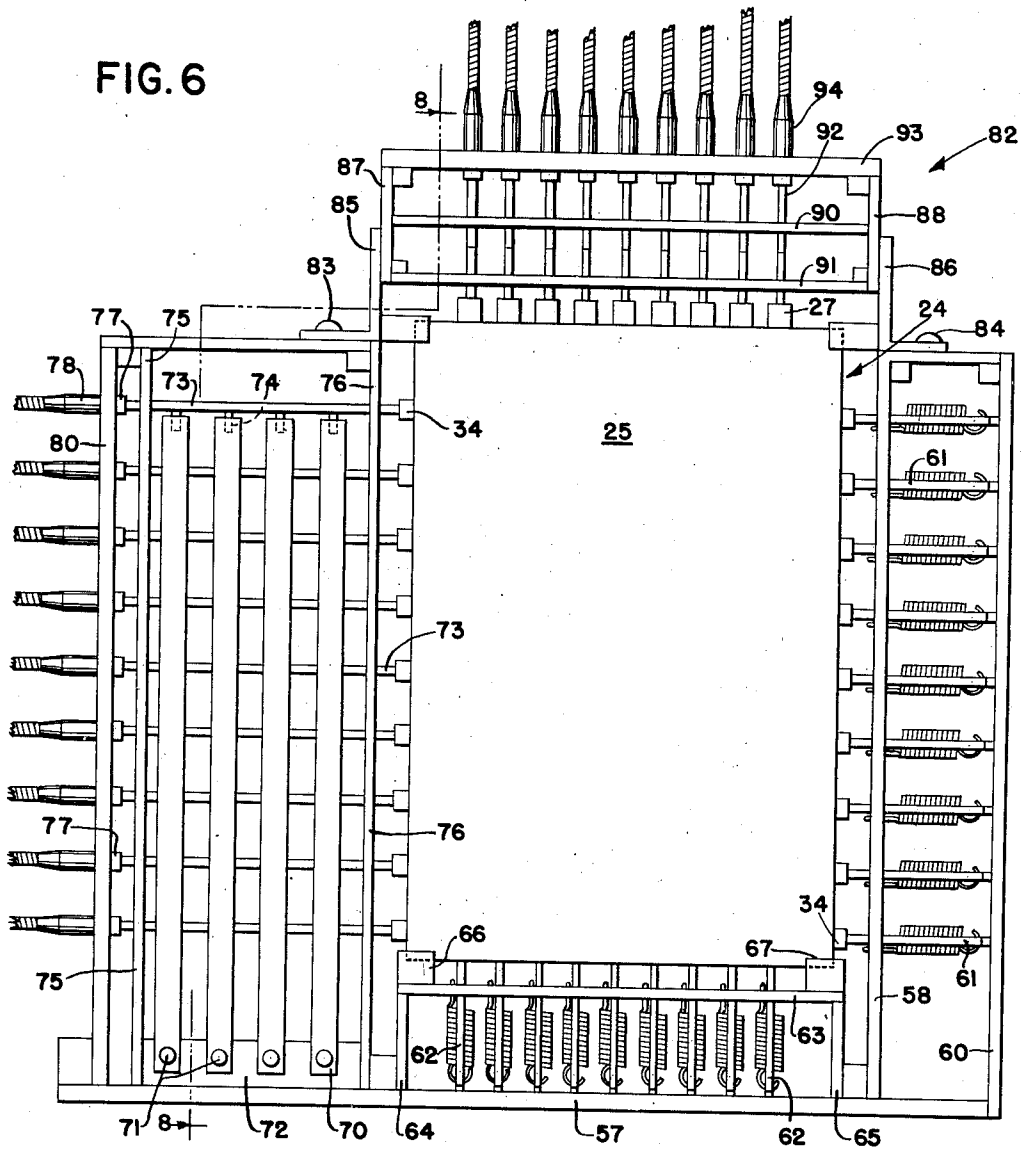
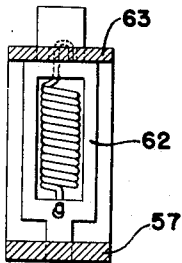


FIG. 7



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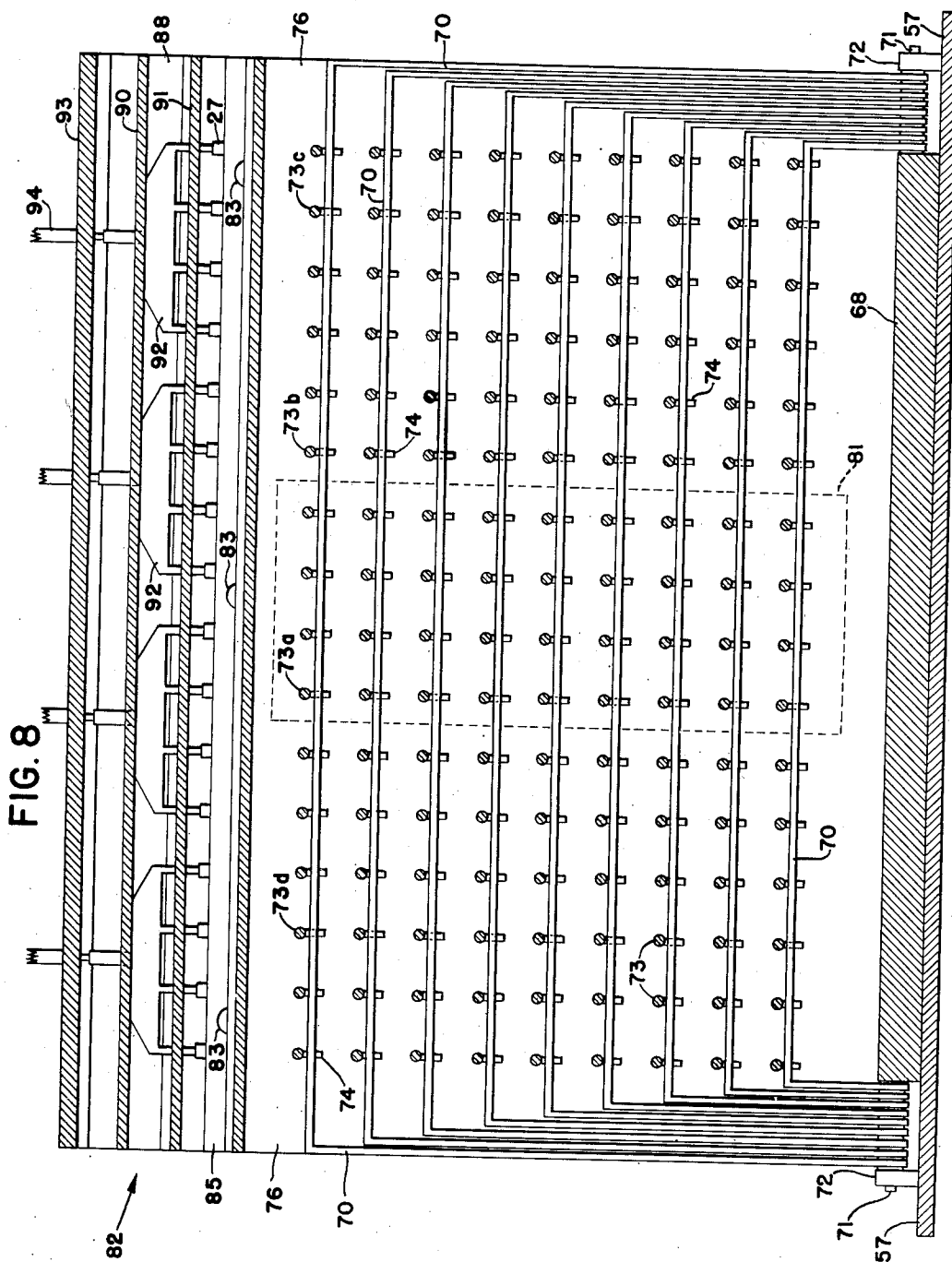
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PARTIAL PRODUCTS MECHANISM

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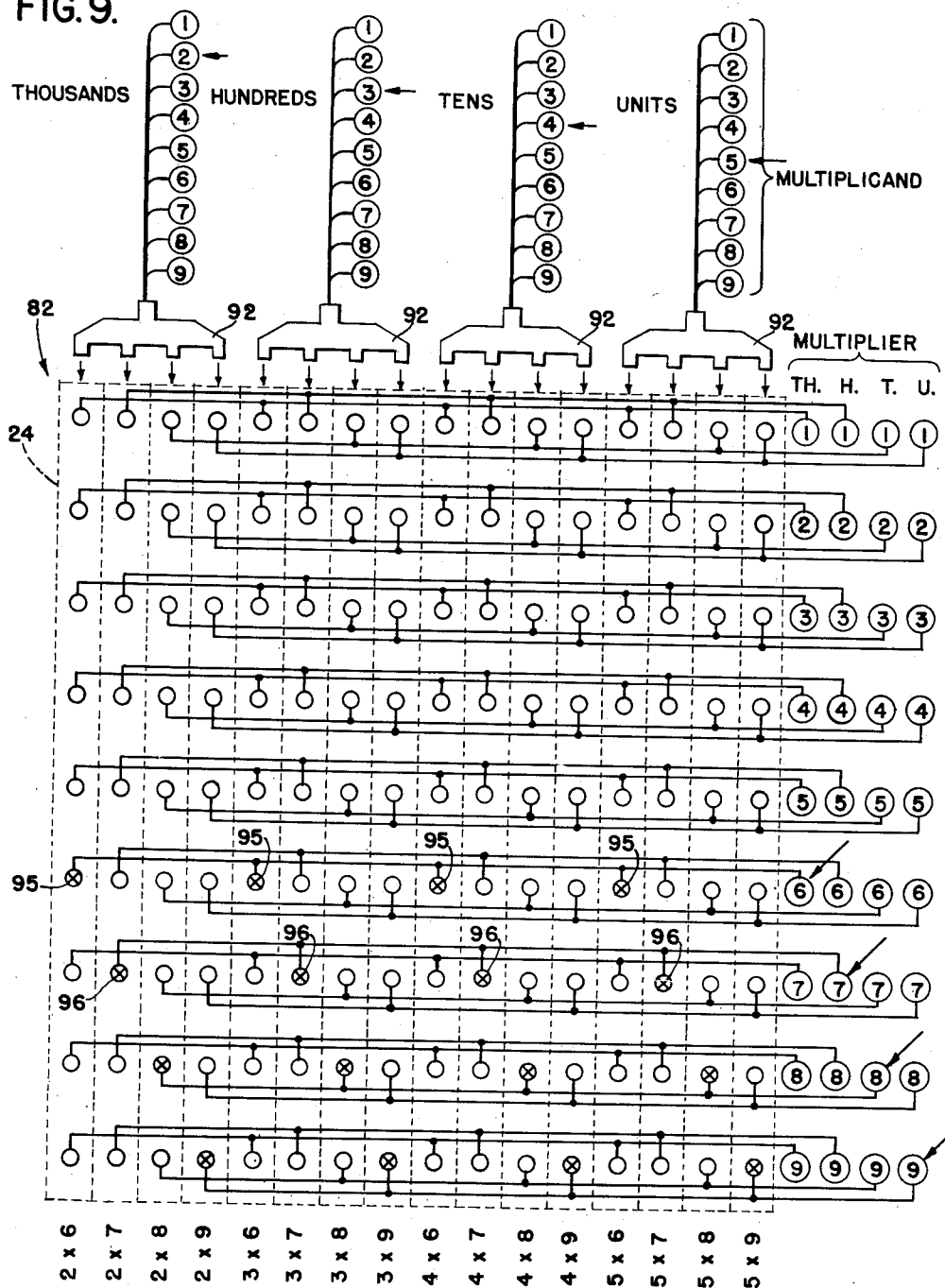
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FIG. 9.



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FIG. 10

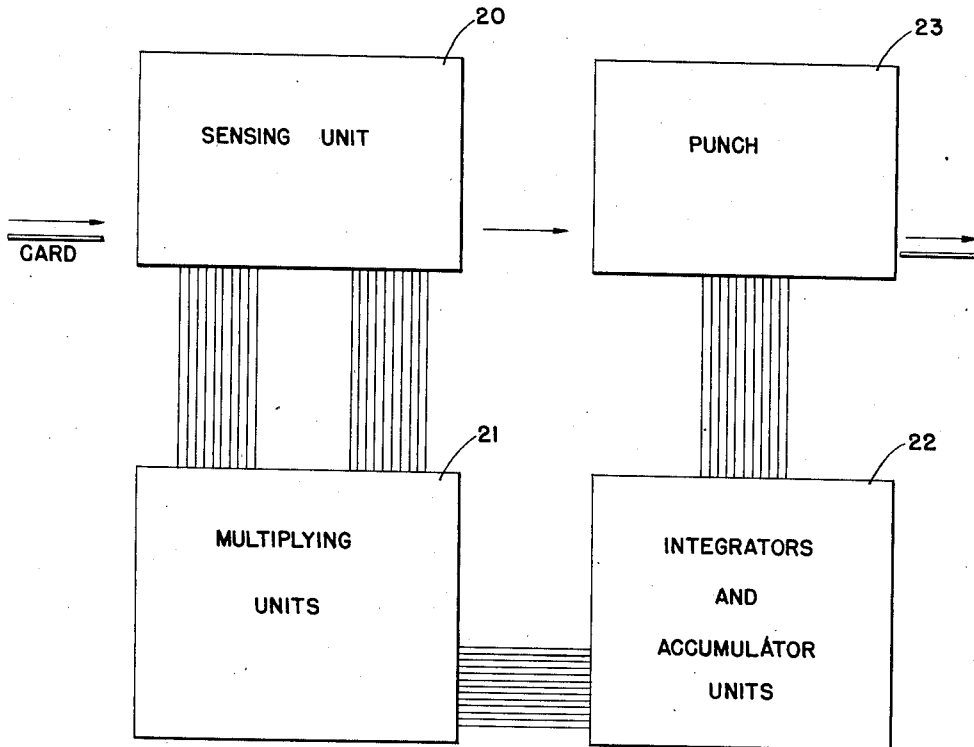
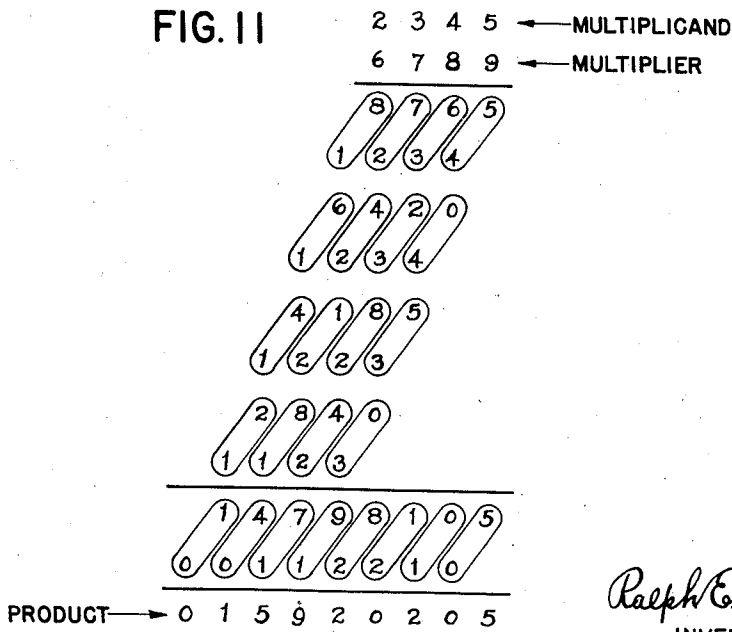


FIG. 11



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UNITED STATES PATENT OFFICE

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PARTIAL PRODUCTS MECHANISM

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Application November 13, 1945, Serial No. 628,038

7 Claims. (Cl. 235—61)

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This invention relates to a mechanism for obtaining a series of partial products from the digits of a multiplier and multiplicand. It more particularly relates to the details of construction of mechanisms which contain the multiplication table as a part of their structure and which are to be used as a component part of fast-operating multiplying machines. While the invention is subject to a wide range of applications, it is especially suited for use in punched card systems and will be particularly described in that connection.

True multiplying machines, as distinguished from computing machines using repeated addition, are not new. One prior machine employs a series of seventeen multiplier plates for each denominational order to derive the partial products, and a plurality of stepped cups for integrating the partial products to obtain the final product. Because of the many mechanical movements involved the speed of this machine is limited to twenty punched cards per minute.

Another prior machine uses a series of commutator rings cut in accordance with the multiplication table. A plurality of mechanical clutches operate differential accumulators to integrate the partial products. The multiplicand is multiplied by each digit in the multiplier separately, hence the speed is kept down to twenty cards per minute.

Still another prior machine multiplies a multiplicand, sensed from a card, by a multiplier which is sensed by electrical contact fingers as the card is moved through a sensing chamber. The time of transit determines the time a clutch is in operative contact to register the partial products in two accumulators, one for the units digits and one for the tens digits. This machine is considerably faster than the ones enumerated above but is limited by small tolerances, accuracy of adjustment, and dependable contacts through the card while it is in motion.

One of the objects of the invention, therefore, is to provide a partial products mechanism which substantially avoids one or more of the limitations of the prior art machines.

Another object of the invention is to provide a mechanism which will derive all the partial products resulting from the product of all the digits in a multiplicand paired with all the digits in a multiplier and make them available at substantially the instant the numbers are sensed.

Another object of the invention is to provide a partial products mechanism for a punched card multiplier which will cooperate with an integrator to multiply a ten digit multiplicand by a ten digit multiplier at the rate of one hundred cards per minute.

Still another object of the invention is to provide a partial products mechanism which will

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contain components that are not dependent upon small tolerances nor fine adjustments to produce an accurate result.

Another object of the invention is to provide a mechanism which will be capable of long and continued use without the necessity of repair and adjustment.

One feature of the invention comprises a multiplying unit for producing the product of two digits and comprises a plurality of nine multiplier rods movably mounted in parallel relationship, also a plurality of nine multiplicand rods mounted in parallel relationship, each of the rods designated by a digit from one to nine. A plurality of electrical contact fingers are secured to each multiplier rod and a plurality of contact lugs are secured to each multiplicand rod. Actuating means are provided so that any designated multiplier rod may be moved to a position where contact may be made with the contact fingers and actuating means are also provided so that any designated multiplicand rod may be moved to a position where contact may be made with the contact lugs. The lugs and fingers are so disposed that they will make contact with each other only at one place and that place represents the product of the designated multiplier digit by the designated multiplicand digit. Suitable electromagnetic means are provided to transmit the product of the two digits to an integrator.

Another feature of the invention comprises the provision of a multiplying unit for each pair of digits selected from the multiplier and multiplicand. Actuating means are controlled by each denominational order in the multiplier to actuate a selected number of the multiplying units and actuating means are also controlled by each denominational order in the multiplicand to actuate a selected number of multiplying units whereby each digit in the multiplier is paired with each digit in the multiplicand to actuate a multiplying unit and derive all the partial products resulting from the multiplication of the two numbers.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

Fig. 1 represents a plan view of a multiplying unit.

Fig. 2 is a schematic diagram of connections of the multiplying unit, battery, and seventeen electromagnets.

Fig. 3 is an enlarged plan view of one corner of the multiplying unit showing two rods in their actuated position.

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Fig. 4 is a sectional drawing of the unit in Fig. 3 taken along line 4—4 of that figure.

Fig. 5 is a sectional drawing of the unit in Fig. 3 taken along line 5—5 of that figure.

Fig. 6 is a side view of the multiplying units set up in position where the multiplier and multiplicand digits can actuate the designated rods.

Fig. 7 is a detailed view of a spring unit used in Fig. 6.

Fig. 8 is a sectional drawing of the mechanism shown in Fig. 6 taken along line 8—8 of that figure.

Fig. 9 is a schematic drawing to illustrate the method and means of pairing each digit of the multiplier with each digit of the multiplicand to actuate the multiplying units for deriving all the partial products of two numbers simultaneously.

Fig. 10 is a schematic drawing to illustrate the method of combining the present invention with a sensing unit, integrator and accumulator unit, and a punch to provide a complete multiplying machine for punched data cards.

Fig. 11 is a sample multiplication of a four digit multiplicand by a four digit multiplier to show the method of digit pairing and marshalling of the partial products.

Referring now to the drawings, Fig. 10 illustrates a schematic combination of a complete punched data card multiplying machine. Briefly, the machine comprises a sensing unit 20, a plurality of multiplying units 21, which will be described in detail hereinafter, an integrator 22, and a punch 23. The sensing unit may contain any one of the sensing mechanisms now known to the art and its function is to sense the multiplier and multiplicand and transmit their values to the multiplying unit. The multiplying unit 21 receives the digit actuations and produces a series of partial products which must be added together to produce the final product. For a "ten by ten" multiplying machine, which has the facilities for handling a multiplier and multiplicand of ten digits each, there will be a total of one hundred partial products.

The partial products, comprising a possible 200 digits, are received by the integrator unit 22 and added together in their proper denominational orders to produce the product. The final product is then sent to the punch 23 where it may be used to control the punching of a data card.

The multiplying mechanism in a "ten by ten" multiplier contains one hundred small multiplying units 24, the mechanical details of which are shown in Figs. 1, 3, 4, and 5. The unit comprises a metallic base member 25, on which is secured a series of rod-like insulator strips 26, equally spaced to form a series of nine channels into which are placed nine multiplicand rods 27. The multiplicand rods 27 are made of insulating strips 28 with a metallic conductive base 30 which extends for the entire length of the rods 27 and forms a conductive path to the base 25. At spaced intervals a portion of the metallic base is bent upward to form a lug 31, each rod having 18 lugs along its length.

A series of retaining screws 32, secured to the base 25 at each end thereof, holds the rods 27 in place and, because of a slot 33, restricts the motion of the rods to a predetermined range.

Above the plane of the multiplicand rods and at right angles thereto is mounted a series of nine multiplier rods 34. These rods are slidably mounted by means of retaining screws 35 in a manner similar to rods 27. Each rod has

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mounted on it a series of 18 contact fingers 37, in spaced relation, held securely by a rivet 38. The lower end of the contact spring is formed into a spherical surface so that the contact spring can slide over the surface of the insulator and into contact with the lugs 31. The upper end of the contact finger extends vertically above the rod surface so that a connecting wire may be soldered to it to provide a path for an electrical circuit as will be described hereinafter. To insure the mechanical stability of the fingers as they are moved into and out of contact with the lugs, each finger is fitted into a slot 40 cut in the side of rod 34.

When the multiplying unit is in operation, it is set up in an arrangement which holds all the rods in the no-contact position by spring pressure. When a partial product is desired, one of the multiplier rods 34 is moved to contact position and one of the multiplicand rods is also moved to contact position. This condition is illustrated in Fig. 3 where parts of two multiplicand rods and two multiplier rods are shown. The lower multiplicand rod 27 is shown in its actuated position having been moved to the right as far as the slot 33 permits and the lugs 31 thereon have been moved to a position where they are in line with the rounded contact points of fingers 37.

The right hand multiplier rod 34 is shown in its actuated position, having been lowered so that the contact fingers 37 are in line with all the lugs. At one, and only one, position two contact fingers make electrical contact with two lugs and the currents through these two contacts select two electromagnets to control the designation of a units digit and a tens digit to complete the partial product.

The electrical wiring of the multiplying unit is shown in Fig. 2. A battery 41 has its positive terminal connected to a line 42 which is connected to two series of 17 electromagnets; a units series 43, designated from 1 to 9; and a tens series 44, designated from 1 to 8. The negative terminal of the battery 41 is shown connected to one of the contact terminals in each of 81 contact assemblies. Actually such connection is made to the metallic conducting base 25 (see Figs. 4 and 5) and is thereby distributed to all the lugs 31 to give the same result as indicated in the wiring diagram.

In the diagram of Fig. 2 each contact assembly is represented by one or two contacts, and each such position is designated by a product. The upper horizontal row is numbered from 1 to 9 to represent the product of any multiplier digit by one. The left hand vertical row is numbered from 1 to 9 to represent the product of any multiplicand digit by one. All the other product designations are determined by multiplying the corresponding number at the top of the row with the number at the left of the row. Each multiplying unit contains 81 contact assemblies, representing all the products resulting from the multiplication of two digits from 1 to 9, inclusive.

The diagram of connections (Fig. 2) shows only those contacts that are necessary to obtain the product and for a number of products only one pair of contacts is required, such as 1×6 or 4×5 . The drawings of Figs. 1, 3, 4, and 5 show double contacts (two lugs and two contact springs) for each contact assembly because in practice it has been found easier to make all multiplier rods and multiplicand rods with the same number of components, thereby simplifying the process of manu-

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facture and the ease of servicing. Where only one contact is needed instead of two, both contact fingers are connected together.

The wiring is so arranged that when the contacts of any one position are made, current flows from the battery 41 through the left hand contact points to one of the solenoids in the tens series 44 and through the right hand contact points to one of the solenoids in the units series 43. To illustrate the operation of the unit, let it be assumed that a 6 is sensed in the multiplier and a 3 is sensed in the multiplicand. Then the sixth multiplier rod and the third multiplicand rod are actuated and the only contacts that are made thereby are the two contacts 45 designated by the product 18. The left hand contact makes a circuit which may be traced from the battery 41, over conductor 46, then over conductor 47, to the bottom portion of contact position 45, through the left hand contact point, over conductor 48, to conductor 50, thence by conductor 51 to the first solenoid in the tens series 44 and back to the battery 41 by way of conductor 42.

The right hand contact point also makes a circuit which may be traced from the battery 41 over conductors 46 and 47 as before to the contact position 45, then through the right hand contact finger and over conductor 52, conductor 53, to a solenoid in the units series 43, designated as "8" and from there back to the positive terminal of battery 41 by way of common conductor 42.

The result of the above series of connections is to cause the actuations of solenoids designated as the product "18" when a "6" and a "3" are multiplied together. The armatures of the solenoids (not shown) are connected to an integrator which adds all the partial products together. However, the products derived from the action of the multiplying boards may be used for any statistical purpose desired.

In order to multiply two numbers, each having a plurality of digits, in a small interval of time, all the partial products should be determined as soon as practicable after the sensing mechanism has sensed the values. This requirement may be met by using the same number of multiplying units as is obtained by multiplying the number of digits in the multiplier by the number of digits in the multiplicand. For a "ten by ten" machine, one hundred units will be required. In the description that follows a "four by four" machine is used as an example in order to describe the mechanisms and operation with as little complication as possible. Sixteen multiplying units are necessary for the "four by four" machine and they are mounted parallel to each other in a cage which enables the sensing mechanisms to actuate the multiplying unit rods in accordance with the requirements of multiplication.

Figs. 6 and 8 illustrate scheme of mounting the units. A base 57 supports plates 58 and 60 at one side of the cage and between the latter plates a series of spring pressed members 61 are mounted, nine for each multiplying unit. A similar set of spring members 62 is mounted below the multiplying units by means of a horizontal perforated plate 63 and two vertical sideplates 64 and 65. A pair of grooved rods 66 and 67 are mounted on plate 63 to hold the sixteen multiplying units in spaced relation and in proper register for the actuating levers.

To the left of spring pressed members 62 is a thick plate 68 which supports a series of thirty-six balls 70. The balls are pivoted on four shafts

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71 which extend to both ends of plate 68 and are anchored by a support 72. Each ball is provided with four holes (in a "four by four" machine) by which the movements of the ball are controlled and the selected multiplier rods 34 are actuated. The balls are controlled by control rods 73, each of which has a single downwardly extending projection 74 which fits into the hole in the top of the ball. The control rods are slidably mounted in holes in two plates 75 and 76 which are secured to the base plate 57 in a rigid vertical position. One end of each control rod 73 engages a multiplier rod 34 while the other end is engaged by a Bowden wire lug 77. The Bowden wire terminals 78 are secured in a vertical plate 80 which is suitably secured to the base plate 57. The Bowden wires, control rods 73, multiplier rods 34, and balls 70 are all resiliently held in their non-actuated position by the spring members 61.

The purpose of the balls is to properly distribute the actuating impulses received from the sensing unit so that each digit of the multiplier is paired with each digit of the multiplicand. Accordingly there are four series of nine Bowden wires running from the sensing unit to the plate 80. Each Bowden wire actuates a control rod 73 which in turn moves a ball 70. Each ball 70 controls three other control rods 73 so that when a single actuation of a Bowden wire is made, four control rods and four multiplier rods 34 are moved to their actuated position. The drawing Fig. 8 illustrates how the action is distributed. If control rod 73 is actuated, then control rods 73b, 73c, and 73d are also actuated because the ball 70 is engaged by the projections 74 of these particular control rods. In order to distribute the strains of actuation equally along the balls, the Bowden wires are mounted in the central portion of the plate 80 and engage those control rods 73 that are within the dotted line 81.

The actuation of the multiplicand rods is somewhat similar but to cause the requisite pairing of digits the ball system is not necessary and a simple forked distributor is used. The multiplicand actuator mechanism is contained in a cage 82 which may be removed from the main nit by unscrewing screws 83 and 84. The cage 82 is supported by angle irons 85 and 86 and side plates 87 and 88. Two horizontal plates 90 and 91 serve as guide plates, with the necessary perforations, to guide the vertical motion of a plurality of forked distributors 92. A top plate 93 holds terminal 94 of the Bowden wires. The wires, distributors 92 and multiplicand rods 27 are all resiliently held in their non-actuated position by the spring members 62.

Fig. 9 shows the method of digit pairing in a schematic representation. In this figure the multiplier units 24 are indicated by a series of dotted lines, the multiplicand distributors 92 are schematically shown as controlled by nine keys for each order, and the multiplier balls are indicated by a series of lines connected with controlling keys.

In order to consider the operation of the system of multiplier units, let it be assumed that a multiplicand, 2,345 is to be multiplied by a multiplier 6,789. (See Fig. 11.) The multiplicand is entered into the cage 82 by the actuation of the designated forked distributors 92. In the thousands order the second distributor will be actuated and hence the second multiplicand rod in the first four multiplying units will be lowered. In the hundreds order the third distributor and the third multiplicand rod in each of the next

four units will be actuated, and in a similar manner, the fourth distributor in the tens order and the fifth in the units.

On the multiplier side in the thousands order, the sixth Bowden wire and the sixth bail will be actuated causing four multiplier rods to be moved. The representation of these rods is indicated by a cross in circles 95 in Fig. 9, the circles occurring in the first of each of the four units 24 as divided into orders by the multiplicand.

In the hundreds order a "7" is entered into four units, shown in Fig. 9 by crosses in circles 96. And in a similar manner an "8" in the tens order and a "9" in the units order are entered into their respective units as indicated.

At the bottom of the drawing the factors are listed adjacent to the multiplying unit in which they are entered. A comparison of these paired factors and the sample multiplication in Fig. 11 shows that the correct combination of all factors is represented. Fig. 11 also shows the familiar marshalling of the product digits in their proper orders to be added by the integrator into the final product.

In the foregoing description one set of multiplying rods was designated as "multiplier" and another set as "multiplicand." These designations were made to make the description more clear and understandable; actually either set of rods or either number used in the example might have either designation because the partial products are all formed at the same time and none of the sequence operations, which usually identify both multiplier and multiplicand, were present.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention.

I claim:

1. A partial products mechanism for producing the product of two digits comprising, a plurality of multiplier rods movably mounted in parallel relationship, each of said rods corresponding to a digit, a plurality of multiplicand rods movably mounted in parallel relationship, each of said rods corresponding to a digit, mechanical limit means for restricting the rod motion to an actuated or an unactuated position, a plurality of contact fingers secured to each of said multiplier rods in spaced relation thereon, each finger representing a product digit, a plurality of contact lugs secured to each of said multiplicand rods in spaced relation thereon, a base structure for slidably holding said multiplicand rods which comprises channels for the rods and intermediate rod-like strips for sliding engagement by the multiplier fingers, a plurality of electromagnetic coils, each corresponding to a product digit, for transmitting product values to an integrating mechanism, and electrical connecting means joining all contact fingers of similar product-digit value with the electromagnetic coil having a corresponding value.

2. A partial products mechanism for producing the product of two digits comprising, a plurality of multiplier rods movably mounted in parallel relationship, each of said rods corresponding to a digit, a plurality of multiplicand rods movably mounted in parallel relationship, each of said rods corresponding to a digit, mechanical limit means for restricting the rod motion to an actuated or an unactuated position, a plurality of contact fingers secured to each of said multiplier rods in

spaced relationship thereon, each finger representing a product digit, a plurality of contact lugs secured to each of said multiplicand rods in spaced relationship thereon, actuating means for moving any one of said multiplier rods to its actuated position where electrical contact may be made by said fingers, actuating means for moving any one of said multiplicand rods to its actuated position where electrical contact may be made by said lugs, a base structure for slidably holding said multiplicand rods which comprises channels for the rods and intermediate rod-like strips for sliding engagement by the multiplier fingers, a plurality of electromagnetic coils, each corresponding to a product digit, for transmitting product values to an integrating mechanism, and electrical connecting means joining all contact fingers of similar product-digit value with the electromagnetic coil having a corresponding value.

3. A partial products mechanism for producing the product of two digits comprising, nine multiplier rods movably mounted in parallel relationship, nine multiplicand rods movably mounted in parallel relationship, each of said multiplier rods and multiplicand rods corresponding to a digit from one to nine, mechanical limit means for restricting the rod motion to an actuated or an unactuated position, a plurality of contact fingers secured to each of said multiplier rods in spaced relationship thereon, each finger representing a product digit, a plurality of contact lugs secured to each of said multiplicand rods in spaced relationship thereon, actuating means for moving any one of said multiplier rods to its actuated position where electrical contact may be made by said fingers, actuating means for moving any one of said multiplicand rods to its actuated position where electrical contact may be made by said lugs, a base structure for slidably holding said multiplicand rods which comprises channels for the rods and intermediate rod-like strips for sliding engagement by the multiplier fingers, a plurality of electromagnetic coils, each corresponding to a product digit, for transmitting product values to an integrating mechanism, and electrical connecting means joining all contact fingers of similar product-digit value with the electromagnetic coil having a corresponding value.

4. A partial products mechanism for producing the product of two digits comprising, nine multiplier rods movably mounted in parallel relationship, nine multiplicand rods movably mounted in parallel relationship, each of said multiplier rods and multiplicand rods corresponding to a digit from one to nine, mechanical limit means for restricting the rod motion to an actuated or an unactuated position, a plurality of contact fingers secured to each of said multiplier rods in spaced relationship thereon, each finger representing a product digit, a plurality of contact lugs secured to each of said multiplicand rods in spaced relationship thereon, actuating means for moving any one of said multiplier rods to its actuated position where electrical contact may be made by said fingers, actuating means for moving any one of said multiplicand rods to its actuated position where electrical contact may be made by said lugs, said contact fingers on the multiplier rods so disposed as to complete a circuit through the lugs on the multiplicand rods only when one of each rods is in the actuated position and then only at the point of crossing of the two actuated rods, a base structure for slidably holding said multiplicand rods which comprises channels for

the rods and intermediate rod-like strips for sliding engagement by the multiplier fingers, a plurality of electromagnetic coils, each corresponding to a product digit, for transmitting product values to an integrating mechanism, and electrical connecting means joining all contact fingers of similar product-digit value with the electromagnetic coil having a corresponding value.

5. A partial products mechanism for producing the product of two digits comprising, nine multiplier rods movably mounted in parallel relationship, nine multiplicand rods movably mounted in parallel relationship, each of said multiplier rods and multiplicand rods corresponding to a digit from one to nine, mechanical limit means for restricting the rod motion to an actuated or an unactuated position, a plurality of contact fingers secured to each of said multiplier rods in spaced relationship thereon, each finger representing a product digit, a plurality of contact lugs secured to each of said multiplicand rods in spaced relationship thereon, actuating means for moving any one of said multiplier rods to its actuated position where electrical contact may be made by said fingers, actuating means for moving any one of said multiplicand rods to its actuated position where electrical contact may be made by said lugs, said contact fingers on the multiplier rods so disposed as to complete a circuit through the lugs on the multiplicand rods only when one of each rods is in the actuated position and then only at the point of crossing of the two actuated rods, a base structure for slidably holding said multiplicand rods which comprises a base plate of conducting material and rod-like insulator strips secured to the base plate to form channels for said multiplicand rods, the top surfaces of the rods and strips forming a substantially plane surface for sliding engagement by the multiplier contact fingers, a plurality of electromagnetic coils, each corresponding to a product digit, for transmitting product values to an integrating mechanism, and electrical connecting means joining all contact fingers of similar product-digit value with the electromagnetic coil having a corresponding value.

6. A partial products mechanism for producing the product of two digits comprising, nine multiplier rods movably mounted in parallel relationship, nine multiplicand rods movably mounted in parallel relationship, each of said multiplier rods and multiplicand rods corresponding to a digit from one to nine, mechanical limit means for restricting the rod motion to an actuated or an unactuated position, a plurality of contact fingers secured to each of said multiplier rods in spaced relationship thereon, each finger representing a product digit, a plurality of contact lugs secured to each of said multiplicand rods in spaced relationship thereon, actuating means for moving any one of said multiplier rods to its actuated position where electrical contact may be made by said fingers, actuating means for moving any one of said multiplicand rods to its actuated position where electrical contact may be made by said lugs, said contact fingers on the multiplier rods so disposed as to complete a circuit through the lugs on the multiplicand rods only when one of each rods is in the actuated position and then only at the point of crossing of the two actuated rods, a base structure for slidably holding said multiplicand rods which comprises a base plate of conducting material and rod-like insulator strips secured to the base plate to form channels for said multiplicand rods, the top surfaces of

the rods and strips forming a substantially plane surface for sliding engagement by the multiple contact fingers, each of said rods containing one contact where the product may be expressed by a single digit and containing two contacts where the product requires two digits, a plurality of electromagnetic coils, each corresponding to a product digit, for transmitting product values to an integrating mechanism, and electrical connecting means joining all contact fingers of similar product-digit value with the electromagnetic coil having a corresponding value.

7. A partial products mechanism for producing the product of two digits comprising, nine multiplier rods movably mounted in parallel relationship, nine multiplicand rods movably mounted in parallel relationship, each of said multiplier rods and multiplicand rods corresponding to a digit from one to nine, mechanical limit means for restricting the rod motion to an actuated or an unactuated position, a plurality of contact fingers secured to each of said multiplier rods in spaced relationship thereon, each finger representing a product digit, a plurality of contact lugs secured to each of said multiplicand rods in spaced relationship thereon, actuating means for moving any one of said multiplier rods to its actuated position where electrical contact may be made by said fingers, actuating means for moving any one of said multiplicand rods to its actuated position where electrical contact may be made by said lugs, said contact fingers on the multiplier rods so disposed as to complete a circuit through the lugs on the multiplicand rods only when one of each rods is in the actuated position and then only at the point of crossing of the two actuated rods, a base structure for slidably holding said multiplicand rods which comprises a base plate of conducting material and rod-like insulator strips secured to the base plate to form channels for said multiplicand rods, the top surfaces of the rods and strips forming a substantially plane surface for sliding engagement by the multiple contact fingers, each of said rods containing one contact where the product may be expressed by a single digit and containing two contacts where the product requires two digits, a series of seventeen electromagnets, nine corresponding to the units product digits and eight corresponding to the tens product digits from one to eight, inclusive, and a plurality of electrical circuits connecting said electromagnets with corresponding contact fingers on the multiplier rods, the lugs on said multiplicand rods, and a source of electrical power.

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