June 24, 1969 J. D. MARKHAM ET AL 3,451,633

WINDING APPARATUS

Filed May 6, 1965 Sheet 1 of 15

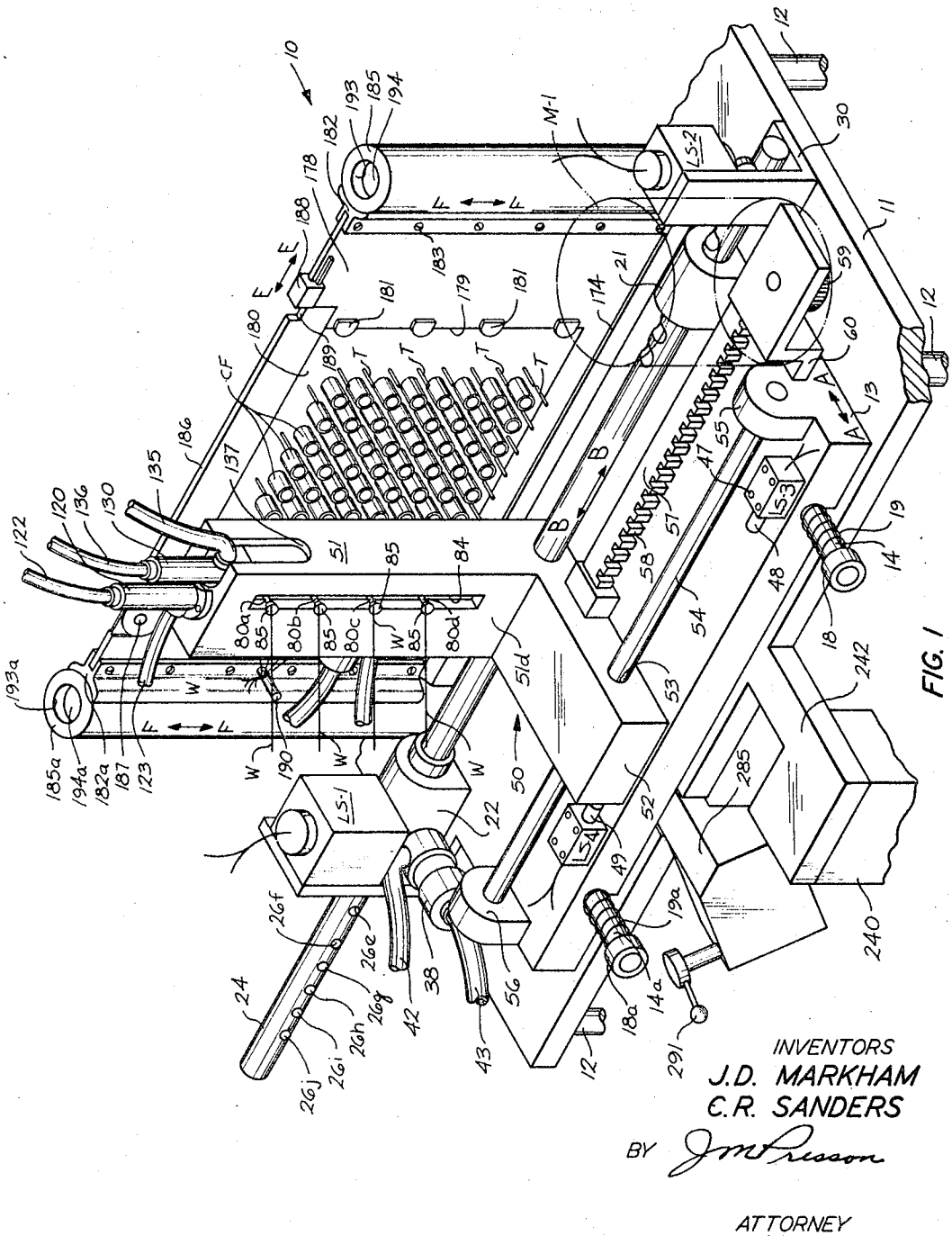


FIG. 1

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C.R. SANDERS
BY J. M. Prisson
ATTORNEY

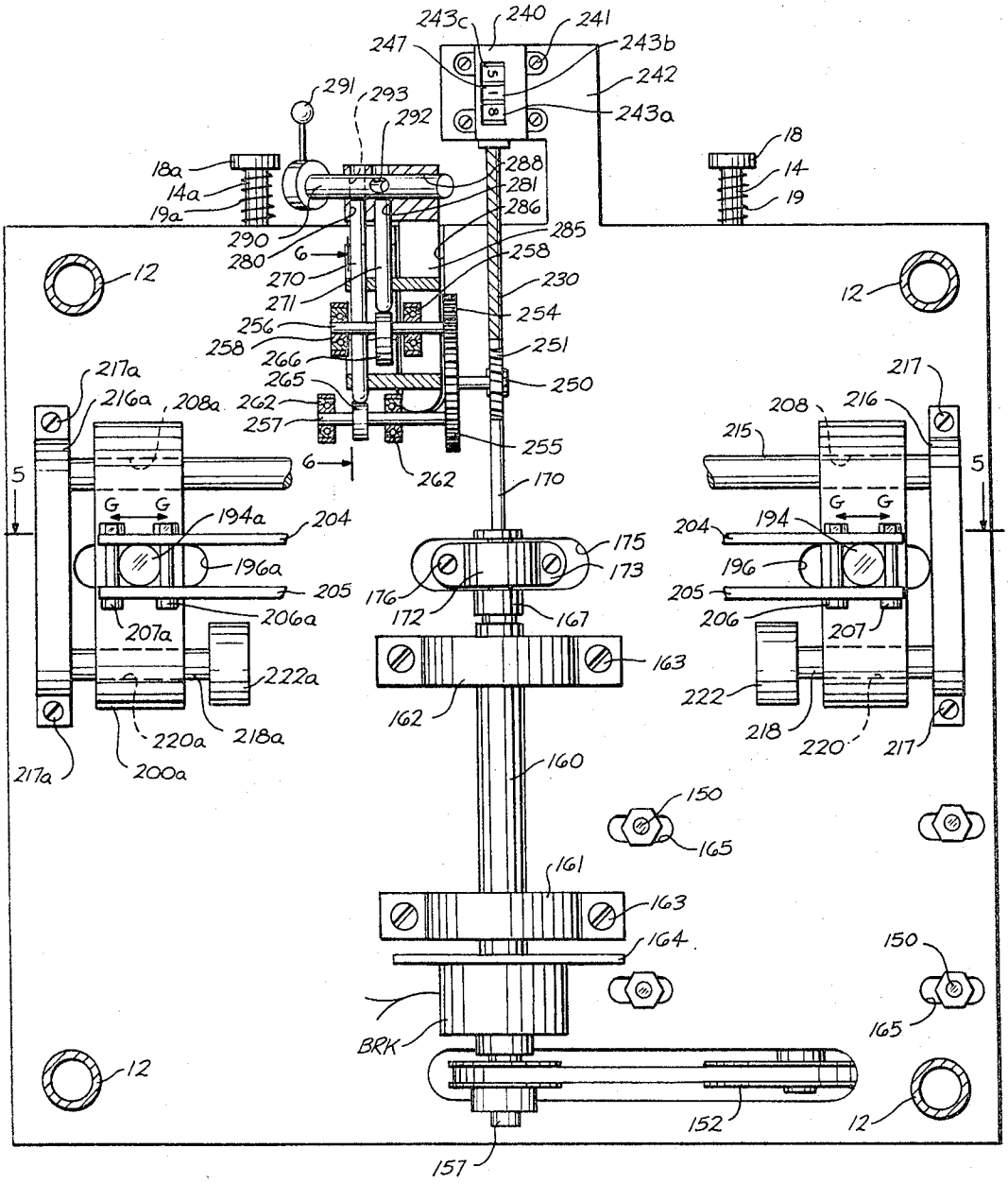

243c
240
241
247
243b
242
243a
291
293
292
18a
14a
19a
288
281
286
290
280
6
285
258
270
230
271
254
256
258
266
251
265
250
262
257
255
6
262
170
217a
216a
208a
217
216
208
215
5
5
G G
194a
204
194
175
196a
173
196
205
176
172
167
205
206a
206
207a
207
163
222a
222
162
218a
218
220a
220
217a
200a
217
160
150
165
161
163
164
150
165
BRK
12
12
12
12
152
157

FIG. 2

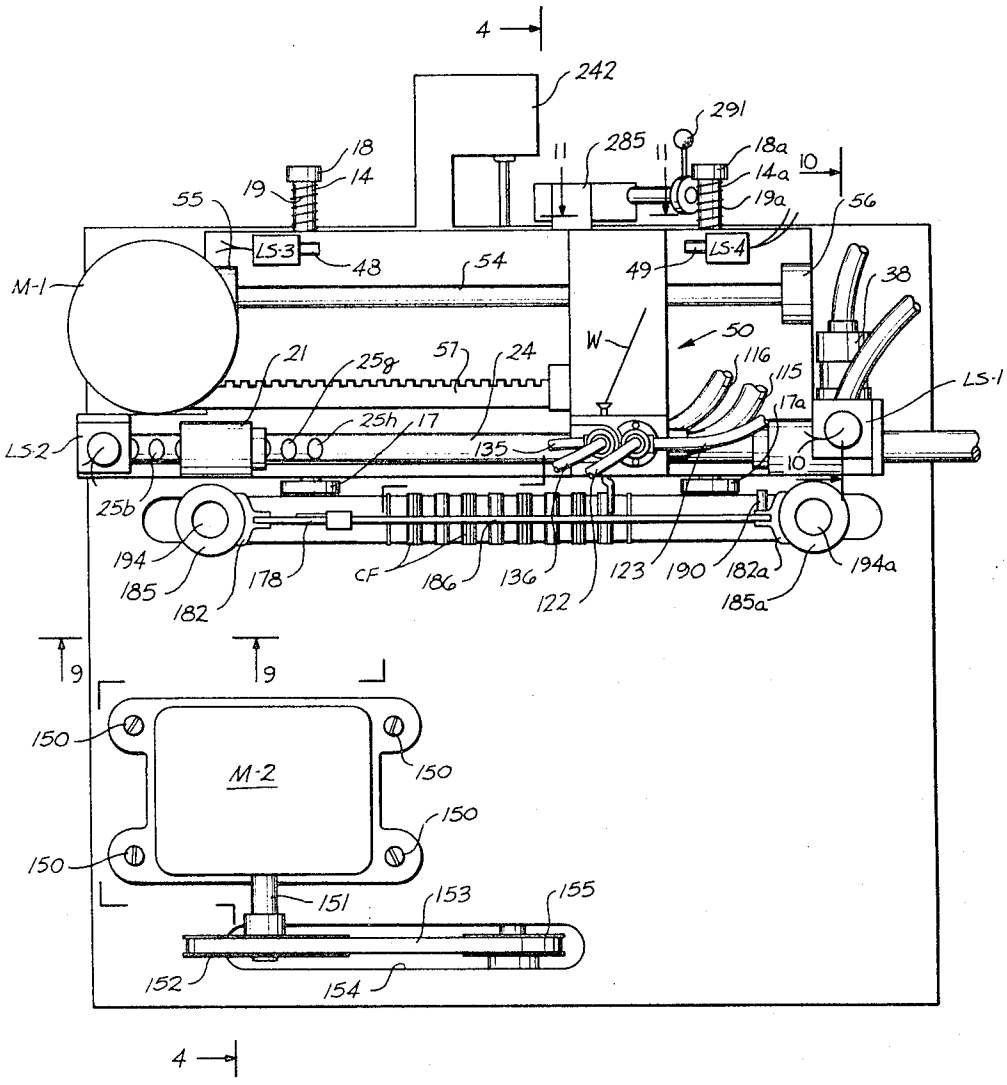

4
242
291
18
14
285
18a
14a
19a
10
55
19
56
LS-3
48
54
49
LS-4
38
M-1
W
50
21
25g
57
24
116
115
17a
LS-1
LS-2
25h
17
135
10
25b
194
185
182
178
CF
186
136
122
123
190
182a
185a
194a
9
9
150
M-2
150
150
150
151
153
155
152
154
4

FIG. 3

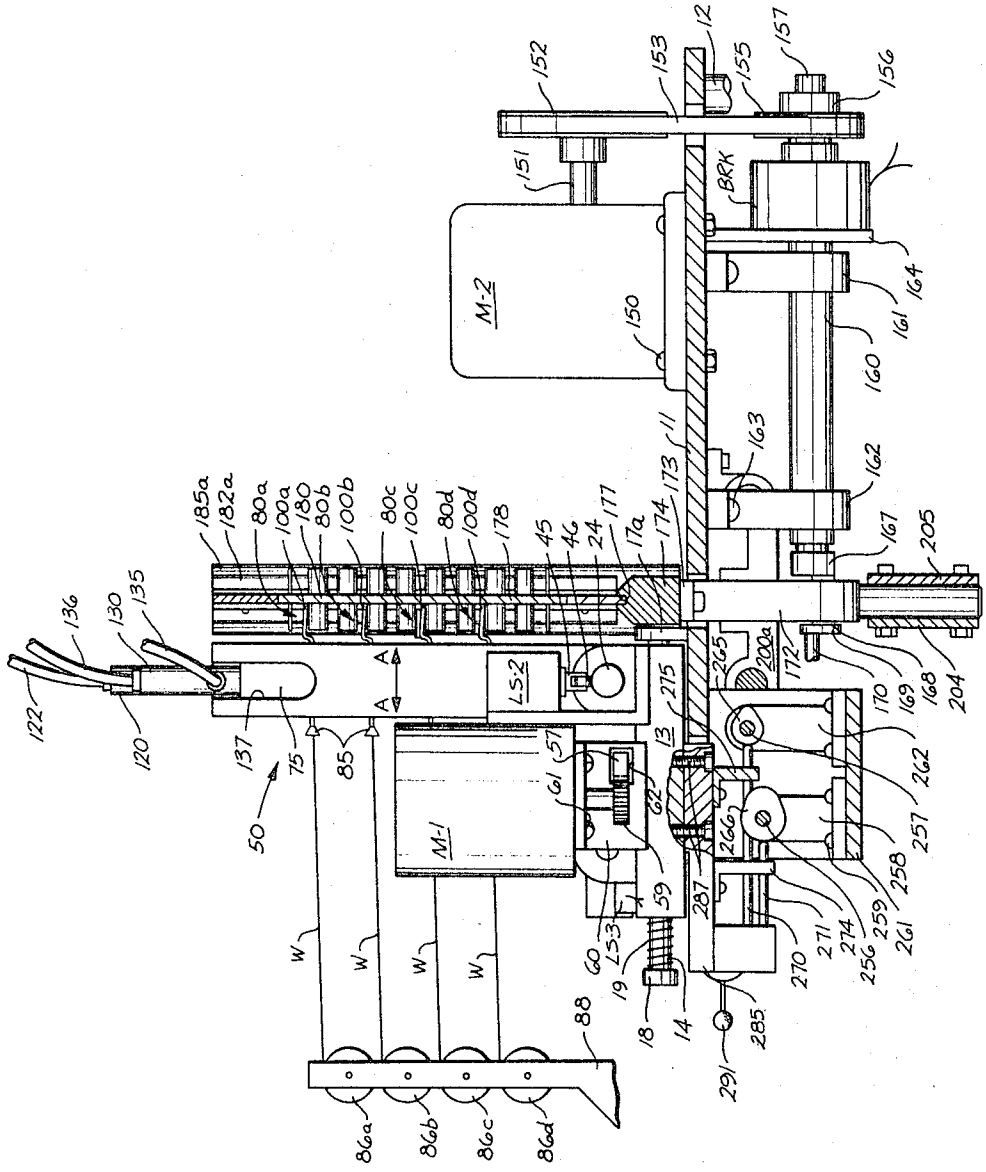


FIG. 4

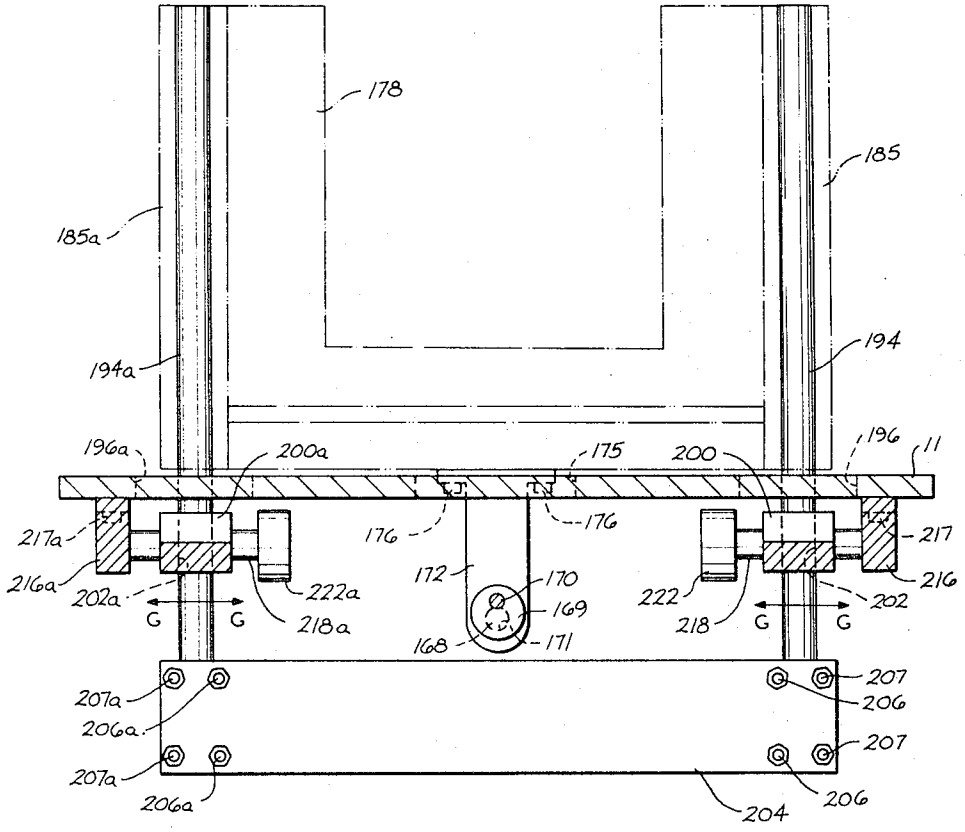

178
185
185a
194
194a
196
196a
200
200a
175
11
176
217
217a
216
216a
172
170
169
171
168
222
222a
218
218a
202
202a
G
207
207a
206
206a
204

FIG. 5

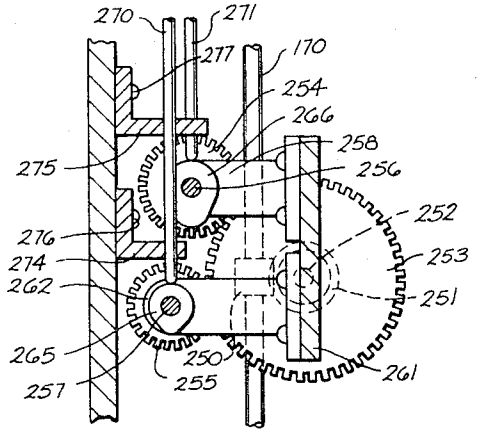

270
271
277
170
254
266
258
256
252
253
251
275
276
274
262
265
257
250
255
261

FIG. 6

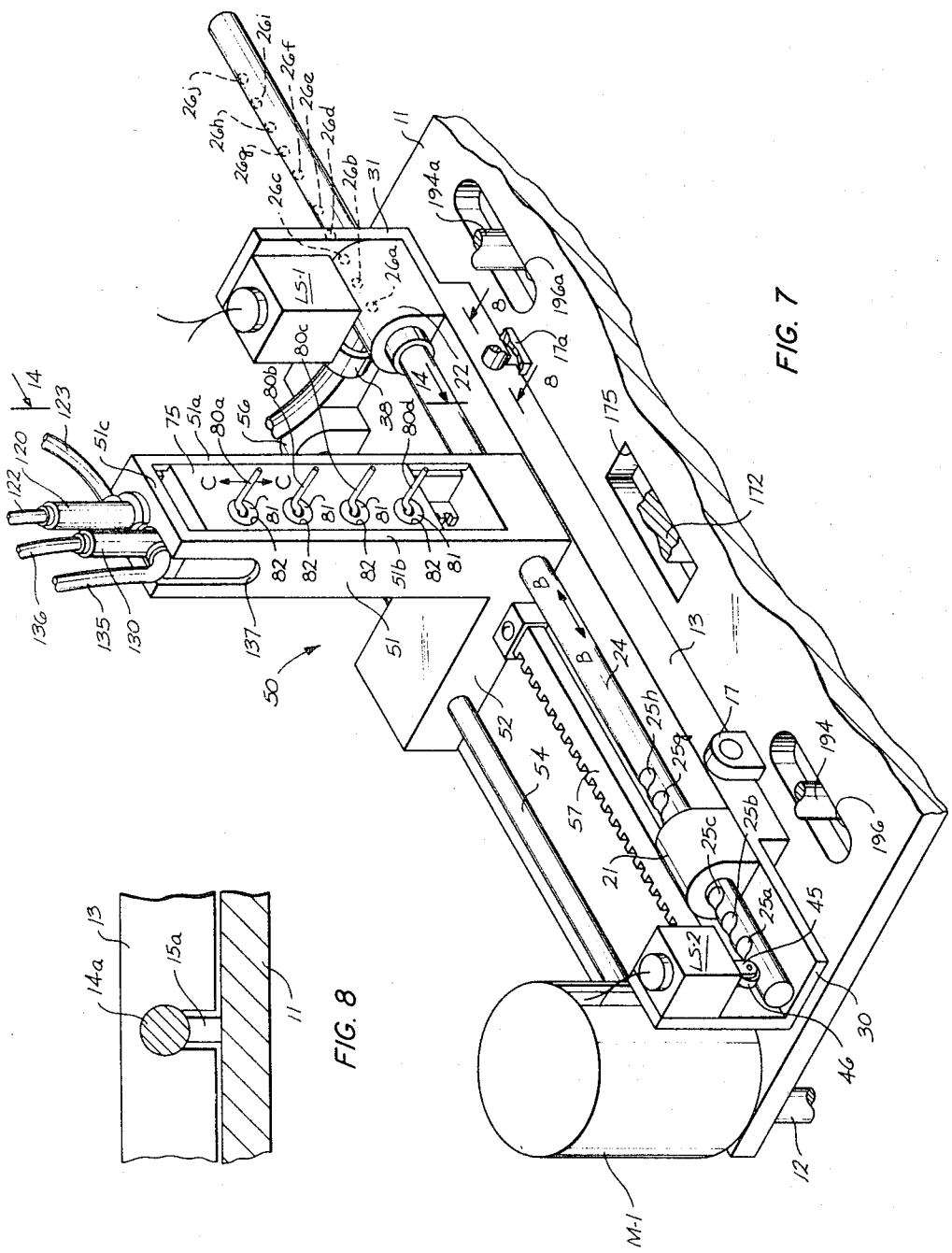

26j
26h
26g
26c
26i
26f
26e
26d
26b
31
11
194a
196a
17a
LS-1
26a
80c
80b
14
22
38
80d
175
172
75
51a
80a
56
123
51c
120
122
136
135
130
137
50
51
51b
82
81
C
B
24
13
52
54
57
21
17
194
196
25h
25g
25c
25b
25a
45
LS-2
30
46
12
M-1

FIG. 7

13
14a
15a
11

FIG. 8

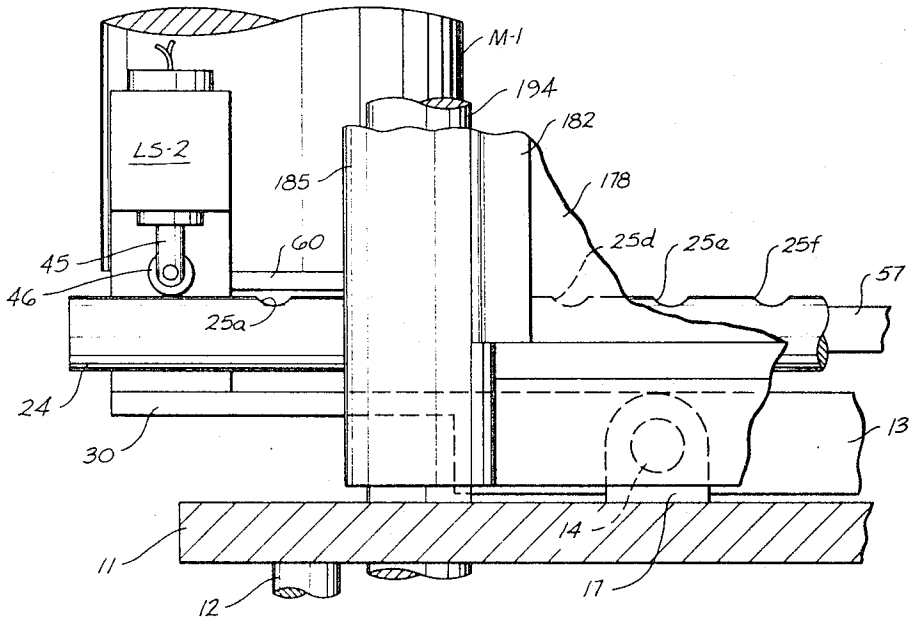

M-1
194
182
178
185
LS-2
45
46
60
25a
25d
25e
25f
57
24
30
13
14
11
12
17

FIG. 9

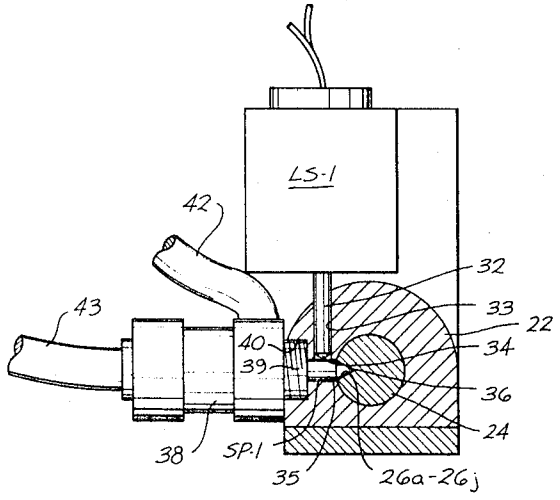

LS-1
42
43
32
33
22
34
40
39
36
24
38
SP-1
35
26a-26j

FIG. 10

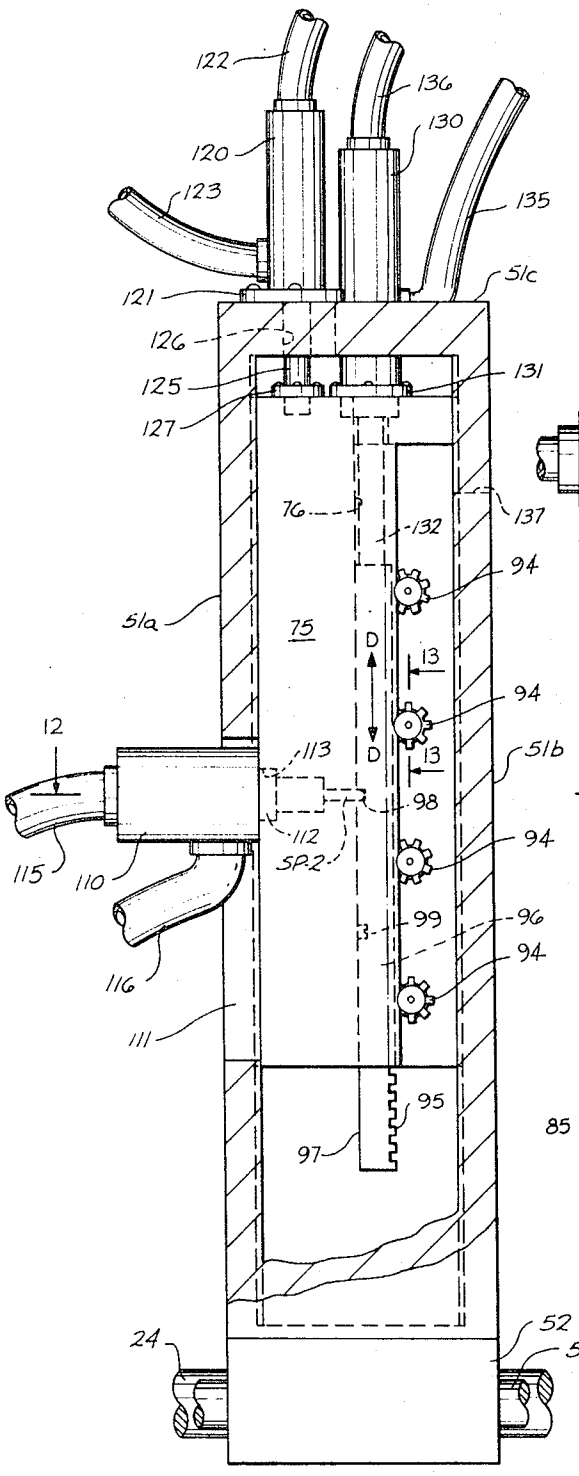


FIG. 11

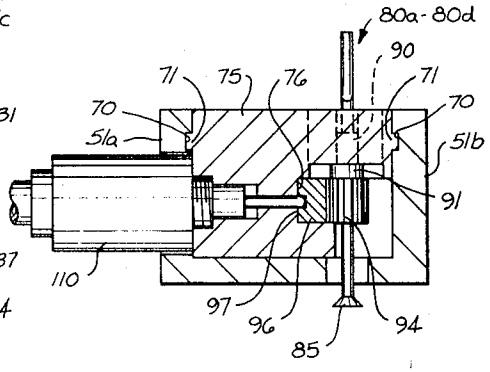


FIG. 12

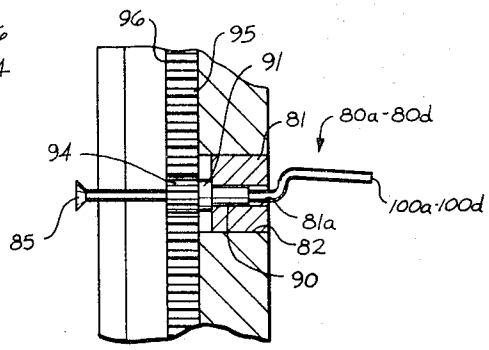


FIG. 13

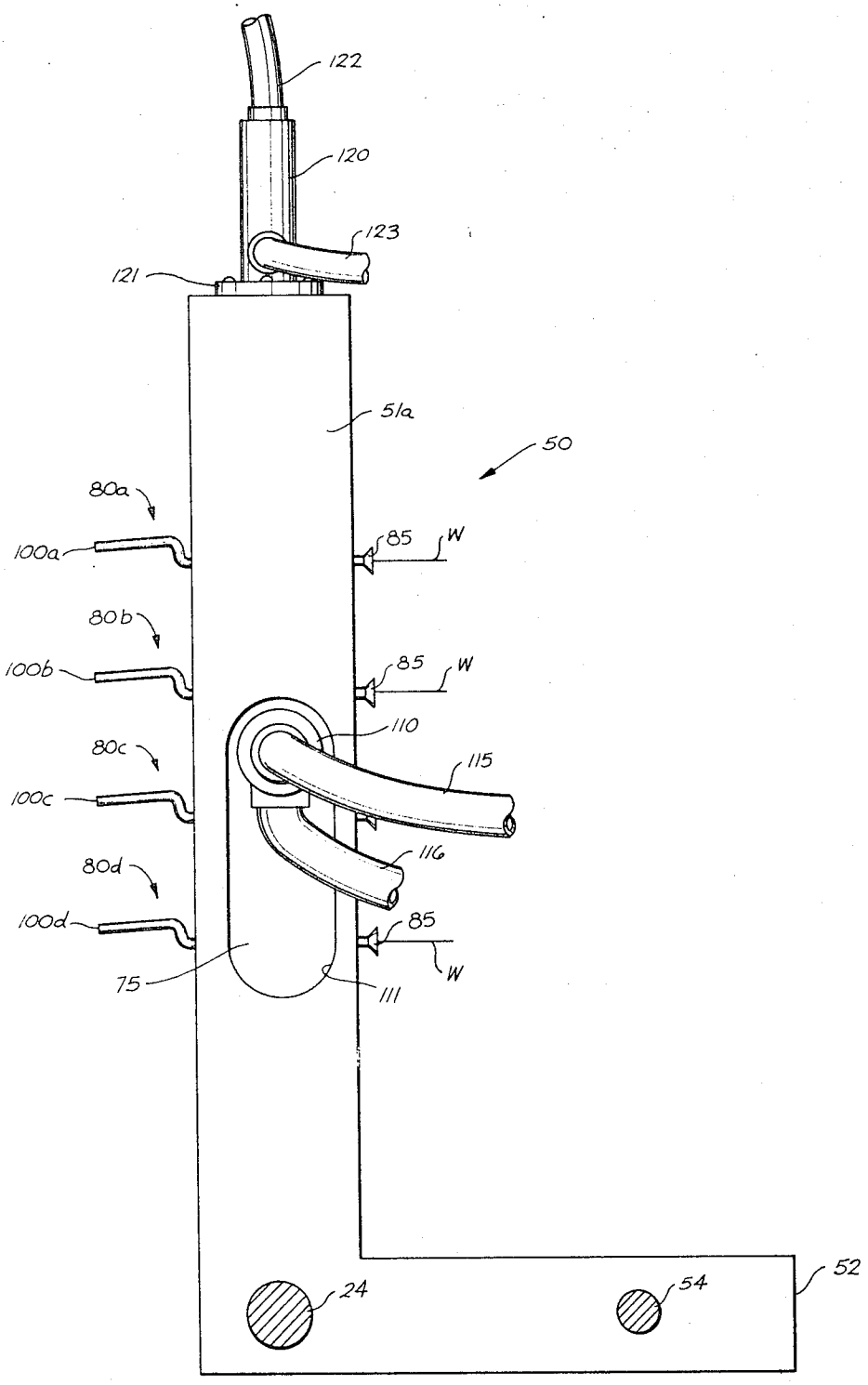

122
120
123
121
51a
50
80a
100a
85
W
80b
100b
85
W
110
80c
115
100c
116
80d
100d
85
W
75
111
24
54
52

FIG. 14

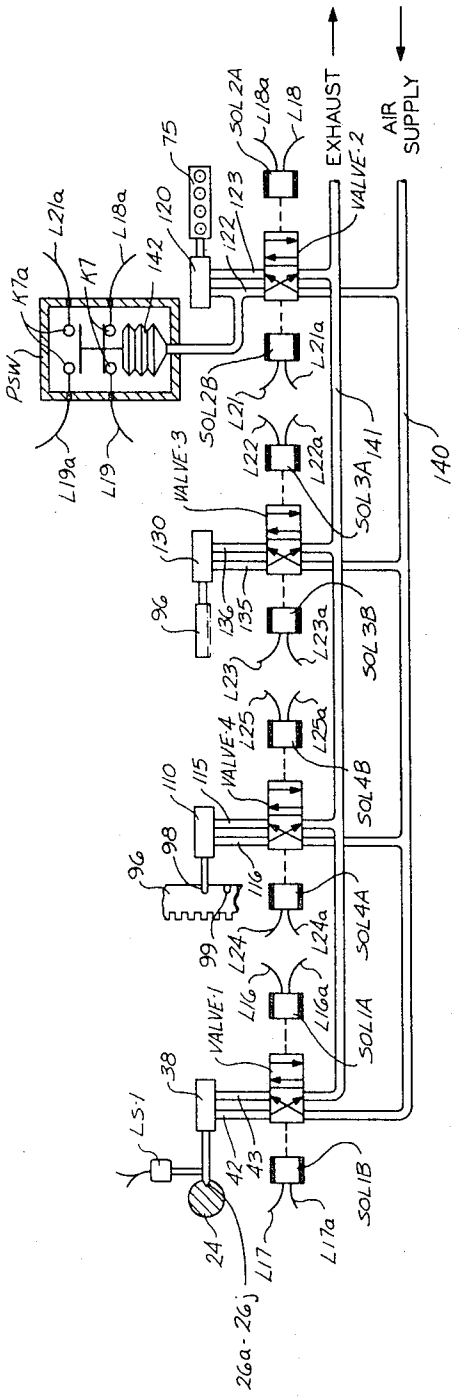

EXHAUST
AIR SUPPLY
VALVE-2
VALVE-3
VALVE-4
VALVE-1
SOL 2A
SOL 2B
SOL 3A
SOL 3B
SOL 4B
SOL 4A
SOL 1A
SOL 1B
PSW
K7a
K7
L21a
L18a
L19a
L19
L18
L21
L22
L22a
L23
L23a
L25
L25a
L16
L16a
L24
L24a
L17
L17a
LS-1
75
120
122
123
142
130
136
135
96
110
115
98
116
99
38
42
43
24
26a-26j
141
140

FIG. 15

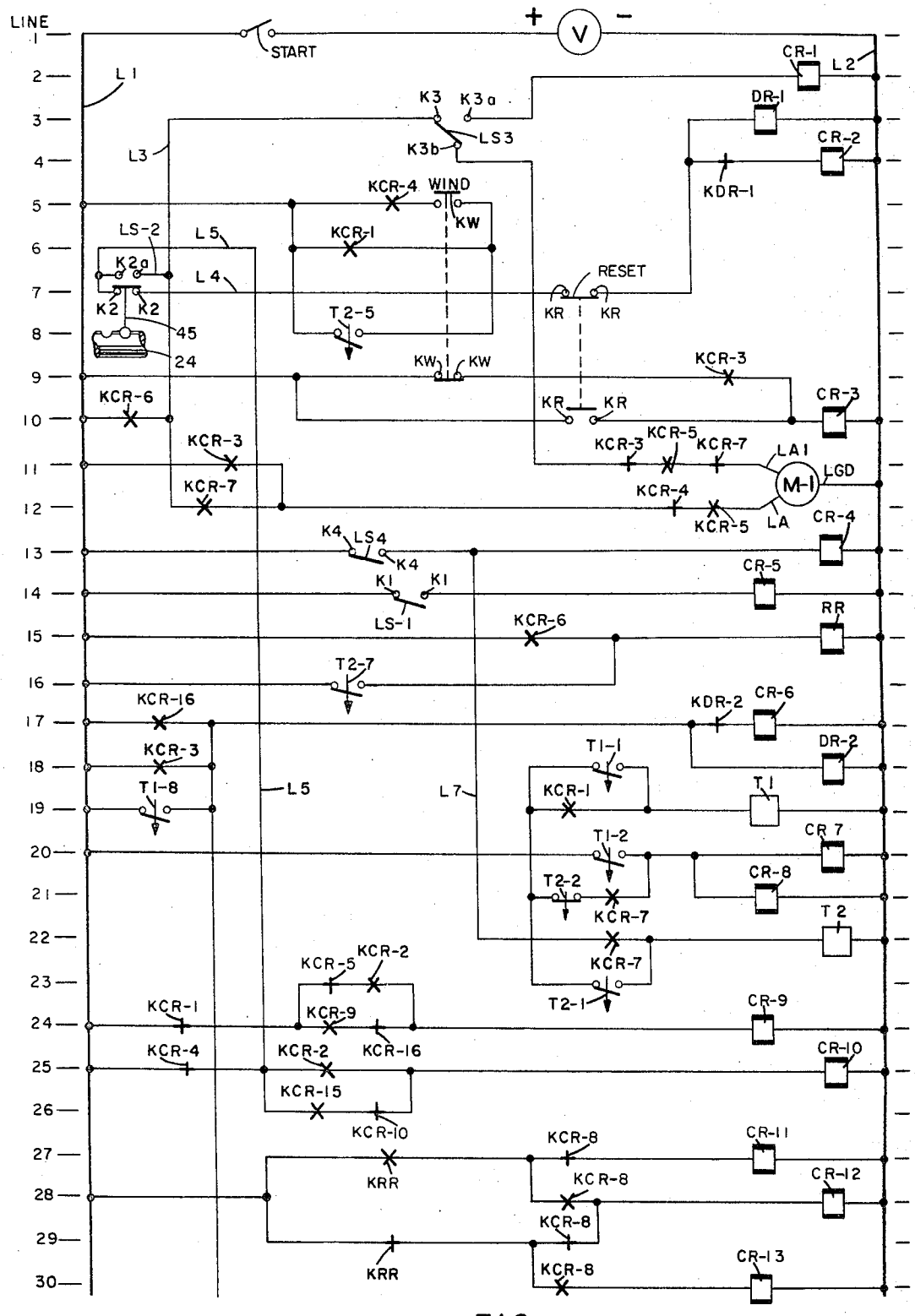

LINE
START
V
L1
L2
L3
L4
L5
L7
CR-1
DR-1
CR-2
K3
K3a
K3b
LS3
KDR-1
KCR-4
WIND
KW
KCR-1
LS-2
K2a
K2
45
24
RESET
KR
T2-5
KCR-3
CR-3
KCR-6
KCR-5
KCR-7
LA1
M-1
LGD
LA
CR-4
K4
LS4
K1
LS-1
CR-5
RR
T2-7
KCR-16
KDR-2
CR-6
DR-2
T1-1
T1-8
T1
CR 7
T1-2
T2-2
CR-8
T2
KCR-2
KCR-9
T2-1
CR-9
KCR-15
CR-10
KCR-10
KRR
KCR-8
CR-11
CR-12
CR-13

FIG. 16

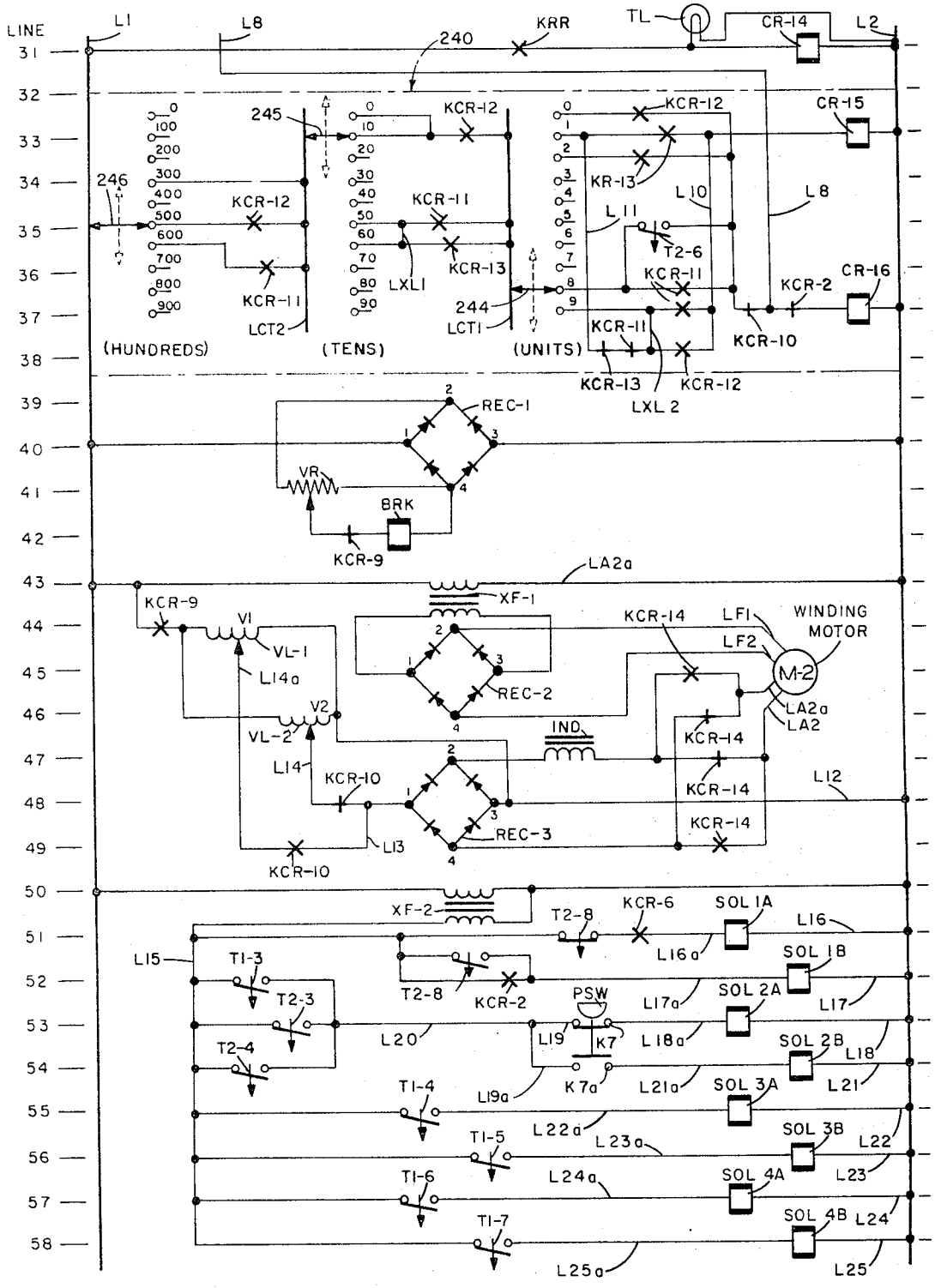

LINE
L1
L8
240
KRR
TL
CR-14
L2
245
KCR-12
CR-15
246
KCR-11
KCR-13
KR-13
L10
L11
L8
T2-6
CR-16
KCR-2
KCR-10
LXL1
LCT2
LCT1
244
(HUNDREDS)
(TENS)
(UNITS)
LXL 2
REC-1
VR
BRK
KCR-9
LA2a
XF-1
VI
VL-1
L14a
V2
VL-2
REC-2
KCR-14
LF1
LF2
WINDING MOTOR
M-2
LA2a
LA2
IND
L14
L13
REC-3
L12
XF-2
T2-8
KCR-6
SOL 1A
L16
L16a
SOL 1B
L15
TI-3
T2-3
T2-4
PSW
L17a
SOL 2A
L17
L20
L19
K7
L18a
SOL 2B
L18
K7a
L21a
SOL 3A
L21
TI-4
L19a
L22a
TI-5
L23a
SOL 3B
L22
L23
TI-6
L24a
SOL 4A
TI-7
SOL 4B
L24
L25a
L25

FIG. 17

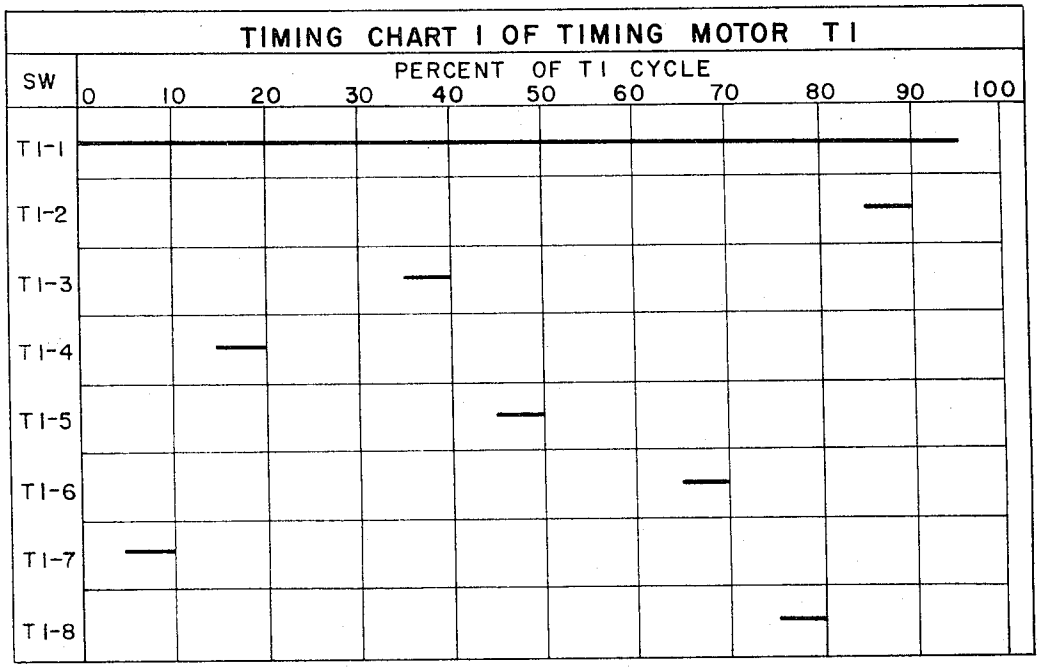

TIMING CHART I OF TIMING MOTOR T I
SW
PERCENT OF T I CYCLE
0 10 20 30 40 50 60 70 80 90 100
T I-1
T I-2
T I-3
T I-4
T I-5
T I-6
T I-7
T I-8

FIG. 18

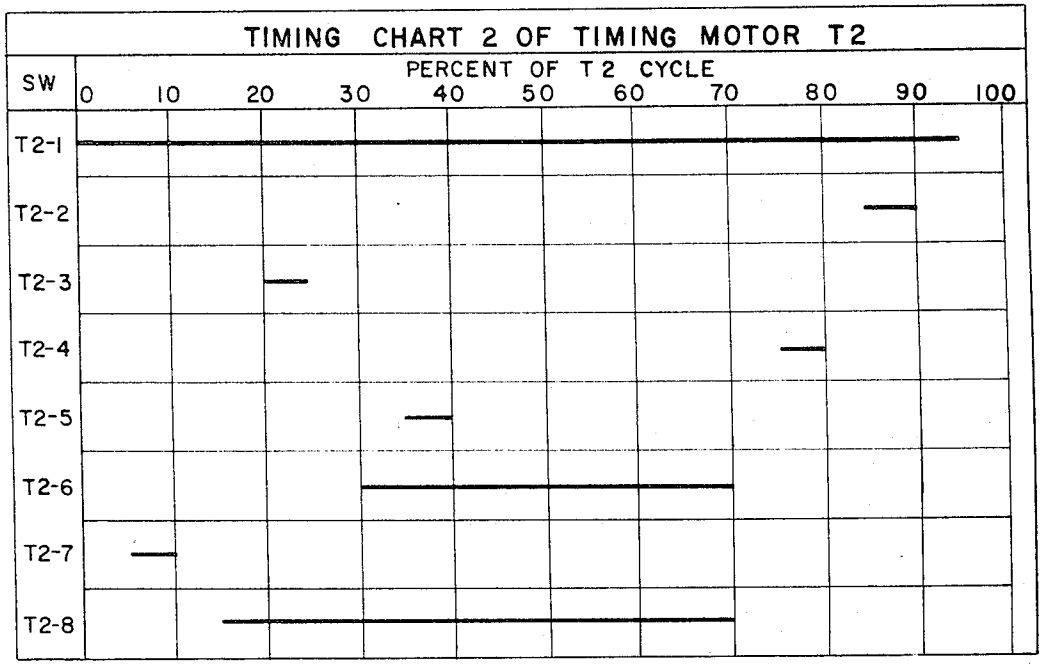

TIMING CHART 2 OF TIMING MOTOR T2
SW
PERCENT OF T 2 CYCLE
0 10 20 30 40 50 60 70 80 90 100
T2-1
T2-2
T2-3
T2-4
T2-5
T2-6
T2-7
T2-8

FIG. 19

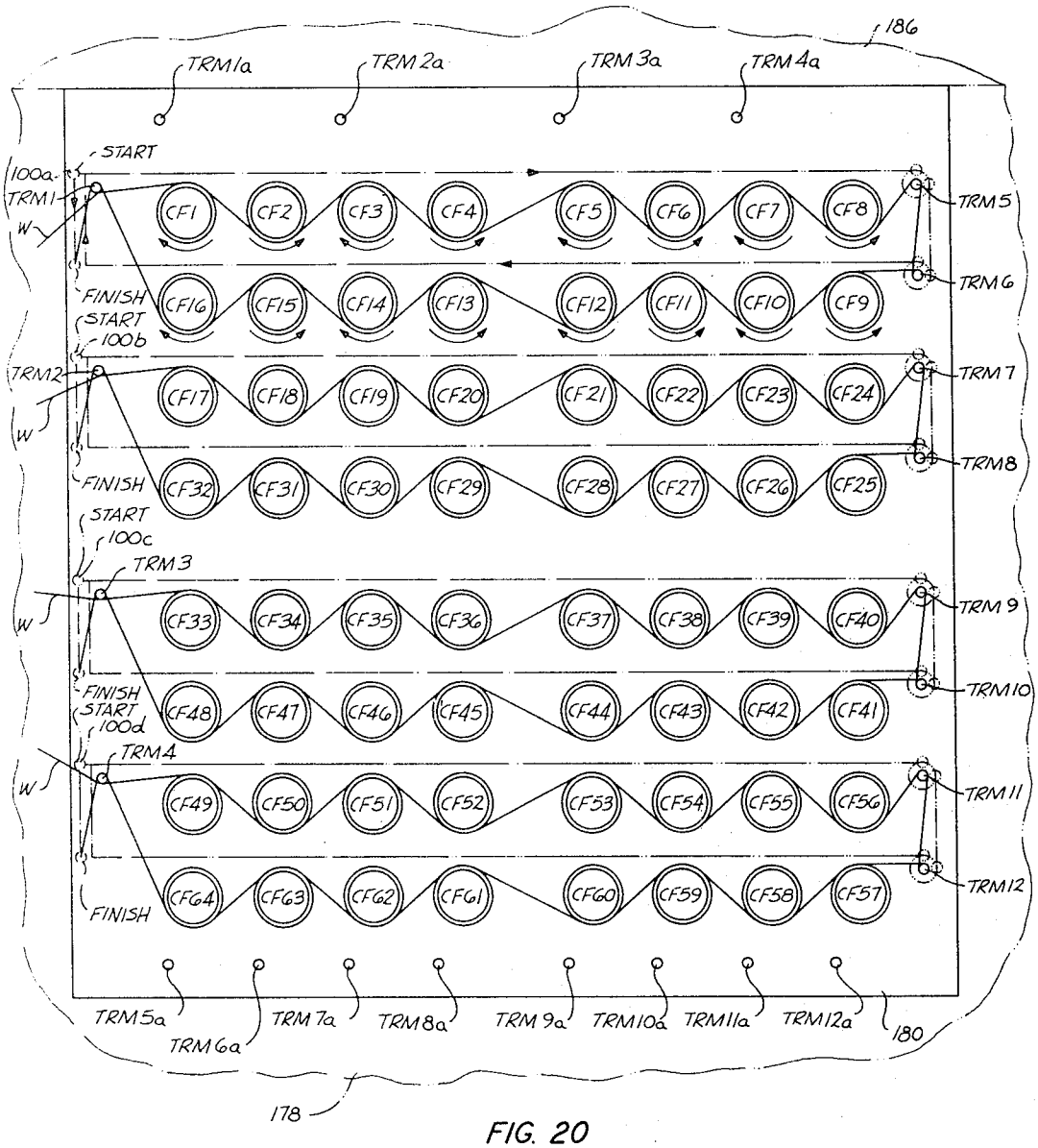

186
TRM1a
TRM2a
TRM3a
TRM4a
START
100a
TRM1
W
CF1
CF2
CF3
CF4
CF5
CF6
CF7
CF8
TRM5
TRM6
FINISH
START
100b
TRM2
CF16
CF15
CF14
CF13
CF12
CF11
CF10
CF9
CF17
CF18
CF19
CF20
CF21
CF22
CF23
CF24
TRM7
TRM8
FINISH
START
100c
TRM3
CF32
CF31
CF30
CF29
CF28
CF27
CF26
CF25
CF33
CF34
CF35
CF36
CF37
CF38
CF39
CF40
TRM9
TRM10
FINISH
START
100d
TRM4
CF48
CF47
CF46
CF45
CF44
CF43
CF42
CF41
CF49
CF50
CF51
CF52
CF53
CF54
CF55
CF56
TRM11
TRM12
FINISH
CF64
CF63
CF62
CF61
CF60
CF59
CF58
CF57
TRM5a
TRM6a
TRM7a
TRM8a
TRM9a
TRM10a
TRM11a
TRM12a
180
178

FIG. 20

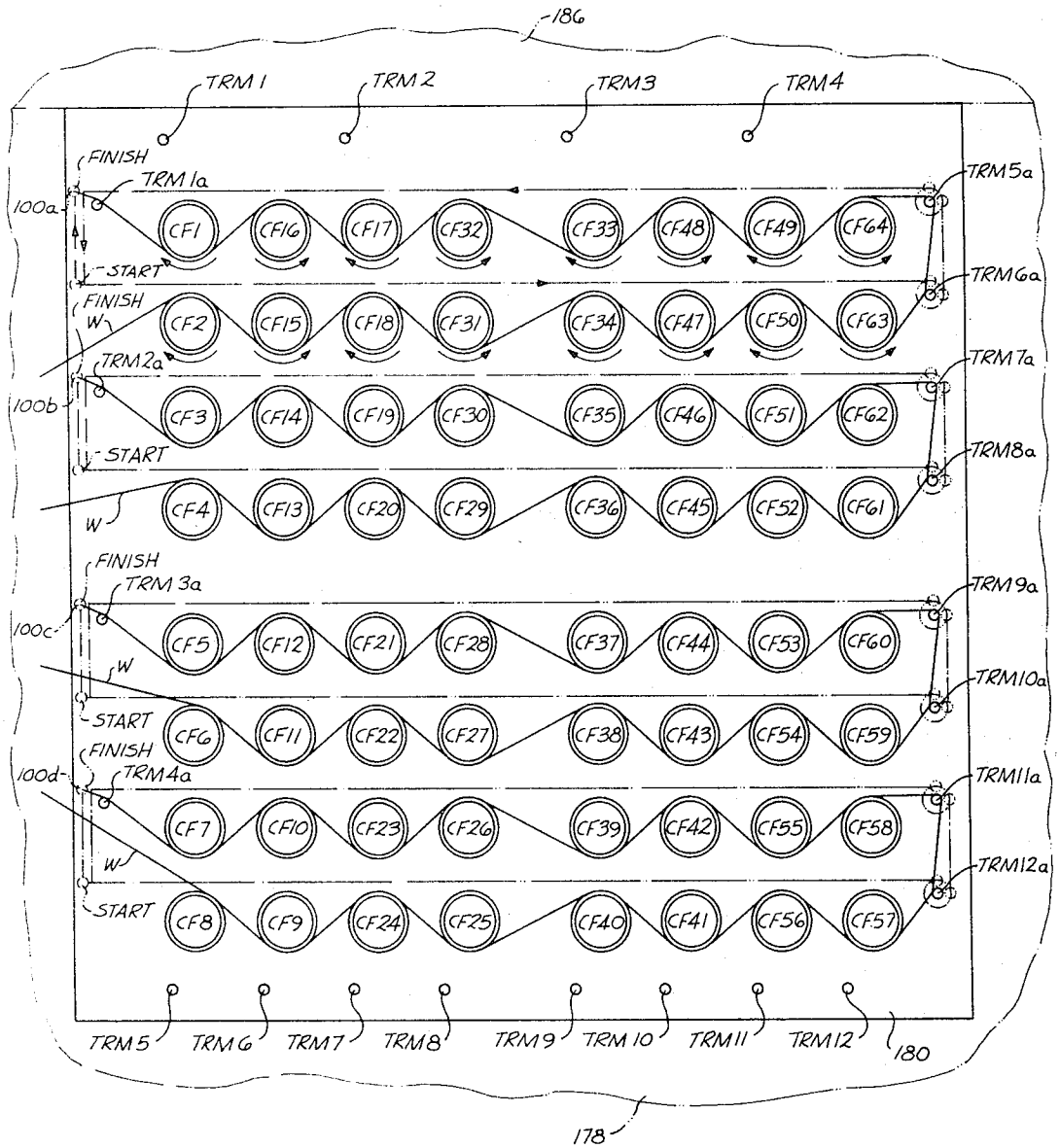

186
TRM 1
TRM 2
TRM 3
TRM 4
FINISH
TRM 1a
100a
START
FINISH
W
TRM 2a
100b
START
W
FINISH
TRM 3a
100c
W
START
FINISH
TRM 4a
100d
W
START
TRM 5a
TRM 6a
TRM 7a
TRM 8a
TRM 9a
TRM 10a
TRM 11a
TRM 12a
CF1 CF16 CF17 CF32 CF33 CF48 CF49 CF64
CF2 CF15 CF18 CF31 CF34 CF47 CF50 CF63
CF3 CF14 CF19 CF30 CF35 CF46 CF51 CF62
CF4 CF13 CF20 CF29 CF36 CF45 CF52 CF61
CF5 CF12 CF21 CF28 CF37 CF44 CF53 CF60
CF6 CF11 CF22 CF27 CF38 CF43 CF54 CF59
CF7 CF10 CF23 CF26 CF39 CF42 CF55 CF58
CF8 CF9 CF24 CF25 CF40 CF41 CF56 CF57
TRM 5
TRM 6
TRM 7
TRM 8
TRM 9
TRM 10
TRM 11
TRM 12
180
178

FIG. 21

United States Patent Office 3,451,633
Patented June 24, 1969

3,451,633

WINDING APPARATUS

James D. Markham, Gahanna, and Charles R. Sanders, Columbus, Ohio, assignors to Western Electric Company, Incorporated, New York, N.Y., a corporation of New York

Filed May 6, 1965, Ser. No. 453,727
Int. Cl. B65h 81/06; B21f 3/00
U.S. Cl. 242—7.09 20 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for winding wire onto a plurality of coil forms extending from a plate includes a frame for supporting the plate and a wire guide having a plurality of wire guide fingers extending therefrom in the direction of the coil forms. The wire guide is moved to position the fingers adjacent to a first row of the coil forms and the frame is moved in an orbiting motion to orbit each coil form about an associated one of the fingers so that wires paying out from the fingers are wound onto the coil forms. The wire guide is moved axially of the coil forms during the winding operation to facilitate a distribution of the wires onto the associated coil forms. Further, the wire guide is indexable to successively position the guide adjacent to successive rows of the coil forms for successive winding operations. The wire guide fingers are also rotatable to facilitate the wrapping of portions of the wires about associated terminals.

This invention relates generally to an apparatus for winding a length of elongated material onto an elongated material-receiving element, and more particularly to an apparatus for successively winding convolutions of wire onto a plurality of coil forms which may be utilized in a ferreed switching array.

A basic crosspoint element in use in electronic telephone switching systems is the ferreed switch. The ferreed switch is designed to provide a pulse operated, two-wire connection and typically includes two miniature reed contacts of magnetic material which are mounted in a plastic coil form of substantially cylindrical shape.

Each coil form is molded into an aperture of an array of coil-receiving apertures formed in a square or rectangular steel mounting plate. The steel mounting plate for the coil forms is known as a "shunt plate" since, in addition to providing a support for the ferreed switches, it also serves as a magnetic shunt dividing each ferreed switch into separately controlled magnetic halves, one on each side of the plate. Winding-receiving sections of each coil form extend from opposite sides of the steel plate sufficiently to receive thereon plural convolutions of small gauge copper wire, typically 25-gauge copper wire.

The winding pattern on each end of a coil form comprises two layers of M turns of wire and two additional layers of oppositely applied N turns of wire superimposed thereon. In a typical ferreed switching array, N is equal to 18 turns and M is equal to 39 turns.

The wound coil forms are arranged on the shunt plate in what may be visualized as an array of "rows" and "columns" of coils such that when the shunt plate is held vertically, the "rows" are oriented horizontally and the "columns" are oriented vertically. On each side of the shunt plate, the M turns "column" coil is connected to an N turns "row" coil, and conversely an M turns "row" coil is connected to an N turns "column" coil.

With this dual winding arrangement on the coil forms, if a current pulse of the same polarity is passed to the column and the row of the desired coordinate at the same time, the magnetic effect of the M winding turns on the reed contacts in the selected coil form overcomes the magnetic effect on these contacts that is produced by the N winding turns. The resultant effect in this case may be thought of as the column coil on one side of the shunt plate working in series with the corresponding row coil on the other side of the shunt plate to close the reed contacts at this coordinate, and to release all other reed contacts in the same row and column.

In order to reduce magnetic interaction between horizontally adjacent ferreed switches as well as to reduce signal noise produced by ferreed energizing pulses, horizontally adjacent row or column coils are wound in opposite relative directions. In addition, a single length of wire must connect the multiple coils forming each row or column so that the desired crosspoint may be selected by supplying current pulses to one continuous row wire and one continuous column wire through terminals that are also mounted on the shunt plate.

Since each end of a coil form is typically provided with windings of 18 turns and 39 turns, respectively, a typical ferreed switching array comprising eight rows and eight columns of coil forms would require 256 individual coil windings. In addition, a typical eight-by-eight coil form array may have associated therewith forty terminals that are each typically wound with at least one convolution of wire. The manual winding of 256 coil forms with dual windings of 18 and 39 turns, respectively, and associated terminal ends obviously would involve tedious and time-consuming effort. The requirement that the coil forms of each row and column be multiply connected by a single length of wire and that every adjacent coil of a row or column be wound in an opposite relative direction to reduce magnetic interaction between adjacent switches further complicates the winding of the coil forms, as will be evident to those working in the winding art.

One object of this invention is an apparatus for winding elongated material onto an element by paying out the material and orbiting the element into an intercepting relationship with the payed out material.

Another object of this invention is an apparatus for successively winding a continuous length of wire onto plural elements with a directionally alternating winding pattern.

Still another object of this invention is an apparatus for winding at least two rows of elements with a continuous length of wire such that successive elements in both rows are wound with a directionally alternating winding pattern.

Another object of this invention is an apparatus for winding plural rows of an array of elements simultaneously and in a continuous succession with a winding pattern that reverses direction with each winding.

Yet another object of this invention is an apparatus for winding a continuous length of wire onto plural adjacent elements by paying out the wire and orbiting one element into an intercepting relationship with the payed out wire and thereafter rotating the wire around the second element.

And still another object of this invention is an apparatus for winding wires onto plural coil forms and terminals of conventional types of ferreed switching arrays.

Other objects and advantages of the present invention will be apparent from the following detailed description when considered in conjunction with the accompanying drawings, wherein:

FIG. 1 is a partial perspective view of one side of the apparatus that is constructed in accordance with this invention;

FIG. 2 is a bottom view of the apparatus with parts of a traverse mechanism shown sectioned;

FIG. 3 is a plan view of the apparatus of this invention;

FIG. 4 is an upright end view of the apparatus taken on section line 4—4 of FIG. 3 but further includes an illustration of a limit switch LS–2 and an indexing motor M–1;

FIG. 5 is an upright section view of the apparatus taken along section line 5—5 of FIG. 2;

FIG. 6 is a section view taken along section line 6—6 of FIG. 2;

FIG. 7 is a partial perspective view of another side of the apparatus constructed in accordance with this invention;

FIG. 8 is a section view taken along section line 8—8 of FIG. 7;

FIG. 9 is a section view taken along section line 9—9 of FIG. 3;

FIG. 10 is a section view taken on section line 10—10 of FIG. 3;

FIG. 11 is a section view taken on section line 11—11 of FIG. 3;

FIG. 12 is a section view taken on section line 12—12 of FIG. 11;

FIG. 13 is a section view taken on section line 13—13 of FIG. 11;

FIG. 14 is a section view taken on section line 14—14 of FIG. 7;

FIG. 15 schematically illustrates a pneumatic system constructed in accordance with the principles of this invention for effecting the operation of the apparatus of the instant invention;

FIGS. 16 and 17 schematically illustrate the electrical circuitry and components that are utilized to effect the operation of the apparatus of this invention;

FIGS. 18 and 19, respectively, illustrate typical timing charts for two timing motors that are incorporated in the apparatus of this invention, and

FIGS. 20 and 21 illustrate successive winding patterns that may be applied to a typical shunt plate by the operation of the apparatus of this invention.

Brief description of the apparatus

Referring to FIG. 1 of the drawings, an apparatus, designated generally by the reference numeral **10**, that is constructed in accordance with the principles of this invention includes a plate holder **178** for supporting a shunt plate **180** with a plurality of coil forms CF—CF vertically disposed as an array of rows and columns, and a carriage **50** that is mounted for traversing movement in the directions of the arrows A—A and for indexing movement in the directions of the arrows B—B. Four wire guides or feed tubes **80***a*–**80***d* are mounted on the carriage **50** for eccentric rotation. Each feed tube **80***a*–**80***d* is designed to receive and guide a wire W toward a row of coil forms CF—CF, FIG. 1, and adjacent left and right columns of terminals T—T that extend from the shunt plate **180**. The left and right columns of terminal T are respectively located adjacent the left and right ends of the shunt plate **180**, as viewed in FIG. 1, and although the left column of terminals is covered by the carriage **50** and cannot be seen in this figure, this column of terminals may be visualized as being located to the left of the leftmost column of coil forms CF—CF. The feed tubes **80***a*–**80***d* are locked against rotation while the left column of terminals T—T and the coil forms CF—CF are being wound and are released for rotation before the right column of terminals T—T are to be wound.

The traversing movement of the carriage **50** in the directions of the arrows A—A in FIG. 1 is effected by the rotation of a reversible winding motor M–2, FIG. 4, which is initiated by the actuation of a limit switch LS–1. The winding motor M–2 also serves as a drive for orbiting the holder **178**, and thus the coil forms CF—CF and left column of terminals T—T (not shown) on the shunt plate **180**, about the feed tubes **80***a*–**80***d*, so that the left column of terminals and the coil forms CF—CF successively wind upon themselves the wires W that issue from the feed tubes **80***a*–**80***d*. After each column of coil forms CF—CF is wound with a wire W, the direction of rotation of the reversible winding motor M–2 is reversed so that each successive coil form column is wound with a directionally reversed winding.

A reversible indexing motor M–1 (shown in phantom in FIG. 1) is utilized to index the carriage **50** to the right and then to the left as viewed in this figure to successive positions such that the feed tubes **80***a*–**80***d* are successively located in predetermined winding positions relative to the coil forms CF. With references to FIG. 7, a plurality of notches **25***a*–**25***h* formed in a bar **24** act in conjunction with a limit switch LS–2 to define the spatial intervals of indexing of the carriage **50**.

The carriage **50**, FIGS. 1 and 7, houses mechanism for releasing the feed tubes **80***a*–**80***d* for rotation and for subsequently rotating the feed tubes **80***a*–**80***d* when the carriage **50** is indexed to the right, as viewed in FIG. 1, to a position where every other terminal T that comprises the right column of terminals T—T is within the radius of eccentricity of a feed tube **80***a*–**80***d*. In this position, the carriage **50** will actuate a limit switch LS–3 which then initiates the release and the subsequent rotation of the feed tubes **80***a*–**80***d*. The wires W—W are wound onto the right terminals T—T by the rotation of the tubes **80***a*–**80***d*. Additional mechanism is also housed in the carriage **50** for driving the feed tubes **80***a*–**80***d* vertically upward or downward, as indicated by the arrows C—C in FIG. 7, at the termination of a row-winding operation so that the feed tubes **80***a*–**80***d* may be vertically displaced to predetermined positions for applying the wires W—W onto the remaining terminals T—T that comprise the right column of terminals and for subsequently applying the wires W—W onto the remaining rows of coil forms CF—CF upon the return indexing movement of the carriage **50**.

A limit switch LS–4 is actuated by the carriage **50** when the carriage **50** is indexed to the prescribed limit of its return movement. The actuation of the limit switch LS–4 initiates the stoppage of further indexing of the carriage **50** to the left, as viewed in FIG. 1, and also initiates the final winding of the wires W—W onto the left column of terminals T—T, not shown in FIG. 1.

Detailed description of the apparatus

As best seen in FIG. 1, the apparatus **10** is mounted on a stationary, flat table **11** having four vertical legs, three of such legs being illustrated and referred to by the numerals **12**. A horizontal, substantially flat base **13** for the carriage **50** is mounted for reciprocative movement above the flat upper surface of the table **11** in directions indicated by the arrows A—A in FIG. 1 on a pair of parallel, spaced-apart liner pins **14** and **14***a*. With reference to FIG. 8, a pair of parallel ribs **15** and **15***a*, integral with the table **11**, rigidly secure the liner pins **14** and **14***a* in elevated positions relative to the upper surface of the table **11**.

As illustrated by FIGS. 4 and 7, the innermost ends of the liner pins **14** and **14***a*, respectively, are externally threaded and are held secured by mating threaded bores formed in a pair of projecting abutments **17** and **17***a*, respectively, which also extend upwardly from the flat upper surface of the table **11** and may be formed integral therewith. The abutments **17** and **17***a* serve as mechanical stops to limit the inward movement of the base **13** riding on the liner pins **14** and **14***a*.

Referring to FIGS. 1 and 7, the outermost ends of the liner pins **14** and **14***a* are formed with enlarged flanges or collars **18** and **18***a*. A pair of compressed coil springs **19** and **19***a* supported on the pins **14** and **14***a*, respectively, abut the collars **18** and **18***a*, respectively, and the base **13** and resiliently urge the base **13** inward toward the abutments **17** and **17***a*.

A pair of bearing blocks **21** and **22** are mounted on the base **13** adjacent the respective opposite ends of the base **13** and receive an essentially round rod **24** for slidable movement therethrough in directions indicated by the arrows B—B in FIGURE 7. The carriage **50** is secured to the rod **24** and is movable therewith. The upper edge of the rod **24** is typically formed with eight spaced, substantially hemispherical notches **25***a*–**25***h*, corresponding to eight columns of coil forms CF on the shunt plate **180**, and the outermost edge of the rod **24** is formed with ten spaced holes **26***a*–**26***j* of substantially conical shape, FIG. 10, for receiving a shot pin SP–**1** that successively locks the carriage **50** in position. There is a prescribed relationship that exists between the horizontal distances between the consecutively lettered holes **26***b*–**26***i* and the consecutively lettered notches **25***a*–**25***h*. The horizontal distance between the centers of the successive notches **25***a*–**25***h* is substantially equal to the respective horizontal distances between the centers of the holes **26***b*–**26***i*. The reason for this required relationship between the consecutively lettered notches **25***a*–**25***h* and the consecutively lettered holes **26***b*–**26***i*, respectively, will be discussed subsequently during the description of operation of the apparatus **10**.

The limit switches LS–**2** and LS–**1** are of conventional type and are positioned adjacent the bearing blocks **21** and **22**, respectively, on base **13**. The limit switches LS–**2** and LS–**1**, FIG. 7, are respectively fixedly attached to the base **13** by L-shaped brackets **30** and **31** secured thereto. The limit switch LS–**1**, FIG. 10, includes an actuator rod **32** which is vertically movable in a vertical bore **33** in the bearing block **22**. The downwardmost end of the actuator rod **32** preferably is formed with a conical tip **34**. The axis of the bore **33** is positioned slightly to the left of the longitudinal axis of the rod **24**, as seen in FIG. 10, and perpendicularly intersects the axis of a horizontal bore **35** in the bearing block **22**. The shot pin SP–**1** is axially movable in the horizontal bore **35** under the control of a conventional double-acting air cylinder **38**. The shot pin SP–**1** has a substantially conical tip **36** which serves to pilot the shot pin SP–**1** into any one of the holes **26***a*–**26***j*, FIG. 7, in the rod **24**. The innermost end **39** of the air cylinder **38** is externally threaded for effecting a threaded connection with a mating threaded bore **40** in the bearing block **22**.

A pair of tubes **42** and **43** are connected adjacent respective opposite ends of the air cylinder **38** with the ends of these tubes communicating with the interior of the cylinder **38**. The air cylinder **38** is designed such that the shot pin SP–**1** will be driven out of one of the holes **26***a*–**26***j* when pressurized air is supplied to the tube **42** and will be driven back and into one of the holes **26***a*–**26***j* when pressurized air is supplied to tube **43**. The tube **43** serves as an exhaust tube for the air cylinder **38** when pressurized air is supplied to the tube **42**, and vice versa.

With the shot pin SP–**1** inserted into any one of the holes **26***a*–**26***j* in the rod **24**, for example, the hole **26***a* as illustrated by FIG. 10, the rod **24** will be locked against movement. The actuator rod **32** of the limit switch LS–**1** also will be retained in the raised position, as viewed in FIG. 10, by the tip **34** bearing against the extended shank of the shot pin SP–**1**. When the shot pin SP–**1** is retracted from any one of the holes **26***a*–**26***j*, the rod **24** will be released for movement. The tip **34** of the actuator rod **32** also will ride off the shank of the shot pin SP–**1** and move downward, as viewed in FIG. 10, to a lower or extended position where the tip **34** projects less than halfway into the bore **35**, so that the shot pin SP–**1** will be able to drive the rod **32** up again. The release of the actuator rod **32** by the retraction of the shot pin SP–**1** will actuate the limit switch LS–**1**. Conversely, the driving of the shot pin SP–**1** back into any one of the holes **26***a*–**26***j* will drive the conical tip **36** of the shot pin SP–**1** against the downwardly extended tip **34** of the actuator rod **32** and the actuator rod **32** thereupon will be driven upward to reactuate the limit switch LS–**1**.

The limit switch LS–**2**, FIGS. 7 and 9, is also provided with an actuator rod **45**, and the downward end of the actuator rod **45** supports a roller **46** for rotation thereon. The roller **46** is designed to roll against the outer periphery of the rod **24** as the rod moves to the left, as viewed in FIGS. 7 and 9, until one of the notches **25***a*–**26***h* is displaced to a position under the roller **46**. The actuator rod **45** will then be driven downward, as viewed in this figure, by internal springs (not shown) in the limit switch LS–**2** a distance substantially equal to the depth of the notch **25***a*. This downward movement of the rod **45** will initiate the actuation of the limit switch LS–**2**. When the rod **24** is indexed further to the left so that the roller **46** rides out of the notch **25***a* and back onto the outer periphery of the rod **24**, the actuator rod **45** will be driven upward and limit switch LS–**2** will be reactuated.

The limit switches LS–**3** and LS–**4**, that are also of conventional type, are fixedly mounted to the upper surface of the base **13** by any suitable means, such as machine screws **47**. The limit switch LS–**3** has a contact button **48** which extends from the switch LS–**3** so as to be contacted and depressed by a leg **52** of the carriage **50** when the carriage **50** is indexed to a predetermined limit of displacement to the right, as viewed in FIG. 1.

The limit switch LS–**4**, located proximate the opposite end of the base **13**, also has a contact button **49** that extends from the switch LS–**4** to be contacted and depressed by the leg **52** of the carriage **50** when the carriage **50** is indexed to a predetermined limit of displacement to the left, as viewed in FIG. 1.

The roles that the limit switches LS–**1**, LS–**2**, LS–**3** and LS–**4** play in the operation of the apparatus **10** will be related in greater detail subsequently.

Referring again to FIG. 1, the rod **24** has the L-shaped carriage **50** fixedly secured thereto and movable therewith relative to the base **13** in the directions indicated by the arrows B—B. The vertical leg of the carriage **50** is designated by the numeral **51** and the horizontal leg by the numeral **52**. The horizontal leg **52** of the carriage **50** has a bore **53** extending therethrough that receives a bearing rod **54**. The bearing rod **54** is mounted substantially parallel to the rod **24**, FIGS. 1 and 3, and has the ends thereof secured to the base **13** by a pair of supporting members **55** and **56** that may be formed integral with the base **13**. The diameter of the bore **53** is slightly greater than the diameter of the bearing rod **54** so that the leg **52** will slide upon the rod **54**. The rods **24** and **54**, FIG. 1, are elevated above the plane of the flat, upper surface of the base **13** so that the leg **52** of the carriage **50** rides slightly above the base **13**. Since the rods **24** and **54** will move with the base **13** in the direction indicated by the arrows A—A in FIG. 1 by virtue of the rods **24** and **54** being mounted in the brackets **21**, **22** and **55**, **56**, respectively, the carriage **50** is also movable with the base **13** in the directions of the arrows A—A.

A rack **57** is also fixedly attached at the left end thereof as viewed in FIG. 1, to the horizontal leg **52** of the carriage **50** and extends substantially parallel to the rods **24** and **54**. The outer edge of the rack **57** is formed with teeth **58** which mesh with the teeth of a spur gear **59**, FIG. 1. The gear **59** may be driven in one of two senses of rotational direction by the reversible carriage indexing motor M–**1**.

The indexing motor M–**1** is mounted stationary to the base **13** on a substantially Z-shaped bracket **60** that may be formed integral with the base **13**. Machine screws **61** may be utilized to attach the motor M–**1** to the horizontal upper surface of the bracket **60**. The bracket **60**, FIG. 4, is formed with a rectangular slot **62** that serves the dual functions of providing a horizontal support for the free end of the rack **57** and of providing a vertical surface against which the toothless edge of the rack **57** bears

to maintain the rack teeth **58** in mesh with the teeth of the gear **59**. The reversible indexing motor M–**1** may be energized so as to rotate in one sense of rotational direction and the gear **59** is thereby rotated in this assumed sense of rotational direction to drive the rack **57** from left to right, as viewed in FIG. 1. The carriage **50** will thereupon be pulled to the right by this movement of the rack **57**. Since the rod **24** is fixedly secured to the carriage **50**, the rod **24** will also be pulled to the right by the carriage **50**. The indexing motor M–**1** may also be energized to rotate in an opposite sense of rotational direction and the gear **59** is thereby rotated in this assumed opposite sense of direction to drive the rack **57** to the left, as viewed in FIG. 1. The carriage **50** and the rod **24** will thereupon also be driven to the left.

Referring to FIG. 7, the vertical leg **51** of the carriage **50** is of U-shaped cross-section and comprises a pair of parallel, vertical side plates **51***a*, **51***b*, an integral upper end plate **51***c* and an integral front plate **51***d*, FIG. 1. The plates **51***a* and **51***b*, FIG. 12, are provided with vertical parallel grooves **70** which slidably receive therein a pair of vertical tongues **71** that extend from the sides of a vertically movable post **75**.

The post **75** is formed with a vertical, substantially L-shaped slot **76** which extends the entire length of the post **75**, as viewed in FIG. 11. Referring again to FIG. 7, four vertically disposed wire guide or feed tubes **80***a*, **80***b*, **80***c* and **80***d* are mounted for rotation on the post **75** in cylindrical bearing blocks **81**—**81**, one of the bearing blocks being shown in detail by FIG. 13. Each bearing block **81** is inserted with an interference fit into each of the four bores **82**—**82** that extend horizontally through the post **75** and is provided with a concentric bore **81***a*.

As best seen in FIGS. 12 and 13, each feed tube **80***a*–**80***d* is formed with a linear section and a curved section. The longitudinal axis of the linear section of each tube **80***a*–**80***d* extends perpendicularly through a vertical slot **84**, FIG. 1, formed in the front plate **51***d* of the leg **51** and the outer end **85** of each tube **80***a*–**80***d* preferably is flared. The flared ends **85**—**85** of the four tubes **80***a*–**80***d* receive individual wires W, FIG. 4, that are payed off from four wire supply reels **86***a*–**86***d*. The wire supply reels **86***a*–**86***d* are rotatably mounted on a stationary reel support **88** and are frictionally braked so that the reels **86***a*–**86***d* apply a predetermined tension to each of the wires W—W.

Referring again to FIGS. 12 and 13, each linear section of a feed tube **80***a*–**80***d* has a substantially T-shaped bearing **90** that is force-fitted onto each feed tube **80***a*–**80***d* and is received for rotation by the bearing block bore **81***a*. The bearing **90** may be composed of any suitable bearing material, for example, nylon or Teflon.

An enlarged cylindrical head **91** is formed by each of the four bearings **90**—**90** and bears against the outer end of each bearing block **81**. Each head **91** serves as a spacer between a bearing block **81** and an associated spur gear **94**. Each of the four heads **91**—**91** may be connected to one of the four gears **94**—**94** by a connective pin (not shown), or each of the four gears may be keyed to the linear section of each feed tube **80***a*–**80***d*. Howsoever the connection is effected between a gear **94** and a tube **80***a*–**80***d*, the axes of rotation of the gears **94**—**94** preferably are coaligned with the longitudinal axes of the straight sections of the tubes **80***a*–**80***d*. To preclude outward axial movement of the gears **94**—**94**, the outer end of each gear **94** abuts the vertical surface formed by the slot **76**.

The teeth of the gears **94**—**94** mesh with teeth **95** formed along one edge of a vertically movable toothed rack **96**. The rack **96** is slidably mounted for vertical displacement in the slot **76**, FIGS. 11 and 12, as indicated by the arrows D—D in FIG. 11. The edge **97** of the rack **96** opposite the toothed edge is provided with two vertically spaced slots **98** and **99**. The slots **98** and **99** are designed to receive a shot pin SP–**2**, and with the

shot pin SP–**2** in either the slot **98** or **99**, the rack **96** will be locked against vertical displacement. With the shot pin SP–**2** retracted from the slots **98** and **99**, the rack **96** will be released for vertical displacement, and the vertical displacement of the rack **96** will effect the simultaneous rotation of the four gears **94**—**94** in the same sense of rotational direction.

Referring again to FIGS. 7 and 13, each of the feed tubes **80***a*–**80***d* is also formed with an eccentric or elbowed tube section that straightens out and terminates as a feed tube tip **100***a*–**100***d*. The four tips **100***a*–**100***d* are essentially identical in size and shape and serve as guides for issuing the wires W—W, FIG. 4 and 14, that are received by the flared ends **85**—**85** of the tubes **80***a*–**80***d*. The tips **100***a*–**100***d* may be rotated clockwise or counterclockwise, as viewed in FIG. 11, by the respective clockwise or counterclockwise rotation of the gears **94**—**94** to trace out four individual circles of revolution that are concentric with the individual axes of rotation of the gears. If the rack **96** is in the position as illustrated by FIG. 11 with the shot pin SP–**2** in the slot **98**, the tips **100***a*–**100***d*, FIG. 7, will be in substantially twelve o'clock positions relative to a common vertical axis that perpendicularly intersects the longitudinal axes of the cylindrical bearings **82**—**82**.

The shot pin SP–**2** is formed by the rod end of a piston (not shown) that is housed for reciprocative movement in a double acting air cylinder **110**. Referring to FIG. 14, a vertical slot **111** is formed in the side plate **51***a* of the vertical leg **51** and receives the air cylinder **110** for vertical movement therein relative to the leg **51**. The inner end **112**, FIG. 7, of the air cylinder **110** is externally threaded and is received in a threaded bore **113** formed in the post **75**. Pressurized air for the air cylinder **110** is supplied and exhausted through a pair of tubes **115** and **116** connected to opposite ends thereof. When pressurized air is supplied to the tube **115**, the piston housed in air cylinder **110** will be operated to drive the shot pin SP–**2** toward the rack **110** and into locking engagement with one of the slots **98** or **99**. The tube **116** will serve as an exhaust line for the air cylinder **110** in this event. The particular slot **98** or **99** into which the shot pin SP–**2** is driven will depend upon the vertical position of the rack **96** in the post **75**. Conversely, when pressurized air is supplied to the tube **116**, the shot pin SP–**2** will be driven from locking engagement with either the slot **98** or **99**, the particular slot from which the shot pin SP–**2** is retracted again depending upon the vertical position of the rack **96** relative to the post **75**. The tube **115** will now serve as an exhaust line for the air cylinder **110**.

The end plate **51***c*, FIGS. 1 and 7, of the vertical leg **51** has a double acting air cylinder **120** affixed thereto by a flange **121** or by other suitable means. Tubes **122** and **123** are connected to opposite ends of the cylinder and serve to supply and exhaust pressurized air for driving the piston of the cylinder. A rod end **125** of the piston rod (not shown) housed in the air cylinder **120** is vertically movable in a vertical bore **126** that extends through the plate **51***c*. The rod **125** is fixed to the upper end of the post **75** by a flange **127** or by other suitable means.

When pressurized air is supplied to the tube **122** of air cylinder **120**, the rod **125** will be driven downward, as viewed in FIGS. 1 and 7, and the downward movement of the rod **125** will effect the downward movement of the post **75**. The tube **123** will serve as an exhaust line under these conditions. Conversely, the application of pressurized air to the tube **123** will drive the rod **125** upward, as viewed in FIG. 11, until the post **75** is returned to the position shown.

It should be noted that since the air cylinder **110** is mounted on the post **75**, the air cylinder **110** will also move upward and downward within the slot **111**, FIG. 14, by respective upward and downward movements of the rod **125**. The upper end of the post **75**, FIG. 11, has a double acting air cylinder **130** directly affixed thereto by

a flange **131**. A rod end **132** of a piston rod (not shown) housed in the air cylinder **130** extends downward into the slot **76**, FIGS. 11 and 12, and preferably is formed integral with the upper end of the rack **96**. Thus, the rack **96** will be driven vertically upward and downward by respective upward and downward movements of the rod **132**.

The air cylinder **130** is designed such that when pressurized air is supplied to a tube **135** connected to one end of the cylinder, the rod **132** will be driven upward, as viewed in FIG. 11. The upward movement of the rod **132** will cause corresponding upward movement of the rack **96**. Tube **136** at the other end of the cylinder serves as an exhaust line for the air cylinder **130** under these conditions. Conversely, when pressurized air is supplied to the tube **136**, the rod **132** will be driven downward, as viewed in FIG. 11, until the rack **96** is returned to the initial position, as shown. The length of the stroke of the rod **132** in the cylinder **130** will, of course, govern the vertical displacement of the rack **96** in the post **75**.

Since the air cylinder **130** is fixedly connected to the post **75** and since the post **75** is also vertically movable, it is necessary to provide a large enough opening in the leg **51** so that the tube **135** will be unobstructed in its movement with the air cylinder **130**. To this end, portions of the plates **51***b* and **51***c*, FIGS. 1 and 7, are cut away at **137** to accommodate the tube **135** during the movement thereof.

A typical cycle of operation of the air cylinders **110**, **120** and **130**, the post **75**, the feed fingers **80***a*–**80***d*, and the rack **96** will now be described.

Assume that the shot pin SP–2, FIG. 11, is retracted from the slot **98** in the rack **96** by the application of pressurized air to the tube **116** of the air cylinder **110**. The subsequent application of pressurized air to the air cylinder **130** via the tube **135** will drive the rod **132** and the rack **96** upward, as viewed in this figure, and the upward movement of the rack **96** will cause the simultaneous rotation of all the gears **94**—**94** in a clockwise direction, as viewed in FIG. 11. The gears **94**—**94** and the teeth **95** of the rack **96** may be designed to impart approximately 1.25 clockwise revolutions to the feed fingers **80***a*–**80***d* when the rack **96** is moved from the lowered position, as illustrated in FIG. 11, to the upper limit of vertical displacement, as determined by the length of the stroke of the rod **132**. The vertical distance between the centers of the slots **98** and **99** is substantially equal to the vertical displacement of the rack **96**. With the rack **96** moved to its upper limit of displacement, the slot **99** will be moved to a position opposite the shot pin SP–2. The application of pressurized air to the tube **115** of the air cylinder **110** will drive the shot pin SP–2 into the slot **99** and thus the rack **96** will be locked into this upper position.

If pressurized air is then supplied to the air cylinder **120** via the tube **122**, the rod **125** will drive the post **75** downward through a predetermined displacement as determined by the length of the stroke of the rod **125**. This vertical movement of the post **75** will cause a corresponding vertical displacement of the feed fingers **80***a*–**80***d* which are now held against rotation by virtue of the shot pin SP–2 projecting into the slot **99**. The shot pin SP–2 travels downward with the post **75** since the air cylinder **110** is attached to the post **75** and is vertically movable in the vertical slot **111**. After the post **75** is driven to a lower position, pressurized air may then be supplied to the tube **116** so that shot pin SP–2 will now be retracted from the slot **99** to release the rack **96** for downward movement relative to the post **75**. Assuming that pressurized air is now supplied to the tube **136** of the air cylinder **130**, the rack **96** will be driven downward, as viewed in FIG. 11, a distance equal to the length of the stroke of the rod **132**. This downward displacement of the rack **96** will effect the rotation of the gears **94**—**94** approximately 1.25 revolutions counterclockwise, as viewed in FIG. 11. If pressurized air is then supplied to the air cylinder **110** via the tube **115**, the shot pin SP–2 will again be driven into the slot **98** which is lowered with the rack **96** to a position opposite the shot pin SP–2 so that the rack **96** is again locked in this lowered position.

The post **75** may then be returned to the position as illustrated in FIG. 11 by the subsequent application of pressurized air to the air cylinder **120** via the tube **123**. As will be subsequently evident, the aforedescribed operation of the post **75**, the feed tubes **80***a*–**80***d*, and the rack **96**, as well as the air cylinders **100**, **120** and **130** that are associated therewith is utilized during two distinct periods of the winding operation.

FIG. 15 schematically illustrates the pneumatic system that is designed in accordance with this invention to operate at various periods during the overall operation of the apparatus **10**. A tube **140** is connected to a supply (not shown) that supplies pressurized fluid, such as compressed air, to one end of the tube **140**. Another tube **141** receives the air that much be exhausted from the several air cylinders embodied in the system when the internal pistons (not shown) of those air cylinders are driven by the compressed air supplied to the tube **140**.

Referring to FIG. 15, a valve VALVE–1 is designed to be actuated by the energization of the solenoid SOL1A and SOL1B. The solenoid SOL1A has a pair of leads **L16** and **L16***a* connected thereto and the solenoid SOL1B has a pair of leads **L17** and **L17***a* connected thereto. The energization of the solenoid SOL1A will actuate the valve VALVE–1 so as to divert compressed air from the tube **140** to the tube **42** and consequently, the shot pin SP–1 housed in the air cylinder **38** will be retracted from locking engagement with one of the holes **26***a*–**26***j*, FIG. 7, in the rod **24**. The actuation of the valve VALVE–1 by the solenoid SOL1A will also provide an exhaust connection between the tube **43** and the exhaust tube **141** and thus air displaced by the movement of the piston (not shown) in the air cylinder **38** will flow through the tube **141**.

Upon the subsequent deenergization of the solenoid SOL1A followed by the reenergization of the solenoid SOL1B, the valve VALVE–1 will be actuated so as to return to that position as depicted by FIG. 15. The shot pin SP–1 will thereupon be driven outward from the air cylinder **38** by compressed air that is now diverted into the tube **43**. This return actuation of the valve VALVE–1 will operate to connect the tube **42** to the tube **141** so that the tube **42** will then act as an exhaust line for the opposite end of the air cylinder **38**.

A valve VALVE–2 is designed to be actuated by the selective energization of the solenoid SOL2A or solenoid SOL2B to divert compressed air from the tube **140** into the tubes **122** or **123**, respectively, connected to the air cylinder **120**. The solenoid SOL2A has a pair of leads **L18** and **L18***a* connected thereto and the solenoid SOL2B has a pair of leads **L21** and **L21***a* connected thereto.

The solenoid SOL2A will be energized by current supplied to the leads **L18** and **L18***a* and the solenoid SOL2B will be energized by current supplied to the leads **L21** and **L21***a*. Assuming that the solenoid SOL2B has been previously energized, the valve VALVE–2 will have been actuated to assume that position as schematically depicted by FIG. 15. The tube **123** will receive compressed air from the tube **140** and the tube **122** will serve as an exhaust line for the other end of the air cylinder **120**. The tube **122** will also serve as an exhaust line for a pressure switch, designated PSW, to the exhaust tube **141**.

The pressure switch PSW is a commercially available item that typically embodies an expandable bellows **142** and a pair of contacts **K7** and **K7***a*. The contacts **K7** have leads **L18***a* and **L19** connected thereto and the contacts **K7***a* have leads **L19***a* and **L21***a* connected thereto. The contacts **K7** are maintained normally closed and the con-

tacts K7*a* maintained normally open by the normally retracted deflated bellows **142**.

The bellows **142** are designed to inflate and expand in an axial direction when the tube **122** receives compressed air from the tube **140**. The bellows are also designed to deflate and retract in an axial direction when an exhaust line to the tube **141** is provided by the tube **122**. With the valve VALVE–**2** in the position illustrated by FIG. 15, the compressed air from the tube **140** will flow into the tube **123** and maintain the post **75** in a raised position, as viewed in FIG. 11, even though the solenoid SOL2B may be deenergized. The valve VALVE–**2** will be actuated by the energization of the solenoid SOL2A to divert compressed air from the tube **140** into the tube **122**. The tube **123** will also be connected to the tube **141** by this actuation of the valve VALVE–**2** so as to provide an exhaust line from one end of the air cylinder **120** to the tube **141**. The application of compressed air to the tube **122** will operate to drive the post **75** downward, as viewed in FIG. 11, and as related above. Compressed air from the tube **140** will be received simultaneously by the bellows **142** in the pressure switch PSW. The bellows **142** will thereupon inflate and expand in an axial direction to effect the coincident opening of the contacts K7 and the closing of the contacts K7*a*. The valve VALVE–**2** will remain in this position upon subsequent deenergization of the solenoid SOL2A.

The subsequent reenergization of the solenoid SOL2B will actuate the valve VALVE–**2** so that the compressed air from the tube **140** will be again diverted into the tube **123**. The application of compressed air to the tube **123** will effect the driving of the post **75** upward, as viewed in FIG. 11, until the post **75** returns to the position as illustrated in that figure. In addition, the tube **141** will be connected to the tube **122** and the tube **122** will thereupon serve as an exhaust line for the air cylinder **120** and the bellows **142**. As soon as the pressure in the bellows **142** is relieved by a connection through the valve VALVE–**2** to the exhaust tube **141**, the bellows **142** will deflate and retract axially to reestablish the normally closed state of the contacts K7 and the normally open state of the contacts K7*a*. It may be noted at this time that the bellows **142** possesses an inherent time delay which will be utilized in the operation of the apparatus **10**.

A valve VALVE–**3** is designed to be actuated by the selective energization of a solenoid SOL3A and SOL3B. The solenoid SOL3A has a pair of leads L**22** and L**22***a* connected thereto and the solenoid SOL3B has a pair of leads L**23** and L**23***a* connected thereto. When current is supplied to the leads L**22** and L**22***a*, solenoid SOL3A will be energized to actuate the valve VALVE–**3** from the position schematically depicted by FIG. 15. The application of current to the leads L**23** and L**23***a* will effect the energization of the solenoid SOL3B which will actuate the valve VALVE–**3** to that position as depicted by FIG. 15.

When the solenoid SOL3A is energized, the valve VALVE–**3** will be actuated so that compressed air from the tube **140** will be diverted into the tube **135**. Since the tube **135**, FIG. 11, is connected to one end of the air cylinder **130**, the application of compressed air to the tube will operate to drive the rack **96** upward, as viewed in FIG. 11, causing the feed tubes **80***a*–**80***d* to be rotated clockwise, as viewed in that figure. The actuation of the valve VALVE–**3** will also operate to provide a connection between the tubes **136** and **141** and therefore, the tube **136** will now serve as an exhaust line for the air cylinder **130**.

After the solenoid SOL3A is deenergized, the subsequent energization of the solenoid SOL3B will actuate the valve VALVE–**3** so that the valve VALVE–**3** reassumes the position schematically depicted by FIG. 15. The tube **136** will then receive compressed air from the tube **140** and as a result, the rack **96** will be driven downward, as viewed in FIG. 11, to effect the counterclockwise rotation of the feed tubes **80***a*–**80***d*. The valve VALVE–**3** will also provide a connection between the tubes **135** and **141** so that the tube **135** operates as an exhaust line for the air cylinder **130**.

The valve VALVE–**4** is designed to be actuated by the selective energization of the solenoid SOL4A and SOL4B. The solenoid SOL4A has a pair of leads L**24** and L**24***a* connected thereto and the solenoid SOL4B has a pair of leads L**25** and L**25***a* connected thereto. The solenoid SOL4A will be energized by current supplied to the leads **24** and **24***a* and the solenoid SOL4B will be energized by current supplied to the leads L**25** and L**25***a*.

When the solenoid SOL4*b* is energized, the valve VALVE–**4** will be actuated to connect tube **116** to the tube **140** and to connect the tube **115** to the tube **141**. The tube **116** will receive compressed air from the tube **140** and direct the compressed air into the air cylinder **110** to drive the shot pin SP–**2** into the air cylinder **110**. Referring to FIG. 11, the retraction of the shot pin SP–**2** will move the shot pin SP–**2** out of locking engagement with one of the slots **98** or **99** in the rack **96** and thereby release the rack **96** for movement in direction of the arrows D—D. The tube **115**, FIG. 15, will serve as exhaust line for the other end of the air cylinder **110** to the tube **141**.

The subsequent deenergization of the solenoid SOL4B followed by the reenergization of the solenoid SOL4A will actuate the valve VALVE–**4** so that the valve VALVE–**4** reassumes the position schematically depicted by FIG. 15. The tube **115** will now receive compressed air from the tube **140**, and the tube **116** by virtue of its connection through the valve VALVE–**4** to the tube **141** will serve as an exhaust line for the air cylinder **110**. When compressed air is received by the air cylinder **110** from the tube **115**, the shot pin SP–**2** will be driven outward and into one of the slots **98** or **99** formed in the rack **96**.

It should be noted that the deenergization of any of the solenoids SOL1A–SOL4B will not alter the position of the valve associated therewith and that the valve VALVE–**1**–VALVE–**4** will be actuated only when the solenoid SOL1A–SOL4B associated therewith is energized.

Referring to FIG. 3, winding motor M–**2** for the shunt plate holder **178** is secured to the table **11** by four machine screws **150**—**150**, or the like, and comprises a drive shaft **151** having a sheave **152** fixedly mounted thereto and rotatable therewith. The sheave **152** drives a drive belt **153** and the belt **153** passes through an elongated opening **154** formed in the table **11** to drive another sheave **155**. Thus, the sheave **155** is driven by the rotation of the reversible winding motor M–**2**.

The sheave **155**, FIG. 2, is formed with a collar **156** that is keyed to a drive shaft **157**. The drive shaft **157** is mounted for rotation in a sleeve roller bearing **160**, the bearing **160** being mounted beneath the table **11** on a pair of supporting blocks **161** and **162**. The blocks **161** and **162** may be affixed to the underside of the table **11**, as viewed in FIG. 4, by machine screws **163**—**163**.

A brake BRK is secured adjacent the underside of the table **11** to a plate **164** that may be formed integral with the table **11** or may be suitably attached thereto. The brake BRK is typically a conventional D-C brake that operates, when deenergized, to release the shaft **157** for rotation and operates when energized to frictionally clamp and hold the shaft **157** against rotation. The circuitry for maintaining the brake BRK normally deenergized and for energizing the brake BRK at certain intervals during the cycle of operation of the apparatus **10** will be discussed in greater detail subsequently.

As may be best seen by FIG. 2 of the drawing, the machine screws **150**—**150** that mount the winding motor M–**2** on the table **11** are movable in elongated slots **165**—**165** that are formed in the table **11**. As will be evident, the slots **165**—**165** permit a positional adjustment to be made between the sheaves **152** and **155** to establish a predetermined tension in the belt **153**. The sheaves **152** and **155** are preferably of the same diameter.

The innermost end of the shaft **157**, FIGS 4 and 5, is formed in the shape of a crank arm **167** that includes a crank pin **168** having a longitudinal axis that is offset with respect to the longitudinal axis of the shaft **157**. A circular disc **169** is formed on the end of the pin **168** with its axis of rotation in substantial coalignment with the longitudinal axis of the crank pin **168**. A drive rod **170** has the innermost end thereof connected to the disc **169** and the longitudinal axis of the rod **170** is in substantial coalignment with the longitudinal axis of the shaft **157**.

The crank pin **168**, FIG. 5, of the crank arm **167** is received wih a slidable fit in a bore **171** that is formed adjacent the downward end of a vertically disposed tongue **172**. The tongue **172** is formed with a flange **173** at the upper end thereof and the tongue **172** and the flange **173** are received for planar orbital movement in an elongated opening **175**, FIG. 2, formed in the table **11**. The flange **173**, FIG. 4, may be attached to a horizontal support plate **174** by machine screws **176—176**. The plate **174** is formed with a vertical slot **177** that extends the length of the plate **174** and receives therein the lower edge of a shunt plate holder **178** with an interference fit. Thus, the flange **173** supports the plate holder **178** for movement.

Referring again to FIG. 1, the plate holder **178** has a substantially rectangular cross section and is formed with a substantially U-shaped opening **179**. The opening **179** is designed to receive therein a typical rectangularly shaped shunt plate, that is designated by the numeral **180**. The 64 coil forms that project from one side of the plate **180** will be generally designated as CF at this time. The cross sectional thickness of the plate holder **178**, FIG. 3, is substantially equal to the cross sectional thickness of the shunt plate **180**. A plurality of tabs **181—181** that may be formed integral with the plate holder **178** project into the U-shaped opening **179**. The tabs **181—181** are utilized to retain the shunt plate **180** in the same vertical plane as that of the plate holder **178**.

The opposite ends of the plate holder **178** have a pair of strips **182** and **182***a* of substantially Y-shaped cross sections affixed thereto, FIGS. 1, 3 and 9, by, for example, machine screws **183—183**. The strips **182** and **182***a* are affixed to the diametrically opposed surfaces of a pair of vertical, parallel columns **185** and **185***a*, respectively, by any suitable means. The plate holder **178** is thus attached by the strips **182** and **182***a* to the columns **185** and **185***a*, respectively, and is accordingly movable therewith.

The plate holder **178** additionally supports a retaining arm **186** and the left end of the arm **186**, as veiwed in FIG. 1, is pivotally connected to the plate holder **178** by a pivot pin **187**. The free end of the arm **186** may be manually raised to permit the removal or insertion of a shunt plate **180** into the U-shaped opening **179**. With the arm **186** in the lowered position as illustrated in FIG. 1, the shunt plate **180** will be constrained in the plate holder **178**. A locking slide **188** is keyed to the upper edge of the shunt plate **178** and is slidable in the directions indicated by the arrows E—E in FIG. 1. An L-shaped slot **189** formed in the right end of the arm **186** is designed to receive therein the locking slide **188**. Thus, when the slide **188** is moved into the slot **189**, the free end of the arm **186** will be connected to the plate holder **178**. As will be evident, the arm **186** may be raised to permit the removal of the shunt plate **180** after the slide **188** is slid to the right, as veiwed in FIG. 1, and from locking engagement with the free end of the arm **186**.

A post **190**, FIG. 1, is fixed adjacent the left end of the plate holder **178** to the strip **182***a*, and serves as a lateral member onto which the free ends of the wire W—W that are payed out of the feed tubes **80***a*–**80***d* may be wrapped. Since the post **190** is also attached to the plate holder **178**, the movement of the plate holder **178** will cause a corresponding movement of the post **190**.

Referring again to FIG. 1 of the drawings, the columns **185** and **185***a* that are attached to the plate holder **178** by the strips **182** and **182***a*, respectively, are formed with vertical, parallel bores **193** and **193***a*, respectively, the bores **193** and **193***a* extending through the columns **185** and **185***a* and receiving for slidable movement therein a pair of vertical, parallel rods **194** and **194***a*, respectively. The rods **194** and **194***a* serve as vertical supports for the columns **185** and **185***a*, respectively, and thus serve as vertical supports for the plate holder **178** during movement of the columns **185** and **185***a* and the plate holder **178** in the directions indicated by the arrows F—F in FIG. 1 in the vetical plane.

The rods **194** and **194***a*, FIGS. 2 and 5, are movable in a pair of elongated slots **196** and **196***a*, respectively, that extend through the table **11**. The slots **196** and **196***a* are long enough to permit an unobstructed longitudinal displacement of the rods **194** and **194***a* therein. Located adjacent the underside of the table **11**, FIG. 5, are a pair of blocks **200** and **200***a* having vertical bores **202** and **202***a*, respectively, extending therethrough. Each of the bores **202** and **202***a* receives one of the rods **194** and **194***a*, respectively, with an interference fit. Machine screws (not shown) may be threaded through the blocks **200** and **200***a* and the rods **194** and **194***a* to further insure that the rods **194** and **194***a* are fixedly attached to the blocks **200** and **200***a*, respectively. The downwardmost ends of the rods **194** and **194***a*, as viewed in FIG. 5 of the drawings, are clamped between a pair of rectangular plates **204** and **205**, FIG. 2. Two pair of bolts extend perpendicularly through the plates **204** and **205** adjacent one end thereof, the bolts forming each pair being referred to by the numerals **206** and **207**. Another two pair of bolts extend perpendicularly through the plates **204** and **205** adjacent the opposite end thereof, the bolts forming each pair being referred to by the numerals **206***a* and **207***a*. Each horizontally opposed pair of bolts **206**, **207** and **206***a*, **207***a* are in contact with diametrically opposite sides of the rods **194** and **194***a*, respectively, and act in conjunction with the plates **204** and **205** to hold the downwardmost ends of the rods **194** and **194***a* together in the spaced-apart relationship required to ensure the parallel alignment of the upper ends of the rods **194** and **194***a*.

Referring again to FIG. 2, the blocks **200** and **200***a* are formed with substantially concentric bores **208** and **208***a*, respectively, that receive for slidable movement therein a shaft **215**. The shaft **215** may be threadedly connected at the opposite ends thereof to a pair of brackets **216** and **216***a* and the brackets **216** and **216***a* are in turn attached to the underside of the table **11** by machine screws **217** and **217***a*, respectively. A pair of stub shafts **218** and **218***a* may also have their respective ends threadedly connected to the brackets **216** and **216***a*, respectively, and are slidably received by respective concentric bores **220** and **220***a* that extend horizontally through the blocks **200** and **200***a*, respectively. The inner ends **222** and **222***a* of the stub shafts **218** and **218***a*, respectively, are enlarged and may serve as inward displacement limit abutments for the blocks **200** and **200***a*. The longitudinal axes of the shafts **215**, **218** and **218***a* are preferably oriented in the same horizontal plane. The blocks **200** and **200***a*, FIG. 5, are mounted by the shafts **215**, **218** and **218***a* for horizontal reciprocation in the directions indicated by the arrows G—G in that figure, and therefore, the rods **194** and **194***a* by virtue of their fixed connection to the blocks **200** and **200***a*, respectively, are constrained for movement in the horizontal plane as indicated by the arrows G—G. The columns **185** and **185***a*, however, are slidable in the directions of the arrows F—F upon the rods **194** and **194***a*, respectively, in the vertical plane, as mentioned previously. The plate holder **178** is thus constrained for a circular orbital movement in the vertical plane.

Referring to FIGS. 4 and 5, the rotation of the shaft **157** by the winding motor M–2 will cause rotation of

the crank arm **167**. The crank pin **168** will be driven from the illustrated bottom dead center position to rotate as indicated by the phantom lines in FIG. 5 about the coaligned axes of rotation of the shaft **157** and the rod **170**. The eccentric rotation of the crank pin **168** will drive the tongue **172** and thus the plate holder **178** in a vertical plane through corresponding circular orbits. The plate holder **178** will thus be driven through one circular orbit with each revolution of the shaft **157** since the sheaves **152** and **155** have the same diameters.

Referring again to FIG. 2 of the drawings, the rod **170** that is rotatably driven by the reversible winding motor M–2 through the drive shaft **157** is rotatable in one of two senses of rotational direction as determined by the direction of rotation of the motor M–2.

A flexible shaft **230** is threadedly connected at one end thereof to the rod **170** and is joined at the opposite end thereof to an input shaft (not shown) of a bidirectional counter **240**. The flexibility of the flexible shaft **230** facilitates the manual disconnection of the shaft **230** from the rod **170** and the resulting disconnection of the counter **240** from the rod **170**. When the shaft **230** is disconnected from the rod **170**, the crank arm **167** may be turned to change the position of the shunt plate holder **178** without affecting the count that is registered by the counter **240**.

The counter **240** is attached by machine screws **241**, for example, to an L-shaped extension **242** formed integral with the outer edge of the table **11** and may be any known commercial type of bidirectional counter, of a mechanical or electronic type, that possesses a reset capability. It will be assumed for the purpose of describing the illustrated embodiment of this invention that the counter **240** is a mechanical, bidirectional counter, but it should be understood that invention is not limited to the use of this particular type of counter. The flexible shaft **230** could, for example, have an apertured disc mounted on the end thereof positioned to interrupt the light beam of a photocell device upon the rotation thereof, thereby producing pulses for driving a bidirectional electronic counter.

Referring again to FIG. 2, the counter **240** includes units, tens and hundreds number wheels designated **243***a*, **243***b* and **243***c*, respectively. The units number wheel **243***a* is driven by the rotation of the flexible shaft **230** and the rod **170** through internal gearing (not shown). The internal gearing between the units level number wheel **243***a* and the rod **170** typically provides a 2.5:1 gear ratio between the wheel **243***a* and the rod **170** and therefore it will be hereinafter assumed that a 2.5:1 ratio exists between the rotation of the number wheel **243***a* and the rotation of the rod **170**.

With reference to FIG. 17, the counter **240** is schematically laid out in a horizontal plane for the purpose of clarity and each respective units, tens and hundreds counting level of the counter **240** is designated as such. The units number wheel **243***a*, FIG. 2, mounts a contact element **244**, FIG. 17, for rotation therewith, and the vertically oriented arrows that are associated with the contact element **244** indicate the corresponding directions of the movement of the contact element **244** in the horizontal plane.

The units level number wheel **243***a*, FIG. 2, is rotatable with the rod **170** and is thus rotatable with the winding motor M–2 and is designed to engage and index the tens level number wheel **243***b* after the number wheel **243***a* undergoes one complete revolution. Referring again to FIG. 17, a complete revolution of the number wheel **243***a* and the first contact element **244** in one direction or in an opposite direction corresponds to a differential count of 10. Thus, the counter **240** may be designed such that one complete revolution of the contact element **244** will effect the indexing of the contact element **245**, as indicated by the vertically oriented arrows extending from the contact element **245**, from an initial position where the contact element **245** is in contact with one of the ten terminals numbered **0–90** of the tens counting level to a position in contact with an adjacent terminal of that counting level. As will be evident, the particular terminal that will be contacted by the indexed contact element **245** will depend upon the direction of rotation of the contact element **244** and thus the direction of rotation of the winding motor M–2.

The tens level number wheel **243***b*, FIG. 2, is designed to engage and index the hundreds level number wheel **243***c* after the number wheel **243***b* undergoes one complete revolution corresponding to a differential count of 100. Thus, the counter **240** may be designed such that the number wheel **243***c* and its associated contact element **246**, FIG. 17, will be indexed as indicated by the vertically oriented arrows extending from the contact element **246**, a distance equal to the spacing between the adjacent ten terminals **0–900** in the hundreds counting level for each complete revolution of the contact element **245**. Again, the particular terminal that will be contacted by the indexed contact element **246** will depend upon the direction of rotation of the contact element **245** and thus the direction of rotation of the winding motor M–2.

The three level counter **240**, FIG. 2, will provide a maximum count of 1000 under any conditions and the count that is registered at any instant by the counter **240** may be read through a window **247** from the numbers that appear on the indexed number wheels **243***a*, **243***b*, and **243***c*. As may be seen in FIG. 2, the counter **240** is shown registering a count of 518.

The resetting of the counter **240** may be effected by the operator turning the pulley **152**, FIG. 2, of the winding motor M–2. The rotation of the pulley **152** rotates the numbered wheels **243***a*, **143***b* and **243***c* and the associated contact elements **244**, **245** and **246**, respectively, FIG. 17, in the counter **240** to establish any desired initial count.

Because the internal gearing (not shown) that mechanically connects the rod **170** to the number wheel **243***a* and thus to the element **244** is assumed to provide a 2.5:1 gear reduction ratio therebetween, every complete revolution of the shaft **170** in one direction or the other will cause the counter **240** to add or subtract a count of four in the units counting level to or from the previous registered count. Since the rod **170** rotates one complete revolution for each complete revolution of the shaft **157**, one revolution of the shaft **157** will, therefore, produce a four count number differential in the registry of the counter **240**.

As mentioned previously, the shunt plate holder **178**, FIG. 4, will be rotated through one complete orbit of revolution with each complete revolution of the crank arm **167** and the shaft **157**. Accordingly, for every orbit of the plate holder **178**, a count differential of four will be registered by the counter **240**. For reasons that will be subsequently revealed, the plate holder **178** must be orbited by the rotation of the winding motor M–2 approximately 39.5 times to wind substantially 39 convolutions of wire W onto each coil form CF. The differential count that corresponds to 39.5 revolutions of the coil forms CF—CF will be four times 39.5 or 158. Since the counter **240** has a count capacity of 1000, a count of 510, which is approximately one-half this capacity, will be used as the optimum base count number to which the count of 158 is added or subtracted, depending upon the direction of rotation of the winding motor M–2. The manner in which the counter **240** functions in specific winding cycles will be discussed in greater detail subsequently.

The rod **170**, FIGS. 2 and 6, that is driven by the winding motor M–2 has a worm **250** keyed thereto, and the worm **250** is designed to mesh with and drive a worm gear **251** that is mounted at right angles to the axis of rotation of the worm **250** at typically a 20:1 ratio. The gear **251** is keyed to a shaft **252** having a spur gear **253**

keyed to the end thereof. The gear **253** meshes with a pair of spur gears **254** and **255**, which are in turn keyed to a pair of shafts **256** and **257**, respectively. The shaft **256** is mounted for rotation on a pair of upright bearing blocks **258—258** that are vertically mounted, FIG. 4, by machine screws **259—259** on the horizontal leg of an L-shaped bracket **261**. The bracket **261** may be formed integral with the table **11**, or may be affixed thereto. The shaft **257**, FIGS. 2 and 6, is also mounted for rotation by a pair of upright bearing blocks **262—262** that are also vertically mounted, FIG. 4, on the horizontal leg of the bracket **261** by the machine screws **259—259**. The shaft **257** has a cam **265** keyed thereto and rotatable therewith, and the shaft **256** also has a cam **266** keyed thereto and rotatable therewith. Thus, the cams **265** and **266** are drivable by the rotation of the winding motor **M-2**.

As best seen in FIG. 4, the cam **266** is larger than the cam **265**, but has a similar peripheral contour and both of the cams **265** and **266** are generally symmetrical with respect to the longitudinal axes of the rods **270** and **271**, respectively. The inner ends of a pair of cam follower rods **270** and **271** contact and lineally follow the peripheral contour of the cams **265** and **266**, respectively. The cam follower rods **270** and **271**, FIG. 6, are mounted for lineal movement in a pair of brackets **274** and **275**, respectively, which are affixed to the underside of the table **11** by machine screws **276** and **277**, respectively.

The outer ends of the cam follower rods **270** and **271**, FIG. 2, are received in a pair of parallel bores **280** and **281**, respectively. The bores **280** and **281** extend completely through one leg of an essentially L-shaped plate **285**, and have diameters that are slightly larger than the diameters of the cam follower rods **270** and **271**, respectively, so that the rods **270** and **271** are mounted for slidable movement in the bores **280** and **281**, respectively. The other leg of the plate **285** is received for slidable movement in a slot **286** that is formed in the table **11** parallel to the longitudinal axes of the cam follower rods **270** and **271**. A bore **288** also extends through the L-shaped plate **285**, and perpendicularly intersects the bores **280** and **281**, respectively. The bore **288** receives a rod **290** that has a handle **291** attached to one end thereof. The rod **290** is tightly received by the bore **288**, but may be manually turned about its longitudinal axis.

The rod **290** is also formed with a pair of bores **292** and **293** that are oriented perpendicularly with respect to one another and have diameters at least equal to the diameters of the bores **280** and **281**, respectively. With the rod **290** in a position as illustrated in FIG. 2, the bore **293** will be aligned with the bore **281**, and under this condition, the cam follower rod **270** may be driven axially through both of the coaligned bores **281** and **293** by the rotation of the cam **265**. However, since the bore **292** in the rod **290** will be at a right angle with respect to the bore **280**, the rod **290** will present a peripheral surface to the outer end of the cam follower rod **271**. The surface that is presented by the rod **290** to the outer end of the cam follower rod **271** will transmit the outward lineal movement of the follower rod **271** to the L-shaped plate **285**. Conversely, with the handle **291** turned so that the bore **292** is aligned with the bore **280**, the rod **290** will present a solid peripheral surface to the outer end of the cam follower rod **270**; and therefore, the outward lineal movement of the cam follower rod **270** produced by the rotation of the cam **265** will be transmitted to the plate **285**.

As may be seen in FIG. 4, the plate **285** is connected to the base **13** by a pair of studs **287—287** and thus the base **13** will move with the plate **285**. The rotation of the cams **265** and **266**, in either sense of rotational direction, through an initial 180° of angular rotation will drive the cam follower rods **270** and **271**, respectively, and thus the plate **285** outward, as viewed in FIG. 4. The coil springs **19** and **19***a* will be compressed by the outward movement of the base **13** that moves with the plate **285**. During the next 180° of angular rotation of the cams **265** and **266**, the expansion of the hitherto compressed coil springs **19** and **19***a* will drive the base **13** inward, as viewed in FIG. 4, under the control of one of the cam follower rods **270** or **271**. Since the base **13** will move the carriage **50** in the directions of the arrows A—A, and since the carriage **50** mounts the feed tubes **80***a*–**80***d* with the tips **100***a*–**100***d*, respectively, extending therefrom, the movement of the carriage **50** in the directions of the arrows A—A will cause the tips **100***a*–**100***d* of the feed tubes **80***a*–**80***d*, respectively, to traverse adjacent coil forms CF—CF and distribute the wires W issuing therefrom evenly onto these coil forms.

The particular cam follower rod **270** or **271**, FIG. 2, that controls the traverse of the carriage **50** will be the follower rod that abuts the periphery of the rod **290**. With the cams **265** and **266** in their initial positions as illustrated in FIGS. 4 and 6, the crank arm **167** will be in a bottom dead center position. The tips **100***a*–**100***d* of the feed tubes **80***a*–**80***d*, respectively, will then be in positions adjacent one side of the shunt plate **180** and at twelve o'clock positions relative to the coil forms CF—CF that extend from one side of the shunt plate **180**, as viewed in FIG. 4. The gear **255**, FIG. 2, may be designed such that the cam **265** will be rotated clockwise or counterclockwise through a prescribed number of revolutions, typically one revolution, upon 19.75 revolutions of the shaft **157**. The carriage **50** will then be reciprocated once by the follower rod **270** so that the tips **100***a*–**100***d*, FIG. 4, traverse and apply four layers of the wires W—W onto the orbiting coil forms CF—CF from initial positions where the tips **100***a*–**100***d* are adjacent the periphery of the coil forms CF—CF and the shunt plate **180** to substantially the same final positions after 39.5 coil form orbits.

Referring again to FIG. 2, with the handle **291** in the position as illustrated in this figure, the follower rod **271** will abut the peripheral surface of the rod **290** and reciprocate the plate **285**. The gear **254**, FIG. 2, may also be designed such that the cam **266** will be rotated clockwise or counterclockwise through typically one complete revolution upon 39.5 revolutions of the shaft **157**. The carriage **50** will then be reciprocated once by the follower rod **271** and move the tips **100***a*–**100***d*, FIG. 4, to traverse and lay two superimposed layers of the wires W evenly onto the orbiting coil forms CF—CF from initial positions where the tips **100***a*–**100***d* are adjacent the periphery of the coil forms CF—CF and the shunt plate **180** to substantially the same final positions after 39.5 coil form orbits. A pair of springs (not shown) may be incorporated in the plate **285** to contact the cam follower rods **270** and **271**, respectively, and urge the rods **270** and **271** against the cams **265** and **266**, respectively, in order to preclude the possibility of the rod **270** or **271** extending into the bore **293** or **292**, respectively, at the end of a winding operation thus locking the handle **291** against rotation. Alternatively, the operator may be provided with a rod (not shown) that may be inserted through the bores **280** and **281** to push the rod **270** or **271** back against the cam **265** or **266**, respectively, and thereby free the handle **291** for turning. Thus, the position of the handle **291** will determine the number of layers, two or four, that are applied to the coil forms CF—CF.

Although the tips **100***a*–**100***d*, FIG. 4, initially may be at twelve o'clock positions relative to the coil forms CF—CF that the tips **100***a*–**100***d* are indexed adjacent thereto, the fractional 39.5 clockwise or counterclockwise revolutions of the shunt plate **180** will cause the coil forms CF—CF to assume final twelve o'clock positions relative to the tips **100***a*–**100***d* since the last one-half of a revolution of the crank arm **167** will move the shunt plate 180 degrees to a final top dead center position. For reasons that will be discussed in greater detail subsequently, the carriage **50** is thereafter indexed in a horizontal plane to the right, as viewed in FIG. 4, until the tips **100***a*–**100***d* are in six o'clock positions relative to adjacent coil forms

CF—CF that are located to the immediate right, as viewed in FIG. 4, of the coil forms CF—CF that the tips **100***a*–**100***d* have hitherto guided the wires W—W thereto. The subsequent orbiting of the shunt plate **180** through 39.5 clockwise or counterclockwise revolutions will cause these latter coil forms CF—CF to reassume six o'clock positions relative to the tips **100***a*–**100***d*, as viewed in FIG. 4, or conversely, the tips **100***a*–**100***d* will be again at twelve o'clock positions relative to those coil forms CF—CF. At the termination of this latter winding cycle, the crank arm **167**, FIG. 4, will again be at a bottom dead center position. It will be evident that if the number of orbits of the shunt plate **180** is to be a wholly integer number, for example, 40 orbits, the shunt plate **180** will start its orbital movement from a bottom dead center position and finish at the same position.

FIG. 20 of the drawings illustrates one side of a typical square shunt plate **180** having an array of eight rows of eight coil forms CF—CF each extending from one side thereof. In order to facilitate an understanding of the principles of this invention, the dimensions of a typical eight-by-eight shunt plate **180** and the corresponding dimensions of related parts of the apparatus **10** will be hereinafter disclosed.

The coil forms which have hitherto been designated as CF will now and hereafter be more specifically designated and referred to as CF—CF**64**. The coil forms CF**1**–CF**64** are generally of circular or elliptical cross section and ordinarily have major radii of .22 inch. The coil forms CF**1**–CF**8**, CF**17**–CF**24**, CF**33**–CF**40** and CF**49**–CF**56**, that are shown with their centers in horizontal alignment by FIG. 20, respectively, form what may be regarded as "odd number" rows of coil forms. The horizontally aligned coil forms CF**9**–CF**16**, CF**25**–CF**32**, CF**41**–CF**48** and CF**57**–CF**64**, respectively, form what may be regarded as "even number" rows of coil forms.

In addition to the coil forms CF**1**–CF**64**, the illustrated shunt plate **180** also includes two sets of left and right column terminals as mentioned previously. The left set of column terminals typically comprises four vertically aligned terminals designated TRM**1**–TRM**4**, respectively, and the right set of column terminals typically comprises eight vertically aligned terminals designated TRM**5**–TRM**12**, respectively. The terminals TRM**5**–TRM**12** are attached to the shunt plate **180** and extend vertically through the plate **180** and hence, are generally known by those working the ferreed switching art as feed-through terminals. The terminals TRM**1**–TRM**4** typically extend vertically through the shunt plate **180** and the ends of the terminals TRM**1**–TRM**4** that extend from one side of the shunt plate **180** may be subsequently connected to the ends of the terminals TRM**1**–TRM**4** that extend from the opposite side of the shunt plate **180**.

The centers of the terminals TRM**1**–TRM**4** are in substantially horizontal alignment with the centers of the terminals TRM**5**, TRM**7**, TRM**9** and TRM**11**, respectively, and the vertical distances between the centers of the terminals TRM**1**–TRM**4** and the centers of the odd number rows of coil forms headed by the coil forms CF**1**, CF**17**, CF**33** and CF**49**, respectively, is typically .215 inch. The radii of all the terminals on the shunt plate **180** are typically less than .08 inch. The vertical distance between the centers of the terminals TRM**6**, TRM**8**, TRM**10** and TRM**12** and the centers of the coil forms CF**9**, CF**24**, CF**41** and CF**57**, respectively, and the centers of the remaining coil forms of the even number rows headed by these coil forms is also typically .215 inch.

The shunt plate **180** also includes an additional two sets of row terminals, the four terminals of one set being designated TRM**1***a*–TRM**4***a*, respectively, and the eight terminals of the other set being designated as TRM**5***a*–TRM**12***a*, respectively. When the shunt plate **180** is turned 180° about its horizontal axis and then turned 90° clockwise about its vertical axis, the shunt plate will assume the position illustrated by FIG. 21. It may be seen that the terminals TRM**1***a*–TRM**4***a* that previously formed a row of terminals now form a column of terminals and the terminals TRM**1***a*–TRM**4***a* assume substantially the same respective positions relative to the coil forms CF**1**, CF**17**, CF**33** and CF**49** as previously assumed, FIG. 20, by the column terminals TRM**1**–TRM**4**. Similarly, and as may be seen in FIG. 21, the terminals TRM**5***a*–TRM**12***a* which previously formed a row of terminals will now form a column of terminals having the same respective positions relative to the coil forms CF**8**, CF**9**, CF**24**, CF**25**, CF**40**, CF**41**, CF**56** and CF**57** as previously assumed, FIG. 20, by the terminals TRM**5**–TRM**12**.

The horizontal distances between the terminals TRM**1**–TRM**4** and their horizontally adjacent coil forms CF**1**, CF**17**, CF**33** and CF**49**, respectively, and the horizontal distances between the centers of the terminals TRM**5**–TRM**12** and the centers of horizontally adjacent coil forms CF**8**, CF**9**, CF**24**, CF**25**, CF**40**, CF**41**, CF**56** and CF**57**, respectively, are typically equal to one-half of an inch. The horizontal spacings between the centers of the coil forms CF**4** and CF**5** and the remaining coil forms in the fourth and fifth columns that are headed by the coil forms CF**4** and CF**5** are typically equal to one inch. The vertical spacings between the centers of the fourth and fifth horizontal rows of coil forms CF**25**–CF**32** and CF**33**–CF**40**, respectively, are also typically equal to one inch.

The horizontal spacing between the centers of the consecutively numbered coil forms CF**5**–CF**8** is equal to the horizontal spacing between the centers of consecutively numbered coil forms CF**1**–CF**4** and each spacing is typically seven-tenths of an inch.

With reference to FIG. 1, the horizontal spacing between the centers of the holes **26***a* and **26***b* in the rod **24** preferably is greater than the horizontal distance between the centers of the terminals TRM**1**–TRM**4** and the centers of their respective horizontally adjacent coil forms CF**1**, CF**17**, CF**33** and CF**49**, respectively, and may be equal to the seven-tenths of an inch spacing between the consecutively numbered coil forms CF**1**–CF**4** or CF**5**–CF**8**. The horizontal spacing between the centers of the holes **26***i* and **26***j* is equal to the horizontal spacing between the left column of terminals TRM**5**–TRM**12***a* and the adjacent column of coil forms headed by the coil form CF**8** and is, therefore, equal to one-half of an inch.

The horizontal distances between the centers of consecutively lettered holes **26***b*–**26***e* correspond to the distances between consecutively numbered coil forms CF**1**–CF**4**, FIG. 20, and is, therefore, equal to seven-tenths of an inch. The horizontal distance between the centers of the holes **26***e* and **26***f*, FIG. 1, corresponds to the horizontal distance between the centers of the coil forms CF**4** and CF**5** and is, therefore, typically equal to one inch. The horizontal distances between the centers of consecutively lettered holes **26***f*–**26***i* correspond to the horizontal distances between the centers of consecutively numbered coil forms CF**5**–CF**8**, respectively, and these distances are therefore seven-tenths of an inch.

The horizontal spacing between each two consecutively lettered notches **25***a*–**25***h* is equal to the corresponding spacing between each two consecutively lettered holes **26***b*–**26***i*, respectively, as disclosed previously.

The feed tube tips **100***a*–**100***d*, FIGS. 7 and 14, are mounted in the vertical leg **51** of the carriage **50** such that the tips **100***a*–**100***d* may be horizontally indexed, as indicated by the phantom lines in FIG. 20, from initial positions, designated as START to the right to successive twelve or six o'clock positions, for reasons discussed previously, relative to each coil form of the odd number coil form rows. The eight horizontal phantom lines are therefore typically .215 inch above the centers of the eight adjacent horizontal rows of coil forms. The radius of each tube tip **100***a*–**100***d* is typically less than .050 inch

and the radius of revolution of each feed tube tip **100***a*–**100***d* is typically .135 inch. The loci of the axes of the revolution of the feed tube tips **100***a*–**100***d* will be essentially parallel to the phantom lines of FIG. 20 but will be displaced .135 inch below these phantom lines. The feed tube tips **100***a*–**100***d* are preferably indexed from positions of near contact with the wire on the wound coil forms to positions of lesser closeness with successive unwound coil forms.

In order to preclude the possibility of the wire that builds up on the orbiting coil form during a winding cycle contacting and rubbing against feed tube tips **100***a*–**100***d* the radius of revolution of the crank arm **168**, FIG. 4, and the shunt plate holder **178** should at least be equal to the overall radius of a fully wound coil form CF**1**–CF**64**, FIG. 20, and the radius of an adjacent wire supplying feed tube tip **100***a*–**100***d*. Assuming that the radii of the feed tube tips **100***a*–**100***d* are equal to or less than .050 inch and that a maximum of four superimposed layers of 25-gauge copper wire may be wound onto these coil forms which will increase the overall radii of the wound coils to substantially .300 inch; the radius of revolution of the crank arm **168** and the plate holder **178** should be at least equal to .350 inch, and is typically .354 inch. At least a .004 inch clearance is thus typically provided between the fully wound coil forms and the wire-issuing tube tips **100***a*–**100***d*.

Brief description of a winding operation

In initiating a winding operation, the feed tubes **80***a*–**80***d*, FIG. 20, are located seven-tenths of an inch to the left of CF**1**, CF**17**, CF**33** and CF**49** at approximately eleven o'clock positions relative to the terminals TRM**1**–TRM**4**. The shunt plate **180** is caused to rotate two revolutions counterclockwise about the aforementioned terminals to wind approximately two turns of wire onto each of these terminals. The tips are then indexed to the right to twelve o'clock positions above the coil forms CF**1**, CF**17**, CF**33** and CF**49**. After winding each consecutive coil form, the feed tubes are indexed to the right to the next column of coil forms CF**2**, CF**18**, CF**34** and CF**50**.

As indicated by the phantom lines in FIG. 20, the indexing of the tips **100***a*–**100***d* continues until the tips **100***a*–**100***d* are indexed to substantially twelve o'clock positions relative to the terminals TRM**5**, TRM**7**, TRM**9** and TRM**11**, respectively. The tips **100***a*–**100***d* are then rotated one and one-quarter revolutions clockwise, as viewed in this figure, about axes of revolution that are substantially concentric with the centers of the terminals TRM**5**, TRM**7**, TRM**9** and TRM**11**, respectively. Since the closest distance between the outermost surface of the wound coil forms CF**8**, CF**24**, CF**49** and CF**56** and adjacent surfaces of the terminals TRM**5**, TRM**7**, TRM**9** and TRM**11** is substantially .21 inch, the .135 inch radius of revolution of the tips **100***a*–**100***d* will permit the tips **100***a*–**100***d* to rotate around the terminals TRM**5**, TRM**7**, TRM**9** and TRM**11** without striking the wound coil forms CF**8**, CF**24**, CF**40** and CF**56**.

After the terminals TRM**5**, TRM**7**, TRM**9** and TRM**11** are wound with wire, the tips **100***a*–**100***d* are moved vertically downward to approximately three o'clock positions relative to the terminals TRM**6**, TRM**8**, TRM**10** and TRM**12**, respectively. The tips **100***a*–**100***d* are then rotated counterclockwise one and one-quarter revolutions about axes of revolution that are concentric with the centers of the terminals TRM**6**, TRM**8**, TRM**10** and TRM**12**, respectively, and reassume twelve o'clock positions relative to these terminals, again missing the coil forms CF**9**, CF**24**, CF**41** and CF**57** in the process.

Thereafter, the tips **100***a*–**100***d* are indexed horizontally to the left, as indicated by the phantom lines in FIG. 20, stopping each time the tips are indexed to twelve or six o'clock positions relative to each of the coil forms of the even number rows. The tips **100***a*–**100***d* proceed to index from right to left until the tips are again seven-tenths of an inch to the left of the centers of the coil forms CF**16**, CF**32**, CF**48** and CF**64**. The tips **100***a*–**100***d* are then moved vertically upward and back to their initial eleven o'clock positions relative to the terminals TRM**1**–TRM**4**, respectively.

After the tips **100***a*–**100***d* reassume substantially eleven o'clock positions relative to the terminals TRM**1**–TRM**4**, respectively, the plate **180** is rotated two revolutions clockwise about these terminals and one winding operation is then finished. However, to condition the apparatus **10** for the winding wire onto the terminals and coil forms extending from the reverse side of the shunt plate **180**, as illustrated by FIG. 21, the tips **100***a*–**100***d* are finally moved vertically downward to positions designated FINISH.

It is important to note that the relatively close spacing of .21 inch between the wound coil forms of the column headed by the coil form CF**8** and the adjacent column of terminals TRM**5**–TRM**12** would preclude the orbiting of the shunt plate **180** as a possible alternative for winding the wire onto the terminals TRM**5**–TRM**12** since, as related above, the orbital radius of the shunt plate **180** should be at least .354 inch to insure that the coil forms will not strike the tips **100***a*–**100***d* during a coil form winding cycle. This problem is not encountered in winding the terminals TRM**1**–TRM**4**, however, since these terminals are spaced far enough from the coil forms CF**1**, CF**17**, CF**33** and CF**49** to permit unimpeded .354 inch orbital displacement of these coil forms.

A complete and detailed winding operation for winding wires onto both sides of the eight-by-eight ferreed switching array illustrated by FIGS. 20 and 21 will be subsequently described.

FIGS. 16 and 17 schematically illustrate the electrical circuitry and the components, including the relays, solenoids and motors, as well as the switches and contacts associated therewith, that are utilized to effect the operation of the apparatus **10** for winding 39 turns of wire onto coil forms CF**1**–CF**64**, FIG. 20, and a considerably lesser number of turns onto the terminals TRM**1**–TRM**12** and TRM**1***a*–TRM**12***a*.

In order to expedite the process of locating the various components on the drawings and the switches and contacts associated therewith, each component and each contact is located either horizontally opposite or midway between one of the vertically spaced lines numbered **1**–**30**, on FIG. 16, and numbered **31**–**58**, on FIG. 17. In referring to the location of various components, switches and contacts, the number of the line or of the point midway between adjacent lines that corresponds to the horizontal location of a particular component, switch or contact will be set forth in a parentheses which immediately follows the letter and number designation of that component, switch or contact. In addition, the contacts will be denoted by the letter "K." For example, a control relay CR–**15** appearing horizontally opposite the line **33** in FIG. 17 has contacts KCR–**15** controlled thereby that appear horizontally opposite the line **26** in FIG. 16. The control relay CR–**15** will therefore be described as the control relay CR–**15**(**33**), and the contacts controlled thereby will be described as the contacts KCR–**15**(**26**).

Referring to FIG. 16, an A.C. source V(**1**) supplies the required electrical power to the various circuit components shown in FIGS. 16 and 17. A switch START(**1**) is series-connected to the source V(**1**) and may be manually closed to apply the voltage of the source V(**1**) to the lead L**1**. The lead L2 to which the operative components are connected provides a common connection to the grounded terminal of the source V(**1**).

A control relay CR–**1**(**2**) has normally open contacts KCR–**1**(**6**) and KCR–**1**(**19**) and normally closed contacts KCR–**1**(**24**). The limit switch LS–**3**(**3.5**) embodies normally open contacts K**3**(**3**), K**3***a*(**3**) and normally

closed contacts K3(3), K3*b*(4). A lead L3 has one terminal thereof connected to the contact K3(3). When the carriage **50** abuts and depresses the contact button **48** of the right limit switch LS–3, FIG. 1, the normally closed contacts K3(3), K3*b*(4), FIG. 16, are opened and the normally open contacts K3(3), K3*a*(3) are closed. Thus, when the carriage **50** reaches the limit of indexing movement to the right, as viewed in FIG. 1, the contacts K3(3), K3*a*(3) will be bridged to complete a circuit from the control relay CR–1(2) to the lead L3.

A pushbutton switch RESET(7) has normally closed contacts KR(7) and normally open contacts KR(10). The switch RESET(7) may be manually depressed by the operator to open the contacts KR(7) and close the contacts KR(10). For reasons that will be subsequently evident, the switch RESET(7) is ordinarily depressed in the event that the carriage **50**, FIG. 1, does not appear to be in the correct starting position.

A time delay relay CR–1(3), of conventional type, has normally closed contacts KDR–1(4) in the circuit of a control relay CR–2(4), the contacts KDR–1(4) being located between the relay CR–2(4) and the common connection that the relays CR–2(4) and DR–1(3) have with a lead L4. Both of the relays DR–1(3) and CR–2(4) are normally in a deenergized state by reason of their common connection to the normally open lead L4. When the time delay relay DR–1(3) is energized by connecting the lead L4 to the lead L1 through normally closed contacts KR(7), the normally closed contacts KDR–1(4) remain closed for a predetermined period of time as prescribed by the time delay characteristics of the relay DR–1(3), and then open and remain open until the relays DR–1(3) are deenergized. The control relay CR–2(4) which is under the time delay control of the relay DR–1(3) by virtue of the time delayed contacts KDR–1(4), controls the states of normally open contacts KCR–2(23), KCR–2(25) and KCR–2(52) and normally closed contacts KCR–2(37), and reverses the respective states of these contacts each time the relay CR–2(4) is energized and deenergized. A pushbutton switch WIND(5) closes normally open contacts KW(5) and opens the normally closed contacts KW(9), for a relatively short period of time, when manually depressed by the operator. The switch WIND(5) is depressed to initiate the start of a winding operation.

The limit switch LS–2(7) embodies the normally closed contacts K2(7) and the normally open contacts K2*a*(6.5). With the actuator rod **45** of the limit switch LS–2(7) in one of the notches **25***a*–**25***h* in the rod **24**, the contacts K2(7) are closed and a connection is made between the leads L4 and L5. If the rod **45** is driven out of one of the notches **25***a*–**25***h* and upward by the movement of the rod **24** to the right, as viewed in FIG. 1, the contacts K2*a*(6.5) are closed to bridge a connection between the leads L3 and L5.

The lead L3 is connected to an armature lead LA through normally open contacts KCR–7(12). The armature lead LA is connected to one terminal (not shown) of the internal windings of the reversible indexing motor M–1(11.5), through normally closed contacts KCR–4(12) and normally open contacts KCR–5(12). A second terminal (not shown) of the internal armature windings of the motor M–1(11.5) is connected to an armature lead LA1, and the lead LA1 is connected to the contact K3*b* through normally closed contacts KCR–3(11) and KCR–7(11) upon the closure of normally open contacts KCR–5(11). The third terminal (not shown) of the internal windings of the motor M–1(11.5) is connected to a lead LGD to the grounded lead L2.

The armature windings of the motor M–1 are wound such that when the motor M–1 is energized by the closure of the contacts KCR–4(12), KCR–5(12) and KCR–3(11), the motor M–1(11.5) will rotate in one direction. With the limit switch LS–3(3.5) in the position illustrated in FIG. 16, and with the contacts KCR–3(11), KCR–5(11) and KCR–7(11) closed, current supplied to the lead L3 will cause the motor M–1(11.5) to rotate in a reverse direction.

Control relay CR–3(1) controls normally open contacts KCR–3(9), KCR–3(11) and KCR–3(18) and normally closed contacts KCR–3(11). The control relay CR–3(10) is normally maintained deenergized by the normally open contacts KR(10) of the switch RESET(7).

When the control relay CR–3(10) is energized by the closure of the contacts KR(10), the contacts KCR–3(9) will close to lock the relay CR–3(10) in the operative state. Since the operation of the control relay CR–3(10) is at least partially governed by the previous closure of the contacts KR(10), the prior operation of the RESET (7) switch will provide at least one condition to the operation of the control relay CR–3(10).

Control relay CR–4(13) controls normally open contacts KCR–4(5) and normally closed contacts KCR–4 (12) and KCR–4(25). The operation of the relay CR–4(13) is under the control of the limit switch LS–4(13) having contacts K4(13). When the carriage **50** is driven to the left limit of indexing movement, FIG. 1, and depresses the contact button **67** of the left limit switch LS–4(13), the normally open contacts K4(13) of the switch LS–4(13) are closed, FIG. 16, to effect the energization of the relay CR–4(13). The release of the contact button **67** by the indexing of the carriage **50** to the right, FIG. 1, reopens the contacts K4(13) of the limit switch LS–4(13), FIG. 16, to effect the denergization of the relay CR–4(13).

A control relay CR–5(14) controls normally open contacts KCR–5(11) and KCR–5(12), and normally closed contacts KCR-5(23). The relay CR–5(14) in turn is under the control of the limit switch LS–1(14) having contacts K1(14). The contacts K1(14) are open when the shot pin SP–1, FIGS. 10 and 15, is in one of the holes **26***a*–**26***j* in the rod **24**; and the contacts K1(14), FIG. 16, are closed when the shot pin SP–1 is retracted from one of the holes **26***a*–**26***j*. Thus, when the shot pin SP–1 is in a hole in the rod **24**, the control relay CR–5(14) will be deenergized; and when the shot pin SP–1 is retracted from the rod **24**, the control relay CR–5(14) will be energized.

A ratchet relay RR(15) controls normally open contacts KRR(27), KRR(31) and normally closed contacts KRR(29), respectively. The ratchet relay RR(15) is of conventional type characterized in that when the coil of the relay is deenergized, the operating arm does not return the relay contacts to their normal respective states. The ratchet relay RR(15) is maintained normally deenergized by the normally open contacts KCR–6(15) and the normally open switch T2–7(16).

A control relay CR–6(17) controls normally open contacts KCR–6(10), KCR–6(15) and KCR-6(51), and in turn is under the control of normally closed contacts KDR–2(17). The control relay CR–6(17) is normally maintained deenergized by the normally open contacts KCR–16(17), KCR–3(18) and T1–8(19), and by a normally open lead L8. The operation of the normally closed contacts KDR–2(17) are controlled by a conventional time delay relay DR–2(18) which is also normally deenergized. When the time delay relay DR–2(18) is initially energized by, for instance, the closure of the contacts KCR–3(18), the relay DR–2(18) operates to hold the contacts KDR–2(17) closed for a predetermined period of time as determined by the time delay characteristics of the relay DR–2(18). The relay DR-2(18) then operates to open the contacts KDR–2(17) and effect the deenergization of the control relay CR–6(17). The contacts KDR–2(17) remain open until the relay DR–2(18) is deenergized.

The time delay relay DR–2(18) may be the same type of time delay relay as the aforedescribed relay DR–1(3), but whereas the time delay relay DR–1(3) is typically designed to provide a time delay of, for instance, one-

fourth of a second, the time delay relay DR–2(18) is typically designed to provide a longer time delay of, for instance, three seconds.

A timing motor T1(19) is utilized to effect the winding of terminals TRM5–TRM12 and TRM5*a*–TRM12*a*, FIG. 20, with the wires W—W. The timing motor T1(19) controls the closing of normally open switches T1–1(18), T1–8(19), T1–2(20), T1–3(52), T1–4(55), T1-5(56), T1–6(57) and T1–7(58) in predetermined sequences and for predetermined periods of time as illustrated by the Timing Chart 1 of FIG. 18. The timing motor T1(19) typically includes a motor-driven shaft (not shown) that mounts in tandem eight cams or commutators (not shown) that rotate with the shaft at a constant velocity when the motor is energized to selectively close each of the normally open switches T1–1(18)–T1–8(19), inclusive, in a prescribed sequence and for predetermined time intervals. The timing motor T1(19) is normally rendered deenergized by the normally open switches T1–1(18) and KCR–1(19).

A control relay CR–7(20) controls normally closed contacts KCR–7(11) and normally open contacts KCR-7(12), KCR–7(21), and KCR–7(22). The contacts KCR–7(22) are connected to one side of the contacts K4(13) of the limit switch LS–4(13) by a lead L7. The control relay CR–7(20) is normally maintained deenergized by the normally open contacts T1–2(20) and the normally open contacts KCR–7(21). A control relay CR–8(21) is connected across both of the terminals of the control relay CR–7(20) and is therefore energized and deenergized when the control relay CR–7(20) is respectively energized and deenergized. The control relay CR–8(21) controls normally closed contacts KCR–8(27) and KCR–8(29) and normally open contacts KCR–8(28) and KCR–8(30).

A timing motor T2(22) is utilized to effect the winding of the wires W—W, FIG. 20, onto the terminals TRM1–TRM4. The timing motor T2(22), which may be of the same type as the aforedescribed timing motor T1(19), is designed to rotate, when energized, to selectively close normally open switches T2–1(23), T2–3(53), T2–4(54), T2–5(8), T2–6(35), T2–7(16), and T2–8(51.5) for predetermined time intervals and in a predetermined sequence as illustrated by the Timing Chart 2 of FIG. 19. The timing motor T2–(22) is also operable upon the energization thereof to open normally closed switches T2–2(21) and T2–8(51) for predetermined time intervals and in predetermined sequences as also illustrated by the Timing Chart 2. It is noted that the switching control of the two switches T2–8(51) and T2–8(51.5) is simultaneous and follows the timing cycle as shown in Timing Chart 2 of FIG. 19 for the "SW" designation T2–8. Hence, switch T2–8(51) is open and switch T2–8(51.5) is closed from fifteen percent to seventy percent of the T–2 cycle as indicated in FIG. 19. The motor T2(22) is normally maintained deenergized by the open circuit established by the normally open contacts KCR–7(22) and by the normally open contacts T2–1(23).

A normally deenergized control relay CR–9(24) controls normally open contacts KCR–9(24) and KCR–9(44) and normally closed contacts KCR–9(42). Closure of the normally open contacts KCR–9(24) locks the control relay CR–9(24) in an operative state when the contacts KCR-1(24) and KCR–16(24) are closed. For reasons which will become apparent subsequently, the operation of the relay CR–9(24) controls the starting and stopping of the winding motor M–2(45).

A normally deenergized winding speed control relay CR–10(25) controls the speed of the winding motor M–2(45) through normally open contacts KCR–10(26) and KCR–10(49) and normally closed contacts KCR–10(37) and KCR–10(48). With the contacts KCR–4(25) and KCR–15(26) closed, the closure of the contacts KCR–10(26) locks the control relay CR–10(25) in an operative state which reverses the state of the contacts KCR–10(48) and KCR–10(49) from that depicted by the drawing to initiate a fast winding cycle of the winding motor M–2(45).

A control relay CR–11(27) controls normally open contacts KCR–11(35), KCR–11(36), KCR–11(36.5) and KCR–11(37) and normally closed contacts KCR–11(38). The relay CR–11(27) is normally maintained deenergized by the normally open contacts KRR(27) and KCR–8(28).

The normally open contacts KCR–11(36) in the hundreds counting level of the counter 240 have one side thereof connected to a terminal numbered 600 and the other side of the contacts KCR–11(36) is connected to the lead LCT2. The terminal numbered 600 is contacted by the contact element 246 when the contact element 246 is moved by the rotation thereof to a position opposite the terminal 600, as mentioned previously, so that when the contacts KCR–11(36) in the hundreds counting level close and the contact element 246 is moved to contact the terminal 600, an electrical path is completed between the lead L1 and the lead LCT2.

The normally open contacts KCR–11(35) in the tens counting level of the counter 240 have one side thereof connected to the terminal numbered 50 and to the terminal numbered 60, by a lead LXL1 and the other side of the contacts KCR–11(35) is connected to the lead LCT1. With the contacts KCR–11(35) in the tens counting level closed and with the contact element 245 moved to contact either the terminal 50 or the terminal 60, an electrical path is completed between the lead LCT1 and LCT2 through the now-closed contacts KCR–11(35).

The normally open contacts KCR–11(37) in the units counting level of the counter 240 have one side thereof connected to a terminal numbered 9, and the other side of the contacts KCR–11(37) is connected to a lead L10 and, hence, to the terminal side of the control relay CR–15(33). With the contact element 244 moved to contact the terminal 9, the closure of the contacts KCR–11(37) will complete a circuit from the lead LCT1 to the lead L2 through the lead L10 and the control relay CR–15(33). The counter number which corresponds to the conditioning of the relay CR–15(33) for operation by the closure of the contacts KCR's–11(35, 36, 37) by the prior operation of the control relay CR–11(27) will be the sum of the numbers of the individual terminals that have to be contacted by the contact elements 244, 245 and 246 to complete the required circuit path through those contacts between the leads L1 and L2 and the relay CR–15(33). This count number will therefore be equal to the sum of the terminal numbers 600, 50 and 9 involved, or a sum of 659. Accordingly, when a count of 659 is registered by the counter 240, the control relay CR–15(33) will be energized.

The normally open contacts KCR–11(36.5) in the units counting level of the counter 240 have one side thereof connected to a terminal numbered 8 in that counting level, and the other side of the KCR–11(36.5) is connected through the normally closed contacts KCR–2(37) and KCR–10(37) to the numbered terminal side of the control relay CR–16(37). If the contacts KCR–11(36.5) are closed and, assuming that the contacts KCR–2(37) and KCR–10(37) are also closed, when the element 244 is moved to contact the terminal numbered 8 in the units counting level, a complete electrical path will be established between the leads LTC1 and the lead L2 through the control relay CR–16(37), the count number that corresponds to the energization of the control relay CR–16(37) by the closure of the contacts KCR's–11(35, 36, 36.5) by the prior operation of the control relay CR–11(27) will also be the sum of the numbers of the individual terminals that have to be contacted by the contact elements 244, 245 and 246 to complete a circuit through these contacts between the leads L1 and L2 and the relay CR–16(37). In this case, the count number is equal to the sum of the numbers 600, 60 and 8, or 668;

and, accordingly, when the counter 240 registers a count of 668, the control relay CR–16(37) will be energized.

In a typical winding cycle, the count of 659 is approached from a lower count of 510 by the rotation in one direction of the winding motor M–2(45). After the contacts KCR's–11(35, 36, 36.5, 37, 38) are operated by the operation of the control relay CR–11(27) to reverse their respective states from those shown by the FIG. 17, it appears that the contact elements 244, 245 and 246 would reach a count of 658 due to the closure of the contacts KCR's–11(35, 36, 36.5) before reaching a count of 659, and thereby effects the energization of the control relay CR–16(37) at a count of 658 rather than at the desired count of 668. In order to preclude the energization of the control relay CR–16(37) at the lower count and prior to the energization of the control relay CR–15(33), the control relay CR–10(25) is energized to open the contacts KCR–10(37) before the counter reaches a count of 658 so that the circuit between the terminal numbered 8 and the control relay CR–16(37) will be open at the count of 658. Thus, the contact element 244 will move from the terminal numbered 8 to the terminal numbered 9 and complete the energization of the control relay CR–15(33) at a count of 659. After the control relay CR–15(33) is energized at the count of 659, the control relay CR–10(25) is deenergized to close the contacts KCR–10(37) and thereby conditions the control relay CR–16(37) for energization at a count of 668. It may be noted that there is a nine count interval between the energization of the control relay CR–15(33) and the subsequent energization of the control relay CR–16(37).

The control relay CR–12(28) has normally open contacts KCR–12(32.5), KCR–12(33), KCR–12(35) and KCR–12(38) and is normally maintained deenergized by the normally open contacts KCR–8(28) and KRR(29). The normally open contacts KCR–12(35) have one side thereof connected to the terminal numbered 500 in the hundreds counting level of the counter 240 and the other side of the contacts KCR–12(35) are connected tot he lead LCT2. The contacts KCR–12(33) in the tens counting level of the counter 240 have one side thereof connected in common to both of the terminals numbered 0 and 10 and the other side of the contacts KCR–12(33) is connected to the lead LCT1. The contacts KCR–12(38) in the units counting level have one side thereof connected to the lead L10 and the other side thereof connected to the lead LXL2 and to the lead L11 as well.

The lead LXL2 is connected to the terminal numbered 9 in the units counting levels and the lead L11 is connected to the terminal numbered 1 in that counting level between the terminal 1 and an adjacent side of normally open contacts KCR–13(33). The lead L10 is connected between the other side of the contacts KCR–13(33) and the numbered terminal side of the relay CR–15(33).

Upon the closure of the contacts KCR–12(38) by the operation of the control relay CR–12(28), one potential circuit path is completed from the terminal numbered 9 to the leads LXL2 and L10 and through the control relay CR–15(33) to the lead L2. Another circuit path is provided through the units counting level by the closure of the contacts KCR–12(38), assuming that the contacts KCR–11(38) and KCR–13(38) are concurrently closed, from the terminal numbered 1 to the lead L11, to the lead L10 and through the control relay CR–15(33) to the lead L2. In this case, a complete circuit path from the terminal numbered 1 through the leads L10 and L11 and around the normally open contacts KCR–13(33) to the control relay CR–15(33) is provided.

The closure of the contacts KCR–12(35) in the hundreds counting level, the closure of the contacts KCR–12(33) in the tens counting level and the closure of the contacts KCR–12(38) in the units counting level of the counter 240 by operation of the control relay CR–12(28) will condition the control relay CR–15(33) for energization. When the respective contact element 246, 245 and 244 are moved to positions of contact with the terminals numbered 500, 0 and 1, respectively, associated with the contacts KCR's–12(33, 35, 38), in the hundreds, tens and units counting levels, respectively, the control relay CR–15(33) will be energized. Therefore, when the counter 240 registers the count of 501, the control relay CR–15(33) will be operated. In addition, the closure of the contacts KCR's–12(33, 35, 38) also conditions the control relay CR–15(33) for operation at a count of 519 when the contact elements 246, 245 and 244 are respectively moved to positions of contact with the terminals numbered 500, 10 and 9 in the hundreds, tens and units counting levels, respectively.

The contacts KCR–12(32.5) in the units counting level of the counter 240 have one side thereof connected to the terminal numbered 0 and the other side of the contacts KCR–12(32.5) is connected to the lead L2 through the normally closed contacts KCR–10(37) and KCR–2(37) and through the control relay CR–16(37). The closure of the contacts KCR–12(35), KCR–12(33) and KCR–12(32.5) by operation of the control relay CR–12(28) conditions the control relay CR–16(37) for energization at a count of 510. Therefore, when the counter 240 registers a count of 510 corresponding to the sum of the numbers of the individual terminals 500, 10 and 0, respectively, which have to be contacted to complete the described circuit path to the relay CR–16(37) and assuming that the contacts KCR–7(37) and KCR–2(37) are closed, the control relay CR–16 will be energized.

The closure of the contacts KCR–12(35) and KCR–12(33) in the hundreds and tens counting level, respectively, also conditions the control relay CR–16(37) for energization, when the switch T2–6(35) in the units counting level is closed, assuming that the contacts KCR–10(37) and KCR–2(37) are also closed. The count number corresponding to this pattern of closed contacts totals 518, as will be evident. The operation of the timing motor T2(22) provides the concurrent closure of the switch T2–6 and the contacts KCR's–12(33, 35) to effect the energization of the control relay CR–16(37) when the counter registers a count of 518, for reasons that will become evident subsequently.

Control relay CR–13(30) has normally open contacts KCR–13(33), KCR–13(33.5) and KCR–13(35.5) and normally closed contacts KCR–13(38). The control relay CR–13(30) is normally maintained deenergized by the normally open contacts KCR–8(30).

The contacts KCR–13(35.5) of the control relay CR–13(30) in the tens counting level of the counter 240 have one side thereof connected in common to the terminal numbered 50 in the tens counting level and to the terminal numbered in that level by the lead LXL1. The other side of the contacts KCR–13(35.5) is connected to the lead LCT1. When contacts KCR–13(35.5) close, a circuit path between the terminals numbered 50 and 60, respectively, in the tens counting level and the lead LCT1 is completed.

The contacts KCR–13(33) in the units counting level of the counter 240 have one side thereof connected to the terminal numbered 1 in the units counting level and the other side of the contacts KCR–13(33) is connected to the numbered terminal side of the control relay CR–15(33). The closure of the contacts KCR–13(33) provides a complete circuit path between the terminal numbered 1 in the units counting level and the control relay CR–15(33). The contacts KCR–13(33.5) are also in the units counting level and have one side thereof connected to the terminal numbered 2 in the units counting level. The other side of the contacts KCR–13(33.5) is connected through the normally closed contacts KCR–10(37) and KCR–2(37) to the numbered terminal side of the control relay CR–16(37).

The contacts KCR–13(33) and KCR–13(33.5) are closed by operation of the control relay CR–13(30) as

the counter 240 counts downward from a count of 510. The closure of the contacts KCR–13(33) and KCR–13(35.5) and the direct connection between the terminal numbered 300 in the hundreds counting level of the counter 240 combine to condition the control relay CR–15(33) for operation at a count of 361. Thus, when the contact elements 246, 245 and 244 move to contact the terminals numbered 300, 60 and 1, respectively, the control relay CR–15 will be energized. It would again appear that since the counter 240 is counting down from an initial count of 510 to a lower count of 361 and since the contacts KCR–13(33.5) would also be closed by operation of the control relay CR–13(30), that the control relay CR–16(37) would be energized prior to the energization of the control relay CR–15(33).

However, and as mentioned above, the control relay CR–10(25) is operated to open the contacts KCR–10(37) prior to the operation of the control relay CR–15(33).

Further downward counting of the counter 240 will move the contact elements 245 and 244 into contact with the terminals numbered 50 and 2 in the tens and units counting level, respectively. Since the control relay CR–10(25) is energized when the control relay CR–15(33) is energized, the contacts KCR–10(37) will have been closed and the circuit path from the lead L1 through the terminals numbered 300, 50 and 2, respectively, through the now closed contacts KCR–10(37) and closed contacts KCR–2(37) through the control relay CR–16(37) to the lead L2 will be completed and the control relay CR–16(37) will be energized at a count of 352.

To summarize briefly, the control relays CR–15(33) and CR–16(37) will be successively energized when the counter 240 also registers counts of 361 and 352, respectively, and it may be again noted that there is a 9 count difference between the counts 361 and 352.

A complete description of the role that the contacts of the control relays CR–2(4), CR–10(25), CR–11(27), CR–12(28) and CR–13(30) play in a typical 39 turns winding operation will be temporarily deferred.

The control relay CR–14(31) controls normally open contacts KCR–14(45) and KCR–14(49) and normally closed contacts KCR–14(46) and KCR–14(47). The contacts of the control relay CR–14(31) are in the armature winding circuit of the reversible winding motor M–2(45) and are selectively opened and closed to reverse the polarity of voltages impressed across armature leads LA2 and LA2*a* which are connected to the internal terminals of the armature windings of the motor M–2. The relay CR–14(31) will be energized or deenergized depending upon the state of the ratchet relay RR(15) which has contacts KRR(31) in the relay CR–14(31) circuit. The relay CR–14(31) is normally maintained deenergized by the open contacts KRR(31). An incandescent lamp, designated TL(31) may be connected across the terminals of the control relay CR–14(31) to monitor the state of the relay CR–14(31). The lamp TL(31) will illuminate only during the period when the relay CR–14(31) is energized by the closure of the ratchet relay contacts KRR(31).

The control relay CR–15(33) control a pair of normally closed contacts KCR–15(26) in the locking circuit of the control delay CR–10(25) and is conditioned for energization by the closing of certain of the contacts in the counting circuit that are under the control of the control relays CR–10(25), CR–11(27), CR–12(28) and CR–13(30), as discussed above. As discussed previously, the control relay CR–15(33) will be energized when the counter 240 registers counts of 361, 501, 519 and 659, respectively. The operation of the control relay CR–15(33) at the counts of 361, 501, 519 and 659, respectively, initiate a slow driving of the winding motor M–2(45) by opening the contacts KCR–15(26) in the locking circuit of the control relay CR–10(25) to effect the deenergization of the relay CR–10(25).

The normally deenergized control relay CR–16(37) has normally open contacts KCR–16(17) and normally closed contacts KCR–16(24). The contacts KCR–16(17) are in a locking circuit with the control relay CR–16(37) and when the contacts KCR–16(17) are closed by the operation of the relay CR–16(37), the contacts KCR–16(17) lock the relay CR–16(37) in the operative state. The control relay CR–16 may receive current from a lead L8, which is connected at the terminals thereof to the normally open contacts KCR–3(18) and to one side of the normally open switch T1–8(19). Closure of the contact KCR–3(18) or of the switch T1–8(19) completes a circuit from the lead L1, through the normally closed contacts KCR–2(37) and through the relay CR–16(37) to the lead L2, whereupon the relay CR–16(37) closes the contacts KCR–16(17) and locks into the operative state. In addition, the control relay CR–16 (37) may be successively conditioned for energization by the closure of the contacts in the counting circuit operated by the relays CR–11(27), CR–12(28) and CR–13(30), and by the closure of switch T2–6(35), as discussed above. At this point of the discussion, it sufficies to state that the relay CR–16(37) is operable, will be energized at counts of 352, 518 and 668 to stop the winding motor M–2 by opening of the contacts KCR–16(24) in the locking circuit of the control relay CR–9(24).

A bridge rectifier REC–1(39) has terminals 1 and 3 connected to the leads L1 annd L2, respectively, to receive the voltage V(1). The alternating voltage V(1) is rectified by the rectifier REC–1(39) to a full-wave D.C. voltage which appears across terminals 2 and 4 of the rectifier REC–1(39). A variable resistor VR(40) may be adjusted so that the voltage applied to the brake BRK(42) is the optimum D.C. voltage required to energize the brake BRK(42). The normally closed contacts KCR–9(42) in series with the brake BRK(42) are under the control of the relay CR–9(24), as mentioned previously. With the contacts KCR–9(42) open, the brake BRK(42) is deenergized to release the shaft 157, FIG. 4, of the winding motor M–2 for rotation. When the contacts KCR–9(42) are closed by the initial operation of the relay CR–9(24), the brake BRK(42) will be energized to apply a braking force to the shaft 157 so that the motor M–2(45) is stopped and precluded from further rotaton until the relay CR–9(24) is again operated to reopen the contacts KCR–9(42).

A voltage transformer XF–1(43) is designed to step up the voltage of the source V(1) and applies this increased magnitude A.C. voltage to the terminals 1 and 3 of a second bridge rectifier REC–2(45). The rectified output voltage which appears across terminals 2 and 4 of the rectifier REC–2(45) is applied by leads F1 and F2 to the interval field windings of the winding motor M–2(45).

A bridge rectifier REC–3(48). similar to the rectifier REC–2(45) has terminals 2 and 4 thereof, connected to the armature windings of the winding motor M–2(45) by the armature leads LA2 and LA2*a*, respectively. An inductance IND(47) may be connected in series with the terminal 2 of the rectifier REC–3(48) to filter out any A.C. ripple present in the D.C. output voltage of the rectifier REC–3(48). As will be evident to those working in the art, with the contacts KCR's–14(45, 46, 47, 49), in those respective states as illustrated by FIG. 17, the voltage polarity of the armature lead LA2 will be positive with respect to the voltage polarity of the armature lead LA2*a*; and with the contacts reversed from those respective states as depicted by FIG. 17 the lead LA2*a* will be positive with respect to the lead LA2. With a positive voltage polarity on the lead LA2, the winding motor M–2 (45) will rotate in one direction, and in a reverse direction, when the lead LA2*a* is positive with respect to the lead LA2. Thus, the respective states of the contacts KCR's–14(45, 46, 47, 49) as determined by the state of the control relay CR–14(31) will establish the polarity of the voltage impressed to the armature windings of the motor M–2(45) and will thus control the winding direction of the motor M–2(45).

Terminal 3 of the rectifier REC–3(48) is connected to the lead L2 by a lead L12 and by a lead L13 to one side of each of two coils, VL–1(44) and VL–2(46). Leads L14 and L14*a* are connected to terminal 1 of the rectifier REC–3(48) through respective normally closed and normally open contacts KCR–10(48) and KCR–10(49). The leads L14 and L14*a* may be positioned to contact the coils VL–2(46) and VL–1(44), respectively, so that an A.C. voltage V1 may be impressed to the leads L13 and L14*a* and an A.C. voltage V2 may be impressed tot he leads L13 and L14, respectively, the voltage V1 being considerably greater in magnitude than the magnitude of the voltage V2.

The coils VL–1(44) and VL–2(46) are connected in parallel with each other and both of the coils VL–1(44) and VL–2(66) may be connected by closure of the normally open contacts KCR–9(44) that are in a series connection with the lead L1. The open or closed state of the contacts KCR–9(44) will obviously determine whether the circuit between the coil VL–1(44) and VL–2(46) and the leads L1 and L2 are respectively opened or closed.

With the contacts KCR–9(44) closed and with contacts KCR–10(48) and KCR–10(49) in the state shown by the drawing, the smaller magnitude voltage V2 will be impressed to terminals 1 and 3 of the rectifier REC–3; whereas when the contacts KCR–10(48) and KCR–10 (49) are reversed from the state shown, the greater magnitude voltage V1 will be impressed to the terminals 1 and 3 of the rectifier REC–3. Thus, the selection of the voltage V1 or V2 which is to be impressed to the terminals 1 and 3 of the rectifier 3 will be controlled by the state of the contacts KCR–10(48) and KCR–10(49).

With the contacts KCR–10(48) open and the contacts KCR–10(49) closed, a full wave rectified voltage V1 which is produced across the terminals 2 and 4 of the rectifier REC–3(48) also appears across the armature leads LA2 and LA2*a*, and conversely, with the contacts KCR's–10(48, 49) in the state depicted by the drawing, a full wave rectified voltage V2 will be produced across the terminals 2 and 4. Since the rectified voltage V1 will be greater in magnitude than the magnitude of the rectified voltage V2, when the state of the contacts KCR's–10(48, 49) are reversed from that depicted by the drawing, the motor M–2(45) will be driven with a higher potential and therefore at a higher speed than when the contacts KCR's–10(48, 49) are in the state depicted.

In summary, the state of the contacts KCR–10(48) and KCR–10(49) as established by the operative state of the control relay CR–10(25) determine whether the motor M–2(45) is driven fast or slow; whereas the direction of the drive of the motor M–2(45) is controlled by the respective states of the contacts KCR's–14(45, 46, 47, 49) that are under the control of the control relay CR–14(31). The state of the contacts KCR–9(44) which are under the control of the relay CR–9(24) determines whether or not the motor M–2(45) will be receiving power, and therefore the control relay CR–9(24) directly controls the starting and stopping of the winding motor M–2.

It should be noted, however, that the control relay CR–9(24) also has the contacts KCR–16(24) in the KCR–9(24) locking circuit so that if either of the contacts KCR–2(23) or the contacts KCR–5(23) are open and if the contacts KCR–16(24) are opened, the relay CR–9(24) will be deenergized and the contacts KCR–9(44) will reopen to deenergize the winding motor M–2(45). Since the contacts KCR–16(24) are controlled by the operation of the control relay CR–16(37), it will be subsequently shown that the energization of the control relay CR–16(37) initiates the stopping of the winding motor M–2(45) by causing the deenergization of the relay C–9(24).

A voltage transformer XF–2(50) is connected between the leads L1 and L2, and is designed to step down the voltage of the source V(1) and provide a decreased magnitude source voltage for energizing the solenoids SOL1A(51)–SOL4B(58). The solenoids SOL1A(51)–SOL4B(58) are selectively connected to a common lead L15, which is connected to one side of the secondary coil of the transformer XF–2(50).

The normally deenergized solenoid SOL1A(51) is connected to the lead L2 by the lead 6(51), and by the lead 16*a*(51) to the lead L15 through the normally closed switch T2–8(51) and through the normally open contacts KCR–6(51). The solenoid SO1A(51) is energized when there is concurrent closure of the contacts KCR–6(51) and the switch T2–8(51).

The normally deenergized solenoid SOL1B(52) is connected to the lead L2 by the lead L17(52), and is connected to the lead L15 by the lead L17*a*(52) through the normally open switch T2–8(51.5) and the normally open contacts KCR–2(52). The solenoid SOL1B(52) is energized by the closure of either the switch T2–8(51.5) or the contacts KCR–2(52).

The normally deenergized solenoid SOL2A(53) is connected to the lead L2 by the lead L18(53) and is connected by the lead L18*a* to the lead L19(53) through the normally closed contacts K7(53) of the pressure switch PSW(53). The lead L19(53) is connected to one terminal of a lead L20(53) and the opposite terminal of the lead L20(53) is connected to the terminal that is common to all of the normally open switches T1–3(52), T2–3(53) and T2–4(54), respectively. With the pressure switch PSW(53) in the position as illustrated by the drawing, the closure of any of the switches T1–3(52), T2–3(53) or T2–4(54) effects the energization of the solenoid SOL2A(53). The contacts K7(53) are opened and the solenoid SOL2A(53) is deenergized by the downward movement of the pressure switch PSW(53).

The normally deenergized solenoid SOL2B(54) is connected by the lead L21(54) to the lead L2, and is selectively connected by the lead L21*a*(54) to the lead L19*a* upon the closure of the normally open contacts K7*a*(54) of the pressure switch PSW(53). The solenoid SOL2B is energized by the closure of any of the switches T1–3(52), T2–3(53) or T2–4(54) concurrently with the closure of the contacts K7*a*(54), the closure of the latter contacts being effected by the downward movement of the pressure switch PSW(53).

The normally deenergized solenoid SOL3A(55) is connected by the lead L22 to the lead L2, and is connected by the lead L22*a* to the lead L15 upon the closure of the normally open switch T1–4(55), and is thusly energized when the switch T1–4(55) is closed.

The normally deenergized solenoid SOL3B(56) is connected by the lead L23 to the lead L2 and is connected by the lead L23*a* to the lead L5 upon the closure of the normally open switch T1–5(56), and is thusly energized when the switch T1–5(56) is closed.

The normally deenergized solenoid SOL4A(57) is connected by the lead L24 to the lead L2, and is connected by the lead L24*a* to the lead L5 upon the closure of the normally open switch T1–6(57), and is thusly energized when the switch T1–6(57) is closed.

The normally deenergized solenoid SOL4B(58) is connected by the lead L25(58) to the lead L2, and is connected by the lead L25*a*(58) to the lead L15 upon the closure of the normally open switch T1–7(58), and is energized when the switch T1–7(58) is closed.

A detailed description of the operation for winding plural wires onto the terminals and coil forms that extend from both sides of a typical shunt plate follows.

Description of the procedure for conditioning the apparatus for a winding operation

Prior to the insertion of the shunt plate 180 into the apparatus 10, the apparatus 10 is conditioned for opera-

tion by the operator. The wires W—W are payed off the individual supply reels 86*a*, 86*b*, 86*c* and 86*d*, FIGS. 1 and 4, are manually threaded through the feed tubes 80*a*–80*d* until the free ends of the wires W—W extend from the tips 100*a*–100*d* of the feed tubes. The operator may then group the free ends of the wires W—W together, pull the wires W—W through the feed tubes 80*a*–80*d*, and wrap these ends together around the post 190. The apparatus 10 is now set up for receiving the shunt plate 180.

At the initial stage of operation of the apparatus 10, it will be assumed that the carriage 50 has been indexed to the extreme left position as shown in FIG. 1. In this position, the carriage 50 contacts and depresses the contact button 49 of the limit switch LS–4, and the shot pin SP–1, FIG. 1, will be in the first hole 26*a* in the rod 24 and the carriage thusly locked against movement. The actuator rod 45 of the limit switch LS–2 will be riding against the outer periphery of the rod 24. With the shot pin SP–1 in the first hole 26*a* in the rod 24, the carriage 50 will be locked in a position where the tips 100*a*–100*d* of the feed tubes 80*a*–80*d*, FIG. 20, will be at eleven o'clock positions relative to the terminals TRM1–TRM4 and designated START so as not to interfere with the terminals TRM1–TRM4 when the shunt plate 180 is inserted into the plate holder 178. The shunt plate 180 having the twelve terminals TRM1–TRM12 and the eight rows with eight coil forms in each row, CF1–CF64, may be inserted into the plate holder 178, as illustrated by FIGS. 1 and 20, with the terminals TRM1–TRM12 and the row coil forms CF1–CF64 initially facing outward. The arm 185 is then lowered to the horizontal position, as illustrated in FIG. 1, and the locking slide 188 is slid to the left, FIG. 1, to lock the shunt plate 180 in the plate holder 178.

The counter 240, FIG. 14, will usually register a count of 518 at the completion of a previous winding operation, and the counter 240 may be designed as mentioned hereinabove such that this number will appear in the window 247, FIG. 4, of the counter 240. If the counter does not register a count of 518, it may be set to this count number by the operator manually turning the pulley 152, FIG. 2, until the contact elements 246, 245 and 244, FIG. 17, respectively contact the terminal numbered 500 in the hundreds counting level of the counter 240, the terminal numbered 1 in the tens counting level and the terminal numbered 8 in the units counting level. If the crank arm 167 and the plate holder 178, FIGS. 2 and 5, are not in a bottom dead center position, the flexible shaft 230, FIG. 2, may be manually decoupled from the rod 170 and the pulley 152 turned until the crank arm 167 and the plate holder 178 are both at bottom dead center. The position of the handle 291, FIG. 2, should be noted by the operator. If it is desired to apply two layers of wire onto each coil form, the handle 291 should be turned to the position as illustrated by FIG. 2 and the handle 291 should be manually turned ninety degrees from this position if four layers are to be wound onto the coil forms.

The operator now manually closes the switch START (1), FIG. 16, to connect the A.C. source V(1) across the leads L1 and L2. Referring to both FIGS. 1 and 16, with the actuator rod 45 riding against the outer periphery of the rod 24, the contacts K2(7) will be open and the contacts K2*a*(6.5) will be bridged and closed. In addition, with the carriage 50 locked to the rod 24 by the shot pin SP–1 and depressing the contact button 49 of the limit switch LS–4(13), FIG. 16, the contacts K4(13) of the limit switch LS–4(13) will be closed and therefore the control relay CR–4(13) will be energized. The energization of the control relay CR–4(13) operates to close the contacts KCR–4(5) and to open the contacts KCR–4(25). The closure of the contacts KCR–4(5) conditions the relays DR–1(3) and CR–2(4) for operation when the contacts KW(5) are subsequently closed by the operator depressing the pushbutton switch WIND(5). The opening of the contacts KCR–4(25) provides an open circuit between the lead L1 and the lead L5.

With the shot pin SP–1 in the first hole 26*a* in the rod 24, the contacts K1(14) of the limit switch LS–1(14) will be opened and therefore the control relay CR–5(14) will be in the normal deenergized state. The deenergized state of the control relay CR–5(14) holds the contacts KCR–5(11) and KCR–5(12) open, and holds the contacts KCR–5(23) closed. The open contacts KCR's–5(11, 12) ensure that the indexing motor M–1 will not be operated during this period, and the closed contacts KCR–5(23) has no effect on the deenergized control relay CR–9(24) because the contacts KCR–2(23) are also open.

The control relay CR–12(28) will be energized upon the closure of the switch START(1) as a result of a complete circuit being established from the lead L1 through the closed contacts KRR(29) and KCR8(29), through the control relay CR–12(28) to the lead L2. With the control relay CR–12(28) in the operative state the contacts KCR's–12(32.5, 33, 35, 38) will be closed, but the closure of these contacts is of no significance to the operation of the control relays CR–15(33) or CR–16(37) since the contact elements 246, 245 and 244 of the counter 240 will be in contact with the terminals numbered 500, 10 and 8 in the hundreds, tens and units counting levels, respectively, of the counter 240. With the contact element 244 in contact with the terminal numbered 8 and with the switch T2–6(36) open and the contacts KCR–11(36.5) also open, the control relay CR–16(37) will not be energized.

The open contacts KRR(31) will hold the control relay CR–14(31) in the inoperable state and in this state, the contacts KCR's–14(45, 46, 47, 49) are in those respective states as depicted by FIG. 17. With the contacts KCR's–14(45, 46, 47, 49) in the states as depicted by the drawing, the winding motor M–2(45) is conditioned for orbiting the shunt plate 180 in a counterclockwise direction, as viewed in FIGS. 1 and 20.

Description of operation for initially winding wires onto terminals TRM1–TRM4

The operator now depresses the pushbutton switch WIND(5), FIG. 16, to momentarily close the contacts KW(5) and to momentarily open the contacts KW(9). Since the contacts KCR–4(5) are now closed, a circuit path is completed between the leads L1 and L2 through the now-closed contacts KCR–4(5), the now-closed contacts KW(5), the lead L4 and the relays DR–1(3) and CR–2(4). The initial energization of the time delay relay DR–1(3) holds the contacts KDR–1(4) closed for an interval of, for instance, three seconds, and then opens the contacts KDR–1(4) so that the control relay CR–2(4) is operated during this three-second interval.

The operation of the control relay CR–2(4) closes the contacts KCR–2(23) and therefore a circuit will be completed from the lead L1 through the closed contacts KCR–1(24), through the now-closed contacts KCR–2(23), through the closed contacts KCR–5(23), and through the control relay CR–9(24) to the lead L2. The control relay CR–9(24) thereupon operates to close the contacts KCR–9(24) and the closure of the contacts KCR–9(24) serves to lock the control relay CR–9(24) in the operative state. The time delay relay DR–1(3) is designed to time-out after the control relay CR–9(24) locks-in, and thus the contacts KDR–1(4) will reopen at that time to effect the deenergization of the control relay CR–2(4).

The initial energization of the control relay CR–2(4) that was effected by the closure of the contacts KCR–4(5) and KW(5) also operates to close the contacts KCR's 2(25, 52) and to open the contacts KCR–2(37). The closure of the contacts KCR–2(25) will not affect the deenergized state of the control relay CR–10(25) because the contacts KCR–4(25) under the control of the operated

control relay CR–4(13) are now open, and the contacts KCR–6(10) and KCR–7(12) are also open. The opening of the contacts KCR–2(37) in the CR–16(37) locking circuit will not effect the inoperative state of the control relay CR–16(37). The closure of the contacts KCR–2(52) effects the energization of the solenoid SOL1B, FIG. 15. However, since the shot pin SP–1 has already been assumed to be in the first hole 26*a* in the rod 24, the reenergization of the solenoid SOL1B has no effect on the assumed extended position of the shot pin SP–1.

The subsequent deenergization of the control relay CR–2(4), FIG. 16, by the timing out of the time delay relay DR–1(3) after the control relay CR–9(24) locks-in, operates to restore the contacts of the relay CR–2(4) to those respective states as depicted by the drawings. The reopening of the contacts KCR–2(23) has no effect on the state of the control relay CR–9(24) because the relay CR–9(24) is now locked-in the operate state. The reopening of the contacts KCR–2(25) does not alter the inoperative state of the control relay CR–10(25). The reclosure of the contacts KCR–2(37), however, conditions the control relay CR–16(37) for operation at a count of 510 since the control relay CR–12(28) is operative to hold closed the contacts KCR's–12(32.5, 33, 35, 38) of the counter 240. The closure of the contacts KCR–12(35) in the hundreds counting level of the counter 240, the closure of the contacts KCR–12(33) in the tens counting level and the closure of the contacts KCR–12(32.5) in the units counting level coupled with the closed contacts KCR–10(37) and the now-closed contacts KCR–2(37) fully conditions the control relay CR–16(37) for operation when the counter registers a count of 510. It may be recalled that the contacts KCR–10(37) were closed and are held closed at this time because the control relay CR–10(25) is in a deenergized state by virtue of the open contacts KCR–4(25), KCR–6(10) and KCR–7(12).

The operation of the control relay CR–9(24) in addition to closing the contacts KCR–9(24), opens the normally closed contacts KCR–9(42) and the brake BRK(42) is thereby deenergized to release the winding motor M–2(45) for rotation. In addition, the operation of the control relay CR–9(24) closes the contacts KCR–9(44) so that the coil VL–2(46) is connected to the lead L1 and the slow-driving voltage V2 is thereupon applied to the terminals 1 and 3 of the rectifier REC–3(48). The slow-driving voltage V2 that is applied to the terminals 1 and 3 of the rectifier REC–3(48) is also applied in rectified form to such of the armature windings (not shown) of the winding motor M–2(45) that the winding motor M–2(45) is energized to drive the shunt plate 180, FIG. 20, slowly through two complete counterclockwise orbits.

The orbiting of the shunt plate 180, FIG. 20, will cause the terminals TRM1–TRM4 to revolve in circular orbits about the stationary tube tips 100*a*–100*d*. The wires W that are attached to the post 190, FIG. 1, pay off the supply reels 86*a*–86*d* and issue from the feed tubes 80*a*–80*d* to be intercepted by the terminals TRM1–TRM4, FIG. 20, during their initial one-quarter counterclockwise revolution. Upon further orbiting, the terminals TRM1–TRM4 will wind the wires W—W that issue from the feed tube tips 100*a*–100*d* upon themselves.

With the contacts KCR's–10(48, 49) in those respective states as depicted by FIG. 17, the motor M–2(45), FIG. 17, will rotate the contact element 244 in the units counting level of the counter 240 from the terminal numbered 8 in the units counting level to the terminal numbered 0 in the units counting level. As can be seen in FIG. 17, when the contact element 244 of the units counting level of the counter 240 is moved to contact the terminal numbered 0 of that counting level, the now-closed contacts KCR's–12(32.5, 33, 35) will trace a circuit from the lead L1 through the contact elements 246, 345 and 244 and the respective contacted terminals numbered 500, 10 and 0 in the hundreds, tens and units counting levels, respectively, through the now-closed contacts KCR–10(37) and KCR–2(37) and through the control relay CR–16(37) to the lead L2. The control relay CR–16(37) will, therefore, be energized at the count of 510 and the shunt plate 180, FIG. 20, will have been driven through two complete counterclockwise orbits corresponding to an eight count differential. The two counterclockwise orbits of the shunt plate 180 will apply one and three-quarters turns of each wire W onto each terminal TRM1–TRM4.

When the control relay CR–16(37), FIG. 16, is energized, the contacts KCR–16(24) in the locking circuit of the control relay CR–9(24) will open. The opening of the contacts KCR–16(24) will break the locking circuit of the control relay CR–9(24) and effect the deenergization of that relay. The consequent return of the control relay CR–9(24) to the inoperative state reopens the contacts KCR–9(44) which breaks the circuit between the lead L1 and the coil VL–2(46) and terminates the application of the slow-driving rectified voltage V2 to the winding motor M–2(45). Simultaneously, the contacts KCR–9(42) reclose so that the brake BRK(42) is again energized to stop and preclude further rotation of the deenergized winding motor M–2(45).

The operation of the control relay CR–16(37) at the count of 510 also closes the contacts KCR–16(17). The closure of the contacts KCR–16(17) locks the control relay CR–16(37) in the operative state and simultaneously completes a circuit between the leads L1 and L2 through the relays CR–6(17) and DR–2(18).

The control relay CR–6(17) is then operated for a predetermined interval of time, as established by the timing cycle of the time delay relay DR–2(18) acting through the contacts KDR–2(17), to close the contacts KCR's–6(10, 15, 51). The closure of the contacts KCR–6(10) establishes a circuit path between the lead L1 and the lead L3. The closure of the contacts KCR–6(15) completes a circuit from the lead L1 through the diode D1 and the ratchet relay RR(15) to the lead L2, so that the ratchet relay RR(15) is operated.

The operation of the ratchet relay RR(15) effects a reversal of the states of the contacts KRR(27, 29, 31) from those respective states as depicted by the drawings. The closure of the contacts KRR(27) in conjunction with the normally closed state of the contacts KCR–8(27) completes a circuit from the lead L1 through these closed contacts, through the control relay CR–11(27) to the lead L2, and accordingly the control relay CR–11(27) is energized. The operation of the control relay CR–11(27) reverses the respective states of the contacts KCR's–11(35, 36, 36.5, 37, 38) of the counter 240 from those states as depicted by FIG. 17, and thereby conditions the control relays CR–15(33) and CR–16(37) for operation when the counter 240 successively registers counts of 659 and 668, respectively.

The opening of the contacts KRR(29) breaks the circuit that previously existed between the leads L1 and L2 and the control relay CR–12(28) and effects the deenergization of that relay. The deenergization of the control relay CR–12(28) operates to reopen the contacts KCR's–12(32.5, 33, 35, 38) that provided the circuit path through the counter 240 corresponding to the count of 510 and thereby destroys this closed contact pattern.

The closure of the contacts KRR(31) by the operation of the ratchet relay RR(15) effects the energization of the control relay CR–14(31), and the relay CR–14(31) then operates to reverse the respective states of the contacts KRC's–14(45, 46, 47, 49) from those states as illustrated by FIG. 17. The winding motor M–2, FIGS. 1 and 20, is thereby conditioned to orbit the shunt plate 180 in an opposite direction or clockwise, as viewed in FIG. 20.

The closure of the contacts KCR–6(51) by the initial operation of the control relay CR–6(17) completes a circuit between the lead L15 and the lead L2, through the

closed switch T2–8(51) and through the solenoid SOL1A(51) so that the solenoid SOL1A is energized. The energization of the solenoid SOL1A, FIG. 15, actuates the valve VALVE–1 so that compressed air is diverted into the tube 42 and the shot pin SP–1 is thus retracted from the first hole 26*a* in the rod 24. The rod 24 and the carriage 50 are now unlocked for indexing movement to the right, as viewed in FIG. 1. The retraction of the shot pin SP–1, FIG. 10, from the rod 24 also releases the actuator rod 32 of the limit switch LS–1 and the contacts K1(14), FIG. 16, of the limit switch LS–1 close to effect the energization of the control relay CR–5(14).

When the control relay CR–5(14) is energized, the contacts KCR–5(11, 12) close and the contacts KCR–5(23) open. The closure of the contacts KCR–5(12) has no effect on the operation of the indexing motor M–1(11.5) because the contacts KCR–3(11) and the contacts KCR–7(12) remain open. The opening of the contacts KCR–5(23) is also of no consequence at this time because the control relay CR–10(25) is still in the inoperative state. However, the closure of the contacts KCR–5(11) in the armature lead LA1 will be concurrent with the now-closed state of the contacts KCR–6(10) and a circuit path may therefore be traced from the lead L1, through the now-closed contacts KCR–6(10), to the lead L3, through the closed contacts K3(3), K3*b*(4) of the limit switch LS–3 to the armature lead LA1, and hence, to the armature windings of the indexing motor M–1(11.5). The indexing motor M–1(11.5) will now be energized for rotation in a direction which drives the unlocked carriage 50 to the right, as viewed in FIG. 1. The indexing of the carriage 50 in this direction causes the actuator rod 45 of the limit switch LS–2(7) to ride along the outer periphery of the rod 24 and therefore the contacts K2*a*(6.5) remain bridged and closed. The carriage 50, FIG. 1, continues to index to the right, as viewed in that figure, to release the contact button 49 of the limit switch LS–4. The release of the contact button 49 opens the hitherto closed contacts K4(13), FIG. 16, and the opening of the contacts K4(13) effects the deenergization of the control relay CR–4(13).

The control relay CR–4(13) then operates to reverse the states of the contacts KCR–4(5) and KCR–4(25) so that the respective states of these contacts are now those states as illustrated by FIG. 16. The reopening of the contacts KCR–4(5) is of no present consequence to the operation of the control relay CR–2(4) since the relay CR–2(4) was previously deenergized by the opening of the time delay contacts KDR–1(4), as related above. The reclosure of the contacts KCR–4(25) is significant, however, because the closure of these contacts completes an alternate circuit path from the lead L1 to the lead L3 and to the lead L5 through the closed contacts K2*a*(6.5). Once this alternate circuit path is provided from the lead L1 to the armature lead LA1, the timing out of the time delay relay DR–2(18) will operate the relay DR–2(18) to open the contacts KDR–2(17), and effect the deenergization of the control relay CR–6(17).

The deenergization of the control relay CR–6(17) reopens the contacts KCR's–6(10, 15, 51) to reestablish the normal open contact pattern for these contacts. The reopening of the contacts KCR–6(10) is of no import because an alternate circuit path for the energization of the indexing motor M–1(11.5) has been established by the closure of the contacts K2*a*(6.5) and KCR–4(25). The reopening of the contacts KCR–6(15) will not alter the state of the ratchet relay RR(15) because the ratchet relay RR(15) only operates its contact control arm (not shown) when energized, and the reopening of the contacts KCR–2(51) will not effect the retracted position of the shot pin SP–1.

Description of the operation for winding wires onto coil forms of odd number rows

The voltage which is applied to the armature windings (not shown) of the indexing motor M–1(11.5) so that the motor M–1(11.5) drives the carriage 50 to the right, as viewed in FIG. 1, is sustained only during the interval when the contacts K2*a*(6.5), FIG. 16, remain closed by the actuator rod 45 riding against the outer periphery of the rod 24. The notch 25*a* is formed in the rod 24 such that the actuator rod 45 will drop into the first notch 25*a* when the feed tube tips 100*a*–100*d* have been advanced, FIG. 20, to respective twelve o'clock positions, as viewed in FIG. 20, relative to the coil forms CF1, CF17, CF33 and CF49. When the actuator rod 45, FIG. 16, drops into the first notch 25*a* in the rod 24, the contacts K2*a*(6.5) will open and the contacts K2(7) will close. The opening of the contacts K2*a*(6.5) breaks the hitherto established electrical path between the leads L3 and L5. The armature windings of the indexing motor M–1(11.5) are thereupon disconnected from the source V(1) and the indexing drive of the motor M–1(11.5) stops.

With the actuator rod 45 in the first notch 25*a* of the rod 24, the contacts K2(7) are closed and the lead L4 is connected via the closed contacts K2(7) to the lead L5. A complete circuit may then be traced from the lead L1 through the now-closed contacts KCR–4(25) and through the relays DR–1(3) and CR–2(4) to the lead L2. The relay CR–2(4) is thereby operated for the period of time prescribed the timing cycle of the time delay DR–1(3) to close the contacts KCR's–2(23, 25, 52) and to open the contacts KCR–2(37). The closure of the contacts KCR–2(23) conditions the control relay CR–9(24) for operation but the relay CR–9(24) remains inoperable at this time by the now-open contacts KCR–5(23). The closure of the contacts KCR–2(25) completes a circuit between the leads L1 and L2 through the closed contacts KCR–4(25) and through the control relay CR–10(25), whereupon the control relay CR–10(25) is energized. The closure of the contacts KCR–2(52) effects the energization of the solenoid SOL1B(52). The energized solenoid SOL1B, FIG. 15, actuates the valve VALVE–1 to divert pressurized air into the tube 43 and into the cylinder 38 such that the shot pin SP–1 is driven into the second consecutive hole 26*b* in the rod 24. The carriage 50, FIG. 1, will now be locked-in position for another winding cycle.

The operation of the control relay CR–10(25) closes the contacts KCR–10(26) and the control relay CR–10(25) is thus locked into the operative state. When operated, the control relay CR–10(25) also reverses the respective states of the contacts KCR's–10(48, 49) from those as depicted by FIG. 17 so that the contacts KCR–10(48) are now open and the contacts KCR–10(49) are now closed. This reversal of the initial respective states of the contacts KCR's–10(48, 49) conditions the rectifier REC–3(48) for receiving the fast drive voltage V1.

The winding motor M–2(45) is thereby conditioned for rotation at the fast winding speed by the sustained operation of the control relay CR–10(25) and in a direction that will orbit the shunt plate 180 clockwise, as viewed in FIG. 20, by the sustained energization of the control relay CR–14(31). The operation of the control relay CR–10(25) also opens the contacts KCR–10(37) which breaks the circuit path between the counter 240 and the control relay CR–16(37), and the control relay CR–16(37) is thereby rendered inoperative.

The energization of the solenoid SOL1B(52) by the operation of the control relay CR–2(4) drives the shot pin SP–1 into the next succeeding hole 26*b* in the rod 24, FIG. 1, as stated above. The movement of the shot pin SP–1 into the rod 24 actuates the limit switch LS–1(15), FIG. 16, to open the previously closed contacts K1(14), and the control relay CR–5(14) is thereupon deenergized.

The deenergization of the control relay CR-5(14) reopens the contacts KCR–5(11) and KCR–5(12) and recloses the contacts KCR–5(23). The reopening of the contacts KCR's–5(11, 12) insures that the indexing motor M–1(11.5) will not be accidentally energized while the carriage is locked-in for a winding cycle. The re-

closure of the contacts KCR–5(23) completes the circuit between the lead L1 and L2 and the control relay CR–9(24) which was previously conditioned for closure by the closure of the contacts KCR–2(23), and the relay CR–9(24) is thereupon operated.

When the relay CR–9(24) operates, it locks-into the operative state by closing the contacts KCR–9(24) in the relay locking circuit. The operation of the control relay CR–9(24) also reopens the contacts KCR–9(42) so that the brake BRK(42) is denergized to release the winding motor M–2(45) for rotation. In addition, the control relay CR–9(24) operates to reclose the contacts KCR–9(44) whereby the fast winding drive voltage V1 is applied to the terminals 1 and 3 of the rectifier REC–3(48) and hence to armature windings (not shown) of the winding motor M–2(45). The reclosure of the contacts KCR–9(44) initiates the fast winding cycle of the winding motor M–2(45).

The energized winding motor M–2(45), FIG. 1, will orbit the shunt plate 180 clockwise, as viewed in FIG. 20, at a fast winding speed when the contacts KCR–9(44), FIG. 17, are closed by operation of the control relay CR–9(24), as discussed above.

The wires W. FIG. 20, that are wound upon the terminals TRM1–TRM4 by the previous winding cycle and issue from the tube tips 100*a*–100*d* during the indexing thereof to final twelve o'clock positions relative to the coil forms CF1, CF17, CF33 and CF49 will be intercepted by the coil forms CF1, CF17, CF33 and CF49 during the initial angular displacement of typically one-quarter of a clockwise revolution of these coil forms about the tube tips 100*a*–100*d*.

The clockwise orbital revolutions of the coil forms CF1, CF17, CF33 and CF49 will pull the wires W—W through the feed tubes 80*a*–80*d* from the supply reels 86*a*–86*d* and the coil forms CF1, CF17, CF33 and CF49 will thus wind the wires W—W upon themselves. The simultaneous traverse provided to the tube tips 110*a*–100*d* by the rotation of the winding motor M–2(45) will effect the even distribution of two layers of the wires W—W onto these orbiting coil forms.

After the control relay CR–9(24) locks into the operative state, the time delay relay DR–1(3) times out and the relay DR–1(3) will then operate to open contacts KDR–1(4) and thus effect the deenergization of the control relay CR–2(4).

The deenergization of the control relay CR–2(4) again operates to reverse the states of the contacts controlled thereby and the contacts KCR's–2(23, 25, 52) reopen. The reopening of the contacts KCR's–2(23, 25) has no effect upon the operation of the control relays CR–9(24) and CR–10(25) because both of these relays are locked-in the operative state by their respective locking circuits. The reopening of the contacts KCR–2(52) effects the deenergization of the solenoid SOL1B(52) but the deenergizing of the solenoid SOL1B(52) will not alter the position of the shot pin SP–1, FIG. 15, in the rod 24, as mentioned hereinabove.

To prevent the motor M–2(45) from overshooting and applying more than the desired 39.5 turns of wires W—W onto each coil form CF1, C17, CF33 and CF49, approximately two turns before the end of the winding cycle, a slow winding drive for the winding motor M–2(45) is substituted for the fast winding drive. This substitution is initiated by the counter 240, FIG. 17.

While the winding motor M–2(45) orbits the shunt plate 180 clockwise, the counter 240 records the number of revolutions of the winding motor M–2(45). Thus, the contact elements 246, 245 and 244 are successively moved to positions in contact with the terminals numbered 600, 50 and 9, FIG. 17, of the counter 240 from a previous count of 510. Since the contacts KCR's–11(35, 36, 36.5, 37) are closed, it would appear that a circuit path through the counter 240 and to the control relay CR–16(37) would be completed at a count of 658. However, it may be recalled that the contacts KCR–10(37) are open at this time and remain open prior to the energization of the control relay CR–15(33) by the previous operation and locking-in of the control relay CR–10(25). Consequently, even though the counter 240 registers a count of 558, the control relay CR–16(37) will not be energized. However, when the counter registers a count of 659 as a result of the contact element 244 moving onto the terminal numbered 9 in the units counting level, the closure of the contacts KCR's–11(35, 36, 37) will trace a circuit path from the lead L1 through the contact element 246 and the contacted terminal numbered 600 of the hundreds counting level, through the contact element 245 and the contacted terminal numbered 50 in the tens counting level and through the contact element 244 and the contacted terminal numbered 9 in the units counting level, to the lead L10 in the units counting level, and through the control relay CR–15(33), to the grounded lead L2. As a result, the control relay CR–15(33) will operate to open the contacts KCR–15(26) in the locking circuit of the control relay CR–10(25). Since the contacts KCR–2(25) are now open, the effect of opening the contacts KCR–15(26) will be to deenergize the control relay CR–10(25).

The deenergization of the control relay CR–10(25) will operate to reclose the contacts KCR–10(48) and reopen the contacts KCR–10(49). The coil VL–1(44) will be disconnected from the terminals 1 and 3 of the rectifier REC–3(48) and the coil VL–2(46) will be reconnected to the terminals 1 and 3 of the rectifier REC–3(48). The winding motor M–2(45) is now conditioned to driven by the rectified slow driving voltage V2.

The deenergization of the control relay CR–10(25) also operates to reclose the contacts KCR–10(37) so that the control relay CR–16(37) is now conditioned for energization at a count of 668. As the winding motor M–2(45) continues to rotate at the slow winding speed, the contact elements 246, 245 and 244 continue to rotate until the terminals numbered 600 in the hundreds counting level of the counter 240, 60 in the tens counting level and 8 in the units counting level are respectively contacted. A complete circuit may then be traced from the lead L1 through the closed contacts KCR–11(36), KCR–11(35) and KCR–11(37), through the now-closed contacts KCR–10(37) and KCR–2(37), and through the control relay CR–16(37) to the lead L2. Thus, at a count of 668 the control relay CR–16(37) is energized to reclose the contacts KCR–16(17) and reopen the contacts KCR–16(24). The reclosure of the contacts KCR–16(17) locks the control relay CR–16(37) in the operative state and also completes a circuit path from the lead L1 through the relays CR–6(17) and DR–2(18) to the lead L2.

The reopening of the contacts KCR–16(24) breaks the locking circuit of the control relay CR–9(24) and thereby effects the deenergization of the control relay CR–9(24). When the control relay CR–9(24) is deenergized, the contacts KCR–9(44) reopen and stop the further rotation of the winding motor M–2(45). In addition, the contacts KCR–9(42) reclose to energize the brake BRK(42) and the brake BRK(42) thereupon operates to stop and preclude the further rotation of the winding motor M–2(95). The coil forms CF1, CF17, CF33 and CF49, FIG. 20, will now be in respective twelve o'clock positions relative to the stationary tips 100*a*–100*d* because of the final half revolution of the shunt plate required to add another one-half turn of a wire W onto each of these coil forms. The coil forms CF1, CF17, CF33 and CF49 are now wound with at least 39 turns and typically 39.25 turns of wire because of the one-quarter non-wire applying revolution that is initially required to bring the coil forms into intercepting relationships with the wires W—W, as related above.

The closure of the contacts KCR–16(17) by the operation of the control relay CR–16(37) effects the energization of the control relay CR–6(17) and consequently the contacts KCR–6(10, 15, 51) reclose. The reclosure of the contacts KCR's–6(10) provides a circuit path between the leads L1 and L3, the reclosure of the contacts KCR–6(15) effects the energization of the ratchet relay RR(15), and the reclosure of the contacts KCR–6(51) effects the energization of the solenoid SOL1A(51). The energized solenoid SOL1A(51) operates to drive the shot pin SP–1, FIG. 1, from the rod 24 and releases the carriage 50 for indexing movement to the right, as viewed in FIG. 1.

The reclosure of the contacts KCR–6(15) effects the reenergization of the ratchet relay RR(15) and the relay RR(15) operates again to reverse the respective states of the contacts KRR's(27, 29, 31) controlled thereby, to those states depicted by the drawings.

The opening of the contacts KRR(27) effects the deenergization of the control relay CR–11(27) and the relay CR–11(27) then operates to reopen the contacts KCR's–11(35, 36, 36.5, 37) and to reclose the contacts KCR–11(38). The reopening of the contacts KCR's–11(35, 36.5, 37) destroys the pattern of closed contacts that conditioned the control relays CR–15(33) and CR–16(37) for operation at the counts of 659, 668, respectively.

The reclosure of the contacts KRR(29) acting in conjunction with the closed contacts KCR–8(29) effects the reenergization of the control relay CR–12(28). The control relay CR–12(28) then operates to close the contacts KCR's–12(32.5, 33, 35, 38) and recondition the counter 240 for counts of 510 and 519.

The reopening of the contacts KRR(31) effects the deenergization of the control relay CR–14(31) which then operates to reverse the respective states of the contacts KCR's–14(45, 46, 47, 49) back to those states as depicted by the FIG. 17 so that the winding motor M–2(45) is conditioned for driving the shunt plate 180 in a counterclockwise direction as viewed in FIG. 20.

The retraction of the shot pin SP–1, FIG. 15, from the rod 24 releases the limit switch LS–1 so that the contacts K1(14), FIG. 16, reclose to reenergize the control relay CR–5(14). The reenergization of the control relay CR–5(16) recloses the contacts KCR's–5(11, 12) and reopens the contacts KCR–5(23). The reclosure of the contacts KCR–5(11) coupled with the reclosure of the contacts KCR–6(10) completes a circuit from the lead L1 to the lead L3 through the closed contacts K3(3), K3*b*(4) of the limit switch LS–3(3) through the closed contacts KCR–3(11), KCR–5(11) and KCR–7(11) in the lead LA1 so that the indexing motor M–1(11.5) is rotated to index the carriage 50, FIG. 1, to the right as viewed in that figure. The reopening of the contacts KCR–5(23) has no effect on the previously deenergized relay CR–9(24) but insures that the contacts KCR–9(44) remain open) to preclude the possibility of accidental energization of the winding motor M–2(45) while the carriage 50 is indexing.

After the contacts K2*a*(6.5), FIG. 15, are bridged by the actuator rod 45 riding onto the outer periphery of the rod 24 to complete a connection between the leads L3 and L5, the previously established circuit path between the leads L1 and L3 through the closed contacts KCR–6(10) is no longer needed. Thus, at this time, the time delay relay DR–2(18) will time out and the control relay CR–6(17) will deenergize to reopen the contacts KCR's–6(10, 15, 51). The reopening of the contacts KCR–6(10) has no effect on the continuing operation of the indexing motor M–1(11.5) for reasons stated above, and the reopening of the contacts KCR–6(15) and KCR–6(51) serves to recondition the ratchet relay RR(15) and the solenoid SOL1A(51), respectively, for operation at the termination of the winding cycle or the coil forms CF2, CF18, CF34 and CF50. The indexing motor M–1(11.5) will continue to drive the carriage 50 and the tubes 80*a*–80*d* to the right, as viewed in FIG. 1, with the tube tips 100*a*–100*d* issuing the wires W—W adjacent the shunt plate 180 until the actuator rod 45, FIG. 1, drops into the second consecutive notch 25*d* in the rod 24.

When the actuator rod 45 drops into the second consecutive notch 25*b* in the rod 24, the contacts K2*a*(6.5) are reopened and the contacts K2(7) are reclosed. The reopening of the contacts K2*a*(6.5) effects the immediate deenergization of the indexing motor M–1(11.5) and the reclosure of the contacts K2(7) effects the simultaneous reenergization of the relays DR–1(3) and CR–2(4). The control relay CR–2(4) operates to reclose the contacts KCR's–2(23, 25, 52) and reopen the contacts KCR–2(37).

The reclosure of the contacts KCR–2(23) reconditions the control relay CR–9(24) for operation, but the now-open contacts KCR–5(23) prevent the operation of the control relay CR–9(24) at this time.

The reclosure of the contacts KCR–2(25) effects the energization of the control relay CR–10(25). The energized control relay CR–10(25) operates to close the contacts KCR–10(26) and thereby locks itself into the operative state. In addition, the control relay CR–10(25) operates to reopen the contacts KCR–10(48) and to reclose the contacts KCR–10(49) so as to condition the winding motor M–2(45) for a fast winding cycle. The control relay CR–10(25) also operates to reopen the contacts KCR–10(37) to preclude the possibility of the control relay CR–16(37) energizing prior to the energization of the control relay CR–15(33).

The closure of the contacts KCR–2(52) by the operation of the control relay CR–2(4) effects the energization of the solenoid SOL1B(52) which they functions to effect the driving of the shot pin SP–1, FIG. 1, back into locking engagement with the third consecutive hole 26*c* in the rod 24. The carriage 50 is thereupon locked into position with the coil forms CF2, CF18, CF34 and CF50 at twelve o'clock positions, as viewed in FIG. 20, relative to the respective feed tube tips 100*a*–100*d*, as result of the final one-half of a revolution of the shunt plate 180 that is required to wind substantially 39 turns of wire W onto the coil forms CF1, CF17, CF33 and CF49.

The movement of the shot pin SP–1, FIG. 1, into locking engagement with the rod 24 reopens the contacts K1(14), FIG. 16, of the limit switch LS–1(14) and thereby effects the deenergization of the control relay CR–5(14). The deenergization of the control relay CR–5(14) effects the reopening of the contacts KCR's–5(11, 12) and the reclosing of the contacts KCR–5(23). The reclosure of the contacts KCR–5(23) will complete a circuit path from the lead L1 through the closed contacts KCR–1(24) and through the now-closed contacts KCR–2(23) through the control relay CR–9(24) to the lead L2, and the control relay CR–9(24) thereupon operates.

The energized control relay CR–9(24) locks itself in the operative state by virtue of closing the contacts KCR–9(24) and, in addition, operates to reclose the contacts KCR–9(44). The reclosure of these latter contacts initiates the application of the rectified fast-driving voltage V1 to the winding motor M–2(45). Since the contacts KCR's–14(45, 46, 47, 49) will be in those respective states as depicted by FIG. 17, the winding motor M–2(45) will orbit the shunt plate 180, FIG. 20, in a counterclockwise direction and at the fast winding speed.

The counter 240, FIG. 17, will also be driven in a downward counting direction by the rotation of the winding motor M–2(45) from the previously attained count of 668 to a lower count of 519 by the rotation of the contact elements 244, 245 and 246. When the count of 519 is registered by the counter 240, the closed contact pattern established by the now-closed contacts KCR–12(35) in the hundreds counting level of the counter 240, the now-closed contacts KCR–12(33) in the tens counting level and the now-closed contacts KCR–12(38) in the units counting level will complete a circuit path

from the lead L1 through the contact element 246 of the terminal numbered 500, through the contact element 245 to the terminal numbered 10, and through the contact element 244 to the terminal numbered 9, to the leads LXL2 and L10; through the control relay CR–15(33) to the lead L2. The control relay CR–15(33) will thereupon be energized to reopen the contacts KCR–15(26) in the locking circuit of the control relay CR–10(25) whereupon the control relay CR–10(25) deenergizes.

The deenergization of the control relay CR–10(25) recloses the contacts KCR–10(37) to recondition the control relay CR–16(37) for operation at a count of 510. The contacts KCR's–10(48, 49) are also operated and resume those respective states as depicted by FIG. 17 to energize the winding motor M–2(45) with the voltage V2.

After the control relay CR–9(24) locks into the operative state, the control relay CR–2(4) is deenergized by the timing out of the time delay relay DR–1(3) and the control relay CR–2(4) then operates to reopen the contacts KCR's–2(23, 25, 52) and to reclose the contacts KCR–2(37). The reopening and reclosing of these respective contacts of the control relay CR–2(4) serve to recondition these contacts for a subsequent operation, as should be apparent.

The winding motor M–2(45) then proceeds to orbit the shunt plate 180, FIG. 2, approximately two more complete revolutions at the slow orbiting speed until the contact element 244, FIG. 17, contacts the terminal numbered 0 at the units counting level of the counter 240. At the corresponding count of 510, the control relay CR–16(37) will be energized and the contacts KCR–16(17) will reclose to lock the control relay CR–16(37) in the operative state. In addition, the contacts KCR–16(24) will reopen and break the locking circuit of the control relay CR–9(24) so that this relay is again deenergized.

The deenergization of the control relay CR–9(24) will effect the reopening of the contacts KCR–9(24) in the CR–9(24) locking circuit and the reopening of the contacts KCR–9(44) in the circuit of the winding motor M–2(45). The reopening of these latter contacts effects the deenergization of the winding motor M–2(45). The concurrent reclosure of the contacts KCR–9(42) will apply the brake BRK(42) to stop and preclude further orbital movement of the shunt plate by the winding motor M–2(45).

The reclosure of the contacts KCR–16(17) by the operation of the control relay CR–16(37) at the count of 510 will effect the simultaneous reenergization of the relays CR–6(17) and DR–2(18).

The reclosure of the contacts KCR–6(17) by the operation of the control relay CR–6(17) for the period prescribed by the time cycle of the time delay relay DR–2(18) will effect there closure of the contacts KCR's–6(10, 15, 51).

The reclosure of the contacts KCR–6(10) reestablishes a circuit path between the leads L1 and L3 to the indexing motor M–1(11.5). The reclosure of the contacts KCR–6(15) effects the reenergization of the ratchet relay RR(15) so that the ratchet relay RR(15) reverses the respective states of the contacts KRR's(27, 29, 31) from those states as depicted by the drawings. The reclosure of the contacts KCR–6(51) effects the reenergization of the solenoid SOL1A(51) which retracts the shot pin SP–1, FIG. 15, from the rod 24 and recloses the contacts K1(14), FIG. 16, of the limit switch LS–1(14) in the process.

With the contacts KRR(27) closed and the contacts KRR(29) open, the control relay CR–11(27) will be energized to recondition the control relays CR–15(33) and CR–16(37) for operation when the counter registers counts of 659 and 668, respectively. The reopening of the contacts KRR(29) effects the deenergization of the control relay CR–12(28) so that the closed contact paths hitherto established by the closed contacts KCR's–12(32.5, 33, 35 and 38), and corresponding to the counts of 519 and 510, are destroyed.

The closure of the contacts KRR(31) operates to effect the energization of the control relay CR–14(31) which thereupon conditions the winding motor M–2(45) for orbiting the shunt plate 180 clockwise, as viewed in FIG. 20, by reversing the respective states of the contacts KCR's–14(45, 46, 47, 49) from those states as depicted by the drawing.

The retraction of the shot pin SP–1, FIG. 15, from the rod 24 recloses the contacts K1(14) and reenergizes the control relay CR–5(14). The reenergization of the control relay CR–5(14) recloses the contacts KCR's–5(11, 12) and opens the contacts KCR–5(23).

The reclosure of the contacts KCR–5(11) completes the circuit from the lead L1 through the now-closed contacts KCR–6(10) to the lead L3 and through the contacts K3(3), K3*b*(4) and through the now-closed contacts KCR–3(11), KCR–5(11), KCR–7(11) in the armature lead LA1 so that the indexing motor M–1(11.5) drives the carriage 50 to the next consecutive coil forms in the odd numbered rows. After the contacts K3*a*(6.5) are closed by the actuator rod 45 riding onto the outer periphery of the rod 24 and thereby establishing the hitherto disclosed alternate circuit path between the leads L1 and L2 and the armature lead LA1 of the indexing motor M–1(11.5), the time delay relay DR–2(18) times out and deenergizes the control relay CR–6(17) so that the contacts KCR's–6(10, 15, 51) reopen. Two layers of substantially 39 turns of wires W—W will have now been applied to the coil forms CF2, CF18, CF34, CF50, as should be apparent.

Description of the operation for winding wires onto terminals TRM5–TRM12

Referring to FIG. 20, after the coil forms CF8, CF24, CF40 and CF56 are each wound with 39 counterclockwise turns of the wires W—W, the carriage 50 continues to index to the right, as viewed in FIG. 1, driven by the rotation of the indexing motor M–1 until the carriage 50 contacts and depresses the contact button 48 of the limit switch LS–3. The shunt plate 180 will have been orbited to a final bottom dead center position by the previous coil form winding cycle and the wire-issuing tips 100*a*–100*d*, FIG. 20, will thereby be moving toward twelve o'clock positions relative to the terminals TRM5, TRM7, TRM9 and TRM11, respectively.

Referring to FIGS. 1, 16 and 20, immediately prior to the actuation of the limit switch LS–3(3.5) by the carriage 50, the various relays, solenoids, motors and the switches and contacts operated thereby will be in the same respective states as described directly above because the winding cycle of the coil forms CF2, CF18, CF34 and CF50 is identical to the winding cycle for the coil forms CF8, CF24, CF40 and CF56. Thus the control relay CR–5(14) will be in an operative state since the contacts K1(14) will be closed while the shot pin SP–1 is out of locking engagement with the rod 33, FIG. 10, and consequently, the contacts KCR's–5(11, 12), FIG. 16, will be closed, and the contacts KCR–5(23) will be open. The contacts K2*a*(6.5) will be bridged and closed, since the actuator rod 45 will be riding against the outer periphery of the rod 24. The ratchet relay RR(15) will have been energized and deenergized at the termination of the coil form winding cycle for the coil forms CF8, CF24, CF40 and CF56 by the successive energizations of the control relays CR–16(37) and CR–6(17). The ratchet relay RR(15) will therefore be ready to condition the winding motor M–2 for orbiting the shunt plate in a clockwise direction, as viewed in FIG. 20, and at the fast winding speed. The contacts KRR(27) will therefore be closed and will complete a circuit path between the leads L1 and L2 through the now-closed contacts KCR–8(27). The control relay CR–11(27) will be energized to condition the counter 240 for successive counts of 659 and 668, respectively.

The contacts KRR(29) will now be open so that the control relay CR–12(28) is deenergized and the contacts of the control relay CR–12(28) in the counter 240 will have those states as depicted by FIG. 17.

The now-closed contacts KRR(31) will effect the energization of the control relay CR–14(31) so that the contacts KCR's–14(45, 46, 47, 49) will be held reversed from those states as depicted by FIG. 17 to condition the winding motor M–2(45) for clockwise rotation.

The control relay CR–16(37) will also be locked into an operative state at this time by the previous energization of the control relay CR–16(37) at the count of 510. The contacts KCR–16(24) will be open to hold the control relay CR–9(24) deenergized.

The fact that the control relay CR–11(27) is in an operative state and reverses the states of the contacts KCR–11 in the counter 240 is of no consequence at this time, because the counter is now registering a count of 510 from the previous winding cycle and the deenergized relay CR–9(24) prevents the rotation of the winding motor M–2(45) by holding contacts KCR–9(44) open.

When the limit switch LS–3(3.5), FIG. 16, is actuated by the movement of the carriage 50 to the right, as viewed in FIG. 1, the contacts K3(3), K3*b*(4) are opened and the contacts K3(3), K3*a*(3) are closed. Since there are no longer any notches in the rod 24 when the carriage 50 moves from the last coil forms of the odd numbered rows to contact the limit switch LS–3(3.5), the actuator rod 45 will continue to ride against the outer periphery of the rod 24 and the contacts K2*a*(6.5) of the limit switch LS–2(7) will therefore remain closed. When the contacts K3(3), K3*b*(4) of the limit switch LS–3(3.5) open, the indexing motor M–1(11.5) deenergizes and stops the further indexing movement of the carriage 50 to the right, FIG. 1.

The closure of the contacts K3(3), K3*a*(3) of the limit switch LS-3(3.5) completes a circuit which may be traced from the lead L1 to the lead L5 through the closed contacts KCR–4(25); to the lead L3 through the now-closed contacts K2*a*(6.5); and through the control relay CR–1(2) to the lead L2. The completion of this circuit effects the initial energization of the control relay CR–1(2).

When the control relay CR–1(2) is energized, the contacts KCR–1(6) close and complete a circuit path from the lead L1 to the lead L4, and hence through the relays DR–1(3) and CR–2(4) to the lead L2, so that the relays DR–1(3) and CR–2(4) are simultaneously energized.

The closure of the contacts KCR–1(19) by the operation of the control relay CR–1(2) effects the energization of the timing motor T1(19), which closes the switch T1–1(18) and thereby locks itself into the operative state.

The contacts KCR–1(24) are also opened at this time to ensure that the previously deenergized control relay CR–9(24), and thus the inoperative winding motor M–2(45), does not accidentally operate during this period of the winding operation.

As mentioned above, the closure of the contacts KCR–1(6) by the operation of the control relay CR–1(2) effects the energization of the control relay CR–2(4). When the control relay CR–2(4) is energized, the contacts KCR–2(23) close, but the closure of these contacts does not alter the inoperative state of the control relay CR–9(24) because the contacts KCR–1(24) are now open and hold the control relay CR–9(24) deenergized.

The closure of the contacts KCR–2(25) by the operation of the control relay CR–2(4) effects the energization of the control relay CR–10(25), and thus the contacts KCR–10(26) reclose to lock the control relay CR–10(25) in the operative state. The operation of the control relay CR–10(25) reverses the respective states of the contacts KCR's–10(48, 49) to those states as depicted by FIG. 17, so that the winding motor M–2(45) is conditioned for receiving the rectified slow-driving voltage V2.

The reopening of the contacts KCR–2(37) effects the deenergization of the control relay CR–16(37) which operates to reopen the contacts KCR–16(17) and to reclose the contacts KCR–16(24).

The reopening of the contacts KCR–16(17) and the reclosure of the contacts KCR–16(24) is obviously of no particular consequence at this time, since the control relay CR–6(17) will have previously timed out and will therefore be in a deenergized state and the control relay CR–9(24) will be held deenergized by the now-open contacts KCR–1(24).

The closure of the contacts KCR–2(52) effects the energization of the solenoid SOL1B, FIG. 15, so that the shot pin SP–1, FIG. 1, is driven into the last hole 26*j* in the rod 24 to lock the carriage 50 against movement.

Upon the actuation of the shot pin SP–1 into the last hole 26*j*, the contacts K1(14), FIG. 16, reopen and thereby effect the deenergization of the control relay CR–5(14). When the control relay CR–5(14) is deenergized, the contacts KCR's–5(11, 12) reopen and the contacts KCR–5(23) reclose. The reopening of the contacts KCR's–5(11, 12) ensures that the indexing motor M–1(11.5) will not be accidentally operated during this period, and the reclosing of the contacts KCR–1(24) will continue to hold the control relay CR–9(24) inoperative. The control relay CR–2(4) thereafter deenergizes by the timing-out of the time delay relay DR–1(3) opening the contacts KDR–1(4).

The deenergization of the control relay CR–2(4) reopens the contacts KCR's–2(23, 25, 52) and recloses the contacts KCR–2(37). The reopening of the contacts KCR–2(23) has obviously no effect on the deenergized state of the control relay CR–9(24), the reopening of the contacts KCR–2(25) has no effect on the operative state of the control relay CR–10(25), since this relay is now locked into the operative state through its own locking circuit, and the reopening of the contacts KCR–2(52) has no effect on the position of the shot pin SP–1 in the rod 24, FIG. 15. The reclosure of the contacts KCR–2(37) conditions the hitherto deenergized control relay CR–16(37) for subsequent operation.

The energization of the timing motor T1(19), initiated by the closure of the contacts KCR–1(19) as related previously, operates to close the switches T1–1–T1–8, inclusive, in predetermined sequences and for predetermined periods of time, as indicated by the Timing Chart I of FIG. 18. Referring to FIG. 18, the switches T1–1–T1–8 are listed consecutively under the heading designated "SW," and their respective periods of closure are indicated by horizontal lines that appear opposite their respective designations.

With reference to FIGS. 16–18, upon the initial operation of the timing motor T1(19), the switch T1–1(18) in the locking circuit of the timing motor T1(19) is closed and locks the timing motor T1(19) in the operative state for a complete cycle of operation. The switch T1–7(58) is then closed by the continued operation of the motor T1–(19) and completes a circuit between the leads L1 and L2 through the solenoid SOL4B(58) so that the solenoid SOL4B is energized. The energization of the solenoid SOL4B, FIG. 15, actuates the valve VALVE–4 so that compressed air is diverted into the tube 116 attached to the air cylinder 110 whereupon the shot pin SP–2 is retracted from the slot 98 in the rack 96, FIG. 11, to unlock the rack 96 for movement. The switch T1–7(58), FIG. 17, thereafter reopens to deenergize the solenoid SOL4B(58), but the retracted shot pin SP–2 remains out of locking engagement with the rack 96.

The switch T1–4(55) closes to effect the energization of the solenoid SOL3A(55), and the energization of the solenoid SOL3A, FIG. 15, actuates the valve VALVE–3 whereby the compressed air is diverted into the tube 135

of the air cylinder **130**, FIGS. 1 and 15, such that the rack **96** is driven upward, as viewed in FIG. 11. As the rack **96** moves upward, the feed tube tips **100***a*–**100***d* are rotated clockwise, as viewed in FIGS. 11 and 20, from the twelve o'clock positions relative to the terminals TRM5, TRM7, TRM9 and TRM11 through substantially one and one-quarter revolutions with the axes of revolution of the tips **100***a*–**100***d* concentric with the centers of these terminals. Since the feed tube tips **100***a*–**100***d* are initially at twelve o'clock positions relative to terminals TRM5, TRM7, TRM9 and TRM11, one and one-quarter clockwise revolutions of these tube tips **100***a*–**100***d* will pay out and apply approximately one clockwise turn of wire W onto each terminal TRM5, TRM7, TRM9 and TRM11 since the initial one-quarter revolution of the feed tube tips will not wind wire onto these terminals. After the rack **96**, FIG. 11, rotates the feed tubes **80***a*–**80***d* one and one-quarter turns clockwise, as viewed in that figure, the switch **T1–4(55)**, FIG. 17, opens by operation of the timing motor **T1(19)** and deenergizes the solenoid SOL3A(**55**). The deenergization of the solenoid SOL3A(**55**) serves to stop and hold the rack **96**, FIG. 11, in the upward displaced position. The feed tube tips **100***a*–**100***d* will now have assumed the three o'clock positions relative to the terminals TRM5, TRM7, TRM9 and TRM11, as illustrated by FIG. 20.

The switch **T1–3(52)** closes to complete a circuit from the lead **L15** through the closed contacts **K7(53)** of the presure switch PSW(**53**) and through the solenoid SOL2A(**53**) to the lead **L2** whereupon the solenoid SOL2A is energized. The energization of the solenoid SOL2A, FIG. 15, actuates the valve VALVE–**2** to divert pressurized air into the cylinder **120** such that the post **75** is driven downward, as viewed in FIG. 11. The feed tubes **80***a*–**80***d* issue the wires W—W during downward movement thereof with the post **75**, and the rack **96** is held against movement by the rod **132**.

As soon as the post **75** is initiated for downward movement, as viewed in FIG. 1, the switch **T1–3** reopens and deenergizes the solenoid SOL2A(**53**). At the downward limit of post displacement, the feed tube tips **100***a*–**100***d*, FIG. 20, will be vertically displaced to substantially three o'clock positions relative to the terminals TRM**6**, TRM**8**, TRM**10** and TRM**12**, respectively, with the axes of revolution of the tips **100***a*–**100***d* concentric with the centers of these terminals. In addition, and subsequent to the deenergization of the solenoid SOL2A, the actuation of the valve VALVE–**2**, FIG. 15, by the operation of the solenoid SOL2A functions to divert pressurized air into the bellows **142**. After a predetermined time delay interval during which the switch **T1–3(52)** reopens, the bellows **142** will inflate sufficiently to open the contacts **K7** and close the contacts **K7***a*. Referring now to FIG. 17, it can be seen that the closure of the contacts **K7***a*(**54**) of the pressure switch PSW(**53**) conditions the solenoid SOL2B for a subsequent energization.

The switch **T1–5(56)** now closes to effect the energization of the solenoid SOL3B(**56**). When the solenoid SOL3B, FIG. 15, is energized, the valve VALVE–**3** is actuated thereby to return to its initial position and divert compressed air from the tube **140** into the tube **136** of the air cylinder **130** so that the rack **96** is driven downward as viewed in FIG. 11. This downward movement of the rack **96** rotates the feed tube tips **100***a*–**100***d* counterclockwise, as viewed in FIGS. 11 and 20, substantially one and one-quarter revolutions about the terminals TRM6, TRM8, TRM10 and TRM12. As will be apparent, the initial one-half of a revolution of the feed tubes **80***a*–**80***d* in a counterclockwise direction does not wind wire onto these terminals, but does apply another approximately one-quarter of a clockwise turn of wire W onto each of the terminals TRM5, TRM7, TRM9 and TRM11, increasing the number of clockwise turns of the wires W—W wound on the terminals TRM5, TRM7, TRM9 and TRM11 to a total of approximately one and one-quarter turns. Substantially three-quarters of a turn of wire W is initially applied to each of the terminals TRM6, TRM8, TRM10 and TRM12, respectively, by one complete cycle of feed tube and tip rotation. After the approximately three-quarters of a turn of wire W is wound onto each of the terminals TRM6, TRM8, TRM10 and TRM12, the switch **T1–5(56)** reopens to effect the deenergization of the solenoid SOL3B(**56**).

The switch **T1–6(57)** is then closed by the further rotation of the timing motor **T1(19)** to effect the energization of the solenoid SOL4A(**57**). When the solenoid SOL4A, FIG. 15, is energized, the valve VALVE–**4** is actuated to divert compressed air into the tube **115** of the air cylinder **110** such that the shot pin SP–**2**, FIG. 11, is driven back into the slot **98** in the rack **96**. The rack **96** is thereby locked to the post **75** to preclude any further movement of the fed tubes **80***a*–**80***d*. The feed tubes **80***a*–**80***d* will now be in twelve o'clock positions, as viewed in FIG. 20, relative to the terminals TRM**6**, TRM**8**, TRM**10** and TRM**12**. The switch **T1–6(57)** then opens to deenergize the solenoid SOL4A(**57**).

The switch **T1–8(19)**, FIGS. 16 and 18, is thereafter closed by operation of the timing motor **T1(19)** to effect the simultaneous reenergization of the relays **CR–6(17)** and **DR–2(18)**. The control relay **CR–16(37)** will also be reenergized at this time by the closure of the switch **T1–8(19)**, and the now-energized control relay **CR–16(37)** closes the contacts **KCR–16(17)** and thereby locks itself into the operative state. The switch **T1–8(19)** is now reopened by the operation of the timing motor **T1(19)**; but since the control relay **CR–16(37)** is locked into the operative state, the contacts **KCR–16(17)** will remain closed and hold both of the relays **DR–2(18)** and **CR–16(37)** in their previously established operative states. The reopening of the contacts **KCR–16(24)** does not alter the inoperative state of the control relay **CR–9(24)** because the control relay **CR–9(24)** is maintained deenergized by the open contacts **KCR–1(24)**.

The energized control relay **CR–6(17)** operates to reclose the contacts **KCR's–6(10, 15, 51)**. The closure of the contacts **KCR–6(10)** connects the lead **L1** to the lead **L3**. The closure of the contacts **KCR–6(15)** effects the energization of the ratchet relay **RR(15)**.

When the ratchet relay **RR(15)** is energized, the respective states of the contacts **KRR's (27, 29, 31)** are reestablished to those respective states as depicted by the drawings. Thus, the contacts **KRR(27)** and **KRR(31)** will be opened and the contacts **KRR(29)** will be closed.

The opening of the contacts **KRR(27)** by the operation of the ratchet relay **RR(15)** deenergizes the control relay **CR–11(27)** so that the contacts **KCR's–11(35, 36, 36.5, 37, 38)** reasume those respective states as depicted by FIG. 17. The closure of the contacts **KRR(29)** establishes a complete circuit path from the lead **L1** through the closed contacts **KCR–8(29)** through the control relay **CR–12(28)** to the lead **L2** so that the control relay **CR–12(28)** is energized. The operation of the control relay **CR.12(28)** is of no present import, however, because the control relay **CR–16(37)** was previously operated by the closure of the switch **T1–8(19)** and remains in the operative state by virtue of the closure of the locking circuit contacts **KCR–16(17)**.

The reopening of the contacts **KRR(31)** effects the deenergization of the control relay **CR–14(31)** and this relay operates to reestablish the contacts **KCR's–14(45, 46, 47, 49)** in those respective states depicted by FIG. 17. The winding motor **M–2(45)** is now conditioned for rotating the shunt plate **180** counterclockwise, FIG. 20, and at the slow winding speed.

The closure of the contacts **KCR–6(51)** by the operation of the control relay **CR–6(17)** energizes the solenoid SOL1A(**51**). The solenoid SOL1A, FIG. 15, when energized, actuates the valve VALVE–**1** to retract the shot pin SP–**1** from locking engagement with the rod **24** and thus releases the carriage for indexing movement, as

viewed in FIG. 1. As the shot pin SP–1 is retracted, the limit switch LS–1(14), FIG. 16, operates to close the contacts K1(14) and the closure of the contacts K1(14) effects the energization of the control relay CR–5(14). When the control relay CR–5(14) is operated, the contacts KCR's–5(11, 12) close and the contacts KCR–5(23) open.

The relay DR–2(18) times out and reopens the contacts KDR–2(17) to deenergize the control relay CR–6(17). The reopening of the contacts KCR–6(10) is of no consequence at this time, since the contacts K2*a*(6.5) remain closed by the actuator rod 45 riding against the outer periphery of the rod 24. The reopening of the contacts KCR's–6(15, 51) is also of no present consequence, as will be apparent.

The switch T1–2(24) now closes to energize the control relay CR–7(20) and this relay locks itself in by virtue of closing the contacts KCR–7(21) in the CR–7(21) locking circuit. In addition, the control relay CR–8(21) is energized and is also locked into the operative state because of the connection of the relay CR–8(21) across the terminals of the relay CR–7(20).

The switch T1–2(20) reopens after the control relays CR–7(20) and CR–8(21) are operated but the reopening of the switch T1–2(20) does not change the operative states of the relays CR–7(20) and CR–8(21) since both of these relays have been locked into their operative states by the closure of the contacts KCR–7(21).

The operation of the control relay CR–7(20) closes the contacts KCR–7(22) but the closure of these contacts has no effect on the operative state of the timing motor T2(22) because the contacts K4(13) are open. The contacts KCR–7(12) close to complete a circuit that may be traced from the lead L1 through closed contacts KCR–4(25) to the lead L5, and hence to the lead L3 through the closed contacts K2*a*(6.5); through the now-closed contacts KCR–7(12), KCR–4(12) and KCR–5(12) in the armature lead LA to the indexing motor M–1(11.5), so that the indexing motor M–1(11.5) is energized to drive the carriage 50, FIG. 1, to the left.

The operation of the control relay CR–8(21), FIG. 16 reverses the states of the contacts KCR's–8(27, 28, 29, 30) from those states as depicted by FIG. 16. This reversal of the states of the contacts KCR's–8(27, 28, 29, 30) coupled with the respective open and closed states of the contacts KRR(27) and KRR(29) effects the deenergization of the control relay CR–12(28) and additionally effects the energization of the control relay CR–13(30). The deenergization of the control relay CR–12(28) operates to reverse the states of the contacts KCR's–12(32.5, 33, 35, 38) to those states as depicted by FIG. 17 thereby destroying the closed contact patterns that hitherto conditioned the control relays CR–15(33) and CR–16(37) for operation at the counts of 519 and 510, respectively. It may be noted that the control relay CR–16(37) is locked into the operative state at this time.

The closure of the contacts KCR's–13(33, 33.5, 35.5) sets up two closed contact patterns in the counter 240 for providing the counts of 361 and 352, respectively, as should be apparent.

Description of the operation for winding wires onto coil forms of even number rows

The carriage then proceeds to index to the left, as viewed in FIG. 1, toward the coil forms CF9, CF25, CF41 and CF57, FIG. 20, with the feed tubes 80*a*–80*d* traveling in positions indicated by the phantom lines in FIG. 20 and the coil forms CF9, CF25, CF41 and CF57 will be in a bottom dead center position from the previous winding cycle of the coil forms CF8, CF24, CF40, and CF56. As the carriage 50, FIG. 1, is displaced to the left by the indexing motor M–1, the contact button 48 of the limit switch LS–3 is released and the limit switch LS–3(3.5), FIG. 16, operates to reopen the contacts K3(3), K3*a*(3) and to reclose the contacts K3(3), K3*b*(4). When the contacts K3(3), K3*a*(3) reopen, the control relay CR1(2) is deenergized and operates to reopen the contacts KCR–1(6) and to reclose the contacts K3(3), K3*b*(4). When the contacts K3(3), K3*a*(3) reopen, the control relay CR1(2) is deenergized and operates to reopen the contacts KCR–1(6) and to reclose the contacts KCR–1(24). It may be noted that the indexing of the carriage 50 to the left causes the feed tubes 80*a*–80*d* to apply an additional approximately one-quarter of a turn of wire W onto each of the terminals TRM6, TRM8, TRM10 and TRM12, so that each of these terminals is finally wound with a total of substantially one turn of wire.

The reopening of the contacts KCR–1(6) has no effect on the operative state of the relay CR–2(4) since this relay has been previously deenergized by the timing out of the time delay relay DR–1(3). The reopening of the contacts KCR–1(19) has no effect on the energization of the timing motor T1(19) since the timing motor T1(19) is locked into the operative state by the closure of the switch T1–1(18) in the T1(19) locking circuit. The reclosure of the contacts KCR–1(24) has no effect on the operative state of the control relay CR–9(24) since the contacts KCR–2(23) and KCR–5(23) are open and the contacts KCR–9(24) are also open at this time.

After the contacts KCR–1(19) reopen, the timing motor T1(19) deenergizes itself by reopening the switch T1–1(18).

The carriage 50, FIG. 1, continues to index to the left, as viewed in that figure, until the actuator rod 45, FIG. 1, drops back into the last notch 25*h* in the rod 24; and consequently, the contacts K2*a*(6.5), FIG. 16, will open and the contacts K2(7) will close. At this time, the feed tube. tips 100*a*–100*d* will be in approximately twelve o'clock positions, as viewed in FIG. 20, with respect to the coil forms CF9, CF25, CF41 and CF57. As soon as the circuit between the leads L3 and L5 is broken by the opening of the contacts K2*a*(7), the indexing motor M–1(11.5) is deenergized and stops.

The closure of the contacts K2(7), FIG. 16, effects the simultaneous energization of the relays DR–1(3) and CR–2(4). The control relay CR–2(4) operates to close the contacts KCR–2(23) and thereby conditions the control relay CR–9(24) for operation, the relay CR–9(24) being held in an inoperative state by the now-open contacts KCR–5(23). The closure of the contacts KCR–2(25) effects the energization of the control relay CR–10(25) which thereupon operates to open the contact KCR–10(48) and to close the contacts KCR–10(49) so that the winding motor M–2(45) is now conditioned for a fast winding cycle. The contacts KCR–2(37) reopen to effect the deenergization of the control relay CR–16(37).

With the control relay CR–16(37) deenergizes, the contacts KCR–16(17) are reopened and the contacts KCR–16(24) are reclosed. The reopening of the contacts KCR–16(17) does not alter the state of the relay CR–6(17) since the time delay relay DR–2(18) previously timed out this relay. The reclosure of the contacts KCR–16(24) conditions the locking circuit of the control relay CR–9(24).

The energization of the control relay CR–2(4) also operates to reclose the contacts KCR–2(52) which in turn effect the energization of the solenoid SOL1B(52). The solenoid SOL1B, FIG. 15, thereupon actuates the valve VALVE–1 such that the shot pin SP–1 is driven into the next to last hole 26*i* in the rod 24, FIG. 1 to lock the carriage 50 against movement.

The movement of the shot pin SP–1 into the hole 26*i* in the rod 24, FIG. 15, actuates the limit switch LS–1(14), FIG. 16, such that the contacts K1(14) reclose and effect the energization of the control relay CR–5(14). The control relay CR–5(14) then operates to reopen the contacts KCR's–5(11, 12) and the reopening of these contacts ensures against the accidental operation of the indexing motor M–1(11.5) at this time. In addition, the

contacts KCR–5(23) are operated to reclose and effect the energization of the control relay CR–9(24).

The control relay CR–9(24) thereupon operates to reopen the contacts KCR–9(42) to release the brake BRK(42) and thus the winding motor M–2(45) for rotation. Concurrently, the contacts KCR–9(44) reclose and effect the energization of the winding motor M–2(45). After the control relay CR–9(24) locks into the operative state, the time delay relay DR–1(3) will time-out and reopen the contacts KDR–1(14) to deenergize the control relay CR–2(4). The contacts KCR's–2(23, 25, 51, 52) will now reassume those respective states as depicted by FIGS. 16 and 17.

It may be recalled that the previous closure of the switch T1–8(19) effected the energization of the control relay CR–6(17) which thereupon closed the contacts KCR–6(15) to effect the energization of the ratchet relay RR(15) so that the contacts KRR(31) were operated to close. The closure of the contacts KRR(31) effected the energization of the control relay CR–14(31) so that the contacts KCR's–14(45, 46, 47, 49) were operated to condition the winding motor M–2(45) for orbiting the shunt plate in a counterclockwise direction as viewed in FIG. 20.

The winding motor M–2(45) then proceeds to orbit the shunt plate 180, FIG. 20, in a counterclockwise direction, as viewed in this figure, and at the fast winding speed; and the counter 240, FIG. 17, will then proceed to rotate downwardly from a count of 510 to the counts of 361 and 352, respectively. When the counter 240 registers a count of 361, the control relay CR–15(33) will be energized to reopen the contacts KCR–15(26) and thereby effect the deenergization of the control relay CR–10(25). The control relay CR–10(25) then operates to reclose the contacts KCR–10(37) and to condition the control relay CR–16(37) for operation when the counter 240 subsequently registers a count of 352. In addition, the contacts KCR–10(48) are reclosed and the contacts KCR–10(49) are reopened by the operation of the control relay CR–10(25) so that the slow winding voltage V2 is now applied to the winding motor M–2(45). The winding motor M–2(45) then proceeds to rotate at the slow winding speed to complete the 39 turns winding cycle of the coil forms CF9, CF25, CF41 and CF57. When the count of 352 is registered by the counter 240, the control relay CR–16(37) operates to reclose the contacts KCR–16(17) in the CR–16(37) locking circuit, and to reopen the contacts KCR–16(24) in the CR–9(24) locking circuit, whereupon the control relay CR–16(37) locks into the operative state and the control relay CR–9(24) deenergizes. The feed tube tips 100*a*–100*d* will now be in six o'clock positions relative to the coil forms CF9, CF25, CF41 and CF57 because of the required final one-half revolution of the winding motor M–2(45).

The deenergization of the control relay CR–9(24) operates to reopen the contacts KCR–9(24) in the CR–9(24) locking circuit and further operates to reclose the contacts KCR–9(41) so that the brake BRK(42) is again applied to stop and prevent the further rotation of the winding motor M–2(45). Simultaneously with the application of the brake BRK(42) to the winding motor M–2(45), the contacts KCR–9(44) will reopen to effect the deenergization of the motor M–2(45).

The reclosure of the contacts KCR–16(17) effects the reenergization of the control relay CR–6(17) which thereupon operates to reclose the contacts KCR's–6(10, 15, 51). The reclosure of the contacts KCR–6(10) reestablishes a circuit path between the leads L1 and L3. The reclosure of the contacts KCR–6(15) effects the reenergization of the ratchet relay RR(15), and the reclosure of the contacts KCR–6(51) effects the reenergization of the solenoid SOL1A(51).

The reenergization of the ratchet relay RR(15) operates to reverse the respective states of the contacts KRR's (27, 29, 31) from those respective states as depicted by FIGS. 16 and 17. The reclosure of the contacts KRR(27) completes a circuit path from the lead L1 through the now-closed contacts KCR–8(28), through the control relay CR–12(28) to the lead L2 so that the control relay CR–12(28) is energized. The reopening of the contacts KRR(29) effects the deenergization of the control relay CR–13(30) so that the hitherto closed contact patterns provided by the contacts KCR's–13(33, 33.5, 33.5) corresponding to the partial counts of 61 and 52 will now be destroyed.

The energization of the relay CR–12(28) will reestablish the two closed contact patterns in the counter 240 corresponding to the counts of 501 and 510, respectively. The closure of the contacts KRR(31) will effect the reenergization of the control relay CR–14(31) which thereupon operates to reverse the respective states of the contacts KCR's–14(45, 46, 47, 49) from those states as depicted by FIG. 17 so that the winding motor M–2(45) is now conditioned for orbiting the shunt plate 180 in a clockwise direction. The closure of the contacts KCR–6(51) by operation of the control relay CR–6(17) initiates the retraction of the shot pin SP–1, FIG. 1, from locking engagement with the hole 26*i* in the rod 24 and simultaneously actuates the limit switch LS–1 to close the contacts K1(14), FIG. 16. The closing of the contacts K1(14) effects the energization of the control relay CR–5(14) so that the contacts KCR's–5(11, 12) are reclosed and the contacts KCR–5(23) are reopened. The closure of the contacts KCR–5(12) coupled with the now-closed states of the contacts KCR–6(10) and KCR–7(12) and the closed state of the contacts KCR–4(12) will complete a circuit from the lead L1 to the armature lead LA of the indexing motor M–1(11.5). The indexing motor M–1(11.5) will thereupon be energized to drive the carriage 50 to the left as viewed in FIGS. 1 and 20 and toward the coil forms CF10, CF26, CF42 and CF58.

It should now be apparent that when the feed tube tips 100*a*–100*d*, FIG. 20, are indexed to substantially six o'clock positions relative to the coil forms CF10, CF26, CF42 and CF58, respectively, the actuator rod 45, FIG. 7, will again drop into the notch 25*g* in the rod 24 and thereby effect the reenergization of the control relay CR–2(4), FIG. 16. The control relay CR–2(4) then initiates the operation of the control relay CR–10(25) which operates to again reverse the states of the contacts KCR's–10(48, 49) from those states as depicted by FIG. 17 and condition the winding motor M–2(45) for a fast winding cycle. In addition, the contacts KCR–10(37) reopen to preclude the energization of the control relay CR–16(37) during this period. Further, the operation of the control relay CR–2(4) will initiate the locking of the carriage against movement by operating to close the contacts KCR–2(52), and will subsequently condition the control relay CR–9(24) for initiating the fast winding cycle by operating to close the contacts KCR–2(23). The movement of the shot pin SP–1, FIG. 15, back into the hole 26*h* in the rod 24 will initiate the deenergization of the control relay CR–5(14) and the control relay CR–5(14) thereupon operates to close the contacts KCR–5(23) and effect the energization of the control relay CR–9(24). Consequently, the winding motor M–2(45) is initiated to orbit the shunt plate 180 clockwise, as viewed in FIG. 20, at the fast winding speed. The control relay CR–2(4) is thus deenergized by the timing out of time delay relay DR–1(3) operating to reopen the contacts KDR–1(4).

The counter 240, FIG. 17, will also be rotated by the winding motor M–2(45) from the count of 361 to a count of 501. The closed contact pattern provided by the closed contacts KCR–12(35) in the hundreds counting level of the counter 240, the closed contacts KCR–12(33) in the tens counting level and the closed contacts KCR–12(38) in the units counting level will establish a circuit path from the lead L1 through the contact element 246 and the contacted terminal

numbered 0 in the tens counting level and through the contact element 244 and the contacted terminal numbered 1 in the units counting level, through the leads L11 and L10, through the control relay CR–15(33) to the lead L2. The control relay CR–15(33) then operates to deenergize the control relay CR–10(25) so that the contacts KCR's–10(48 49) are operated to reassume those respective states as depicted by FIG. 17 whereby the winding voltage V2 is impressed to the winding motor M–2(45). In addition, the contacts KCR–10(37) reclose to condition the control relay CR–17(37) for operation. The winding motor M–2(45) then proceeds to orbit the shunt plate 180 clockwise, FIG. 20, 39.5 times until the counter 240, FIG. 17, registers a count of 510 whereupon the control relay CR–16(37) is energized. The feed tube tips 100*a*–100*d*, FIG. 20, at the end of this winding cycle wil again be in twelve o'clock positions relative to the coil forms CF10, CF26, CF42 and CF58, respectively.

The winding operation for the remaining coil forms of the even numbered rows of coil forms will continue until each consecutive coil form is wound with substantially 39 turns of wire W and with a winding pattern that alternates with each consecutive coil form. The carriage 50, FIGS. 1 and 20, will proceed to index to the left until the coil forms CF16, CF32, CF48 and CF64 are each wound with substantially 39 clockwise turns of wire W.

Description of operation for the final winding of wires onto terminals TRM1–TRM4

After completing the winding cycle for the coil forms CF16, CF32, CF48 and CF64, the carriage 50, FIG. 1, will proceed to index to the left until the limit switch LS–4 is again actuated by the carriage contacting and depressing the contact button 49 of this switch. The feed tube tips 100*a*–100*d* will have been oriented in twelve o'clock positions relative to those coil forms at the termination of that winding cycle.

Referring to FIG. 16, the contacts K2*a*(6.5) will be closed by the actuator rod 45 riding against the outer periphery of the rod 24 and the contacts KCR–7(12), KCR–4(14) and KCR–5(12) will be closed to provide the desired circuit path for energizing the indexing motor M–1(11.5). When the contacts K4(13) of the limit switch LS–4(13) close, the control relay CR-4(13) operates to close the contacts KCR–4(5) and to open the contacts KCR–4(25). The closure of the contacts KCR–4(5) does not effect the energization of the control relay CR–2(4) because the contacts KW(5) of the pushbutton switch WIND(5) are open. The opening of the contacts KCR–4(25) effects the deenergization of the indexing motor M–1(11.5) so that the motor M–1(11.5) stops indexing the carriage 50 to the left, as viewed in FIG. 1. The feed tube tips 100*a*–100*d*, FIG. 20, will now be moved to substantially seven o'clock positions relative to the terminals TRM1–TRM4.

In addition, the closure of the contacts K4(13) completes a circuit path from the lead L1 through the now-closed contacts KCR–7(22) through the timing motor T2(22) to the lead L2 and the timing motor T2(22) is thereby energized to operate.

The timing motor T2(22) operates during one comple cycle to reverse the respective states of the switches T2–1–T2–8, inclusive, in prescribed sequences and for prescribed time intervals as indicated by the Timing Chart 2 of FIG. 19. The switches T2–1–T2–8 are listed under the heading designated "SW" and the period during the T2 cycle when each switch is opened or closed as the case may be is indicated by a horizontal line that appears opposite each switch. Referring then to FIGS. 16, 17 and 20, the initial operation of the timing motor T2(22) closes the switch T2–1(23) which serves to lock the timing motor T2(22) in an operative state for a complete cycle of operation.

The switch T2–7(16) is thereafter momentarily closed by the operation of the timing motor T2(22) to effect the energization of the ratchet relay RR(15). The ratchet relay (RR(15) operates to close the contacts KRR's(27, 31) and to open the contacts KRR(29). The closure of the contacts KRR(27) coupled with the now-closed state of the contacts KCR–8(28) effects the energization of the control relay CR–12(28) and this relay partially conditions the counter 240 for energizing the control relay CR–16(37) at a count of 518 by operating to close the contacts KCR–12(35) in the hundreds counting level of the counter 240 and the contacts KCR–12(33) in the tens counting level. The opening of the contacts KRR(29) effects deenergization of the hitherto energized control relay CR–13(30). The control relay CR–11(27) is held inoperative by the now-open contacts KCR–8(27). The closure of the contacts KRR(31) effects the energization of the control relay CR–14(31) which then operates to reverse the contacts KCR's–14(45, 46, 47, 49) from those states as established at the termination of the previous coil form winding cycle. At the termination of the last coil form winding cycle, the control relay CR–14(31) was deenergized to reestablish the states of the contacts KCR's–14(45, 46, 47, 49) to those respective states as indicated by FIG. 17 so that the winding motor M–2(45) was conditioned for orbiting the shunt plate 180, FIG. 20, counterclockwise as viewed in that figure. The reenergization of the control relay CR–14(31), FIG. 17, by operation of the switch T2–7(16) now condiions the winding motor M–2(45) for orbiting the shunt plate 180 in a clockwise direction, as viewed in FIG. 20. The reopening of the switch T2–7(16) conditions the ratchet relay RR(15) for subsequent operation.

The switch T2–8(51) is then opened to prevent energization of the solenoid SOL1A(51), and the switch T2–8(51.5) is closed to effect the energization of the solenoid SOL1B(52). The solenoid SOL1B(52) operates to drive the shot pin SP–1, FIG. 1, into the first hole 26*a* in the rod 24 to lock the carriage 50 against further movement. Since the horizontal spacing between the centers of the holes 26*a* and 26*b* is slightly greater than the horizontal distances, FIG. 20, between the centers of the coil forms CF16, CF32, CF48 and CF64 and the centers of the terminals TRM1–TRM4, with the shot pin SP–1 in the hole 26*a*, the feed tips 100*a*–100*d* will assume substantially seven o'clock positions relative to the terminals TRM1–TRM4, as indicated by the phantom lines in FIG. 20. The switches T2–8(51) and T2–8(51.5) maintain their respective closed and open states, as depicted by FIG. 17, until the termination of the operation of the switch T2–6(35), as an examination of FIG. 19 will bear out.

The switch T2–3(53) then momentarily closes to effect the energization of the solenoid SOL2B(54) through the now-closed contacts K7*a*(54) of the pressure switch PSW(53). When energized, the solenoid SOL2B, FIG. 15, returns the valve VALVE–2 to the position illustrated in that figure so that the post 75, FIG. 11, is driven upward as viewed in FIG. 11 through a vertical displacement, FIG. 20, substantially equal to the vertical distances between the respective centers of the coil forms CF1, CF16; CF17, CF32; CF33, CF48; and CF49, CF64. The upward movement of the post 75 carries the feed tube tips 100*a*–100*d* to substantially eleven o'clock positions, as viewed in FIG. 20, relative to the terminals TRM1–TRM4, and thus back to their START positions. The return actuation of the valve VALVE–2, FIG. 15, back to the position illustrated in that figure, allows the air in the bellows 142 to exhaust into the tubes 122 and 141, and thus the bellows 142 retract with a predetermined time delay that is sufficient to permit the reopening of the switch T2–3(53) prior to the reopening of the contacts K7*a*(54) and the reclosing of the contacts K7(53). The reclosure of the contacts K7(53) reconditions the solenoid SOL2A(53) for subsequent energization.

The switch T2–6(35) then closes to complete a circuit path from the terminal numbered 8 in the units counting level of the counter 240, through the control relay CR–16(37) to the lead L2, through the now-closed contacts KCR–10(37) and KCR–2(37). The closure of the switch T2–6(35) coupled with the previous closure of the contacts KCR–12(35) in the hundreds counting level and the closure of the contacts KCR–12(33) in the tens counting level as related hereinabove conditions the control relay CR–16(37) for energization when the counter registers a count of 518.

The movement of the shot pin SP–1 back into the rod 24 caused by the closure of the switch T2–8(51.5), FIG. 17, will have now actuated the limit swich LS–1(14) so that the contacts K1(14), FIG. 16, will have opened to effect the deenergization of the control relay CR–5(14). The deenergization of the control relay CR–5(14) operates to reopen the contacts KCR's–5(11, 12) and to reclose the contacts KCR–5(23). The switch T2–5(8) now momentarily closes to complete a circuit path between the leads L1 and L2 through the relays DR–1(3) and CR–2(4) so that the control relay CR–2(4) is energized. The energization of the control relay CR–2(4) operates to reclose the contacts KCR's–2(23, 25, 52) and to reopen the contacts KCR–2(37). The reclosure of the contacts KCR–2(25) is of no consequence at this time because the contacts KCR–4(25) and KCR–6(10) are open and, therefore, the control relay CR–10(25) remains inoperative. The contacts KCR's–10(48, 49) thus remain in those respective states indicated by FIG. 17, and the winding motor M–2(45) is thereby conditioned for orbiting the shunt plate 180 at the slow winding speed.

The closure of the contacts KCR–2(52) does not alter the state of the solenoid SOL1B(52) because the closure of the contacts KCR–2(52) coincides with the period of closure of the switch T2–8(51.5) and the solenoid SOL1B(52) remains energized as a result.

The opening of the contacts KCR–2(37) renders the control relay CR–16(37) deenergized so that the contacts KCR–16(17) reopen and the contacts KCR–16(24) reclose. The closure of the contacts KCR–2(23) coupled with the now-closed state of the contacts KCR–5(23) effects the energization of the control relay CR–9(24).

The control relay CR–9(24) then operates to open the contacts KCR–9(42) and to close the contacts KCR–9(44). The opening of the contacts KCR–9(42) effects the release of the brake BRK(42) so that the winding motor M–2(45) is released for rotation. The closure of the contacts KCR–9(44) initiates the rotation of the winding motor M–2(45). The motor M–2(45) thereupon proceeds to orbit the shunt plate 180, FIG. 20, at the slow winding speed and in a clockwise direction, as viewed in this figure.

After the control relay CR–9(24), FIG. 16, locks into the operative state, the control relay CR–2(4) is deenergized by the time delay relay DR–1(3) timing out and reopening the contacts KDR–1(4). The reopening of the contacts KCR's–2(23, 25, 52) is of no importance at this time, as will be apparent. The reclosure of the contacts KCR–2(37), however, conditions the control relay CR–16(37) for energization when the now operative counter 240 registers a count of 518.

The winding motor M–2(45) continues the slow winding of the wires W—W onto the terminals TRM1–TRM4 until the counter 240 registers the count of 518; whereupon, the control relay CR–16(37) will be energized to reclose the contacts KCR–16(17) and to reopen the contacts KCR–16(24). The reclosure of the former contacts KCR–16(17) locks the control relay CR–16(37) in an operative state and also effects the reenergization of the control relay CR–6(17). The reopening of the contacts KCR–16(24) breaks the locking circuit of the control relay CR–9(24) and effects the deenergization of this relay. The deenergized control relay CR–9(24) operates to reclose the contacts KCR–9(42) and to reopen the contacts KCR–9(44) and this operation obviously stops and precludes the further orbiting of the shunt plate 180 by the winding motor M–2(45).

The reenergization of the control relay CR–6(17) by the reclosure of the contacts KCR–16(17) operates to reclose the contacts KCR's–6(10, 15, 51). The reclosure of the contacts KCR–6(10) has no effect on the operation of the indexing motor M–1(11.5) since the contacts KCR–4(12) are now open. The reclosure of the contacts KCR–6(15) effects the reenergization of the ratchet relay RR(15) which thereupon operates to reestablish the states of the contacts KRR's(27, 29, 31) to those respective states as depicted by FIGS. 16 and 17. The reclosure of the contacts KRR(29) coupled with the now-closed state of the contacts KCR–8(30) effects the reenergization of the control relay CR–13(28). The reenergization of the control relay CR–13(28) operates to reestablish two closed contact paths through the counter 240 corresponding to the counts of 361 and 352, respectively. However, and as will become apparent subsequently, the reenergization of the control relay CR–13(28) will be of no significance to the operation of the counter 240 during this period. The reopening of the contacts KRR(27) effects the deenergization of the control relay CR–12(28), and the hitherto closed contact pattern in the counter 240 corresponding to the count of 510 is again destroyed. The hitherto deenergized control relay CR–11(27) will be maintained deenergized during this period by the now-open contacts KCR–8(27).

The reopening of the contacts KRR(31) effects the deenergization of the control relay CR–14(31) which thereupon operates to reverse the respective states of the contacts KCR's–14(45, 46, 47, 49) so that these contacts resume those respective states as depicted by FIG. 17. The winding motor M–2(45) is now conditioned for orbiting the shunt plate 180 counterclockwise, as viewed in FIG. 20.

The reclosure of the contacts KCR–6(51) will not effect the reenergization of the solenoid SOL1A(51) because the switch T2–8(51) is still held open at this time by the operation of the timing motor T2(22) and therefore the shot pin SP–1, FIG. 15, will remain in locking engagement with the rod 24. The control relay CR–6(17) is now deenergized by the operation of the time delay DR–2(18) timing out and reopening the contacts KDR–2(17). The deenergization of the control relay CR–6(17) operates to reopen the contacts KCR's–6(10, 15, 51).

The switch T2–6(35) is thereafter opened by the operation of the timing motor T2(22) to reopen the circuit path between the units terminal numbered 8 in the counter 240 and the contacts KCR–10(37). The reopening of the switch T2–6(35) has no effect on the now operative state of the control relay CR–16(37). The reopening of the switch T2–6(35) coincides with the reclosure of the switch T2–8(51) and with the reopening of the switch T2–8(51.5). The reclosure of the switch T2–8(51) and the reopening of the switch T2–8(51.5) serve to condition the solenoids SOL1A and SOL1B, respectively, for subsequent operations.

The switch T2–4(54) is thereafter momentarily closed to complete a circuit from the lead L15 through the now-closed contacts K7(53) through the solenoid SOL2A(53) to the lead L2 so that the solenoid SOL2A(53) is energized. The energization of the solenoid SOL2A, FIG. 15, moves the valve VALVE–2 to divert compressed air from the tube 140 into the tube 122, which initiates the actuation of the pressure switch PSW and drives the post 75 downward, as viewed in FIG. 11. The feed tube tips 100*a*–100*d*, FIG. 20, are driven vertically downward, as indicated by the phantom lines in FIG. 20, by this downward movement of the post 75. The final positions of the feed tube tips 100*a*–100*d* are designated FINISH (FIG. 20), and the reason for moving the tips 100*a*–100*d* back to positions designated FINISH will be disclosed subsequently. The switch T2–4(34), FIG. 17, then opens fol-

lowed by the time-delayed opening of the contacts K7(53) and the time-delayed closing of the contacts K7*a*(54) of the actuated pressure switch PSW. Since the switches T1–3(52), T2–3(53) and T2–4(54) are now open, the reclosure of the contacts K7*a*(54) has no effect on the deenergized state of the solenoid SOL2B(54).

The timing motor T2(22) momentarily opens the switch T2–2(21) which breaks the locking circuit of the control relays CR–7(20) and CR–8(21) so that both of these relays deenergize. The deenergization of the control relay CR–7(20) effects the reclosure of the contacts KCR–7(11) and the reopening of the contacts KCR–7(12). The reclosure of the contacts KCR–7(11) conditions the indexing motor M–1(11.5) for driving the carriage 50 to the right, as viewed in FIG. 1, and the reopening of the contacts KCR–7(12) is obviously of no immediate consequence.

The simultaneous deenergization of the control relay CR–8(21) operates to reestablish the respective states of the contacts KCR's–8(27, 28, 29, 30) to those respective states as illustrated by FIG. 16. The now-open state of the contacts KRR(27) and KCR–8(28) however maintains the control relay CR–11(27) deenergized. The closure of the contacts KCR–8(29) coupled with the now-closed state of the contacts KRR(29) reenergizes the control reay CR–12(28) so that the closed contact pattern corresponding to a count of 510 is reestablished by the counter 240. The control relay CR–13(30) is deenergized by the reopening of the contacts KCR–8(30), and the closed contact patterns of the counter 240 corresponding to the counts of 61 and 52, respectively, are thereby destroyed. Thus, the winding motor M–2 is now conditioned for orbiting the shunt plate 180, FIG. 20, in a counterclockwise direction, as viewed in that figure, from the count of 518 to the count of 510.

The timing motor T2(22) finally times out by the opening of the switch T2–1(23). The opening of the switch T2–1(23) coupled with the previous opening of the contacts KCR–7(22) effects the deenergization of the timing motor T2(22) and this motor thereupon stops.

Referring again to FIG. 1, the free ends of the wires W—W that are wrapped around the post 190 may now be unwound and the locking slide 188 may be slid to the right, as viewed in that figure, to permit the removal of the shunt plate 180 from the plate holder 178. The shunt plate 180, FIG. 1, may then be removed from the plate holder 178 by the operator and the wires W—W that issue from the feed tubes 80*a*–80*d* may be cut to desired lengths. In addition, the wires W—W, FIG. 20, that now extend between the terminals TRM5, TRM6–TRM11, TRM12, respectively, may be cut and each severed end may then be manually wrapped around each of the terminals TRM5–TRM12.

The shunt plate 180 is turned 180° about its horizontal axis and then 90° clockwise about its vertical axis, so that the terminals and coil forms assume those respective positions as illustrated by FIG. 21. The shunt plate 180 may be vertically reinserted into the plate holder 178 for another 39 turns winding operation.

The initial positions of the tube tips 100*a*–100*d* relative to the terminals TRM1*a*–TRM4*a*, respectively, are designated START. Since the terminals TRM1*a*–TRM4*a* are now located beyond the .354 inch orbital radius of the shunt plate 180, the shunt plate will be caused to rotate two revolutions counterclockwise, but the four wires W—W obviously will not be applied to these terminals. The 39 turns winding operation of the coil forms CF1–CF64 will then proceed in the same manner as discussed hereinabove with respect to the reverse side of the shunt plate 180. However, the even number rows headed by the coil forms CF2, CF4, CF6 and CF8 will now be wound first by the indexing of the feed tube tips 100*a*–100*d* to the right, as viewed in FIG. 21, and the indexing of the tube tips 100*a*–100*d* will continue until all the remaining coil forms of the even number rows are wound with 39 turns of wire. The directions of winding are indicated by the arcuate arrows shown directly underneath the coil forms of the first two rows.

The tube tips 100*a*–100*d* will be further indexed to twelve o'clock positions relative to the terminals TRM6*a*, TRM8*a*, TRM10*a* and TRM12*a*, respectively, and rotated substantially one and one-quarter revolutions clockwise to apply substantially one clockwise turn of the wires W—W onto these terminals. Subsequently the tips 100*a*–100*d* will be displaced vertically upward to positions for winding substantially one counterclockwise turn of the wires W—W onto the terminals TRM5*a*, TRM7*a*, TRM9*a*, and TRM11*a*, respectively. Thereafter, the tube tips 100*a*–100*d* will index from right to left, as viewed in FIG. 21, to apply 39 turns onto the coil forms of the odd number rows headed by the coil forms CF64, CF62, CF60 and CF58, respectively. The final successive downward and upward displacements of the tube tips 100*a*–100*d* to the FINISH positions conditions the apparatus 10 for receiving another eight-by-eight shunt plate since the FINISH positions of the tube tips 100*a*–100*d* in FIG. 21 are the same as the START positions of the tube tips in FIG. 20.

Assuming that there are no terminals onto which the wires W—W may be initially wound, the unattached wires W—W will extend to the left, as seen in FIG. 21, from the coil forms CF2, CF4, CF6 and CF8 so that after the wound shunt plate 180 is removed from the apparatus 10, the four wires W—W that extend from the coil forms CF2, CF4, CF6 and CF8 may be connected to other terminals (not shown) of other circuits or shunt plates. In addition, the vertical downward displacement, FIG. 21, of the tube tips 100*a*–100*d* at the termination of every alternate winding operation conditions the apparatus 10 for winding other types of shunt plates that may have terminals located within .354 inch of the tips 100*a*–100*d*.

Another winding apparatus which may be of similar construction to that of the apparatus 10 may then receive the shunt plate 180 for winding 18 turns of either two or four layers of wire onto the 39 turns of wire that are now wound on both ends of the coil forms CF1–CF64.

The aforedescribed apparatus 10 obviously may be modified by those skilled in the art to wind any predetermined number of turns of wire onto the coil forms and a predetermined but lesser number of turns onto the terminals that comprise this type of shunt plate.

Description of the operation for resetting the apparatus

For reasons disclosed hereinabove, the initiation of the next winding operation is contingent upon the carriage 50, FIG. 1, being indexed to the left far enough to contact and depress the contact button 49 of the limit switch LS–4 so that the contacts K4(13), FIG. 16, are closed to effect the energization of the control relay CR–4(13). If it does not appear to the operator that the carriage 50 is depressing the contact button 49 by virtue of being indexed to the extreme left position of the apparatus 10, as viewed in FIG. 1, it will be necessary for the operator to reset the apparatus 10 to that position.

The resetting of the apparatus 10 is effected by the operator depressing the pushbutton switch RESET(7), FIG. 16. The depression of the switch RESET(7) will effect the momentary opening of the contacts KR(7) and the momentary closure of the contacts KR(10). The opening of the contacts KR(7) ensures that the control relay CR–2(4) remains inoperative during the reset operation.

Since there will be no notches for the actuator rod 45 to ride into when the carriage 50 is adjacent the left end of the apparatus 10, as viewed in FIG. 1, the actuator rod 45, FIG. 16, will be riding upon the outer periphery of the rod 24, and, therefore, the contacts K2*a*(6.5) of the limit switch LS–2(6.5) will be bridged. In addition, the shot pin SP–1 will not ordinarily be extended and

therefore the control relay CR–5(14) will be in an operative state and the contacts KCR's–5(11, 12) will be closed. Since the contacts K4(13) of the limit switch LS–4(13) will not be closed, the control relay CR–4(13) will be in the inoperative state and the contacts KCR–4(25) will thereupon be closed to complete a circuit between the leads L1 and L5, through the now-closed contacts KR(10), through the control relay CR–3(10) to the lead L2. Accordingly, the control relay CR–3(10) will be energized to close the contacts KCR–3(9) which thereupon locks the control relay CR–3(10) in the operative state. The contacts KW(9) of the switch WIND(5) will have been closed prior to this period by the return of the switch WIND(5) to the normal state as depicted by FIG. 16.

The operation of the control relay CR–3(10) also effects the closing of the previously open contacts KCR–3(11) and KCR–3(18). The closure of the contacts KCR–3(18 effects the energization of the control relay CR–6(17) and the time delay relay DR–2(18). The control relay CR–6(17) then operates for a predetermined period of time as determined by the time delay characteristic of the relay DR–2(18) to close the contacts KCR's–6(10, 11, 51). The closure of the contacts KCR–6(51) effects the operation of the solenoid SOL1A(51), which thereupon operates to effect the retraction of the shot pin SP–1 from the bar 24 in the event that the shot pin SP–1 has not been previously retracted. The operation of the control relay CR–5(14) is also ensured by the closure of the contacts K1(14). The closure of the contacts KCR–5(12), coupled with the now-closed state of the contacts KCR–3(11) completes a circuit from the leads L1 to the armature lead LA and through the armature windings of the indexing motor M–1(11.5) to the lead L2 so that the motor M–1(11.5) rotates to index the carriage 50 to the left, as viewed in FIG. 1, until contact is made with the contact button 49. The closure of the contacts KCR–6(10) will be of no present significance because the closed state of the contacts KCR–3(11) will provide the required connection between the lead L1 and the armature lead LA to energize the indexing motor M–1(11.5).

When the contact button 49 is depressed, the contacts K4(13) of the limit switch LS–4 close to energize the control relay CR–4(13) which operates to open the contacts KCR–4(12) and stop the motor M–1(11.5) from further indexing the carriage 50 to the left, as viewed in FIG. 1.

The operation of the control relay CR–6(17) also closes the contacts KCR–6(15), which effects the energization of the ratchet relay RR(15). Therefore, the actuation of the switch RESET(7) in addition to initiating the indexing movement of the carriage 50 to the left, as viewed in FIG. 1, may also be employed to reset the ratchet relay RR(15) in the event that the winding motor M–2(45) is conditioned for rotating the shunt plate 180 in a reverse sense to that desired. It may be recalled that when the contacts KRR(31) are closed by the operation of the ratchet relay RR(15), the control relay CR–14(31) will be enrgized to reverse the respective states of the contacts KCR's–14(45, 46, 47, 49) and thereby reverse the direction of rotation of the winding motor M–2(45) and the direction of shunt plate revolution. The respective states of the contacts KRR's(27, 29, 31) of the ratchet relay RR(15) may be ascertained by the use of the lamp TL(30.5). The lamp TL(30.5) will illuminate if the contacts KRR(31) are closed and the closed state of the contacts KRR(31) is indicative of the fact that the control arm of the ratchet relay RR(15) is in the second of its two possible positions. Thus, if the contacts KRR(31) are open or closed and it is desired to reverse the states of those contacts to effect the energization or denergization of the control relay CR–14(31), the switch RESET (7) may be depressed to effect the reenergization of the ratchet relay RR(15) through operation of the control relay CR–6(17) and thereby reverse the respective states of the contacts KRR's(27, 29, 31).

Other types of shunt plates that are commonly used by those working in the art are formed with coil form arrays that are other than eight-by-eight. These arrays are typically designed with terminals in substantially the same positions relative to their coil forms as the terminals TRM1–TRM4 are relative to the coil forms CF1, CF17, CF33 and CF49 of the illustrated shunt plate 180. These other arrays are also typically designed with feed-through terminals in substantially the same positions relative to their coil forms CF4, CF13, CF20, CF29, CF36, CF45, CF52 and CF61 as the terminals TRM5–TRM12 are with respect to the coil forms CF8, CF9, CF24, CF25, CF40, CF41, CF56 and CF57 of the illustrated shunt plate 180.

It is a relatively easy matter to adapt the apparatus 10 for winding wire onto other arrays of coil forms. Basically, the adaption involves unscrewing the machine screws 47—47, FIG. 1, and shifting the limit switch LS–3 on the base 13 to the left, as viewed in that figure, to a position where the carriage leg 52 will actuate the limit switch LS–3 as the feed tube tips 100*a*–100*d* are indexed to twelve o'clock positions relative to the eight terminals that extend from the right end of the shunt plate. With the limit switch LS–3 fixed at that location, the apparatus 10 will operate to wind a coil form array that is less than eight-by-eight, for instance, a four-by-four or a four-by-eight array. By shifting the limit switch LS–3 to the right, as viewed in FIG. 1, from the position as depicted in that figure, and by mounting an additional feed tube or tubes on the post 75, the apparatus 10 may be adapted to wind a shunt plate having a coil form array that is greater than eight-by-eight, for instance, a twelve-by-twelve array. Since the spacing between the wound column of coil forms located adjacent the right end of the shunt plate and the right column of terminals may be less than the minimum orbital radius required to wind the wires onto the coil forms, it is important that the apparatus 10 provides the feature of dual rotatability of the shunt plate and feed tubes.

As should also be apparent, the aforedescribed rod 24 may be substituted by a rod having different relative spacings between consecutive holes 26*a*–26*j* and consecutive notches 25*a*–25*h* to correspond to the respective horizontal distances between the centers of terminals and adjacent coil forms, and between horizontally adjacent coil forms of other types of arrays.

It is to be understood that the above-described apparatus is merely illustrative of the application of the principles of the invention. Numerous other modifications may be devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

What is claimed is:

1. Apparatus for winding a length of elongated material onto an elongated material-receiving element having a longitudinal axis, the apparauts comprising:

means for driving the element at least once in a defined orbital path and in a plane substantially perpendicular to the longitudinal axis of the element,

means for guiding the material from a supply to the one element,

the guide means being mounted for movement from a first location outside of the orbital path of the element to a second location at least within said orbital path so that the material payed out by said guide means lays in intersecting relationship to the orbital path, whereupon orbital movement of the element causes the element to initially intercept and subsequently wind the material upon itself, said guide means being mounted for movement in a plane substantially parallel to the longitudinal axis of the element to traverse the orbiting element and lay at least one layer of material thereon,

means for driving said guide means for both movements,

a counter connected to the orbital drive means including circuitry for counting the number of element orbits and for producing successive first and second signals when the number of element orbits equal respective first and second predetermined counts,

means connected to said couter for reducing the speed of said orbital drive means in response to the first signal therefrom, and

means for stopping said orbital drive means in response to the second signal from said counter.

2. Apparatus for winding a length of elongated material onto an elongated material-receiving element having a longitudinal axis, the apparatus comprising:

means for orbiting the element in a plane substantially perpendicular to the longitudinal axis of the element, the element circumscribing a substantially circular orbital path of movement,

a material guide for guiding the elongated material from a supply to the element, said guide being mounted for movement in at least two directions,

means for driving said guide in one direction from a location outside of the orbital path of the element to a location where the material payed out by said guide intersects the orbital path, the orbiting element thereby initially intercepting and winding the material upon itself, and

means for driving said guide in a second direction substantially parallel to the longitudinal axis of the element to traverse the orbiting element and lay at least one layer of material thereon.

3. Apparatus for winding elongated material onto a row of elongated material-receiving elements extending from a supporting plate, the apparatus comprising:

a carriage mounted for movements substantially parallel and perpendicular to the longitudinal axes of the elements,

a material guide member mounted on said carriage in substantial alignment with the row of elements and extending toward the supporting plate for issuing and guiding out material to the elements,

means for driving the supporting plate in an orbital path about said member so that the elements circumscribe individual orbital paths relative to said member,

means for indexing said carriage in a direction substantially perpendicular to the longitudinal axes of the elements, the spacial intervals of carriage indexing being substantially equal to corresponding distances between the centes of adjacent elements,

said member being indexed by said carriage to successive positions where the material issuing from said member successively intersects the orbital paths of the elements so that the orbiting elements successively intercept and wind the material upon themselves, and

means connected to the plate driving means for driving said carriage substantially parallel to the longitudinal axes of the elements during orbital movement of the elements so that said member applys at least one layer of material onto each element.

4. Apparatus for winding elongated material onto a row of elongated material-receiving elements extending from a supporting plate, which apparatus comprises:

a carriage mounted for movements substantially parallel and perpendicular to the longitudinal axes of the elements,

a tube mounted on said carriage and extending toward the supporting plate for issuing and guiding the material to the elements,

reversible drive means for driving the supporting plate in an orbital path about said tube a predetermined number of revolutions that define a winding cycle,

second drive means connected to said carriage for indexing said carriage in the direction substantially perpendicular to the longitudinal axes of the elements after each winding cycle, the spacial intervals of carriage indexing being approximately equal to the corresponding distances between the centers of adjacent elements,

said tube being indexed by said carriage to successive positions where the material issuing from said tube successively intersects the orbiting paths of the elements so that adjacent elements successively intercept and initially wind the material upon themeslves in one of the two senses of winding direction,

a carriage traversing mechanism driven by said reversible drive means for driving said carriage substantially parallel to the longitudinal axes of the elements during each winding cycle so that said tube applies at least one layer of material onto each element,

a bidirectional counter connected to said reversible drive means for counting the number of plate orbits of the winding cycle, said counter producing an output signal when a predetermined number of unidirectional orbits are counted thereby, and

relay means energizable by output signals from said counter for controlling the operation of said reversible and second drive means, said relay means being selectively energized by an output signal from said counter to:

(a) stop said reversible drive means.

(b) initiate said second drive means for indexing said carriage, and

(c) condition said reversible drive means for a reversal of the orbital driving direction from that of the previous orbital driving direction.

5. Apparatus for winding elongated material onto a row of elongated material-receiving elements extending from a supporting plate, the apparatus comprising:

a carriage mounted for movements substantially parallel and perpendicular to the longitudinal axes of the elements,

a tube mounted on said carriage and extending toward the supporting plate for issuing and guiding the material to the elements,

a reversible drive for driving the supporting plate in an orbital path about said tube a predetermined number of revolutions that define a winding cycle.

a second drive connected to said carriage for indexing said carriage in the direction substantially perpendicular to the longitudinal axes of the elements at the end of each winding cycle, the spacial intervals of carriage indexing being approximately equal to the corresponding distances between the centers of adjacent elements,

said tube being indexed by said carriage to successive positions where the material issuing from said tube successively intersects the orbiting paths of the elements so that the elements successively intercept and wind the material upon themselves in one of the two senses of winding direction,

a carriage traversing mechanism driven by said reversible drive and connected to said carriage for driving said carriage substantially parallel to the longitudinal axes of each element during each winding cycle so that said tube traverses and applies at least one layer of material onto each element,

a bidirectional counter connected to said reversible drive for counting the number of orbits of the support plate in either orbintal direction,

a circuit in said counter for producing an output signal when the number of unidirectional plate orbits equals a predetermined number, and

at least one relay connected to said circuit and energizable in response to an output signal therefrom to:

(a) stop said reversible drive,

(b) condition said second drive for indexing said carriage through a spacial interval, and

(c) condition said reversible drive to reverse the direction of plate orbiting from the previous direction of plate orbiting.

6. An apparatus for winding a continuous length of elongated material onto plural material-receiving elements extending from a supporting plate and having substantially parallel longitudinal axes, the apparatus comprising:

at least one guide mounted for at least two-dimensional movement relative to the longitudinal axes of the elements for issuing and guiding material thereto that is received by said guide from a supply,

said guide also being mounted for eccentric rotation about an axis that is substantially parallel to the longitudinal axes of the elements,

said guide including a tip that extends toward the supporting plate for guiding the wire onto the elements,

means attached to the supporting plate for orbiting the supporting plate about said tip in an orbital path having a minimum radius that is larger than the radius of eccentricity of said tip,

means for indexing said guide in a direction substantially perpendicular to the logitudinal axes of the elements to a position where said tip guides the material to intersect the orbital path that is circumscribed by the orbiting movement of one of the elements so that the one element initially intersects and subsequentially winds upon itself a substantial number of turns of the material issuing from said tip,

said guide being further indexed to a position adjacent a second element such that the second element is located entirely within the radius of eccentricity of said tip, and

means for rotating the guide about said axis of rotation so that the tip winds a lesser number of turns of the material onto the second element.

7. The apparatus as claimed in claim 6, wherein means are provided for locking said guide against rotation during the orbiting of the elements and for unlocking said guide for rotation after said guide is indexed to the position adjacent the second element.

8. An apparatus for winding a continuous length of elongated material onto plural material-receiving elements extending from a supporting plate and having substantially parallel longitudinal axes, the apparatus comprising:

at least one material feed guide mounted for at least two-dimensional movement relative to the longitudinal axes of the elements for issuing and guiding material thereto that is received by said guide from a supply,

said guide also being mounted for eccentric rotation about an axis that is substantially parallel to the longitudinal axes of the elements, said guide including a tip that extends toward the supporting plate for guiding the wire onto the elements,

means for normally locking said guide against rotation,

means for orbiting the supporting plate about the locked guide tip in an orbital path having a minimum radius that is larger than the radius of eccentricity of said tip,

means for indexing the locked guide in a direction substantially perpendicular to the longitudinal axes of the elements to a position where said tip guides the material to interact the orbital path that is circumscribed by the orbiting movement of one of the elements so that the one element initially interacts and subsequently winds upon itself the material issuing from said tip,

means for traversing the locked guide in a direction substantially parallel to the longitudinal axis of the one element for applying at least one layer of material thereto during the orbiting of the one element,

said guide being further indexed to a position adjacent a second element such that the second element is located entirely within the radius of eccentricity of said tip, and

means responsive to the position of said guide adjacent the second element for unlocking said guide for rotation and for subsequently rotating said guide about said axis of rotation so that the tip winds the material onto the second element.

9. An apparatus for winding a continuous length of elongated material onto first and second vertically disposed elongate material-receiving elements having substantially parallel longitudinal axes, the apparatus comprising:

a carriage mounted for horizontal movement to a position adjacent the first material-receiving element,

a post mounted on said carriage for vertical displacement a distance substantially equal to the vertical distance between the centers of the two elements,

a substantially cylindrical material feed tube for issuing and guiding elongated material to the elements,

a bearing for mounting said feed tube on said post for eccentric rotation about an axis substantially parallel to the axes of the elements, said tube including a tip that extends to a position for guiding the material to the first element, the eccentricity of said tube permitting rotation of said tip about the first element,

a gear fixedly mounted on said tube and having an axis of rotation that is substantially coaligned with the axis of rotation of said tube,

a rack mounted on said post and including teeth that mesh with said gear,

said rack being displaceable relative to said post for rotating the said gear so that said tube rotates eccentrically to wind elongated material onto the first element,

means mounted on said post for locking said rack against movement relative to said post after the displacement thereof so that said tube is locked against rotation after winding material onto the first element, and

means mounted on said carriage and connected to said post for displacing said post with said rack locked thereto to a position such that the locked tube is vertically displaced to a position for winding material onto the second element.

10. An apparatus for winding a continuous length of elongated material onto first and second substantially parallel rows formed by material-receiving elements having substantially parallel longitudinal axes, the apparatus comprising:

a carriage mounted for horizontal movement adjacent the material-receiving elements,

means for indexing said carriage from one element to a second element of the first row of elements,

a post mounted on said carriage for vertical displacement a distance substantially equal to the vertical distance between the centers of the two rows of elements,

at least one material feed tube mounted on said post for eccentric rotation about an axis that is substantially parrallel to the longitudinal axis of the elements, said feed tube issuing and guiding elongated material received thereby to the elements and including a tip that extends to a predetermined position adjacent the one element of the first row,

means for driving the one element of the first row in an orbital path with a radius sufficient to effect the initial interception by the one element of the elongated material issuing from said tip so that the one element winds the material upon itself upon further orbital movement thereof, said carriage being subsequently indexed to a predetermined position adjacent a second element of the first row,

means mounted on said carriage for locking said feed

tube against rotation while the one element of the first row undergoes obital movement and for unlocking said feed tube prior to the rotation thereof,

means mounted on said carriage for rotating the feed tube for winding the elongated material onto the second element of the first row, and

means mounted on said carriage and connected to said post for displacing said post to a position such that said tip is moved to a predetermined position relative to an element of the second row for applying the material thereto.

11. An apparatus for winding a continuous length of elongated material into first and second substantially parallel rows formed by material-receiving elements having substantially parallel longitudinal axes, the apparatus comprising:

a carriage mounted for horizontal movement adjacent the material-receiving elements,

means for successively indexing said carriage from one element to a second element of the first row of elements,

a post mounted on said carriage for vertical displacement a distance substantially equal to the vertical distance between the centers of the two rows of elements,

at least one material feed tube mounted on said post for eccentric rotation about an axis that is substantially parallel to the longitudinal axis of the elements, said feed tube issuing and guiding elongated material received thereby to the elements and including a tip that extends to a predetermined position adjacent the one element of the first row,

means for securing the free end of the material that issues from said feed tube,

orbital drive means for driving the one element of the first row in an orbital path of a radius sufficient to effect the initial interception by the one element of the elongated material issuing from said tip so that the one element subsequently winds a substantial number of convolutions of material upon itself during further orbital movement thereof,

a counter connected to the driving means for counting the number of orbits of each wound element and for producing a signal that at least slows said driving means when a predetermined number of orbits are counted, said carriage being subsequently indexed to a predetermined position adjacent a second element of the first row,

means mounted on said carriage for securing said feed tube against rotation while the one element of the first row undergoes orbital movement and for releasing said feed tube prior to the rotation thereof,

means mounted on said post for rotating the feed tube for winding a considerably lesser number of convolutions of elongated material onto the second element of the first row, and

means mounted on said carriage and connected to said post for displacing said post to a position such that said tip is moved to a predetermined position relative to an element of the second row for applying the material thereto.

12. The apparatus as claimed in claim **11**, wherein:

a traverse mechanism connected to said orbital drive means is provided for driving said carriage substantially parallel to the longitudinal axes of the one element so that said tip traverses and applies at least one layer of material onto the one element while the one element orbits around said tip.

13. The apparatus as claimed in claim **11**, wherein:

means connected to the carriage indexing means are provided for resetting said carriage to a position adjacent the one element.

14. An apparatus for winding a substantial number of turns of a continuous length of wire onto plural rows of spaced-apart, elongated elements having substantially parallel longitudinal axes extending perpendicularly from a supporting plate, and for additionally winding a lesser number of turns of wire onto at least one terminal located adjacent at least one element of the row and having a longitudinal axis extending perpendicularly from the supporting plate, the apparatus comprising:

a carriage mounted for movements in directions substantially parallel and perpendicular to the longitudinal axes of the elements,

at least one wire feed tube mounted on said carriage and extending therefrom for issuing and guiding the wire received by said tube to the elements and to the terminal,

said tube being mounted on said carriage for eccentric rotation about an axis that is substantially parallel to the longitudinal axis of the terminal, the radius of eccentricity of said tube being less than the closest spacing between the one element and the terminal and being greater than the largest radial dimension of the terminal,

a reversible motor connected to the supporting plate for orbiting the supporting plate by the rotation thereof in an orbital path a predetermined substantial number of times, the orbital path having a radius in a plane perpendicular to the longitudinal axes of the elements that is less than the closest spacing between adjacent wound elements and less than the closest spacing between the one element and the terminal, so that each element and the terminal circumscribes individual and nonintersecting orbital paths,

an indexing drive connected to said carriage for indexing said carriage in directions substantially perpendicularly to the longitudinal axes of the elements from a first to a last element of an element row so that said tube guides the wire to successively intercept the individual orbital paths of the elements whereby each element initially intercepts and subsequently winds upon itself the wire issuing from said tube,

means movable to a position for locking the carriage against movement in directions perpendicular to the longitudinal axes of the elements during each orbital period,

means for normally securing said tube to said carriage so that said tube is secured against rotation while said tube issues the wire to the elements, the securing means being responsive to a signal for releasing said tube for rotation,

a traverse mechanism connected to said carriage and driven by said reversible motor for driving said carriage substantially parallel to the longitudinal axes of the elements so that said tube traverses an orbiting element while issuing the wire thereto,

said indexing motor also indexing said carriage from the one element to a position relative to the terminal adjacent thereto such that the terminal lies entirely within the radius of eccentricity of said tube,

carriage position sensing means for providing a signal when said carriage is indexed to a position where the terminal is within the radius of eccentricity of said tube,

the securing means responding to said signal for releasing said tube for rotation, and

means mounted on said carriage connected to the carriage position sensing means and operative in response to said signal therefrom for rotating the released tube so that said tube winds the wire onto the terminal.

15. The apparatus as claimed in claim **14**, wherein:

a counter is connected to said reversible motor for counting the number of unidirectional revolutions thereof, and wherein said counter includes counting circuitry that produces a stop signal for deenergizing said reversible motor after a predetermined number

of unidirectional revolutions corresponding to the desired number of windings on an element are counted.

16. The apparatus as claimed in claim **15**, wherein:

a polarity reversing circuit is electrically connected to said counter for receiving stop signals therefrom, said polarity reversing circuit also being connected to said reversible drive for reversing the polarity and thus the direction of said reversible drive each time a stop signal is received by said reversing circuit.

17. The apparatus as claimed in claim **14**, wherein:

means connected to said indexing motor are provided for resetting said carriage to a position substantially adjacent the first element of the element row.

18. The apparatus as claimed in claim **14**, wherein:

said carriage position sensing means includes a limit switch having a contact that is depressed by the indexing of said carriage to a position where the terminal is at least within the radius of eccentricity of said tube.

19. The apparatus as claimed in claim **14**, which further comprises:

a first source of electrical energy for driving said reversible motor at one speed,

a second source of electrical energy for driving said reversible motor at a second speed that is substantially faster than the one speed,

switching means energizable for switching the electrical connection of said reversible motor from the first to the second source,

means operated by locking movement of the carriage locking means for energizing said switching means so as to initiate an element winding cycle with said reversible motor connected to said second source, and

a counter operated by the rotation of said reversible

motor for counting the number of rotations thereof, said counter producing an output pulse when a predetermined number of reversible motor rotations are counted thereby,

said switching means being connected to the output of said counter and being energized by the first output pulse therefrom to switch said reversible motor from said second source to said first source so that said reversible motor is driven at said one speed after a corresponding predetermined number of turns of wire are wound onto an element.

20. The apparatus as claimed in claim **19**, wherein:

said counter produces a second output pulse corresponding to an additional predetermined number of turns of wire, and wherein said switching means includes a relay electrically connected to the output of said counter and energizable by the second output pulse therefrom for stopping said reversible drive motor.

References Cited

UNITED STATES PATENTS

2,855,159	10/1958	Mallina	242—7
2,969,827	1/1961	Rosenthal et al.	242—7
3,019,822	2/1962	Jacobson	242—7
3,028,108	4/1962	Bos et al.	242—7
3,122,826	3/1964	Self	29—203
3,128,956	4/1964	Schumann	242—9
3,224,690	12/1965	Holman	242—3
3,279,708	10/1966	Rondas	242—9

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29—203; 140—124; 242—7.18