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Bennett et al.

[11] **3,742,574**

[45] **July 3, 1973**

[54] **WIRE BRAID FORMING APPARATUS**

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[22] Filed: **Dec. 3, 1971**

[21] Appl. No.: **204,500**

[52] **U.S. Cl.** ..... **29/203 MM**

[51] **Int. Cl.** **H01r 43/00**

[58] **Field of Search** ..... 29/203 MM, 203 MW, 29/203 R

[56] **References Cited**

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3,451,129 6/1969 Alonso et al. ..... 29/203 MM

3,639,965 2/1972 Chu ..... 29/203 MM

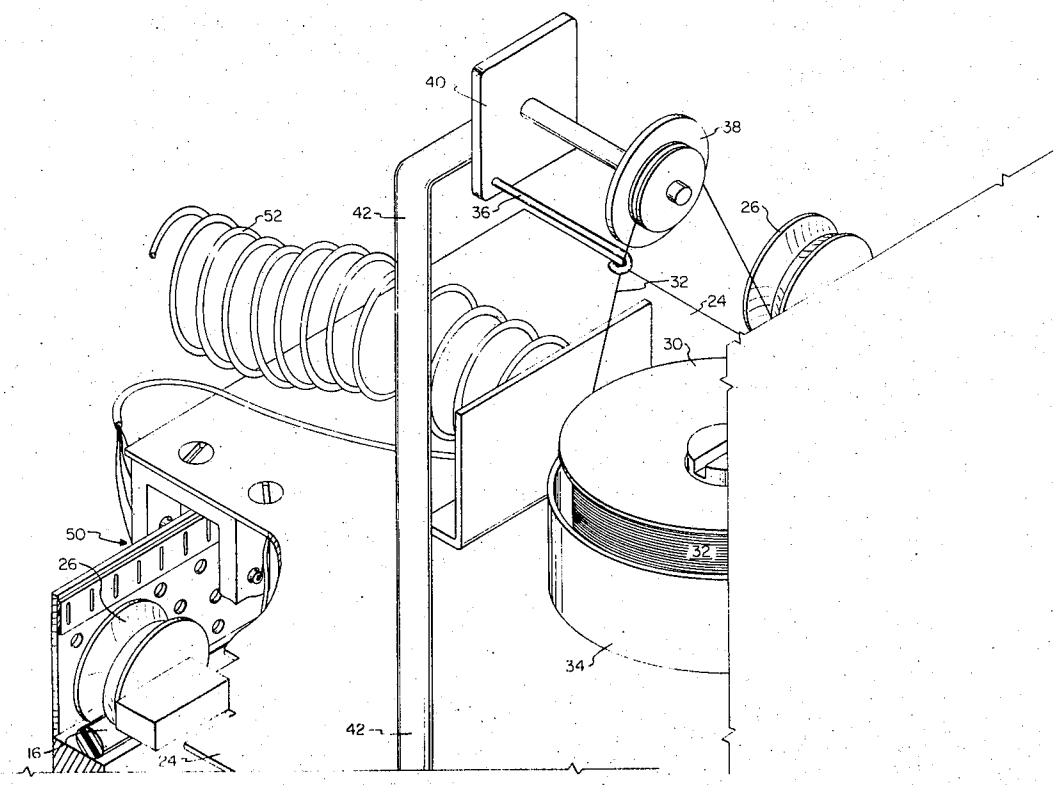
Primary Examiner—Thomas H. Eager

Attorney—K. Mullerheim, B. E. Franz and Theodore C. Jay, Jr.

[57] **ABSTRACT**

A single strand of wire from a supply spool is passed through a carriage-mounted, electromechanically actuated coding wand. As the carriage traverses its line of travel the wire is woven about a fixed linear array of pegs in a desired pattern controlled by a tape reader and timed by preselected electro-optically actuated coding logic. The end of each wire is automatically routed to a desired position for termination on a connector. Repeated reciprocating traversing of the carriage permits the fabrication of a wire braid of particular use in wire braid memories.

20 Claims, 12 Drawing Figures



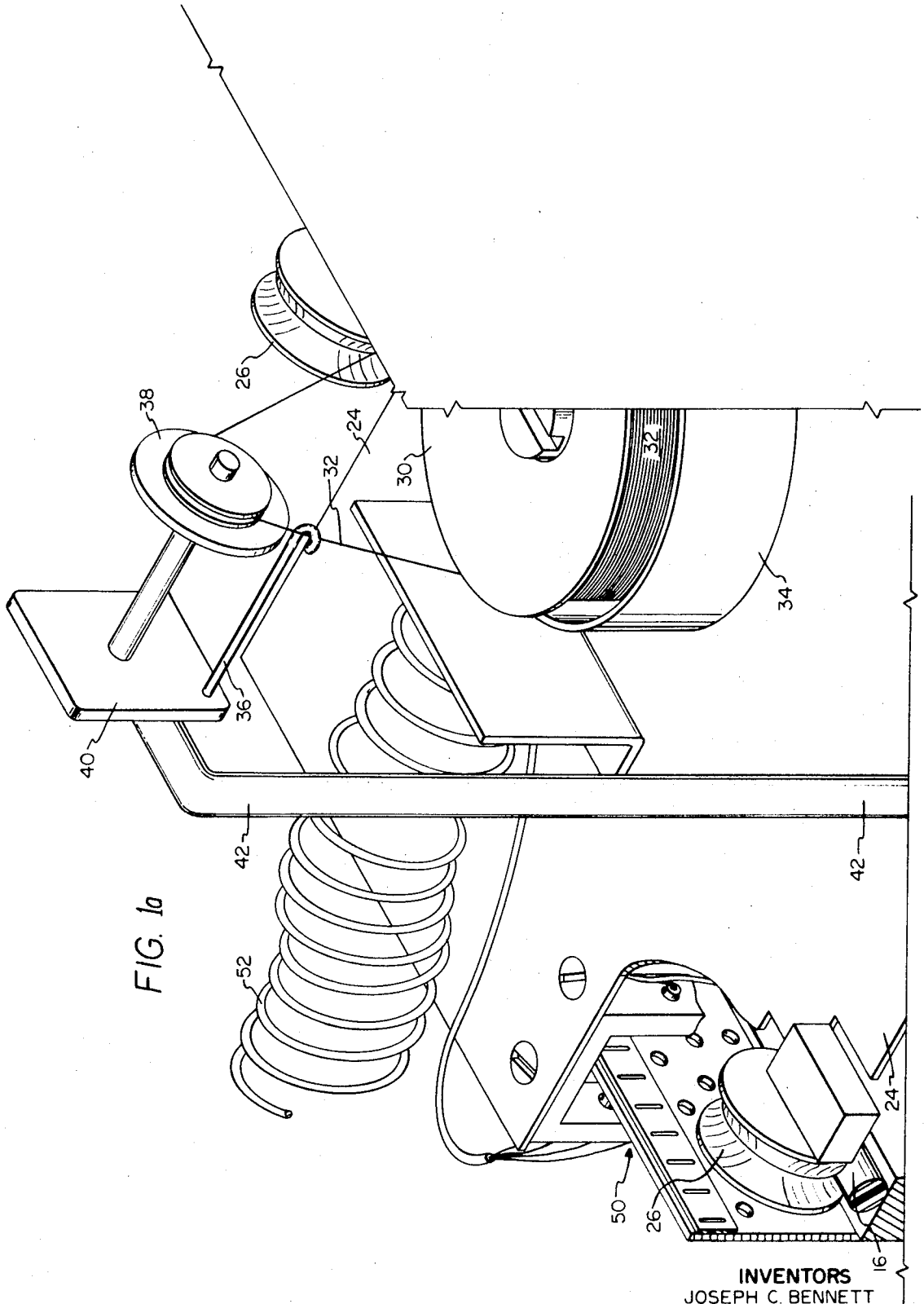


FIG. 1a

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ATTORNEY

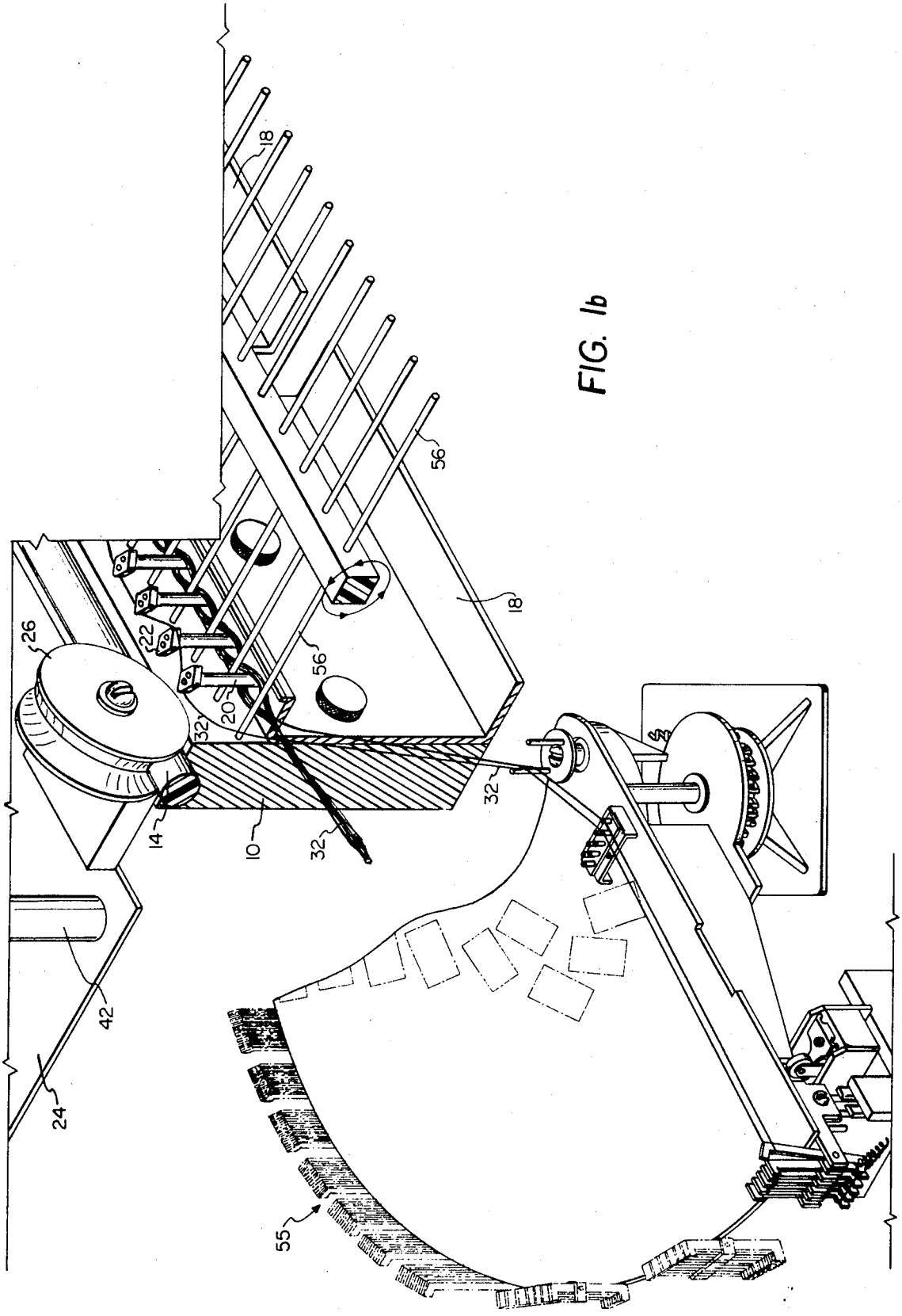


FIG. 1b

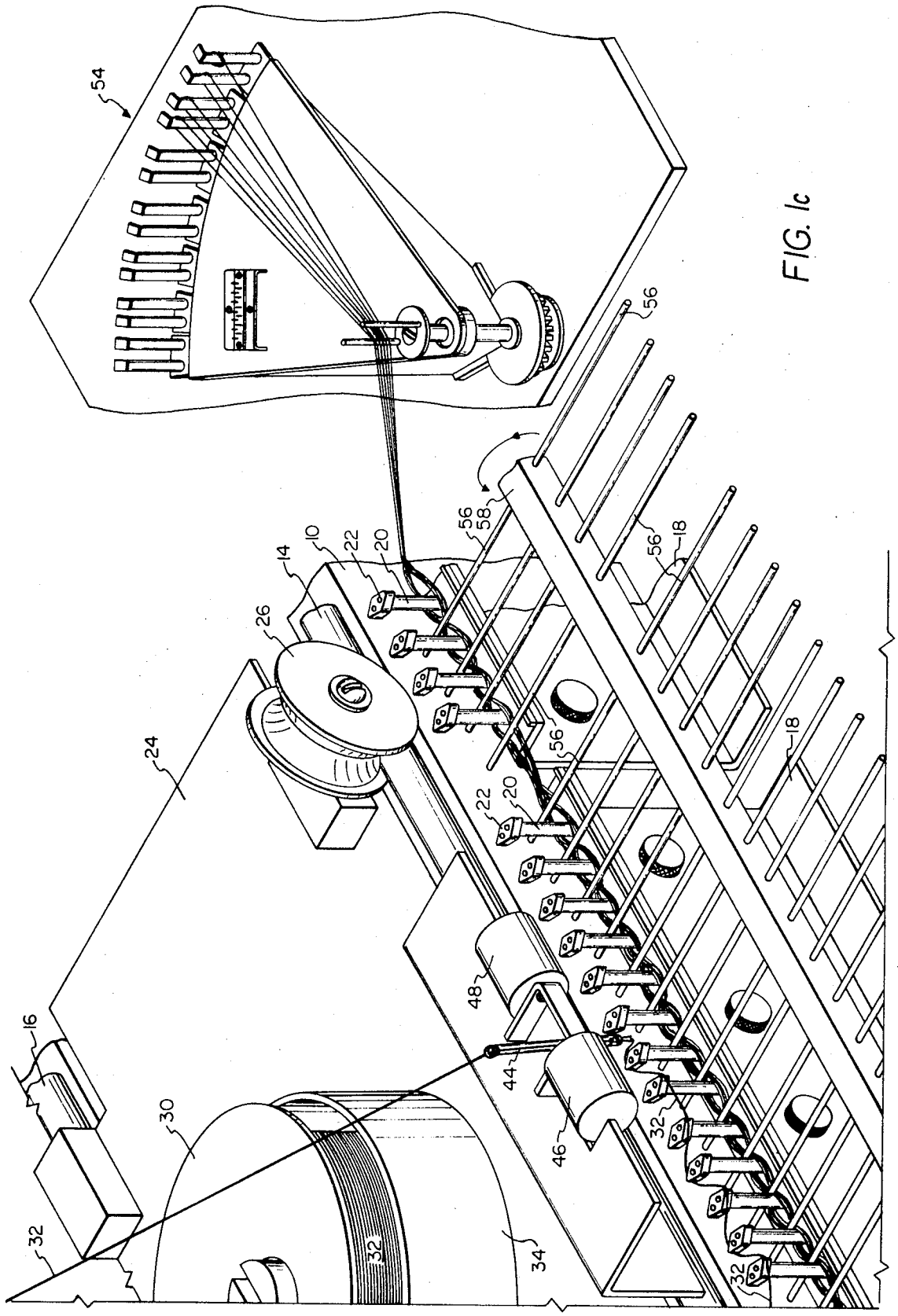


FIG. 1c

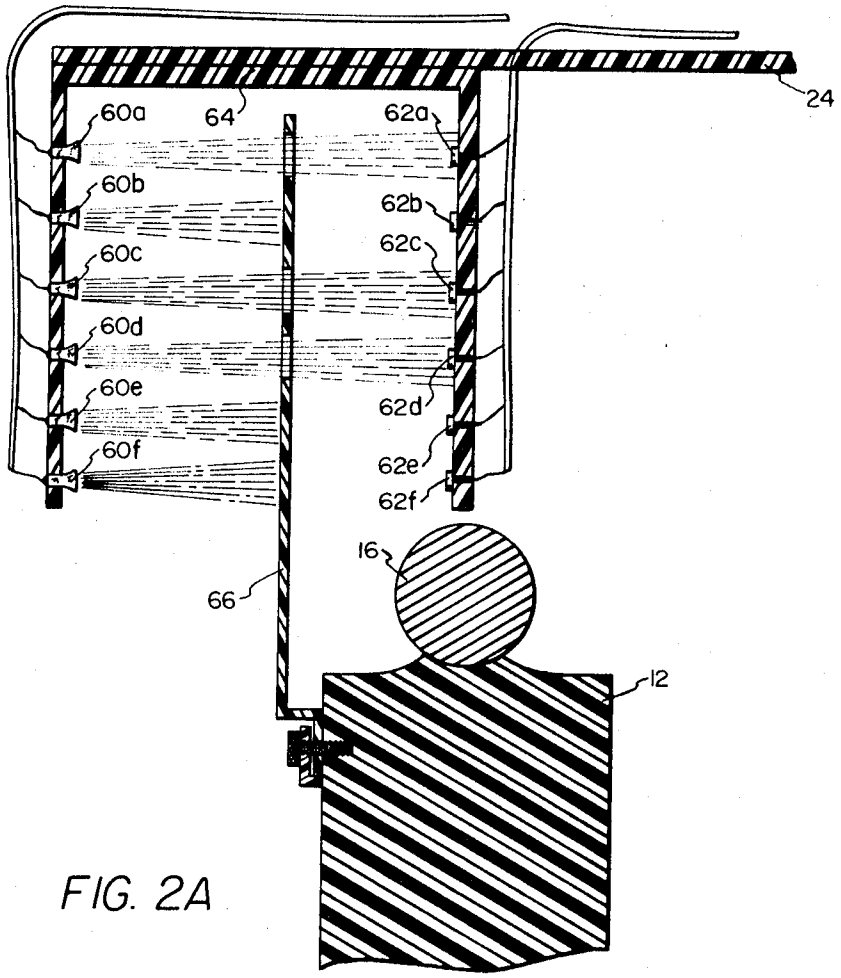

24
64
60a
60b
60c
60d
60e
60f
62a
62b
62c
62d
62e
62f
16
66
12

FIG. 2A

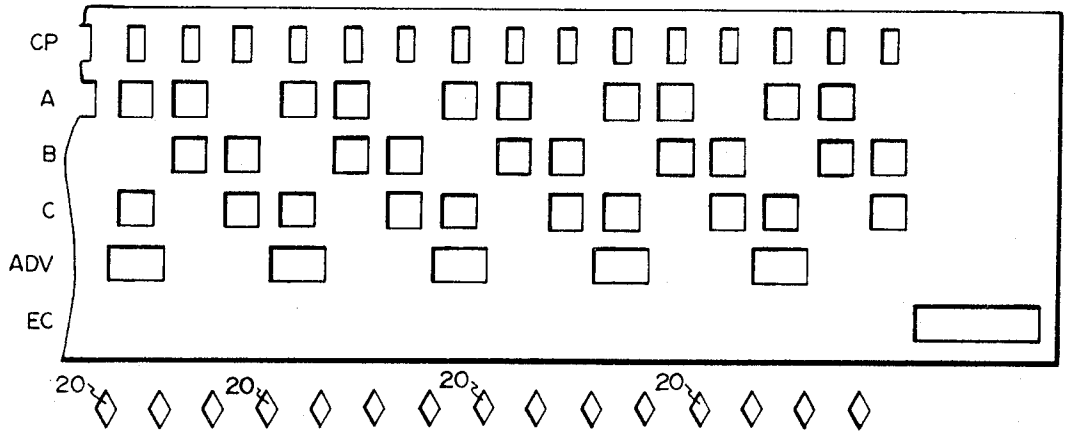

CP
A
B
C
ADV
EC
20
20
20
20

FIG. 2B

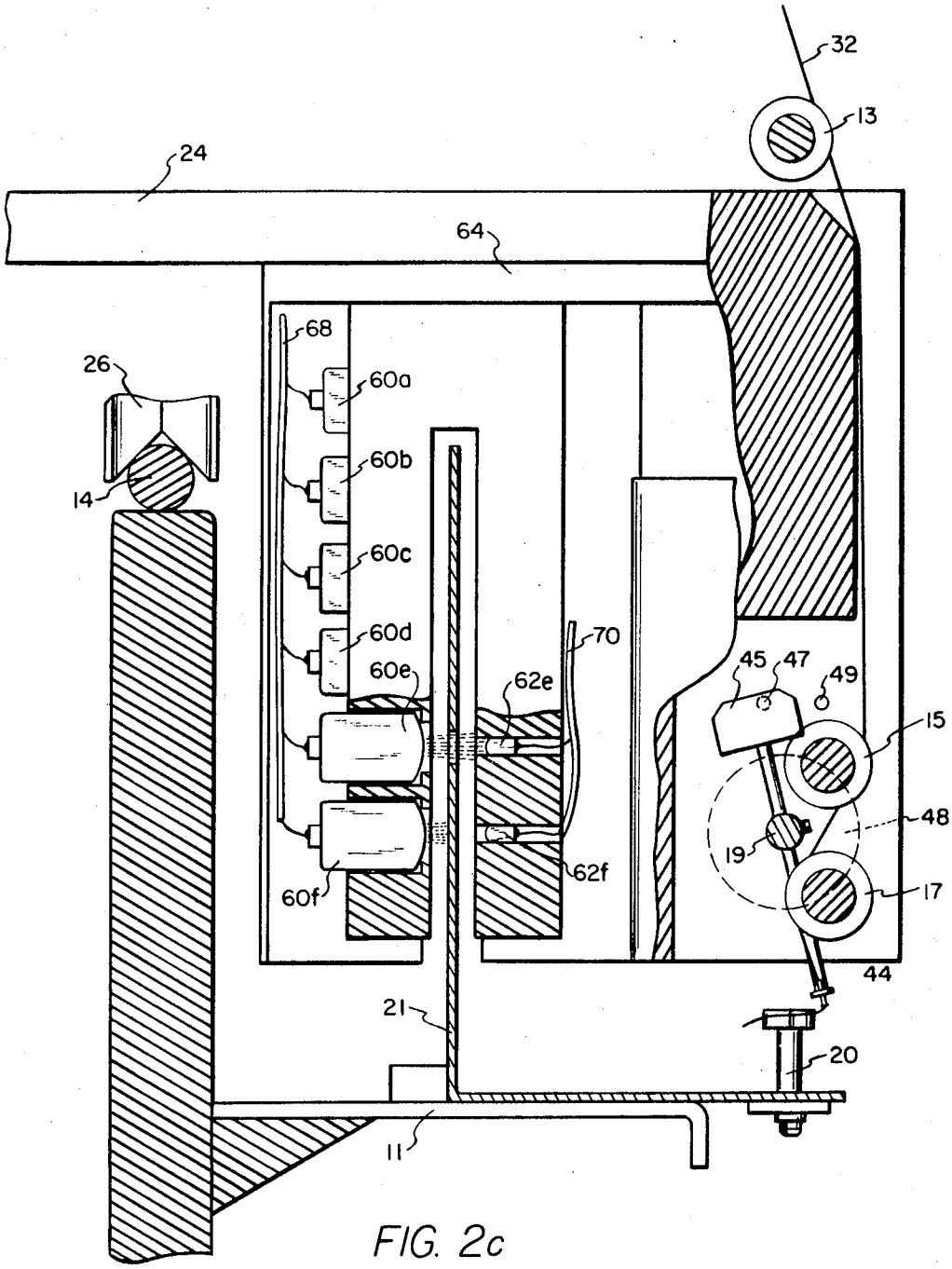

32
13
24
64
68
26
60a
60b
14
60c
60d
70
60e
62e
45
47
49
15
48
19
17
60f
62f
44
21
20
11

FIG. 2c

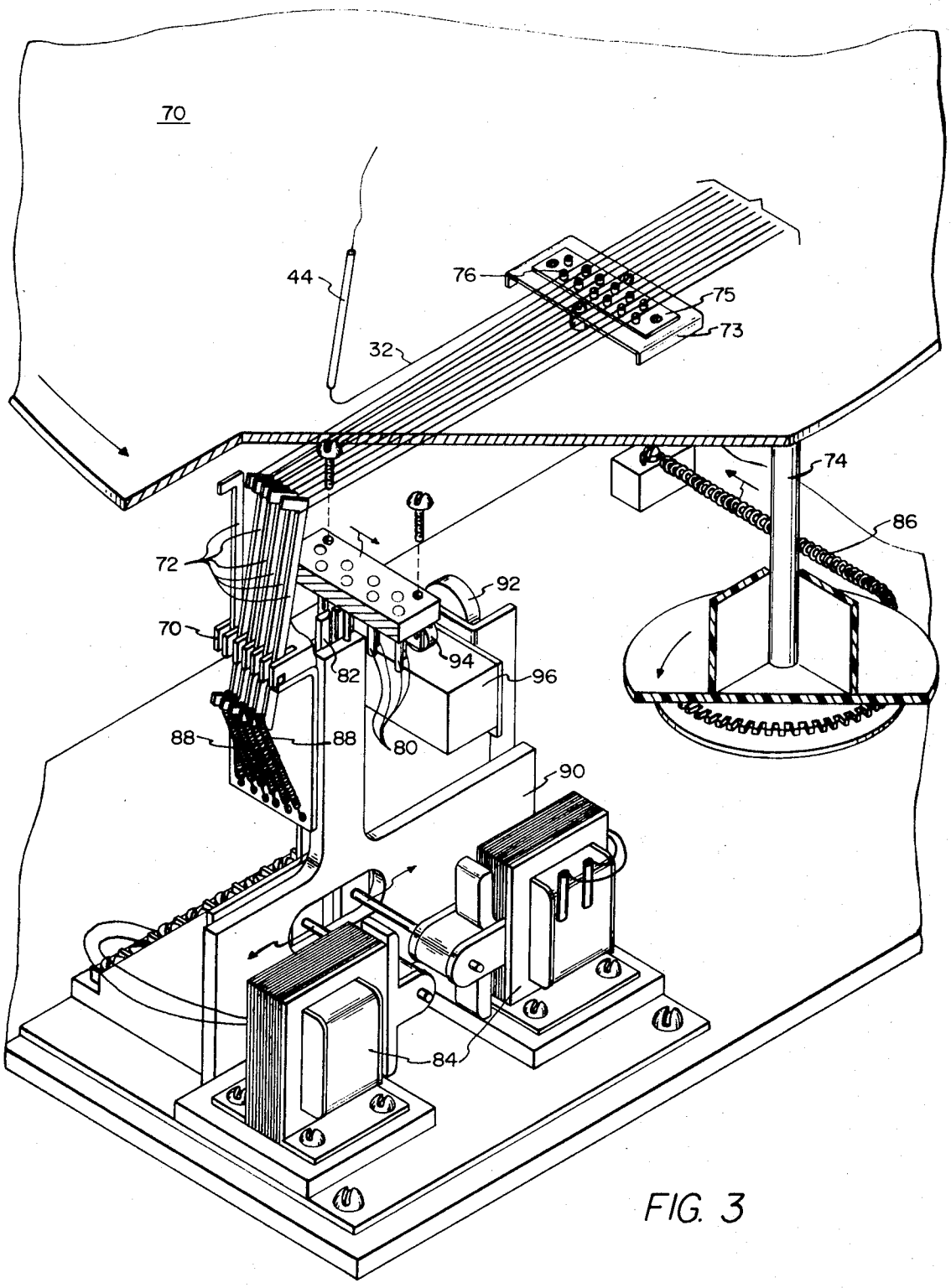


FIG. 3

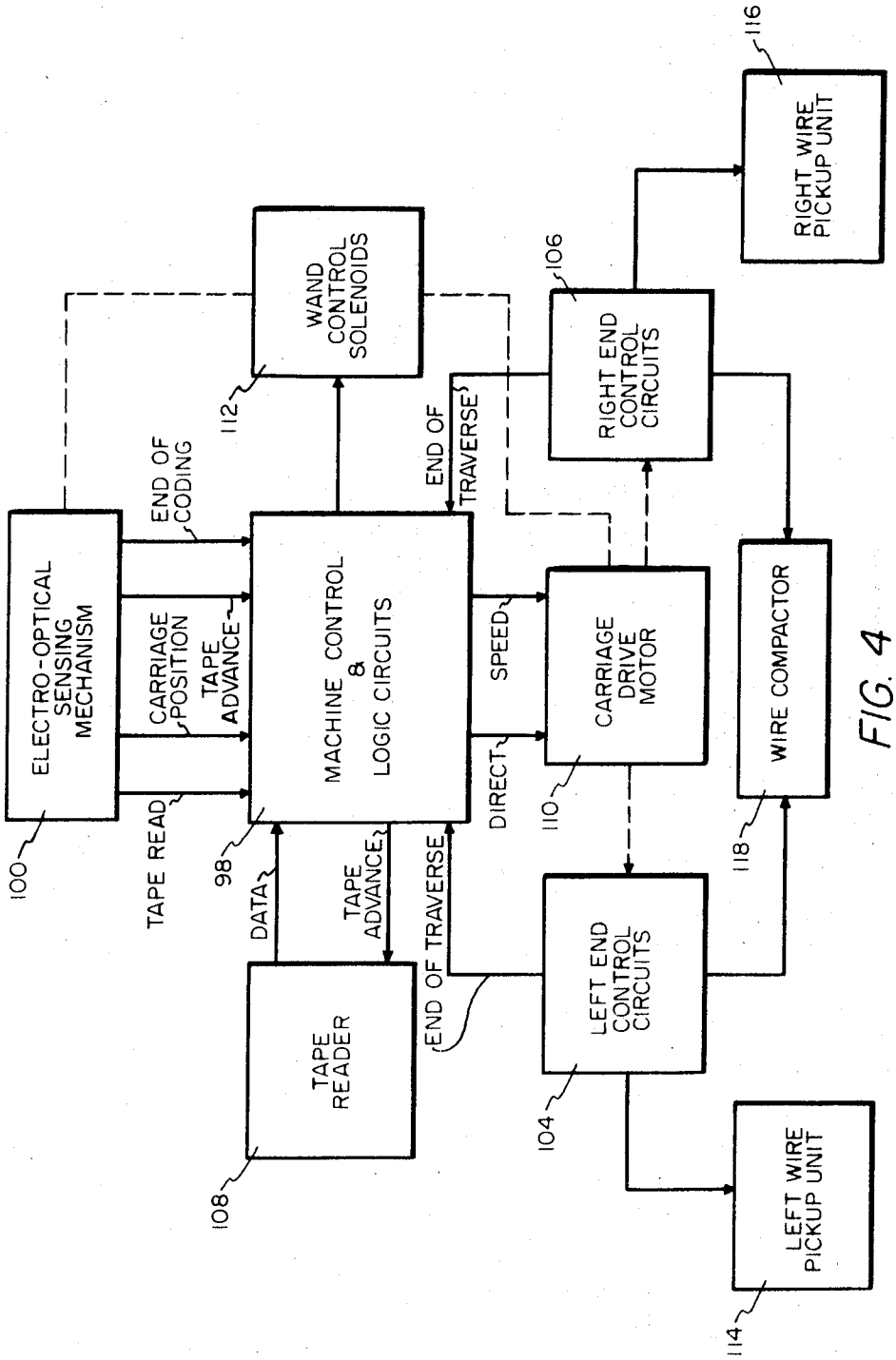

ELECTRO-OPTICAL SENSING MECHANISM
100
END OF CODING
CARRIAGE POSITION
TAPE ADVANCE
TAPE READ
98
MACHINE CONTROL & LOGIC CIRCUITS
WAND CONTROL SOLENOIDS
112
DATA
TAPE ADVANCE
TAPE READER
108
END OF TRAVERSE
SPEED
DIRECT
CARRIAGE DRIVE MOTOR
110
END OF TRAVERSE
RIGHT END CONTROL CIRCUITS
106
RIGHT WIRE PICKUP UNIT
116
WIRE COMPACTOR
118
LEFT END CONTROL CIRCUITS
104
LEFT WIRE PICKUP UNIT
114

FIG. 4

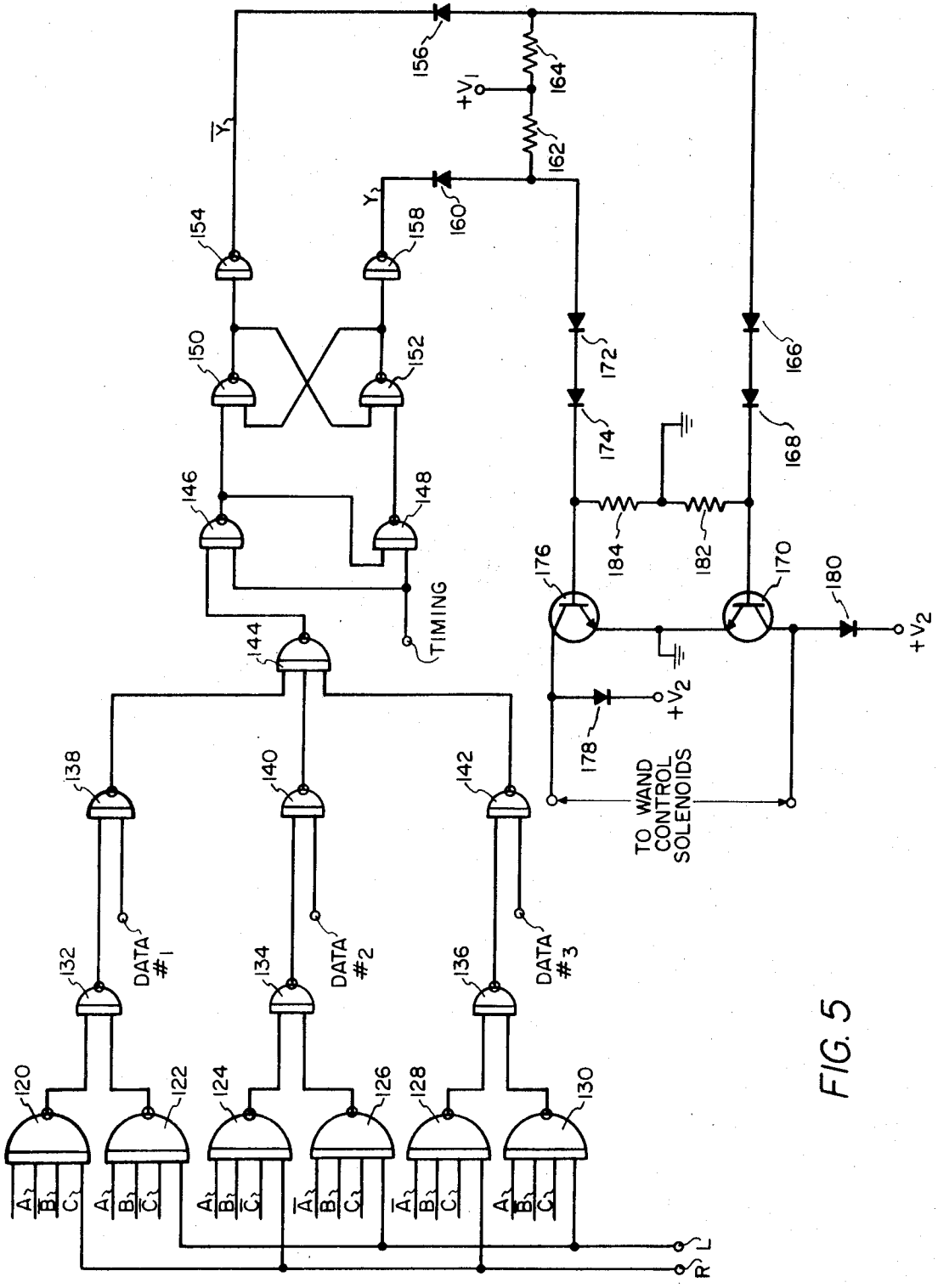

156
164
+V1
162
Y3
160
158
154
150
152
172
166
174
168
146
148
184
182
176
170
180
+V2
TIMING
144
+V2
178
TO WAND CONTROL SOLENOIDS
138
140
142
DATA #1
DATA #2
DATA #3
132
134
136
120
122
124
126
128
130
A3 B3 C3
A3 B3 C3
A3 B3 C3
A3 B3 C3
A3 B3 C3
L
R

FIG. 5

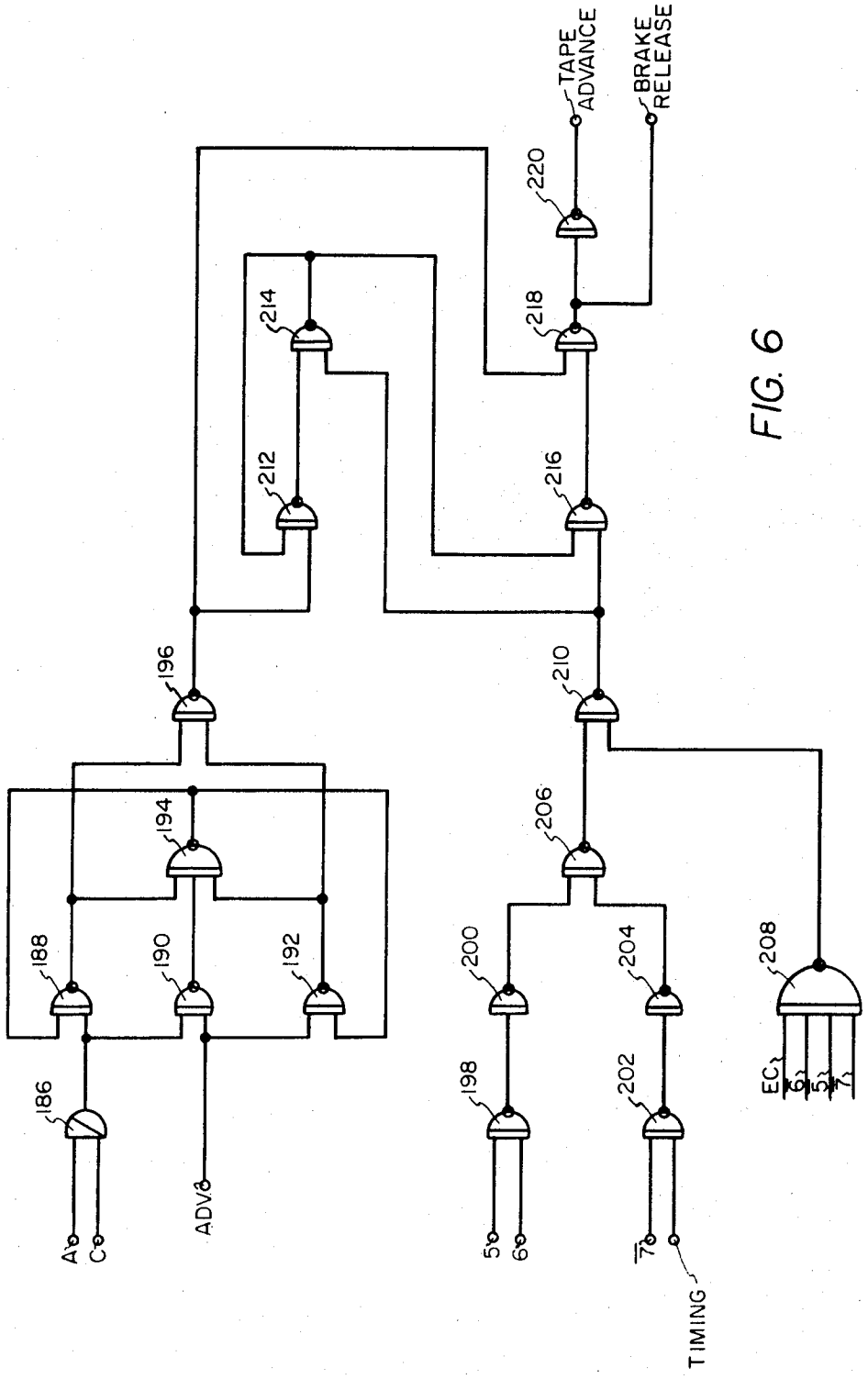

TAPE ADVANCE
BRAKE RELEASE
220
218
214
212
216
196
210
194
206
188
190
192
200
204
208
186
198
202
EC
A
C
ADV
5
6
7
TIMING

FIG. 6

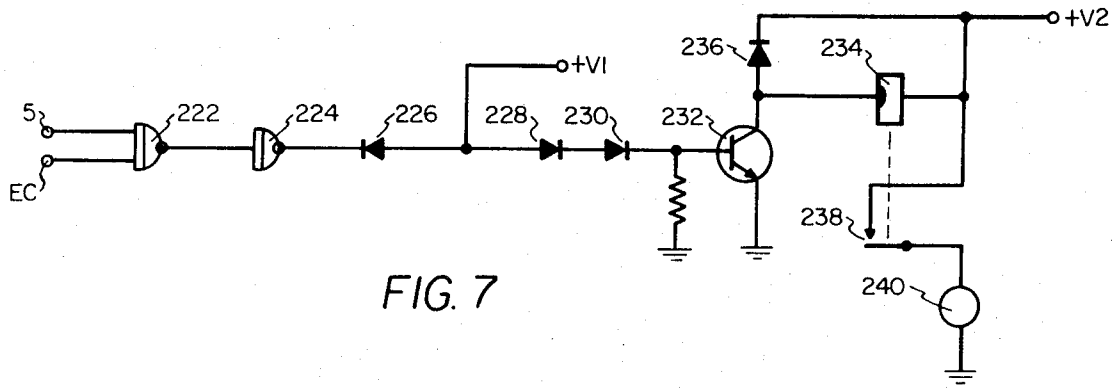

+V2
236
234
+V1
5
222
224
226
228
230
232
238
EC
240

FIG. 7

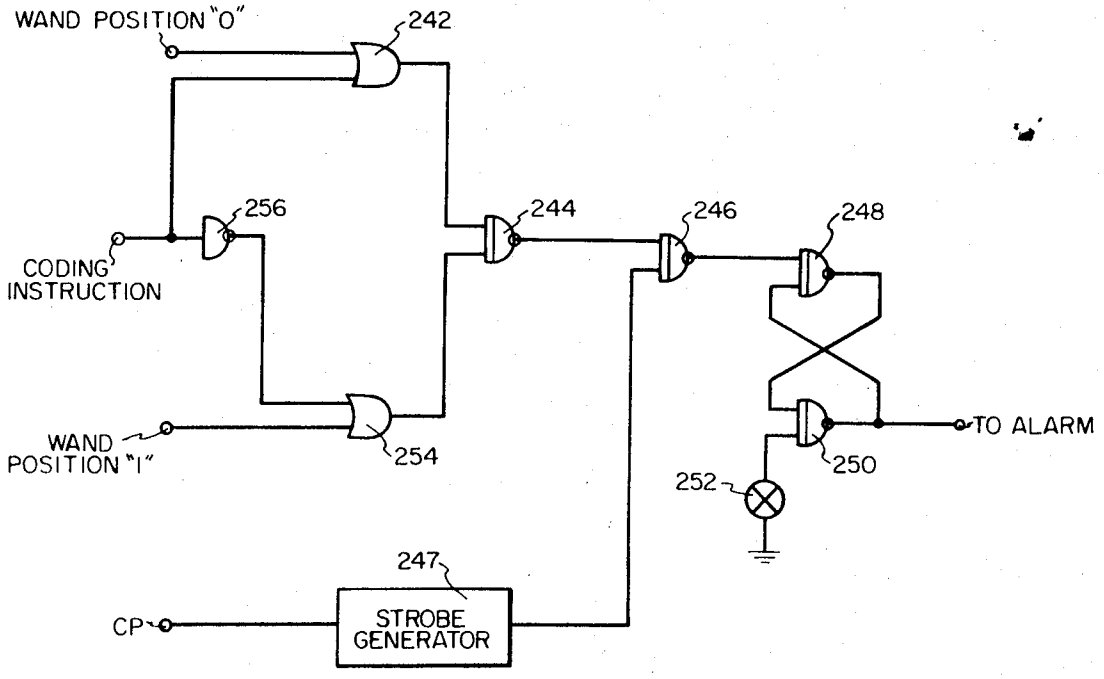

WAND POSITION "0"
242
256
244
246
248
CODING INSTRUCTION
TO ALARM
WAND POSITION "1"
254
250
252
247
CP
STROBE GENERATOR

FIG. 8

WIRE BRAID FORMING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates most generally to the manufacture of digital computer memories and in particular to apparatus for fabricating wire braid for read-only memories.

2. Description of the Prior Art

The wire braid transformer read-only memory has been known for a number of years. Essentially, the memory uses one wire for each word to be stored and one core for each bit of the output word. If a given word wire passes through a particular core a binary "1" is stored at that bit position; if not, a binary "0" is stored there. When a current pulse is passed along a word line the cores through which it passes will produce large voltage pulses on their multi-turn sense windings due to high inductive coupling. Cores which are by-passed by the word line produce a negligible output voltage. By monitoring the outputs of all cores simultaneously, the data which is permanently stored in the memory is read out. Since linear magnetic material is typically used in the transformer memory, cores with air gaps may be used. Thus the memory braid wires may be woven in the desired pattern of ones and zeros and then placed over U-shaped cores which are then capped with ferrite material. For a fuller discussion of braid memories reference may be had to an article entitled "Weaving a Braided Memory That's Fast and Inexpensive" by John J. Marino and Jonathan J. Sirota which appeared at pp. 121–126 of the Sept. 18, 1967 issue of Electronics.

The economic potential of the braid memory is directly dependent upon the ease with which the memory braid may be produced. Prior to the present invention the weaving of memory braid has been accomplished through the use of a modified Jacquard loom the basic structure and operation of which have been well known for over 150 years. A variant of the Jacquard loom used in the manufacture of memory braid is described in U.S. Pat. No. 3,451,129 which issued to R. L. Alonzo et al on June 24, 1969. Basically, this is a tape controlled loom which weaves a large plurality of wires in a prescribed code about a group of removable metal separators. Although having been found acceptable for weaving memory braid the Jacquard loom is a highly complex electro-mechanical apparatus. It requires a matrix of solenoid actuated cross-bars and a combination of heddle rods and one heddle for each address wire in the memory. Once the apparatus is set up with one wire coupled to each heddle a single bunch of address wires is formed. In operation, the loom under the control of a digital tape reader segregates selected ones of the address wires from the bunch thus forming a shed. At this point a metal separator is manually inserted in the shed and the heddles are then returned to finished original position. The sequence is then repeated with the manual insertion of a separator in each shed for each core location. It will be clear that handling all address wires to be used in a memory simultaneously is a complex task which requires complex apparatus which is beyond the financial reach of many users of wire braid. With the complexity of the apparatus goes the increased probability that errors will be introduced into the fnished braid.

OBJECTS AND SUMMARY OF THE INVENTION

From the foregoing discussion it will be understood that among the various objectives of the present invention are:

the provision of a new and novel apparatus for fabricating wire memory braid;

to provide apparatus of the above-described character which is of simplified construction;

to provide apparatus of the above-described character which is fully automatic in its operation;

to provide apparatus of the above-described character which operates to weave a single address wire at a time in the desired coding pattern; and

the provision of apparatus of the above-described character whereby address wires are automatically collected at each end in a desired pattern.

These and other objectives of the present invention are efficiently achieved by providing a carriage-mounted, electro-mechanically actuated coding wand through which address wire is fed from a supply spool, and a fixed linear array of pegs. As the carriage traverses the array of pegs the coding wand is displaced to one of two positions in response to an electro-optically actuated tape coding device such that the address wire is routed to one side or the other of a given peg in the array, corresponding to a binary one or zero. At the end of the carriage traverse the address wire is routed and held in a desired position above a connector terminal and the carriage motion is reversed to weave the next address wire without manual intervention.

The foregoing as well as other objects, features and advantages of the present invention will become more apparent from the following detailed description taken in conjunction with the various views of the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A through 1C are an overall elevation view of a wire braid forming apparatus in accordance with the principles of the present invention;

FIGS. 2A and 2B are more detailed views of the electrooptical sensing mechanism employed in the practice of the present invention;

FIG. 2C is another view of an electro-optical sensing mechanism in its preferred form;

FIG. 3 is a detailed view of an address wire terminating arrangement of utility in the practice of the invention;

FIG. 4 is an electrical schematic block diagram of the apparatus of FIG. 1;

FIG. 5 is a detailed schematic diagram of the coding wand solenoid control circuit portion of the apparatus of FIG. 4;

FIG. 6 is a detailed schematic diagram of the tape reader control circuit portion of the apparatus of FIG. 4;

FIG. 7 is a schematic diagram of an out-of-sync detection circuit of utility in the practice of the present invention; and

FIG. 8 is a schematic diagram of a coding error detection circuit which may be used to advantage with the electro-optical sensing mechanism of FIG. 2C.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to FIG. 1 there is illustrated a braid

forming machine including a machine bed formed of first and second substantially parallel rails **10** and **12** on the top of each of which is provided a track **14** and **16** respectively. To the first or front rail **10** is removably secured one or more carrier plates **18** to which a linear array of upstanding pegs **20** is affixed. The pegs **20** are disposed such as to correspond to the disposition of the cores in the memory for which the braid is to be fabricated. As will be discussed in more detail hereinbelow the upper portion **22** of each peg **20** preferably has an enlarged head portion with respect to the remainder thereof.

A carriage base plate **24** is provided with wheel assemblies **26** adapted to engage and roll upon the tracks **14** and **16** such as to traverse the array of pegs **20.** A supply spool **30** loaded with memory address wire **32** is disposed in a receptacle **34** mounted on the carriage base plate **24.** A wire guide **36** and braked pulley **38** are mounted on a plate **40** which is in turn mounted on an arm **42** which extends from the base plate **24** above the supply spool **30.** A single strand of insulated wire **32** which may be either solid or stranded is thus fed from the spool **30,** through the wire guide **36,** and over the braked pulley **38** to a hollow coding wand **44.** The coding wand **44** is fixed to the armature of first and second rotary electromagnets **46** and **48** which are mounted on the carriage base plate **24** and extends to the plane in which the enlarged head portions **22** of the array of pegs **20** are disposed. The wire **32** is encircled by the coding wand **44** such that when the wand position is changed the wire position follows. External commands from control logic to be presently described drive the two electromagnets such that the coding wand **44** is driven to one side or the other of the pegs **20.** The electromagnets **46** and **48** are preferably mechanically arranged such that the coding wand **44** when electrically pulled by one is mechanically pushed by the other, thus increasing the speed with which the finger may be moved from one side of the array of pegs **20** to the other thereby increasing coding speed.

An electro-optical sensing mechanism shown generally at **50,** and to be described in detail hereinbelow is mounted under the carriage base plate and provides carriage position information, as well as tape read and advance commands to the external control logic (not shown). The electro-optical sensing mechanism is coupled to the control logic via a flexible cable **52** which also includes the conductors which couple the control logic output to the electromagnets **46** and **48.**

At each end of the braid forming apparatus there are provided, wire pick-up units designated generally at **54** and **55** to be described in detail hereinbelow. The pick-up units operate to hold the continuous wire used to form the multiple wire braid, establish the wire termination order and fix the length of wire between the braid and the termination zone.

In operation the carriage **24** is driven, preferably by a variable speed electric motor (not shown), such that it traverses the length of the array of pegs **20.** The electro-optical sensing mechanism **50** couples carriage position information and tape read commands to the external control logic which in turn drives the electromagnets **46** and **48** such as to position the coding wand **44** on the desired side of each peg **20.** The wire **32** is thus woven in the desired pattern about the enlarged portions **22** of pegs **20.** On the completion of a traverse of the carriage **24** the wire **32** is pushed downward about the narrower portion of the pegs **20** by a compactor comrising a plurality of flexible tines **56** fixed to a rotatable rod **58** disposed parallel to the array of pegs **20.** The wires of the braid thus are loosely deposited about the base of the pegs **20** on the carrier plate **18.** When the desired number of address wires have been laid down in the desired pattern they may be sprayed with a low surface tension, mild solvent to bond the wire insulation together prior to their removal from the carrier plate. In this manner inadvertent coding changes during handling of the finished braid are precluded.

With reference to FIGS. **2A** and **2B** there are shown two views of an electro-optical sensing mechanism useful with the apparatus of FIG. **1.** This unit is illustrated for convenience as being disposed to the rear of the apparatus of FIG. **1** and comprises an array of light sources **60**a-e and photoelectric detectors **62***a–e* disposed in alignment on opposite sides of a U-shaped support member **64** affixed to the under side of the carriage base plate **24.** An aperture plate **66** is adjustably affixed to the machine bed rail **12** and extends upwardly between the light sources **60** and detector elements **62.** The aperture plate **66** is provided with a linear array of apertures for each light source/detector pair, in the preferred embodiment six channels being used. In operation the light source/detector array moves with the carriage base plate **24** as it traverses the array of pegs **20** and thus traverses the length of the fixed aperture plate **66.** Each light source **60** is coupled to a remote power supply (not shown) via leads **68** and each detector element is coupled to the external control logic (not shown) via leads **69.**

In the implementation of the present invention the external control logic includes a paper or magnetic tape reader. The memory coding pattern is stored on the tape and the movement of the coding wand **44** of FIG. **1** is controlled by the control logic. Reading of the tape is, however, slaved to the movement of the carriage **24** through the electro-optical sensing mechanism **50.**

Although a variety of data storage devices could be used in the practice of this invention it is preferred that a tape reader employing a standard ASCII code be used. With this type of system the wire coding data in octal format may be stored in channels 1–3 of the tape and channels 4–7 may be used for storage of the non-coding or machine instruction data. As the carriage traverses, the electro-optical sensing mechanism will sequentially select from the three coding data bits in each ASCII octal group and forward the information to the coding wand control circuits.

As stated above the electro-optical sensing mechanism **50** is preferably a six channel arrangment as illustrated in FIG. **2B.** Channel CP contains a carriage position code having an aperture corresponding to each opening between adjacent pegs **20.** Thus at any time that detector **62***a* receives light through a CP aperture from light source **60***a* the coding wand **44** of FIG. **1** is at a position between two pegs **20** and may be moved from one side to the other of the pegs. In the preferred embodiment three channels, A–C, provide "tape read" commands which instruct the external tape reader to read the next code bit stored at that position on the tape. At each bit position the tape will have stored either a binary zero or one which will determine the side of the peg **20** to which the coding wand **44** is to pass.

Each tape read aperture A–C is slightly wider than the carriage position apertures such that the reading of the code from the tape is accomplished by the time the carriage position is such that the coding finger **44** may be moved. Each tape read command is thus generated at the leading edge of each channel A, B and C aperture. The fact that each tape read aperture is slightly wider than the carriage position apertures permits the electro-optical sensing mechanism to operate with the carriage traversing in either direction. The three individual tape read command channels A–C are used to conserve physical space on the aperture plate **66** and to permit more efficient use of the coding tape since three sequential bits of coding information may be stored per tape position.

Further, by using a combination of two of the three "tape read" channels per bit it is possible to determine the direction of carriage travel and assure that the wand position commands will be appropriate to that direction of travel. It is of course possible to vary this arrangement to provide more or fewer bits of coding information per tape position by providing more or fewer channels in the electro-optical sensing mechanism. The ADV channel of the aperture plate **66** provides the tape advance command to the tape reader, i.e., after all bits at a given tape position have been read detector **62e** senses light through the ADV channel aperture from light source **60e** and the tape is advanced to the next read position. The tape advance aperture is disposed in overlapping alignment with the center of the "tape read" apertures in channels A and C, i.e., the combination corresponding to the last tape channel to be read at the tape position. The tape is advanced at the leading edge of the ADV channel aperture and since these apertures overlap the "tape read" apertures the mechanism is operative with the coding wand traversing in either direction. Channel EC of the aperture plate is provided with an extended aperture at each end of the plate and provides an indication that the carriage has reached the end of the address wire coding portion of its traverse. When detector **62** *f* receives light through the EC channel of the aperture plate **66** from light source **60f**, a signal is applied through the control logic to switch the carriage drive motor to a relatively higher speed, lock the coding wand in a preselected position, enable the wire termination mechanism and initiate reversal of the control logic and drive motor as will be discussed in more detail hereinbelow.

It will be understood that by using the electro-optical sensing mechanism **50** to control an external tape reader rather than to actually provide the coding commands, any wire coding arrangement may be woven on a given peg layout by changing the coding tape. Conversely, a given wire coding arrangement may be woven on any peg layout by changing the peg arrangement and electro-optical aperture plate. Further, since the wire coding is controlled by the tape reader which is in turn slaved to the movement of the carriage, the braid forming apparatus may operate at any desired speed and timing problems are reduced to a minimum.

The electro-optical sensing mechanism **50** of FIG. **1** is shown at the rear of the braid forming machine for convenience in illustrating the overall apparatus. In actual implementation of the sensing mechanism, however, it is preferred that the coding plate and peg carrier be integrated in a single structure in order that misalignment of the coding plate and peg array is reduced to a minimum. This arrangement is illustrated in the partial end view with portions cut away of FIG. 2C. In this preferred embodiment elements common to those shown in FIGS. **1** and 2A are identified with like reference numerals.

The forward rail **10** is provided with a forward extending support plate **11** and the U-shaped member **64** carrying the array of light sources **60** and the photoelectric detectors **62** is affixed to the underside of the carriage base plate **24.** The wire **32** is passed over pulleys **13, 15** and **17** and is thus directed through the tip of the coding wand **44.** As stated above the coding wand is fixed to the armature **19** of the rotary electromagnets **46** and **48,** only **48** being illustrated. This embodiment differs from that shown in FIGS. **1** and 2A in that the carrier plate to which the array of pegs **20** are affixed and the aperture plate which extends upwardly between the light sources **60** and detectors **62** are formed in a single structure **21.** Since the arrangement of apertures is uniquely related to the linear peg array and to change one requires a corresponding change of the other, both fabrication and use of the apparatus is facilitated by integrating the peg carrier and aperture plates into a single structure. Misalignment of the aperture array with respect to the peg array is substantially eliminated since both are replaced as a single non-adjustable unit.

In order that a coding error detection provision may be incorporated, the coding wand **44** may be provided with a light opaque tab or shield **45** at its upper end. First and second light sources (not shown) and photoelectric detectors **47** and **49** are disposed in an arrangement similar to that of light sources **60** and detectors **62.** The arrangement is such that when the coding wand **44** is in one of its two coding positions the tab **45** will block the light falling on one or the other of the detector elements **47** or **49.** An output signal from detector **49,** for example, may indicate that the coding wand **44** is in the binary "0" coding position. Correspondingly an output from detector **47** would indicate the coding of a binary "1". These detector outputs may be coupled to error detection circuitry, to be described hereinbelow for comparison with the coding instruction from the tape reader. A dissimilarity may thus be used as the criterion for actuating an alarm and/or automatically stopping the machine.

FIG. **3** illustrates in more detail the structure and operation of the address wire terminating mechanism of the present invention. Although the wire pick-up unit **54** of FIG. **1** will differ in the coding details from pick-up unit **55** their basic operation is the same. Specifically, unit **55** may provide for coupling a plurality of address wires in common to a single connector terminal for coupling to a switch, whereas unit **54** may provide for coupling each address wire via individual pins of a connector to individual drivers. Unit **54,** being the more complex and incorporating all the features of unit **55,** will be described in detail.

As shown in FIGS. **1** and **3** the wire terminating mechanism basically comprises a flat plate **70** having groups of wire holding fingers **72,** having a mounting **73** for connectors **75** and adapted for rotation on a mounting shaft **74.** As described hereinabove, when the carriage reaches the end of a wire coding traverse, as sensed by the electro-optical sensing mechanism, the coding wand **44** is locked in a preselected position (i.e., either 1 or 0) while the carriage continues to move.

The coding wand **44** continues laying down address wire **32** as it passes over a selected connector pin **76** of a connector **75** mounted on the plate **70** of the wire terminating mechanism. When the coding finger **44** has passed between the wire holding fingers **72** the plate **70** is rotated in the direction indicated such that when the carriage motion is reversed the coding wand **44** will pass on the opposite side of the desired wire pickup finger. Reversal of carriage motion may easily be effected by the carriage tripping a micro switch (not shown) at the end of its travel to actuate motor direction control solenoids (not shown). In order to accomplish this stepwise rotation of the plate **70** there is provided at the under side thereof a staggered double row of downwardly extending pins **80** and a pair of plate step arms **82** each activated by an associated solenoid **84.** The mounting shaft **74** has a rotational bias applied thereto via spring **86.** When the plate **70** is thus under torsional bias the alternate activation of solenoids **84** operates to alternately move the respective step arms **82** laterally away from blocking the pins **80** such that the plate **70** with the wire pickup fingers **72** moves the desired distance at the completion of each traverse of the carriage.

Although the wire pickup fingers **72** may be rigidly affixed to the plate **70** it is preferred in the practice of the invention that they be pivotally attached to the plate and outwardly biased by springs **88** such that the address wire **32** is maintained under slight tension. In this manner the wires are more easily maintained in proper position with respect to the connector pins **76.** When the memory braid is completed the individual wires may easily be soldered to their respective connector pins and the looped end trimmed off. Further, although not specifically shown a test connector may also be coupled to the connector **75** through the plate **70** and the memory braid tested before its removal from the apparatus. Finally, if desired, a structural support **90** including a roller bearing **92** may be disposed beneath the plate **70.** The plate **70** may be also provided with a micro switch **94** which operates to either automatically shut off the apparatus when a braid is completed or to activate a plate return motor (not shown) to return the plate **70** to its original position if it is desired to terminate a number of wires in common. As stated hereinabove the wire terminating unit **55** (FIG. **1**) is essentially identical in priciples of construction and operation and will not be described in detail. Any differences between units **54** and **55** will be attributable to the type of termination desired, e.g., unit **55** may terminate each individual wire **32** to individual connector pins **76** whereas unit **54** may operate to terminate groups of wires in common. Basic operation, however, will be the same.

In FIG. **4** there is shown a schematic electrical block diagram of the apparatus of the present invention. Wire braid coding is controlled by the machine control and logic circuits **98** to be described in more detail hereinbelow. These control and logic circuits **98** receive the carriage position, tape read, tape advance and end of coding signals from the electro-optical sensing mechanism **100,** end of carriage traverse signals from the end control circuits **104** and **106** and the coding wand position data from the tape reader **108.** The outputs of the machine logic and control circuits are signals which control the speed and direction of the carriage drive motor **110** and the coding wand control solenoids **112.** As stated above the right and left end control circuits **104** and **106** may be mechanically actuated via the tripping of a micro switch by the carriage and provide an output signal to their respective wire pick-up unit stepping means **114** and **116** respectively and actuate the wire compactor **118.**

FIG. **5** schematically illustrates that portion of the machine control and logic circuitry which operate to provide the coding wand solenoid signals. The A, B and C channels of the electro-optical sensing mechanism are applied to input gates **120–130** with a signal which indicates the direction in which the coding wand is traversing (i.e., the motor direction signal). The outputs of gates **120–130** are applied via gates **131–136** to gates **138–142** where the signals are gated with binary data pulses from the appropriate channel of the tape reader. The outputs of gates **138–142** are then gated together in gate **144** to provide a binary coding instruction. This instruction pulse is applied via a data register to the solenoid drive circuits together with the carriage position pulse from the electro-optical sensing mechanism. The carriage position pulse, CP, is gated with the coding instruction pulse in gate **146** the output from which is applied with the carriage position pulse to gate **148,** and as one input to gate **150.** The output of gate **148** is applied as one input to gate **152.** Gates **150** and **152** each have as their respective second inputs the output of the other. The output of gate **150** will thus be a pulsed signal indicative of a binary **0** and is applied via amplifying gate **154** to the cathode of diode **156.** In a like manner the output of gate **152** representing a binary 1 is coupled via amplifying gate **158** to the cathode of diode **160.** A bias voltage, V_1, in the preferred embodiment being +5 v. d.c. is applied via resistors **162** and **164** to the anodes of diodes **156** and **160** respectively. Any signal passed by diode **156** is coupled through diodes **166** and **168** to the base of a first solenoid driver transistor **170.** In the same fashion any signal passed by diode **160** is coupled through diodes **172** and **174** to the base of a second solenoid driver transistor **176.** The emitters of transistors **170** and **176** are coupled together and the collectors are coupled to the coding wand control solenoids (not shown). Thus when a pulse is applied to either of the grounded emitter transistors **170** or **176** an appropriate solenoid operating voltage, V_2, preferably +12 v. d.c. is applied through either diode **178** or **180** respectively to the proper solenoid and is removed from the other. A pair of balancing resistors **182** and **184** may also couple the base of each transistor **170** and **176** respectively to ground potential.

FIG. **6** is a schematic diagram of the tape reader control portion of the machine control and logic circuits (**98** of FIG. **4**). The tape reader control circuits advance the tape in the reaader after all data bits at the tape position have been read, distinguish between true data bits and machine instructions, and check whether the last data bit was entered in the last location on the wire. To preclude any adverse effect of mechanical jitter in the electro-optical sensing mechanism a tape advance signal will only be generated when signals are coincident in the ADV channel and either the A or C data channels of the sensing mechanism. Signals from channels A and C are applied via OR gate **186** to gates **188** and **190** and the ADV signal is applied to gates **190** and **192.** The outputs of gates **188–192** are applied to gate **194** the output from which is fed back as the second input to gates **188** and **192.** The outputs of gates **188**

and 192 are applied through gate 196 to provide a true tape advance signal so long as ADV and either A or C (whichever occurs first) are present.

Gates 198–206 from a combinatorial logic circuit which tests for the proper signals from the non-coding data channels on the tape and from the tape reader timing pulse. Gate 208 permits tape advance action in the wire-end zones when a signal is present in the EC channel of the electro-optical sensing mechanism and machine instructions may be permitted to control the tape reader.

Gate 210 is an OR gate which receives the outputs from the combinatorial logic circuit comprising gates 198–206 and from gate 208 and provides an input to a sequential logic circuit including gates 212 to 220 which generates the tape advance and tape stop signals. When a true tape advance signal is present at the output of gate 196 the circuit comprising gates 212–218 latches and a tape reader brake release is provided at the output of gate 218 and gate 220 provides the tape advance signal to the tape drive mechanism. When the proper signals from the non-coding data channels on the tape and the tape reader timing pulse are present at the inputs of gates 198 and 202 the sequential logic circuit comprising gates 212–218 is reset, gate 218 applies a braking signal to the tape reader and gate 220 removes the tape advance signal. It is necessary that the non-coding data channels of the tape be in their proper phase for proper circuit operation. In the event that this phase is not proper, tape advance will continue until a character appears on the tape in which their phase is proper.

When the tape and braid forming machine are in proper synchronization, coding data bits will appear only in the coding zone and machine instructions or non-coding data will only appear in the wire end zones of the carriage traverse. FIG. 7 is a schematic illustration of an out-of-sync detector circuit which may be included in the machine control and logic circuits.

The preferred tape format as stated above is such that each sequence of a preselected number of coding data bits is followed by at least two machine instructions, i.e., carriage reverse and line feed. Thus after the last bit is coded on a given traverse the coding wand will proceed into a wire-end zone and the tape will advance to the first machine instruction. Channel 5 from the tape reader is preferred to be always true for a coding data character and false for a machine instruction. That signal may thus be coupled with the EC channel from the electro-optical sensing mechanism via gates 222 and 224 and diodes 226, 228 and 230 to provide an out-of-sync signal whenever a coding data character appears after the carriage has completed a coding traverse. In such a case a voltage, V_1, (preferably +5 v. d.c.) is coupled to the base of transistor 232 which has a grounded emitter and a collector coupled in parallel through the winding of a relay 234 and diode 236 to a voltage source, V_2, (preferably +12 v. d.c.). Thus, whenever a signal from tape channel 5 and EC are coincident, V_2 is applied to the winding of relay 234 which operates to close the normally open contacts 238 thereby actuating any suitable type of alarm 240.

Finally, with reference to FIG. 8 there is schematically illustrated a coding error detection circuit which may be used to advantage in the practice of the present invention as illustrated in FIGS. 2C and 4. As described above with reference to FIG. 2C the position of the coding wand 44 is monitored by two light source-detector assemblies. The light shield 45 attached to the upper end of the coding wand alternately covers or exposes one of the two detector elements 47 or 49 in accordance with the position of the coding wand 44. The output signals are indicative of whether the coding wand is in the binary "1" or "0" position and are compared with the coding instruction signal from the tape reader. In the event there is a mismatch, e.g., a binary "1" instruction when the coding wand is in the "0" coding position, an alarm is sounded and the apparatus automatically stopped.

The binary "0" coding instruction is applied to a first exclusive OR gate 242 together with the output of the "0" wand position detector output signal. This gate detects a mismatch between a binary "1" coding instruction and a coding wand "0" position. The output error signal from gate 242 is in the form of a ground potential at the input of NOR gate 244 which causes the output thereof to rise to a positive voltage. This positive voltage is applied to the input of NAND gate 246 together with an error strobe signal. The error strobe generator 247 may, for example, be a conventional flip-flop delay circuit which receives as is input the carriage position signal, CP, from the electro-optical sensing mechanism. In the event that an error is present the output of NAND gate 246 is coupled to an error latching circuit comprising cross coupled gates 248 and 250. A reset switch 252 may be provided at the input of gate 250 to momentarily apply ground potential to the latching circuit. The output of the error latching circuit may be coupled to the alarm circuit illustrated in FIG. 7 and would be applied to the base of transistor 232. Alternatively, of course, a separate alarm system could be provided.

The second exclusive OR gate 254 receives the output of "1" wand position detector of FIG. 2C. The binary "0" coding instruction is passed through an inverter 256 to put the "0" signal in its complementary state such that a positive voltage is present at the input of gate 254 for the mismatch condition.

The error strobe generator 247 output functions to inhibit NAND gate 246 during time intervals when false errors would tend to be present. Such intervals occur when data changes prior to the generation of a coding instruction. A similar false error may arise as the bit selection pulses from the electro-optical sensing mechanism are sequenced. During the switching interval to the next bit in sequence the data presented is in an unpredictable state. Thus the possibility for false error detection is minimized.

While the present invention has been described particularly as a two position wire braid forming machine it will be understood that the principles of the invention are equally applicable to providing multiple position wire routing. In such an embodiment the machine could, for example, provide efficient wiring harness fabrication.

From the foregoing it will be understood that the Applicants have provided a new and novel wire braid forming apparatus wherein the objectives set forth hereinabove are efficiently met. Since certain changes in the above construction will occur to those skilled in the art without departure from the scope of the invention it is intended that all matter set forth in the foregoing description or shown in the appended drawings

shall be interpreted as illustrative and not in a limiting sense.

Having described what is new and novel and desired to secure by Letters Patent, what is claimed is:

1. Wire braid forming apparatus comprising
an array of spaced apart upstanding pegs;
a mounting means adapted to continuously traverse said array of pegs;
a supply of wire;
a coding wand carried by said mounting means, adapted to move at one end to one of a plurality of positions with respect to said array of pegs, and adapted at said end to guide said wire;
means for sensing the position of said coding wand with respect to said array of pegs and producing a synchronizing signal indicative thereof; and
means for driving said coding wand to a selected one synchronism with the alignment of said coding wand with the spaces between said pegs;
whereby as said mounting means continuously traverses said array of pegs and said coding wand is driven to selected positions with respect to said pegs said wire is routed from said supply through said coding wand into a selected pattern with respect to said pegs.

2. Apparatus as recited in claim 1 wherein
said array of upstanding pegs is a linear array,
said mounting means traverses the length of said linear array, and
said coding wand is adapted to be driven between adjacent pegs to one of two positions on either side of said array.

3. Apparatus as recited in claim 2 wherein said mounting means comprises
first and second substantially parallel rails,
a wheeled carriage adapted to engage and roll upon said rails, and
said linear array of pegs being disposed adjacent to and parallel with one of said rails.

4. Apparatus as recited in claim 1 wherein
said supply of wire is adapted for mounting on and movement with said mounting means.

5. Apparatus as recited in claim 2 wherein
said coding wand driving means includes a rotary electromagnet disposed on said mounting means, and having an armature affixed to said coding wand.

6. Apparatus as recited in claim 2 wherein
each said peg in said array is formed of a base portion of a selected dimension and has an enlarged head portion, the enlarged portion of all of said pegs being linearly arranged in substantially a single plane; and
said wire guiding end of said coding wand extends substantially to said plane such as to route said wire about said enlarged portions of said pegs.

7. Apparatus as recited in claim 6 further including
a wire compactor comprising an extended support member adapted for rotation about a longitudinal axis disposed substantially parallel to said array of pegs, and a plurality of flexible tines extending from said support member intermediate said pegs such that on rotation of said support member said tines remove wire routed about said enlarged portions of said pegs and deposit it about said base portions of said pegs.

8. Apparatus as recited in claim 2 further including
means for sensing the completion of a traverse by said mounting means of said array of pegs, and
means for reversing the direction in which said mounting means traverses said array at the end of each such traverse such that said mounting means repeatedly reciprocally traverses said array.

9. Apparatus as recited in claim 8 further including
means disposed at each end of said array for receiving and retaining said wire at the end of each said traverse of said array by said mounting means.

10. Apparatus as recited in claim 9 wherein each said wire receiving and retaining means comprises
a flat plate adapted for rotation about a vertical axis disposed in substantial alignment with said linear array,
a plurality of spaced apart wire holding fingers disposed on said plate in an arcuate array centered at said vertical axis, and
means for rotating said plate in preselected increments at the end of each said traverse such that said wire is routed by said coding wand around one of said wire holding fingers on said plate.

11. Apparatus as recited in claim 10 wherein
said wire holding fingers are pivotally disposed on said plate, and further including means for outwardly biasing said fingers such as to hold said wire under a preselected tension.

12. Apparatus as recited in claim 10 wherein said plate rotating means comprises
means for torsionally biasing said plate about said vertical axis,
a staggered double row of spaced apart downwardly extending pins affixed to the underside of said plate in an arcuate pattern centered at said vertical axis,
a pair of plate stepping arms extending upwardly to alternately engage said downwardly extending pins, and
means for alternately disengaging said stepping arms from said pins,
whereby said plate is rotated in preselected increments determined by the spacing between said pins.

13. Apparatus as recited in claim 10 further including
means for removably mounting an electrical connector on said plate such that wire routed around said wire holding fingers is also routed and retained over selected terminals of said connector.

14. Apparatus as recited in claim 2 further including
a carrier plate adapted to receive and retain said linear array of pegs in a fixed relationship with one another.

15. Apparatus as recited in claim 1 further including
a coding instruction storate means coupled to said sensing means and responsive to the output therefrom to provide a signal indicative of the position to which said coding wand is to be driven.

16. Apparatus as recited in claim 15 wherein said sensing means comprises
a vertically linear array of light sources,
a like vertically linear array of photoelectric detector elements spaced apart from and in substantial alignment with said array of light sources,
said light source and said detector arrays being disposed on and movable with said mounting means,
an aperture plate interposed between said light source and detector arrays in a fixed spatial relationship with respect to said array of pegs, and hav-

ing a plurality of apertures each corresponding to a space between adjacent pegs of said array, and

each said detector element producing an output signal when an aperture of said aperture place is aligned with a light source and detector of said array.

17. Apparatus as recited in claim **16** wherein said coding instruction storage means comprises

a binary coded tape having a plurality of coding instructions stored at each position along the length thereof, and

a tape reader coupled to said photoelectric detector element array and responsive to the output therefrom to read coding instructions from said tape and provide an output signal indicative of the position to which said coding wand is to be driven,

said aperture plate further including arrays of coding apertures corresponding to the coding instruction on said tape to be read by said tape reader, and tape advance apertures corresponding to the last coding instruction to be read at a selected position on said tape, and

said detector elements providing output signals to said tape reader for controlling the reading and advancing of said tape.

18. Apparatus as recited in claim **17** further including

a light opaque shield affixed to the end of said coding wand opposite said wire guiding end,

first and second light sources dispersed adjacent a first side of said shield,

first and second photoelectric detector elements disposed adjacent the opposite side of said shield and in substantial alignment with said first and second light sources,

said shield operating to interrupt light falling on one said detector when said coding wand is in a first position with respect to said pegs and to interrupt light falling on the other said detector when said coding wand is in said other position with respect to said pegs,

said detectors operative to produce an output signal indicative of the side of said array of pegs to which said coding wand is driven, and

means coupled to said first and second detector elements and to said tape reader for comparing the signal indicative of the position to which said coding wand is to be driven and the signal indicative of the side of said array of pegs to which said coding wand is driven and produce a coding error signal when said signals from said detector elements and said tape reader do not correspond.

19. Apparatus as recited in claim **17** wherein

said aperture plate and said peg carrier plate are integrally formed of a single sheet of light opaque material whereby said arrays of apertures are substantially permanently aligned with said array of pegs.

20. Apparatus as recited in claim **8** further including

means coupled to said coding wand driving means for sensing the direction in which said mounting means traverses said array of pegs.

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