S.M. 506753

PARAMETERS for PROGRAMMING THE GARDNER-DENVER AUTOMATIC Wire-Wrap® MACHINE

GARDNER-DENVER COMPANY

Wire-Wrap® DIVISION

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INTRODUCTION

The Gardner-Denver automatic "Wire-Wrap" machine is a unit designed for automatically attaching interconnecting wiring with solderless wrapped connections. The machine consists of movable carriages containing wrapping tool assemblies and dressing fingers that are positioned on modular points to form a desired wire pattern.

Automatic operation of the machine is initiated from a card reader which reads input data from a control card.

The function of the input data is to translate the output of a computer program into mechanical motion. Input data is punched into control cards in either decimal, binary coded decimal, or column binary code, depending on machine model. For ease of change, each card contains information for only one wire.

The purpose of this manual is to familiarize you with the machine functions and wiring pattern limitations so you can design a computer program for input data to achieve optimum machine operation.

GARDNER-DENVER 14F AUTOMATIC "WIRE-WRAP" MACHINE

MACHINE DESCRIPTION

The automatic "Wire-Wrap" machine consists of two groups of carriages which are positioned on modular points to form various wire patterns. These carriage groups are known as the "X" Carriage Group and the "Y" Carriage Group.

1. "X" CARRIAGE GROUP

The "X" Carriage Group consists of four carriages. They are the "AX" Front Carriage (AXF), the "BX" Front Carriage (BXF), the "AX" Rear Carriage (AXR), and the "BX" Rear Carriage (BXR). The "AX" Carriages and "BX" Carriages are both interconnected with two "Y" connecting shafts. Refer to Fig. 1 for an illustration of this arrangement.

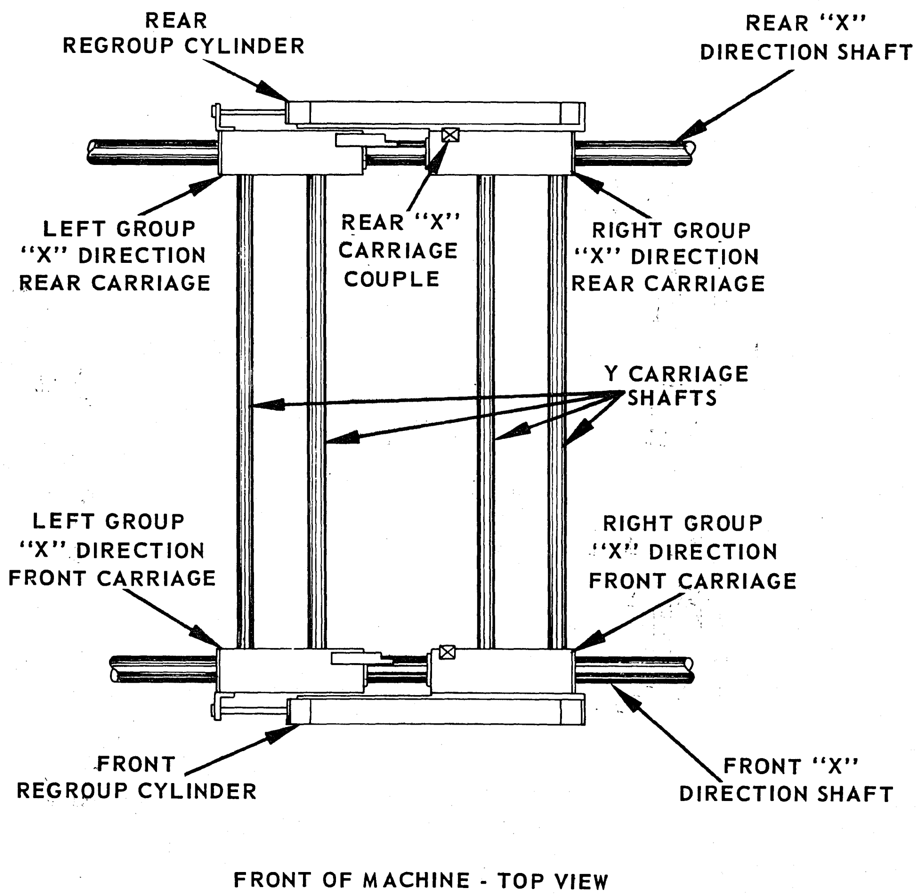


FIG. 1 - "X" MOTION CARRIAGES AND REGROUP CYLINDERS

2. "Y" CARRIAGE GROUP

The "Y" Carriage Group consists of six carriages. They are the "A" Front Dressing Finger Carriage (AFD), the "A" Tool Carriage (AT), the "A" Rear Dressing Finger Carriage (ARD), the "B" Front Dressing Finger Carriage (BFD), the "B" Tool Carriage (BT), and the "B" Rear Dressing Finger Carriage (BRD). Refer to Fig. 2 for the "Y" Carriage arrangement.

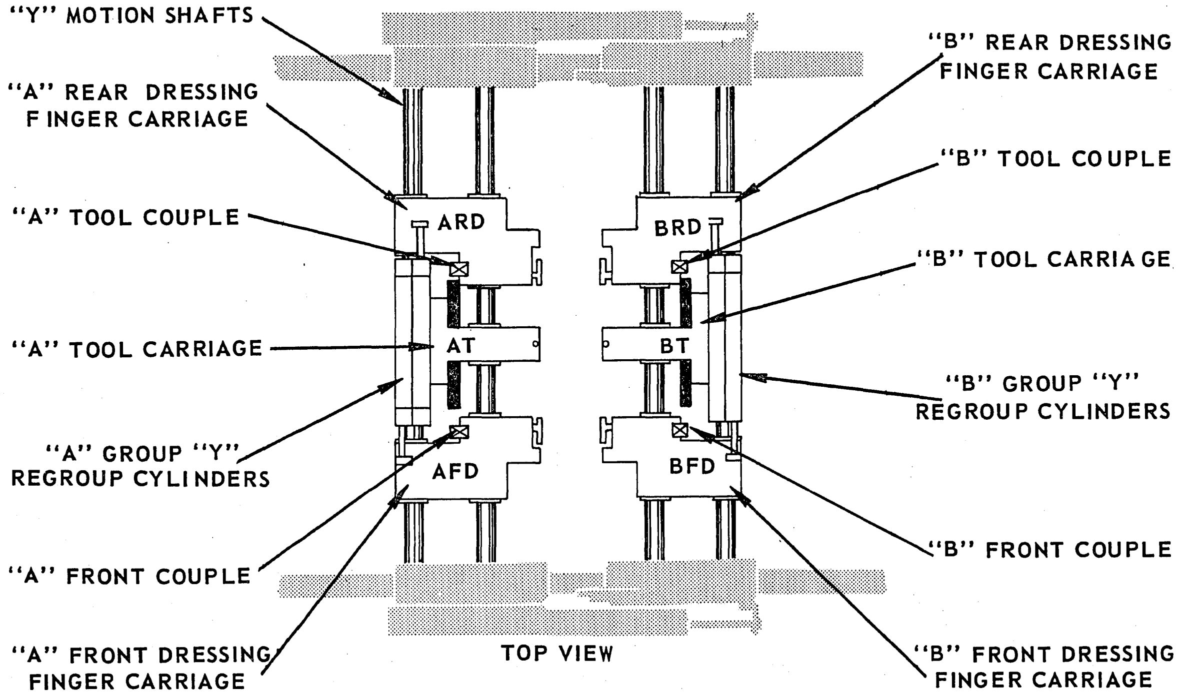


FIG. 2 - "Y" MOTION CARRIAGES AND REGROUP CYLINDERS

DRIVES AND REGROUP CYLINDERS

The "Wire-Wrap" machine has drives for positioning the "X" and "Y" Carriage Groups within the machine. They are known as the "X", "AY", and "BY" Drives. The "X" Drive positions the "AX" and "BX" Carriage Groups. The "X" Drive is connected to the "BX" Carriage Group. You could think of the "BX" Carriage Group as being a locomotive, and the "AX" Carriage Group as being the freight car.

The "AY" and "BY" Drives position the "A" and "B" groups of the "Y" Carriages. The "AY" Drive is connected to the "ARD" Carriage and the "BY" Drive is connected to the "BRD" Carriage. You could think of the "ARD" and "BRD" Carriages as being locomotives, and the "A" and "B" tools and "AFD" and "BFD" Carriages as being freight cars. The relationship of the drive members is shown in Fig.3.

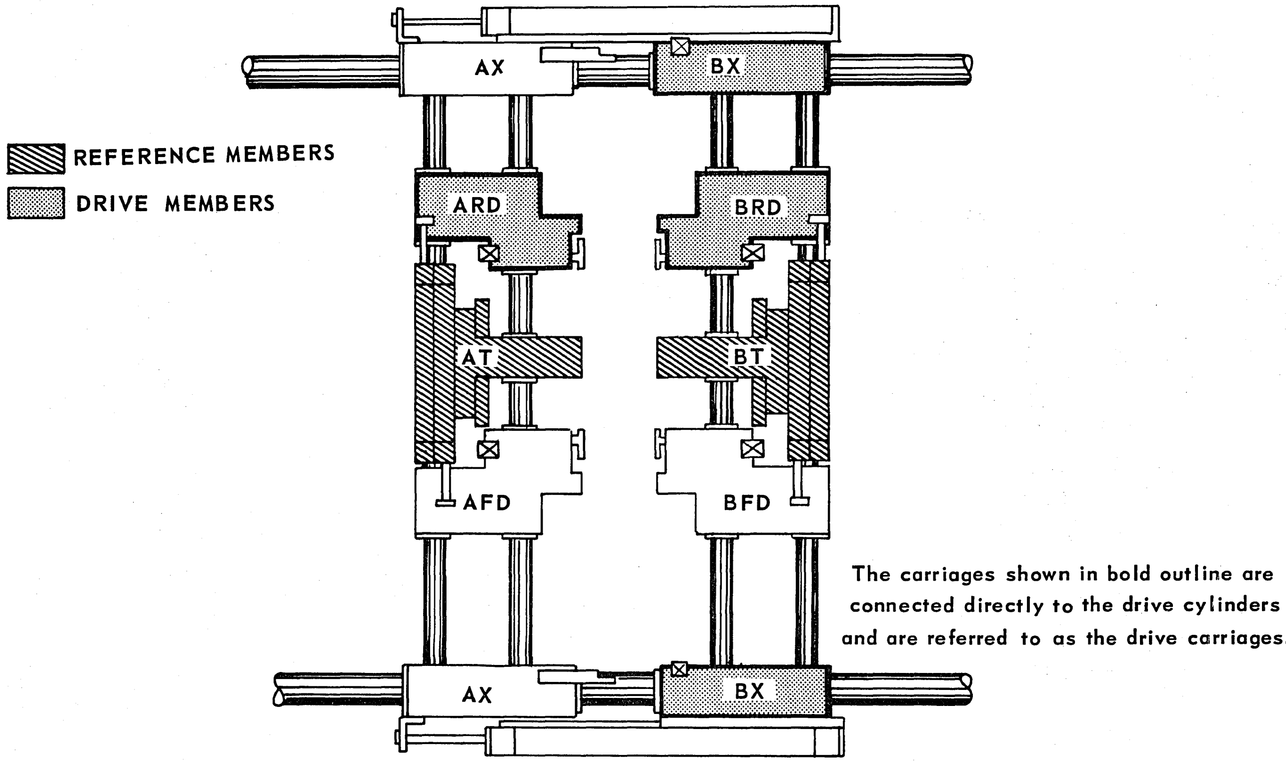


FIG. 3 - DRIVE AND REFERENCE MEMBERS

There are also regroup cylinders mounted to the carriages. These cylinders are used to regroup the carriages when starting a wire pattern. When the "AX" Carriages have regrouped with the "BX" Carriages, couples are engaged so that the "BX" Carriages will pull the "AX" Carriages to their proper position. When the "AX" position is reached, the couple is released and the "AX" Carriages are locked to the "X" Shafts so that when "BX" motion is called for, the "AX" Carriages will stay locked in position. Fig. 1 shows the "X" Carriage and regroup cylinder arrangement.

The "Y" Carriages are regrouped in a manner similar to that of the "X" Carriages. This "regrouping" of the carriages (both "X" Carriages and "Y" Carriages) is necessary to start a wire pattern. Fig. 2 shows the relationship of the "Y" Regroup Cylinders to the "Y" Carriages.

After regrouping, the "Y" Carriages are locked together by means of couples between the carriages. When a carriage is moved into its proper position, it is locked (clamped) to the "Y" Shaft and the couple between it and the next carriage is released. The drive can then move on to position the next carriage in its group.

MACHINE MOTIONS

The wire pattern selected determines the sequence by which the carriages must be positioned. The "B" tool is the reference member for the "X" Carriages and "BY" Carriages, while the "A" tool is the reference member for the "AY" Carriages. The relationship of the reference members is shown in Fig. 3.

The 14F models have four dressing fingers while the 14U2 models have only two dressing fingers. For the purpose of discussion, we will consider the 14F machines with four dressing fingers. These dressing fingers are mounted in the dressing finger carriages as illustrated in Fig. 4. The dressing fingers provide the via points in a given wire pattern, and they are defined as follows.

"AFD" ------ "A" Front Dressing Finger
"ARD" ------ "A" Rear Dressing Finger
"BFD" ------ "B" Front Dressing Finger
"BRD" ------ "B" Rear Dressing Finger

Dressing Finger Pivoted Up and Stored

Dressing Finger Extended and Pivoted Down

Wrapping Bit

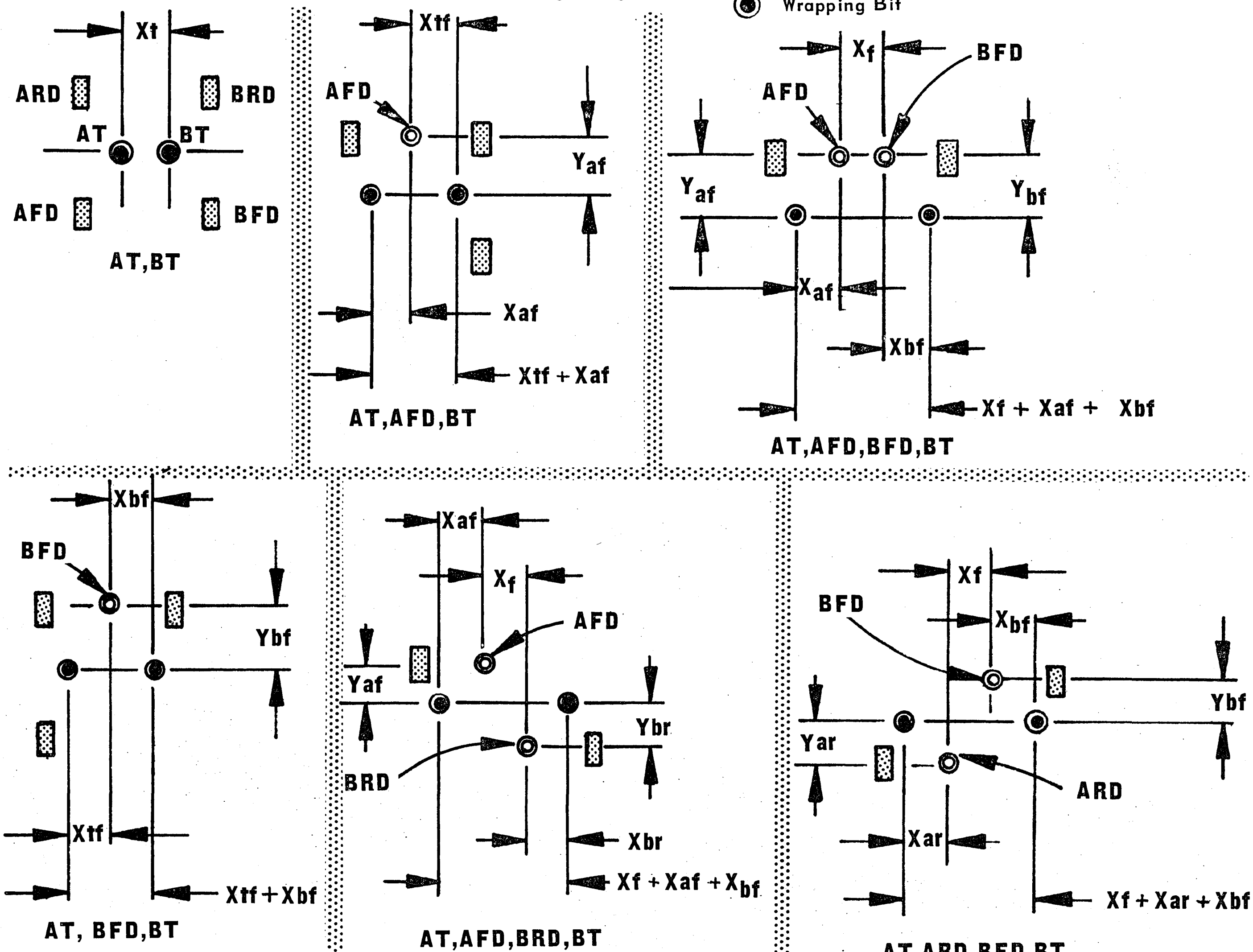


FIG. 4 - DRESSING FINGER ARRANGEMENT

RELATIONSHIP OF REFERENCE MEMBERS

X_t, X_f, Y_{tf}, Y_{af}, Y_{ar}, Y_{bf}, Y_{br}, ARE VARIABLES SHOWN AT THEIR MINIMUMS. ALL OTHERS ARE FIXED DIMENSION FOR ANY GIVEN MACHINE OR GRID SYSTEM. $X_{af} = X_{ar} = X_{bf} = X_{br} = X_{tf}$ MIN X_f MIN.; $Y_{af} = Y_{ar} = Y_{bf} = Y_{br}$ WITH NO Y SEPARATION.

When not in use, the dressing fingers are "stored" in an upright position. In order to use a dressing finger, it must move out a fixed distance in the "X" direction from its carriage and then pivot over and beyond the wire. Thus, a front dressing finger (AFD or BFD) provides a via point in front of the wire while a rear dressing finger (ARD or BRD) provides a via point behind the wire. Fig. 5 illustrates the dressing fingers in both the "stored" position and the pivoted down position.

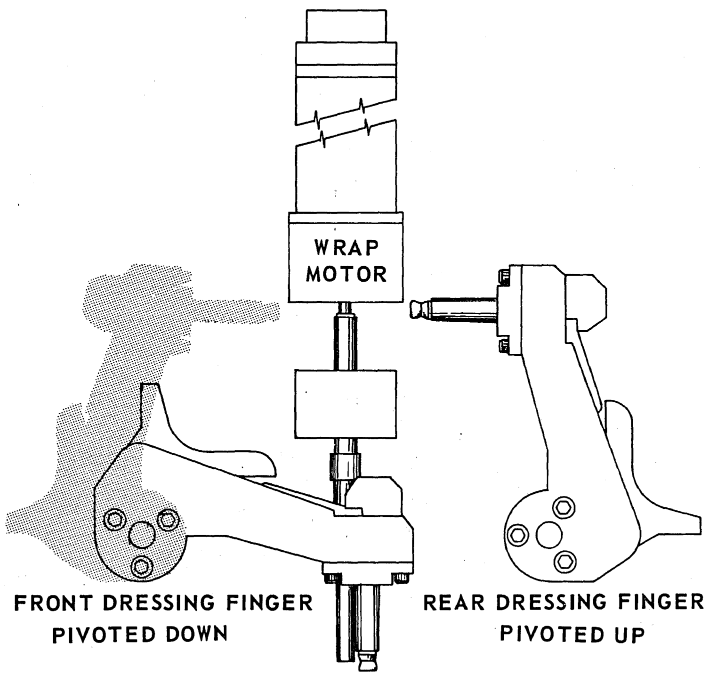


FIG. 5 - DRESSING FINGERS PIVOTED AND STORED (SIDE VIEW)

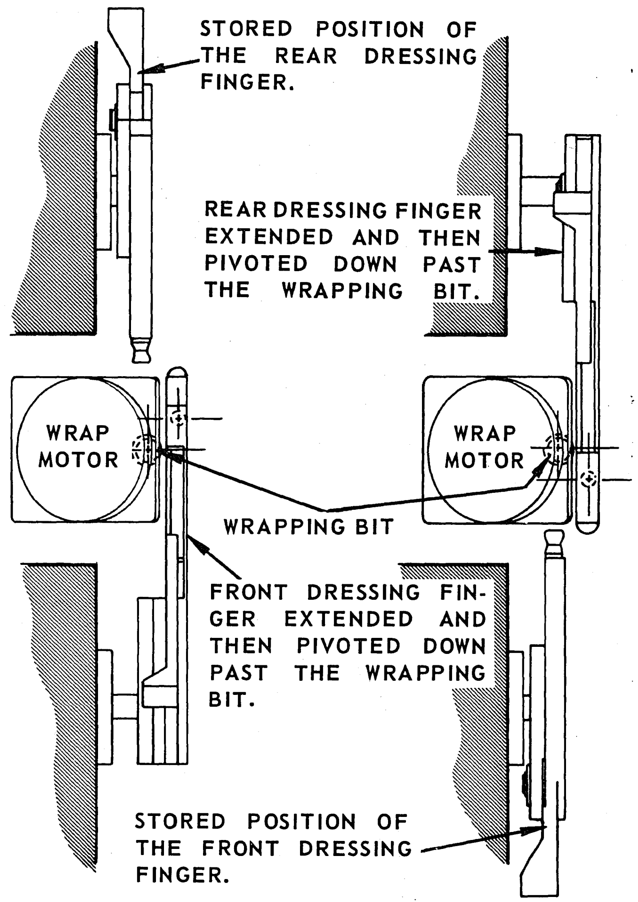


FIG. 6 - DRESSING FINGERS PIVOTED AND STORED (TOP VIEW)

Both front and rear dressing fingers of either the "A" or "B" Carriage Group slide out and swing (pivot) down to the same vertical plane which is parallel to the "Y" axis. Refer to Fig. 6. Therefore, only one dressing finger, either a front or a rear, of the same group may be used in a pattern.

The "BX" Carriages which are coupled to the "AX" Carriages move to initially position the "A" tool in the "X" direction. When this position is reached, the "AX" Carriages are uncoupled and clamped to the "X" Shafts to permit the "BX" Carriages to then position the "B" tool in its "X" position.

The "AFD" Carriage is coupled to the "AT" Carriage which is coupled to the "ARD" Carriage. Since an "A" Front Dressing Finger and an "A" Rear Dressing Finger cannot be used together, two "Y" motions by this drive will position two of the carriages together in one motion and the other carriage in the other motion. If the "A" Front Dressing Finger is required in a wire pattern, the "AFD" Carriage will be "dropped off" (uncoupled and clamped in position), while the "AT" Carriage remains coupled to the "ARD" Carriage for positioning of the "A" tool. If the "A" Rear Dressing Finger were to be used in a wiring pattern, the "AFD" and "AT" are "dropped off" together at the position for the "A" tool, while the "ARD" Carriage moves on to the "Y" position of the "A" Rear Dressing Finger. The "BFD", "BT", and "BRD" Carriages are similarly positioned. This motion sequence is shown in Fig. 7.

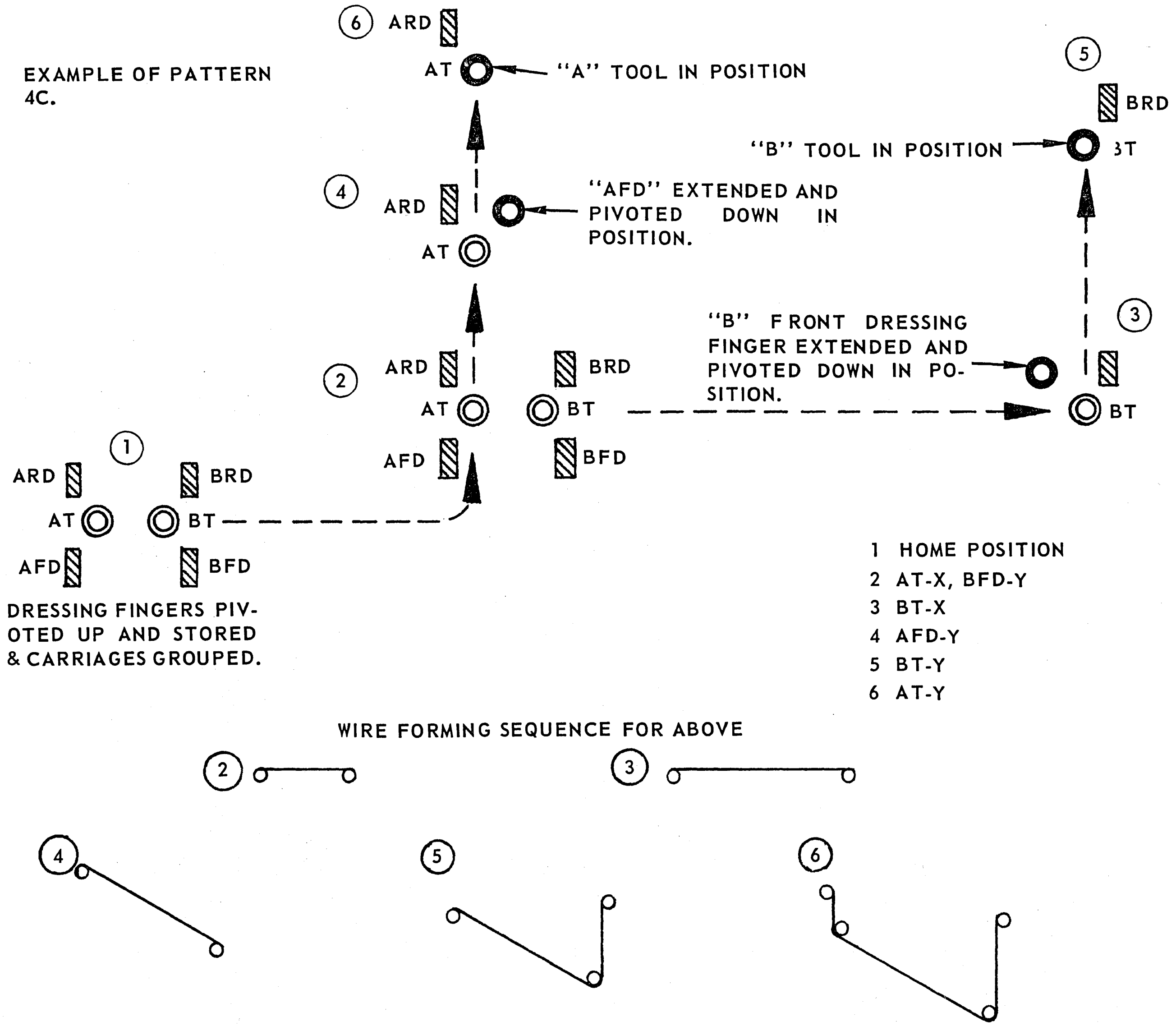


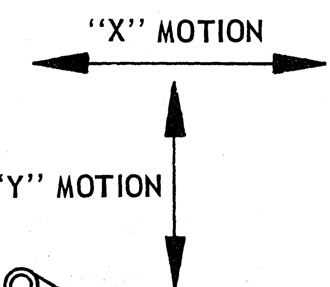
FIG. 7 - MOTION SEQUENCE

BASIC WIRE PATTERNS

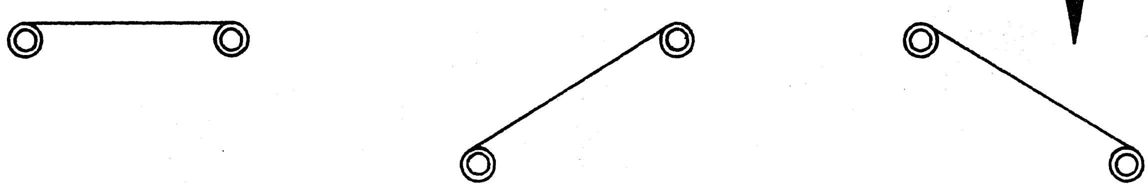
The basic wire patterns shown on the next few pages are typical of those that can be formed by machine. The type of terminal, terminal spacing, and machine model will determine which patterns apply for a given machine and panel combination.

DEFINITION OF SYMBOLS USED

"AT-X"	"A" Wrapping Tool, "X" Position
"AT-Y"	"A" Wrapping Tool, "Y" Position
"BT-X"	"B" Wrapping Tool, "X" Position
"BT-Y"	"B" Wrapping Tool, "Y" Position
"AFD-Y"	"A" Front Dressing Finger, "Y" Position
"BFD-Y"	"B" Front Dressing Finger, "Y" Position
"ARD-Y"	"A" Rear Dressing Finger, "Y" Position
"BRD-Y"	"B" Rear Dressing Finger, "Y" Position
"TRP"	Table Rotational Position
"PLP"	Pallet Longitudinal Position
"AT-Z"	"A" Tool Connection Height
"BT-Z"	"B" Tool Connection Height

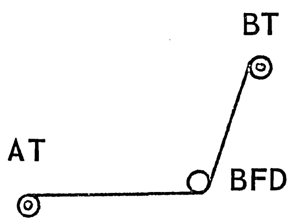


BASIC PATTERN NO. 1

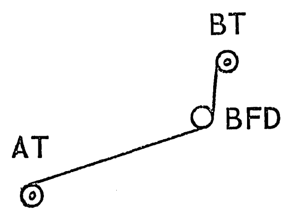


MOTION SEQUENCE	MOTION SEQUENCE	MOTION SEQUENCE
AT-X	AT-X	AT-X
AT-Y	AT-Y	BT-Y
BT-X	BT-X	BT-X
BT-Y	BT-Y	AT-Y

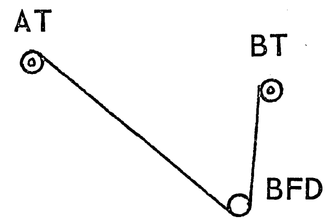
BASIC PATTERN NO. 2



MOTION SEQUENCE
AT-X
AT-Y
BT-X
BFD-Y
BT-Y

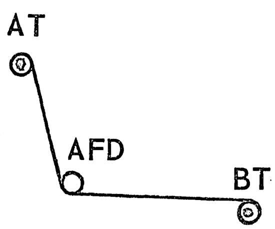


MOTION SEQUENCE
AT-X
AT-Y
BT-X
BFD-Y
BT-Y

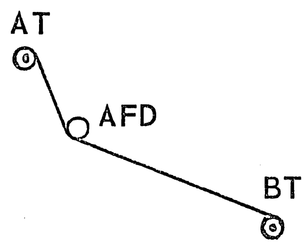


MOTION SEQUENCE
AT-X
BFD-Y
BT-X
AT-Y
BT-Y

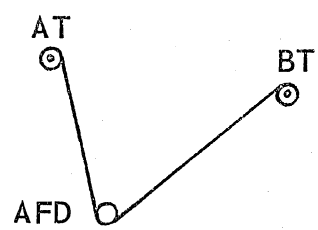
BASIC PATTERN NO. 3



MOTION SEQUENCE
AT-X
BT-Y
BT-X
AFD-Y
AT-Y

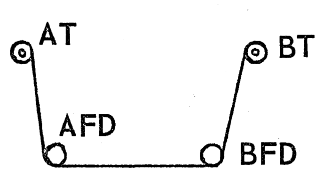


MOTION SEQUENCE
AT-X
BT-Y
BT-X
AFD-Y
AT-Y

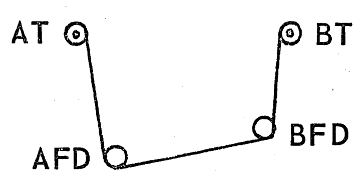


MOTION SEQUENCE
AT-X
AFD-Y
BT-X
BT-Y
AT-Y

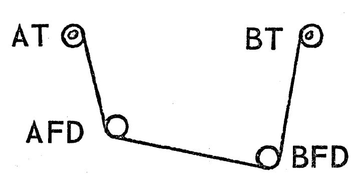
BASIC PATTERN NO. 4



MOTION SEQUENCE
AT-X
AFD-Y
BT-X
BFD-Y
AT-Y
BT-Y

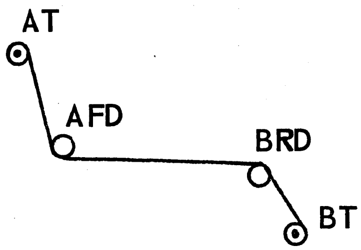


MOTION SEQUENCE
AT-X
AFD-Y
BT-X
BFD-Y
AT-Y
BT-Y

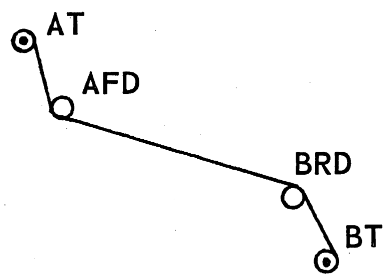


MOTION SEQUENCE
AT-X
BFD-Y
BT-X
AFD-Y
BT-Y
AT-Y

BASIC PATTERN NO. 5

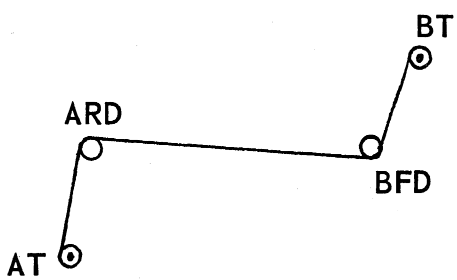


MOTION SEQUENCE
AT-X
BT-Y
BT-X
AFD-Y
BRD-Y
AT-Y

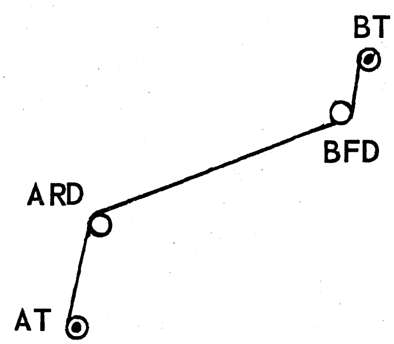


MOTION SEQUENCE
AT-X
BT-Y
BT-X
AFD-Y
BRD-Y
AT-Y

BASIC PATTERN NO. 6



MOTION SEQUENCE
AT-X
AT-Y
BT-X
BFD-Y
ARD-Y
BT-Y



MOTION SEQUENCE
AT-X
AT-Y
BT-X
BFD-Y
ARD-Y
BT-Y

FORMATION OF WIRING PATTERNS

To form a wire pattern, the "A" tool is positioned in the "X" direction and then the member used to form the first "Y" of the pattern is positioned. When the carriages have regrouped and the first "Y" position is reached, the stripped end of the wire is fed to the "B" tool and gripped. Upon completion of the "AT-X" motion, the carriages are ready to separate and complete the wire pattern. The "B" Tool Carriage pulls the wire past the "A" tool and gripper and through stripper from a bulk wire supply to form the wire pattern as the carriages are positioned. When the motion sequence is completed, the wire is cut and stripped at the "A" tool. The wrapping bits then pick up the wire and with the dressing fingers, if used, move the pattern down into the terminal mass and wrap the connections.

When the wrapping has been completed and the tools and dressing fingers are clear of the panel, the collapsing cylinders are actuated, thereby regrouping the carriages.

The sequence of movements and final positions of the carriages for given wire patterns are shown in Fig. 8 thru 12.

During the time the regrouping is taking place, information is read to position the pallet (TRP and PLP), set the "Z" levels, and position the "A" tool in the "X" direction, and locate the first "Y" Carriage for the next wire pattern. When this "Y" position has been reached and the carriages have regrouped the wire is ready to be fed to the "B" tool and the next wire pattern formed.

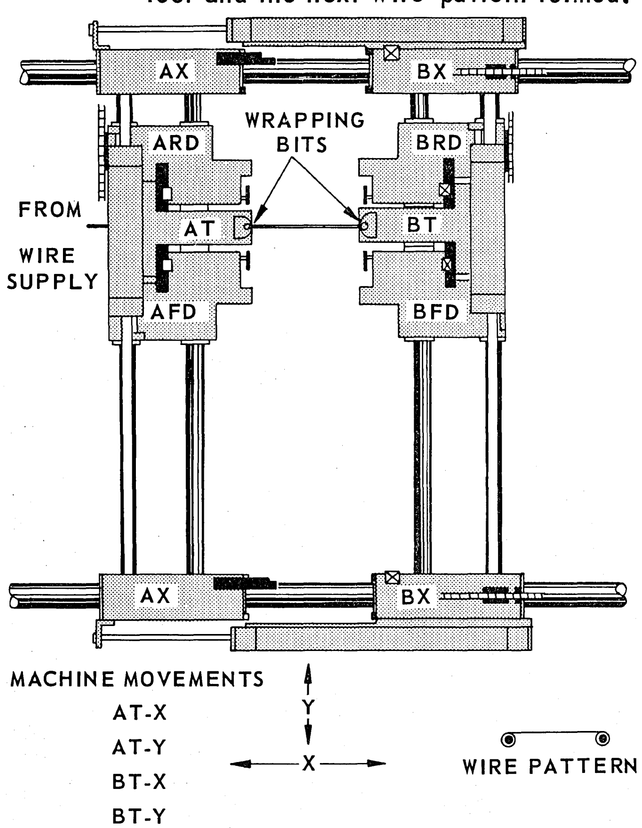


FIG. 8 - FINAL CARRIAGE POSITIONS PATTERN 1

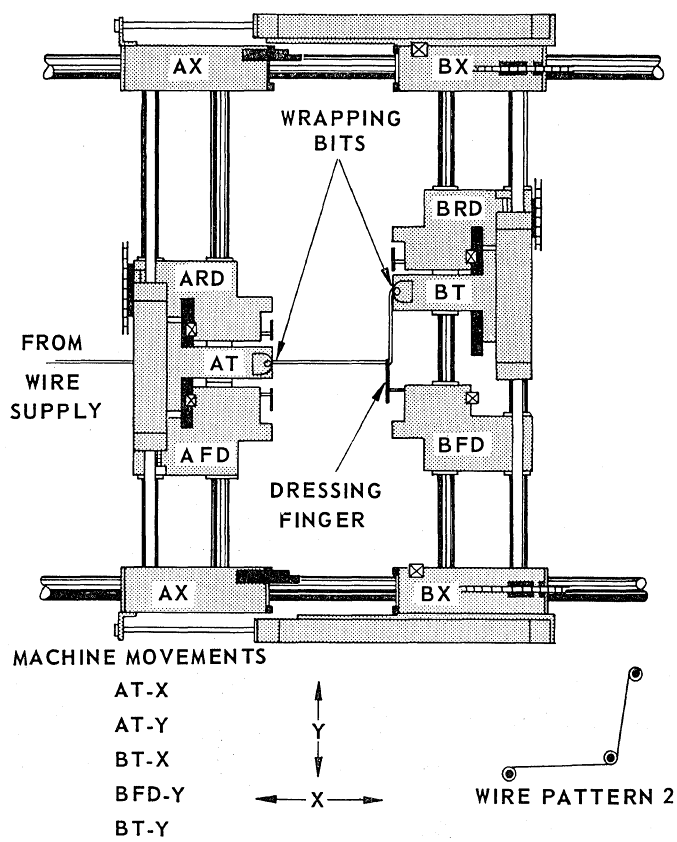
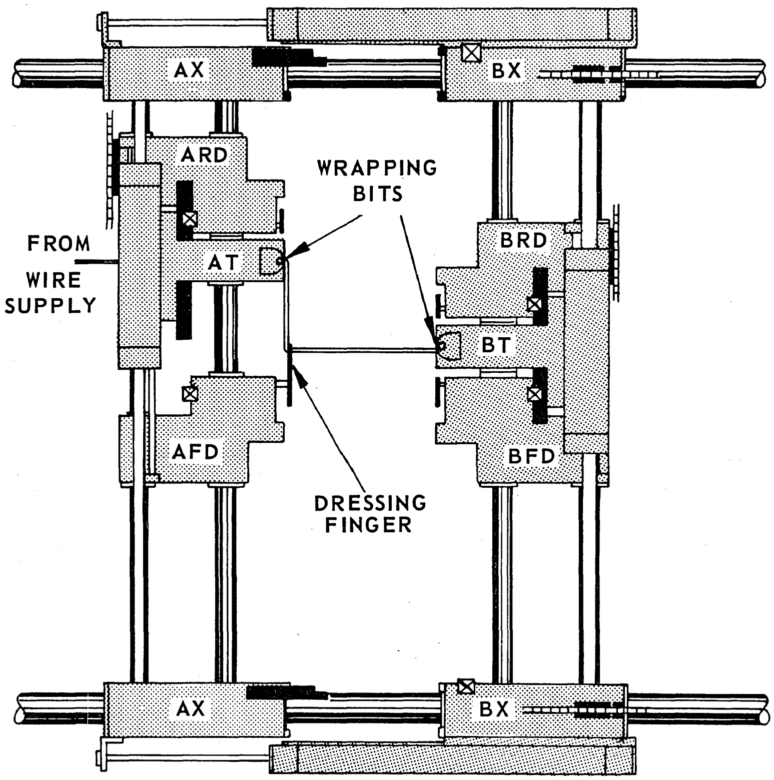
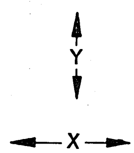
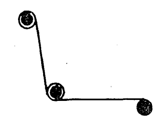


FIG. 9 - FINAL CARRIAGE POSITIONS PATTERN 2



MACHINE MOVEMENTS
AT-X
BT-Y
BT-X
AFD-Y
AT-Y

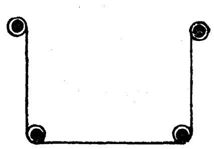




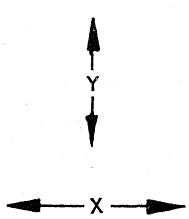
WIRE PATTERN 3

FIG. 10 - FINAL CARRIAGE POSITIONS PATTERN 3

MACHINE MOVEMENTS
AT-X
AFD-Y
BT-X
BFD-Y
AT-Y
BT-Y



WIRE PATTERN 4



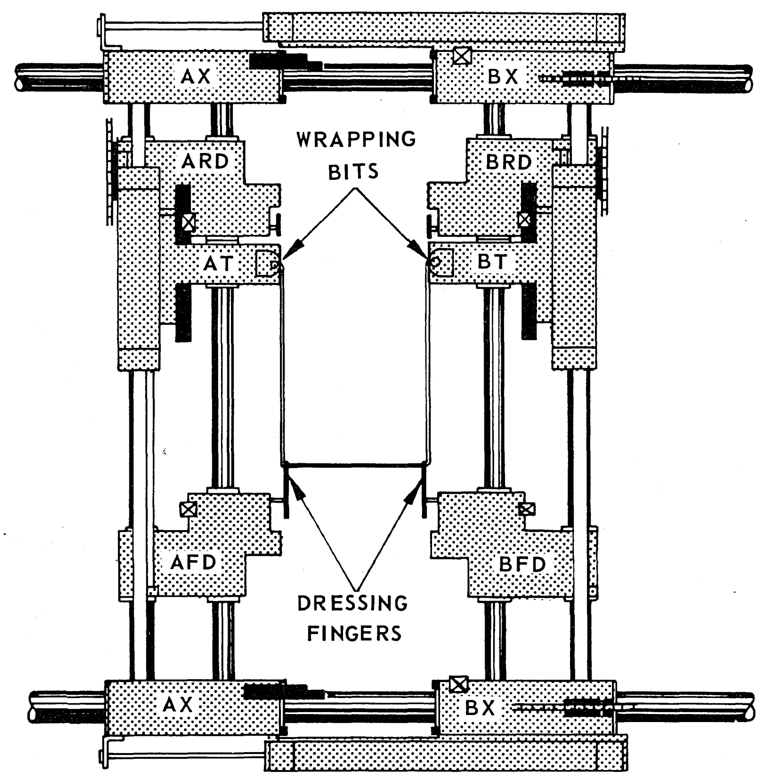
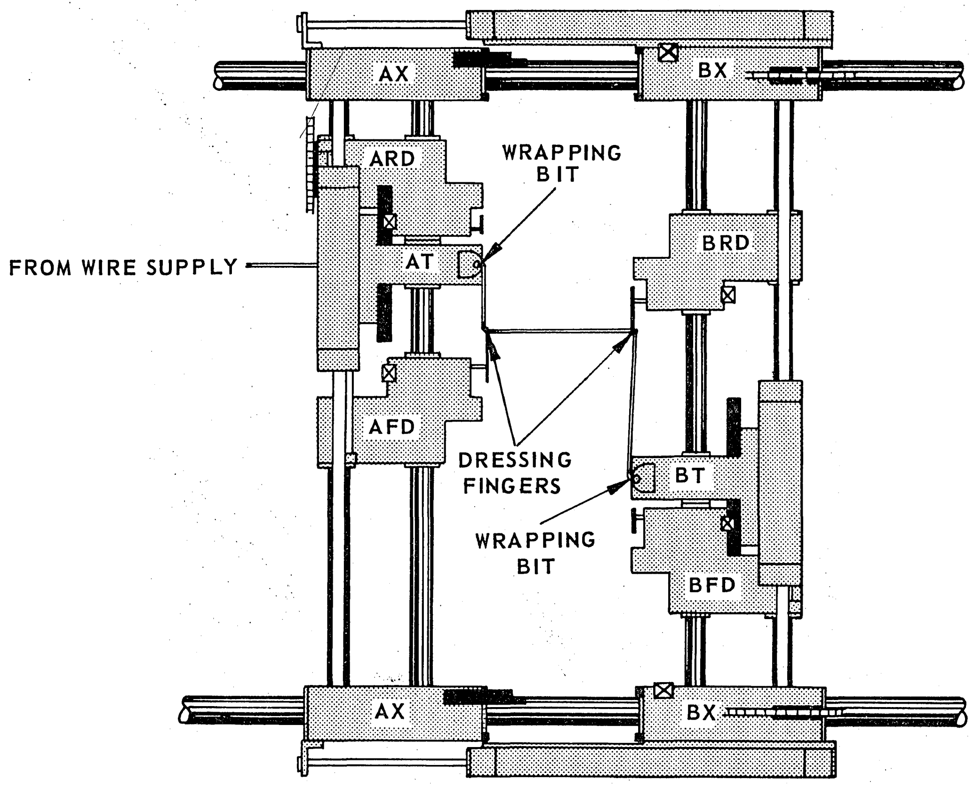
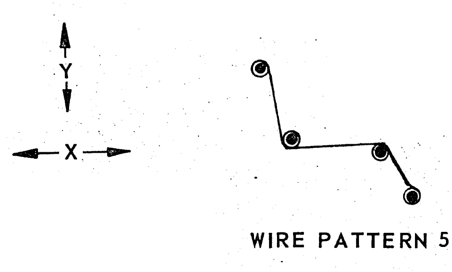


FIG. 11 - FINAL CARRIAGE POSITIONS PATTERN 4





MACHINE MOVEMENTS

AT-X
BT-Y
BT-X
AFD-Y
BRD-Y
AT-Y

FIG. 12 - FINAL CARRIAGE POSITIONS PATTERN 5

CONNECTION LEVEL HEIGHTS

The connection heights are referred to as "Z" levels and are designated as Z-1, Z-2, or Z-3. The level nearest to the panel surface is Z-1 as shown in Fig. 13 below.

To keep the wire dressed straight in a channel, the two wrapping bits rotate in opposite directions. The "A" tool rotates counterclockwise and the "B" tool rotates clockwise.

It is recommended that all wires should be run with the same wrapping level on both tools (ZA=ZB). If split levels are used on relatively short wire runs, the wire will be pulled out of the bit with the higher level as shown below. This produces loss of insulated turns on the higher wrap. Split level wiring also produces problems in panel repair or modification in the field. Minimum wire length for 24-gage wire for a one-level split (Z-1 to Z-2, or Z-2 to Z-3) should be 3/4". For a two-level split (Z-1 to Z-3) this minimum should be 1-1/2". Fig. 14 shows what happens when split levels are used with less than the minimum wire length.

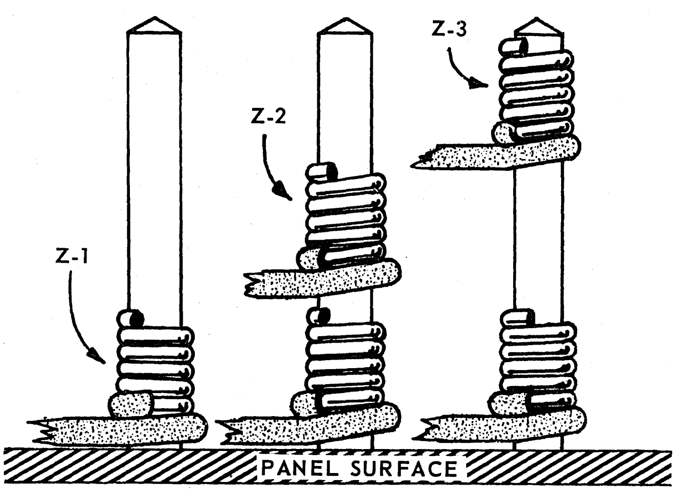


FIG. 13 - CONNECTION LEVEL HEIGHTS

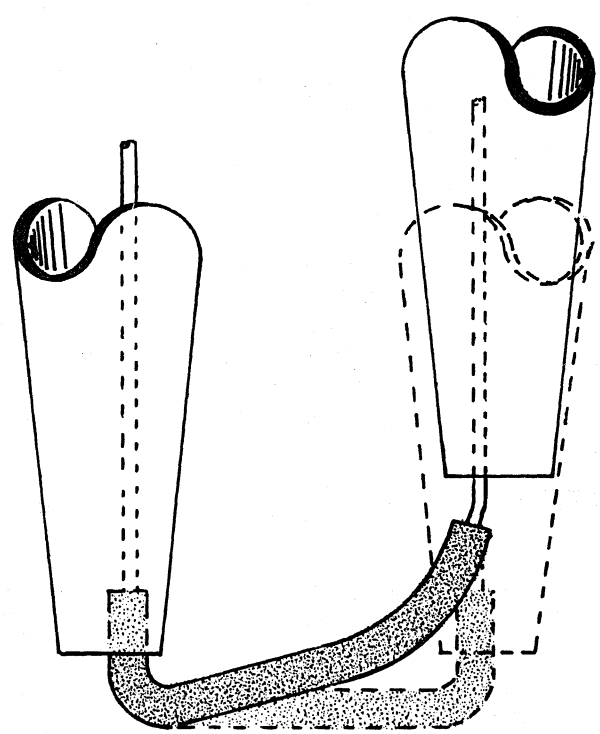


FIG. 14 - AFFECT OF SPLIT LEVELS ON SHORT WRAPS

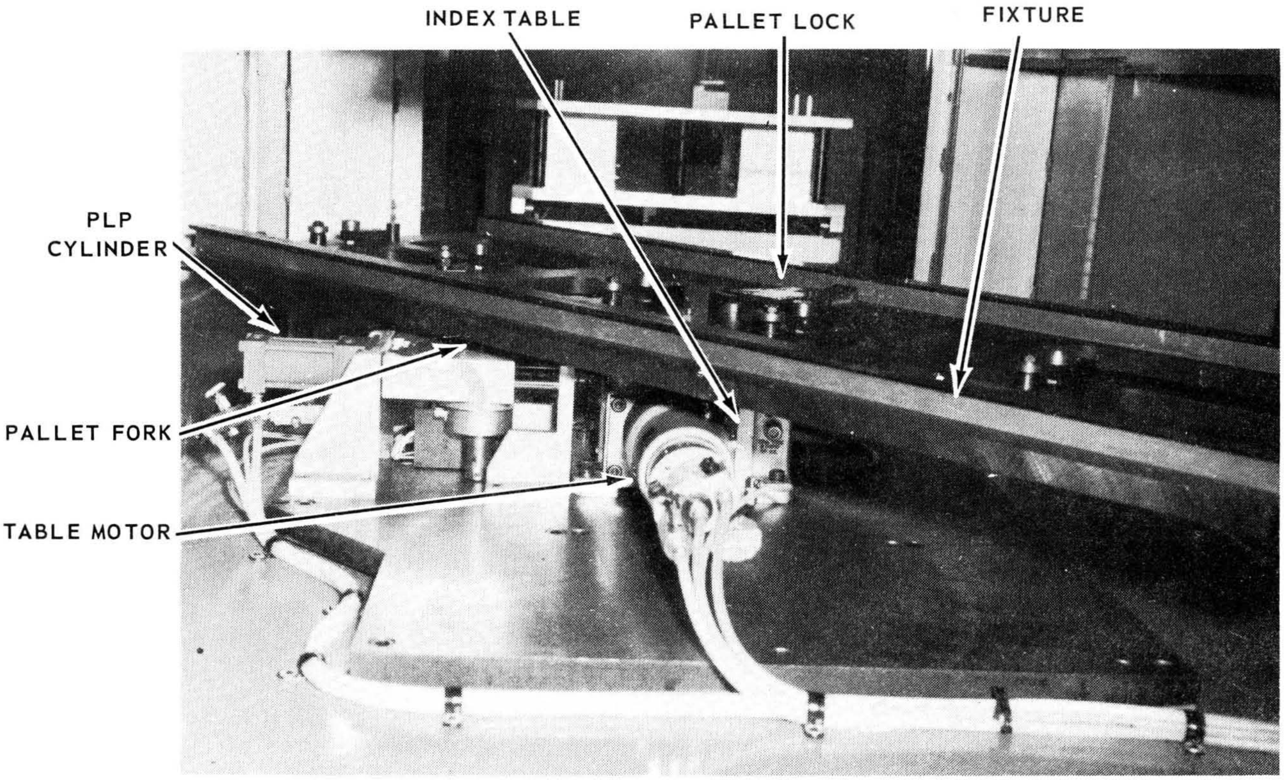
INDEXING TABLE AND PALLET

The indexing table is mounted on the top of the machine base. It is powered by an air motor to any one of four positions at a 90° spacing. These positions are defined as TABLE ROTATIONAL POSITIONS and will be referred to as TRP-1, TRP-2, TRP-3, or TRP-4. The table rotates only in one direction and this direction is normally clockwise.

The pallet is the tooling plate which locates the panel in the machine. It is located on a fixture attached to the index table which allows it to be rolled out of the machine for easy loading and unloading of the panel. Panel loading and unloading is done on the "B" Carriage side of the machine as the wire supply is located on the "A" side.

The pallet can be shifted longitudinally on the fixture. This shifting can take place only in one TRP, normally in TRP-2. To shift the pallet in TRP-4, the table would be indexed to TRP-2 and then the shift mechanism (which operates in either direction so it is not necessary to shift to one end of the pallet and then back to obtain a new position) shifts the pallet to its position. This position is defined as PALLET LONGITUDINAL POSITUDINAL POSITION and is referred to as PLP-1, PLP-2, PLP-3, etc. After the pallet is in its proper PLP position the table indexes back to TRP-4 and wrapping is continued. Each pallet shift is a fixed integral number of machine modules.

Indexing of the table and shifting of the pallet is an automatic function performed by the machine; however, the specific TRP and PLP position required must be called for as part of the program.



NOTES

MACHINE GRIDS AND

TERMINAL CO-ORDINATES

TERMINAL CONFIGURATION

There are many types of terminals, but only square and rectangular terminals are suitable for machine wrapping. Since both ends of the wire are wrapped simultaneously in opposite directions, tension is applied to the wire which tends to pull the terminals toward each other. This is referred to as "terminal toe-in." When enough of this distortion is present, it may become impossible to get down over the terminals for a higher level wrap.

The square terminal with its uniform cross section is affected the same when this tension is parallel to any side, and slightly less when tension is on a diagonal. Toe-in then becomes a function of terminal size.

The rectangular terminal will be more affected by tension applied to its shorter dimension. The solution to the toe-in problem associated with the use of straight line wire patterns is to introduce one or two dressing fingers and use a pattern other than a straight wire. This will relieve the tension after the wire has been applied and allow the terminals to return to their original location.

MACHINE GRIDS

All "Wire-Wrap" machines position on a grid system. Machines such as the 14F-15 x 15 x .125" and 14F-20 x 20 x .200" position on a .125" and .200" increments respectively, and are referred to as "fixed grid" machines. The 14F-22 x 22 x .025" machine, often referred to as the "universal" model is capable of positioning on any grid as long as it is some increment of .025". This .025" dimension is called the basic grid and is equal to one machine "module" for the 14F-22 x 22 machine. The .125" and .200" dimensions are the respective basic grids for the fixed grid machines and are equal to one machine module.

PANEL GRID SYSTEMS

There are two general types of panel grid systems commonly in use, the square and staggered grids. The square grid has rows of terminals coinciding with the panel grid lines, with a terminal at each intersection. The staggered grid has alternate rows of terminals, offset or staggered in one direction.

Each grid system has distinct advantages. The square grid system allows for greater pin density in a given area; however, the wiring must be limited to straight "X" and straight "Y" directions as generally the diagonal channel widths formed by the terminals are not sufficient to allow for successful placement of wire in the channel. The staggered grid achieves less pin density in a given area; however, it does have a greater channel width which allows for diagonal wiring with sufficient channel width. This is advantageous in circuits where electrical noise and crosstalk problems are critical as there is less parallel wiring within a given channel. The above statements are predicated on the assumption that we are comparing similar grids such as the .250" square grid with the .250" staggered grid. A comparison of channel widths on a square and staggered grid using both square and rectangular terminals is shown in Fig. 15.

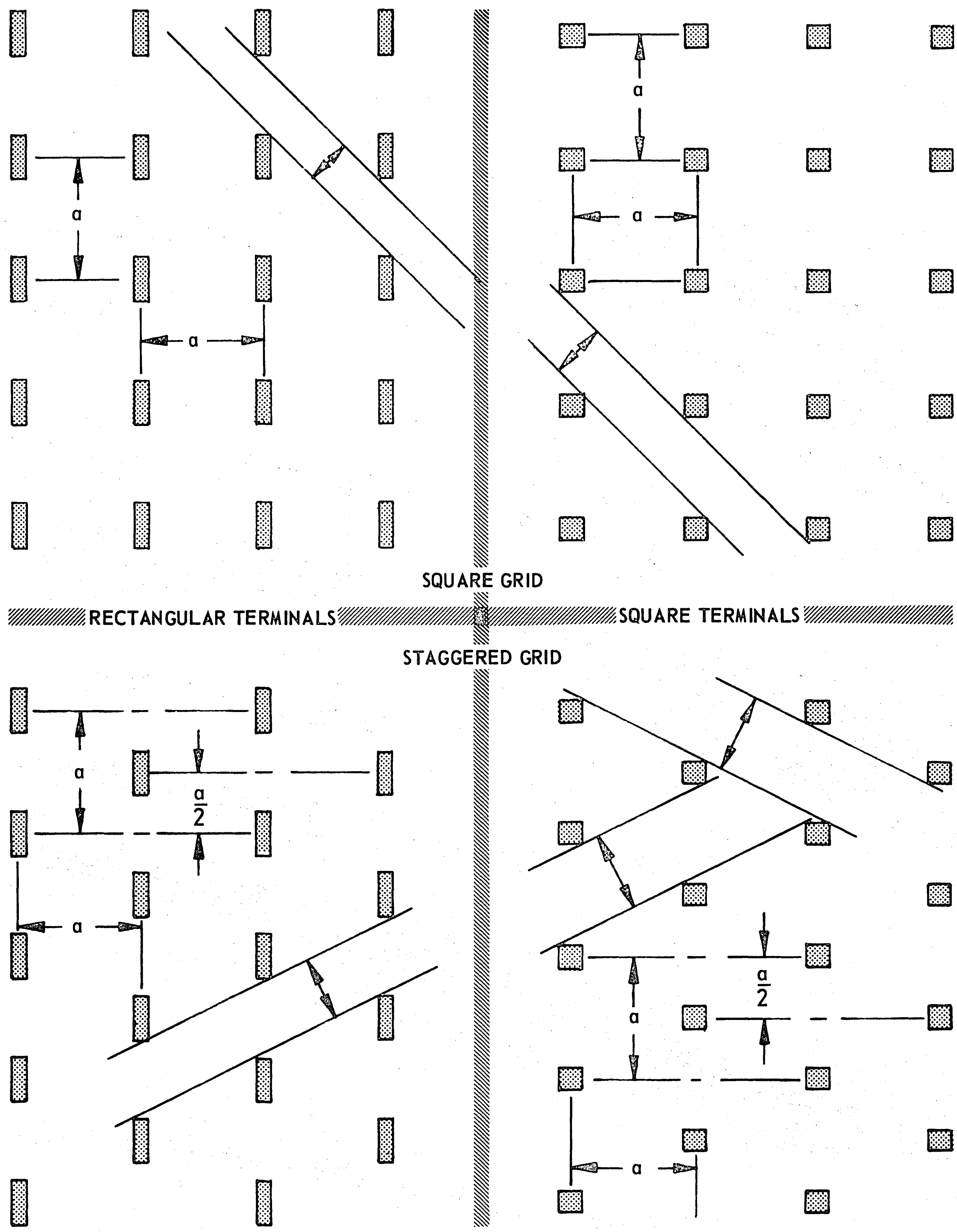


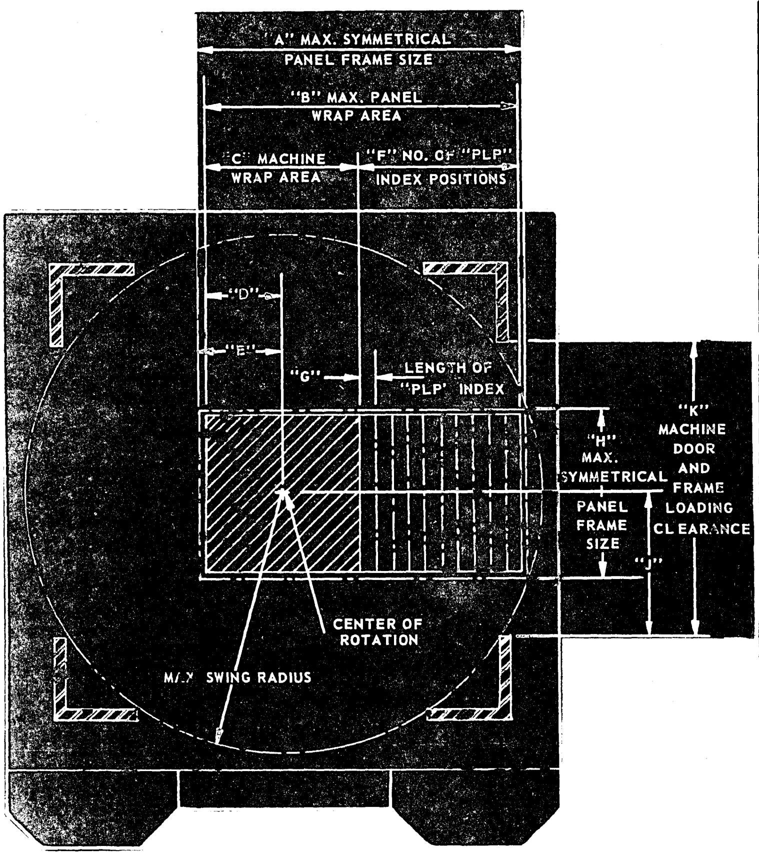
FIG. 15 - PANEL TERMINALS AND GRIDS

LOCATING THE PANELS IN THE MACHINE

The "Wire-Wrap" machine is not a seeking device but rather positions on a grid. Therefore, the panel to be wrapped must be located in the machine so that the location of the terminals coincide with the grid of the machine. The figure below shows the maximum panel sizes for the various "Wire-Wrap" machine models.

Since the "Wire-Wrap" machine positions on a grid, it must have an origin. For purposes of this explanation the origin will be considered at the lower left hand corner, table rotation will be considered clockwise, and the machine will have seven pallet longitudinal shift positions, and a shift to a higher PLP position constitutes a movement of the panel towards the left when viewed in TRP-1.

The initial set up position of the panel is made in TRP-1 and PLP-1 where all terminals will be assigned a position in machine modules. The position of the terminal will change as the table is rotated or the pallet is shifted longitudinally. The machine grid always remains fixed whether the panel is rotated or shifted.



MACHINE MODEL	14F-15x15x.125	14F-20x20x.125	14F-20x20x.200	14F-22x22x.025	14U-22x22
A	39-1/8	40-1/2	40-1/2	44	36
B	15-5/8x 32-1/8	20-3/8x 38-3/8	19.8x 37.8	22x42	22x34
C	15-5/8x 15-5/8	20-3/8x 20-3/8	19.8x 19.8	22x22	22x22
D	7-13/16	10-3/16	9.9	11	11
E	11-5/16	11-1/4	11-1/4	12	12
F	7	7	7	11	6
G	2.75	3.0	3.0	2.0	2
H	22-5/8	22-1/2	22-1/2	24	24
J	13-1/2	14-5/8	14-5/8	18-1/8	17-1/4
K	26-1/2	28-1/4	28-1/4	36-1/4	31-1/2
L	30	31.4	31.4	34-1/4	27

MACHINE PROGRAM

THE CARD FORMAT

The card format is basically the design criteria of the Gardner-Denver "Wire-Wrap" machine and in some respects controls the cycle time of the machine. Since the time required to read a column on the control card is sometimes a singular part of the time to put on a wire, it is advantageous to read as few columns as possible. Straight binary code is therefore preferred as it permits a greater amount of data per column than does binary coded decimal, or octal, etc. Binary code also allows simpler and, therefore, more reliable circuits in the machine control thus reducing the incidence of down time as well as the length of down time.

THE MACHINE CONTROL CARD

The machine data must be in a group of adjacent columns on the control card. This machine data area of the control card should be near the beginning or left end of the card. The reason for this is that registry of the card is more reliably maintained in the front half of the card when backspacing. Being able to backspace to re-run a card, when necessary, provides an appreciable savings in time over having to release and refeed three cards through the card reader.

The order of machine data on the card is dictated by sequence of machine motions or the time required to complete a function.

1. *Card Start Number (CSN or CN).* Used to check the correct order of cards in the deck. This number must match the number on the end of the preceding card.

2. *Pattern Code (PC). (If specified on the card format.)* This information selects what carriage is positioned by the data in Y1 and Y2, and Y3 and Y4, if required for the patterns.

3. *Pallet Longitudinal Position (PLP).* If the machine is designed for a panel longer than the machine wrap area, this data designates the pallet shift position.

4. *Table Rotational Position (TRP).* Rotating the index table and shifting the pallet are the slowest functions of the machine. Information for them is given early so they may be accomplished while the carriages are being positioned.

5. *"A" Tool "Z" Position (AT-Z).* This sets up at what level the "A" members will stop when they are lowered to make the wrap.

6. *"B" Tool "Z" Position (BT-Z)* "B" members wrap level.

7. *"A" Tool "X" Position (AT-X).* This data will be the machine grid "X" ordinate of the terminal to be wrapped by it. The reference member is the "B" wrapping bit.

8. *First "Y" Position (Y1).* This will be the machine grid "Y" ordinate of the "A" or "B" reference member to position it or its front dressing finger. All subsequent "Y" data will be such that both "A" and "B" drive members will either remain at their present positions or move away from the present positions of the front dressing finger carraiges.

9. *"B" Tool "X" Position (BT-X).* This will be the machine grid "X" ordinate of the terminal to be wrapped by the "B" wrapping bit and will always be such that the "B" wrapping bit moves away from the "A" wrapping bit as previously positioned.

10. *Second "Y" Position (Y2).* This data will be for the opposite "Y" drive positioned by "Y1" and will be the "Y" ordinate of the reference member to position it or its front dressing finger. If the particular pattern uses no dressing fingers, "Y1" would be the "Y" ordinate of the terminal to be wrapped by one of the bits. "Y2" would then be the "Y" ordinate of the terminal to be wrapped by the other bit and the last positioning data contained in this card.

11. *Third "Y" Position (Y3).* This data will be for positioning the second carriage of the group moved by "Y1" data, and will be the "Y" ordinate of the reference member to position it (the wrapping bit) or its rear dressing finger. Exceptions to this are patterns 2 and 3. No data will be contained here unless at least one dressing finger is used in the pattern.

12. *Fourth "Y" Position (Y4).* This data will be for positioning the second carriage of the group moved by "Y2" and will be the "Y" ordinate of the reference member (wrapping bit) to position it or its rear dressing finger. No data will appear here unless two dressing fingers are used.

13. *Card End Number (CEN) or Sequence Number (SN).* This data represents a number that is the same as that appearing at the beginning of the next card.

CARD NUMBER, TEST AND DUMMY CARDS

The card number is used to maintain the deck in the sequence that provides the most efficient machine operation as well as the required panel wiring order. Some advance consideration of this subject of card number can provide some very desirable advantages in the use of the wiring deck, quality control information, and engineering changes.

The "Wire-Wrap" machine control provides for the removal of cards from the deck without disturbing the sequence numbering. The removed card is replaced by a dummy card having the same card start and card end numbers as the card it replaces, but with no other data except an eight punch in the column following the card start number. The eight punch causes the reader to skip the machine data and read just the card number columns. Several consecutive cards may be replaced by one dummy card with a card start number matching the first card and a card end number matching the last card of the series removed.

Adding a card to the deck without renumbering the entire deck can be done by using the same card start and card end numbers as appear on the end of the preceding card and the start of the succeeding card. If several cards in a group are added, the machine will not detect mixed order within the group because all cards in the group have the same start and end numbers. A manufacturing sequence number is generally punched in the card somewhere outside the machine data section of the card. This number can be printed out on the card for a visual check of these groups. The use of this print-out-of-card number throughout the deck facilitates visual identification of a card by personnel, since, without it, one must read the punches in the card number columns. Numbering the sequence deck with the IBM 519 Reproducing Punch provided more convenient visual location and recognition than does the row 12 print out. The manufacturing number may be by tens so that up to nine cards may be inserted without disturbing the sequence.

The pallet fixture may have a test wrap block containing test terminals, which, after wrapping, will be removed for quality control tests to determine acceptability of the machine wrapping bits and/or wrapped connections. The cards used to put on these wires are called test wrap cards and are located in the deck as required by quality control. Test wrap cards may contain an identifying punch in the card start number column which voids the card number check for this card and permits placing it anywhere in the deck. However, test wrap cards may be sequenced with the original deck or added to it as described in the above paragraph. If test cards are so sequenced and contain card numbers, the identifying punch is omitted from the card start column.

Quality control may find a "pin (terminal) check list", as well as a wire list, a distinct advantage in checking panels. A pin check list is a list of the terminals in their order on the panel and the number of "Wire-Wrap" connections on each terminal. It will be noted that if each terminal has the correct number of wraps on it, statistically, the panel can be considered completed and correct. This very nearly constitutes a continuity check of the wire panel. Most machine users have found these lists to be not only desirable but adequate for both production and inspection.

THE DECK SEQUENCE

THE DECK SEQUENCE

To obtain the maximum efficiency from a "Wire-Wrap" machine it is necessary to sequence the control cards. This sequencing is generally done in the following manner.

SORT BY WRAP HEIGHT LEVELS

Levels of wraps must be put on in order of the lowest level (Z-1) to the highest level (Z-2 or Z-3). Maintaining a good distribution of wires and keeping wire density build-up in the channels to a minimum is necessary in order to permit the wrapping bits to reach their prescribed levels.

Excessive wire density is a serious problem on the machine wired panel because it impairs machine efficiency. Short, straight wires, or jumpers, as shown in Basic Pattern 1, are a major cause of this density build-up. They produce a bridging effect across the wiring channel, particularly on second level wraps where there is a void left below the wire that could have contained wires.

Bridging can be avoided by putting on the short jumpers first for Level 1 wraps and last for levels other than Level 1. Fig. 16 illustrates what happens when Level 1 jumpers are not put on last.

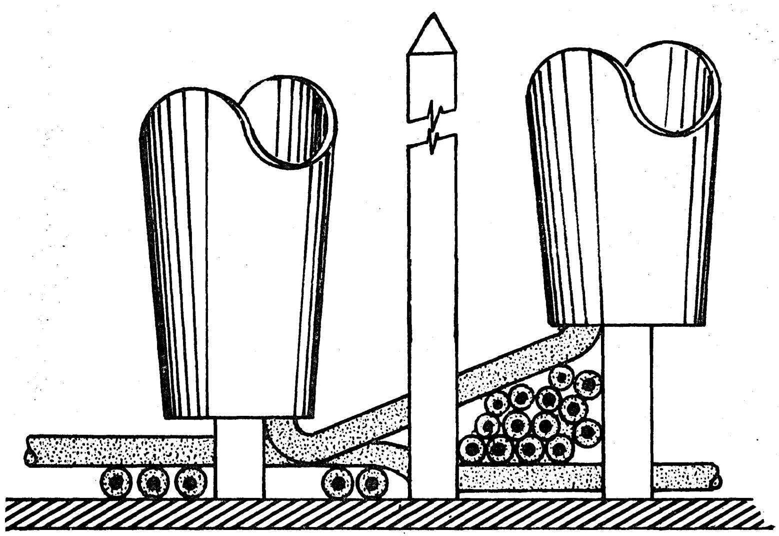


FIG. 16 - CHANNEL BUILD-UP EFFECT ON SHORT Z-1 WRAPS WHEN THEY ARE NOT PUT ON FIRST

There is a second method of handling bridging. It cannot be used on the very short jumpers, but it has some advantages on the long jumpers. The approach is to use two dressing fingers, a change to Basic Pattern 4, or use one dressing finger to form a "V" or "L" as in Basic Patterns 2 or 3. An example of this is shown in Fig. 17. These patterns will take a little more time to form than a straight wire, but they are the most feasible solution to density problems.

The short jumpers on levels other than Level 1 can be used to a very good advantage as "tie-downs" following long wire runs. Sequencing for this will be difficult except as determined by watching for high wires (wires that have popped up above the terminal mass) as a panel is wrapped.

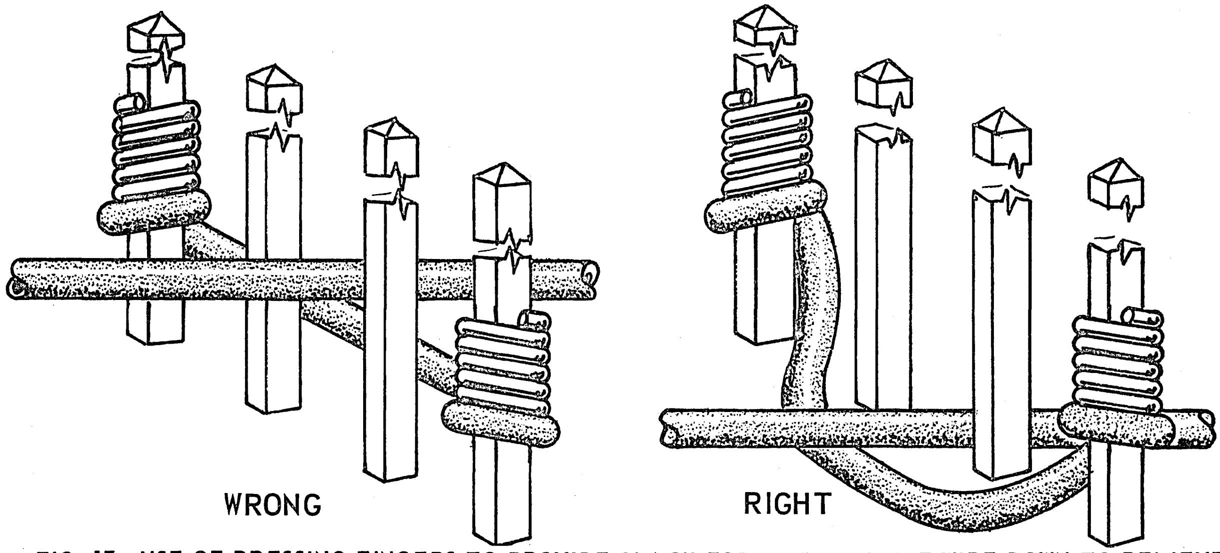


FIG. 17 - USE OF DRESSING FINGERS TO PROVIDE SLACK FOR DRESSING THE WIRE DOWN TO RELIEVE BUILD-UP

Early consideration of wire distribution should make the use of the two suggestions above completely adequate to the problem. Sequencing the laying of wires in a channel properly can gain the most effective use of these channels, as can be seen in Fig. 18.

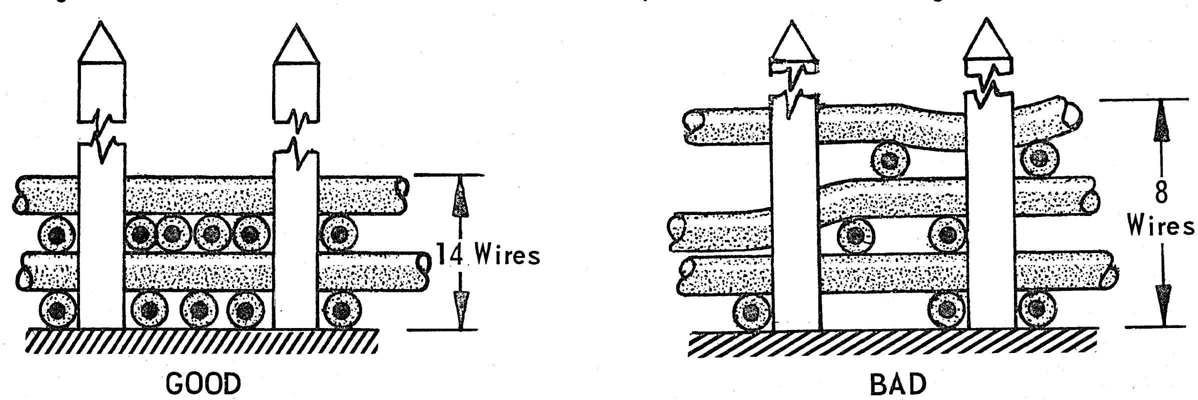


FIG. 18 - SEQUENCING TO REDUCE CHANNEL BUILD-UP

Wires sticking up above the terminals are dangerous for two reasons: (1) They may catch on the carriages as the machine positions for another pattern, causing damage to the panel. (2) The wire may lay across a row of terminals and be forced down between terminals within a row, resulting in "basket-weave." "Basket-weave" is produced by (a) slack in a pattern when it is formed, caused by excessive drive speed or insufficient wire tension or, (b) by failure to use dressing fingers on long excursions, (c) panel not located properly in the machine.

SORT FOR PALLET LONGITUDINAL POSITION

For those panels that are larger than the machine wrap area in one direction, a pallet shift is necessary to wire the entire panel. Shifting the panel takes a relatively long time and may even involve a table rotational change. Because of the time required to accomplish shifting the panel, it is desirable to keep the number of shifts to a minimum. One pallet position shift in TRP-2, where no table rotation is necessary, will not lengthen the cycle time. A PLP shift in other than TRP-2 will require a 360° table rotation in addition to the pallet shift.

SORT FOR TABLE ROTATIONAL POSITION

The change of index table rotational position is the most time consuming function in the machine and must be held to a minimum if efficient use of the "Wire-Wrap" machine is to be achieved. One 90° index change can be made without loss of time because the carriages will be positioning for the wrap pattern while the table is rotating. A 270° change will, however, take nearly twice the average time to position the carriages and wrap a wire.

Since the PLP shift occurs only in TRP-2, the optimum TRP sort is TRP-2, -3, -4, and -1. Patterns put on in TRP-1 and -3 will, in general, provide parallel wire lays; therefore, it may be that 180° rotations are advantageous. The TRP sort, in this case, should then be TRP-3, -1, -2, and -4 or TRP-2, -4, -1, and -3.

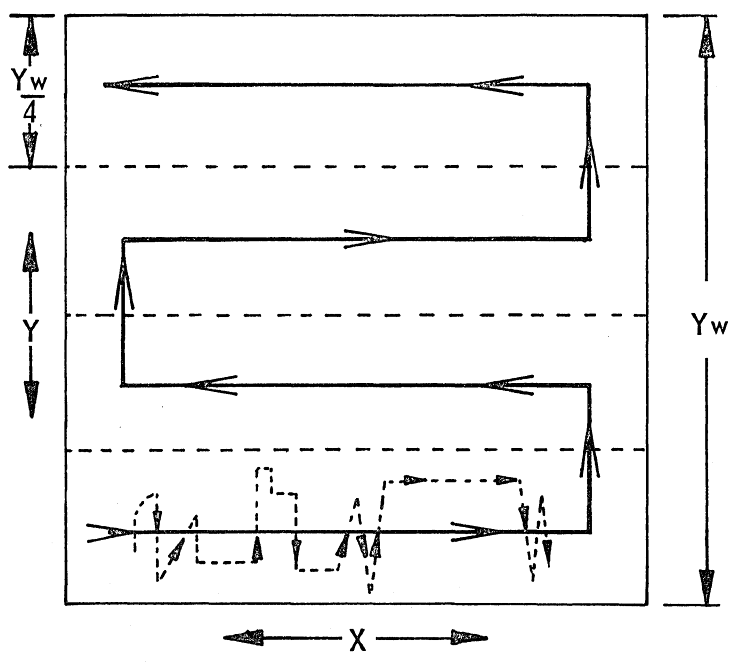
SORT FOR INITIAL "X", "Y" POSITION

It is desirable to reduce the distance the carriages must travel from one wrap to the next as this will result in more wires per hour by the machine. The optimum selection of the next "AT-X" and "Y1" would be "Y1" as close as possible to the "Y" ordinate = $\frac{\text{last lowest "Y" + last highest "Y"}}{2}$ and "AT-X" as close as possible to the "X"

ordinate = $\frac{\text{last "AT-X" + last "BT-X."}}{2}$

A surprising improvement has been noted in average machine cycle time by merely sorting a poorly sequenced deck for lowest "Y1." It is recommended that something slightly more sophisticated be used, since the advantages to be gained are still worthwhile. Sorting for either lowest or highest "Y1" may be supplemented by dividing this into four equal "Y" dimension groups. Sort each of these groups for lowest "AT-X." By putting these groups together so that the first and third "Y" groups have "AT-X" ordered from lowest to highest and the second and fourth "Y" groups have "AT-X" from highest to lowest, the general motion shown in Fig. 19 will result. This "X", "Y" sequence can then be reversed for the next TRP.

The reasons for the above recommendation stems from several facts. The "X" drive is slightly slower in positioning than the "Y" drive, due to a greater carriage mass. Wire is fed to the "B" tool upon the completion of "Y1" and regrouping; the "X" drive may still be positioning "AT-X." The range is therefore taken in "Y," since it can more easily be accomplished with time remaining to feed wire while "AT-X" is positioning and "BT-X" data is being read. This very nearly matches the completion of the feeding of the wire to the check of "BT-X" data, both being required before "BT-X" motion.



General Path of Machine Carriages Resulting from the X,Y Sequencing.

NOTE: $\frac{Yw}{4}$ is arbitrary and may be larger or smaller depending upon the number and location of wires in the particular TRP group.

SUMMARY

The total sequence plan briefly is as follows:

(a) Distribution for consideration of density in the plan for minimum crosstalk.

(b) Sort for levels; 1, 2, 3.

(c) Sort for wire length: length $<1\frac{1}{2}''$, length $\geq 1\frac{1}{2}''$ (nominal) for level 1, reverse for other levels.

(d) Sort for PLP: lowest to highest.

(e) Sort for TRP: 2, 3, 4, 1.

(f) Sort for Y1: lowest (or highest), for first and third $\frac{\text{``YW''}}{4}$ groups, reverse order for second and fourth groups.

(g) Sort for "AT-X": lowest (or highest), for first and third $\frac{\text{``YW''}}{4}$ groups, reverse order for second and fourth groups.

PROGRAM FLOW CHART

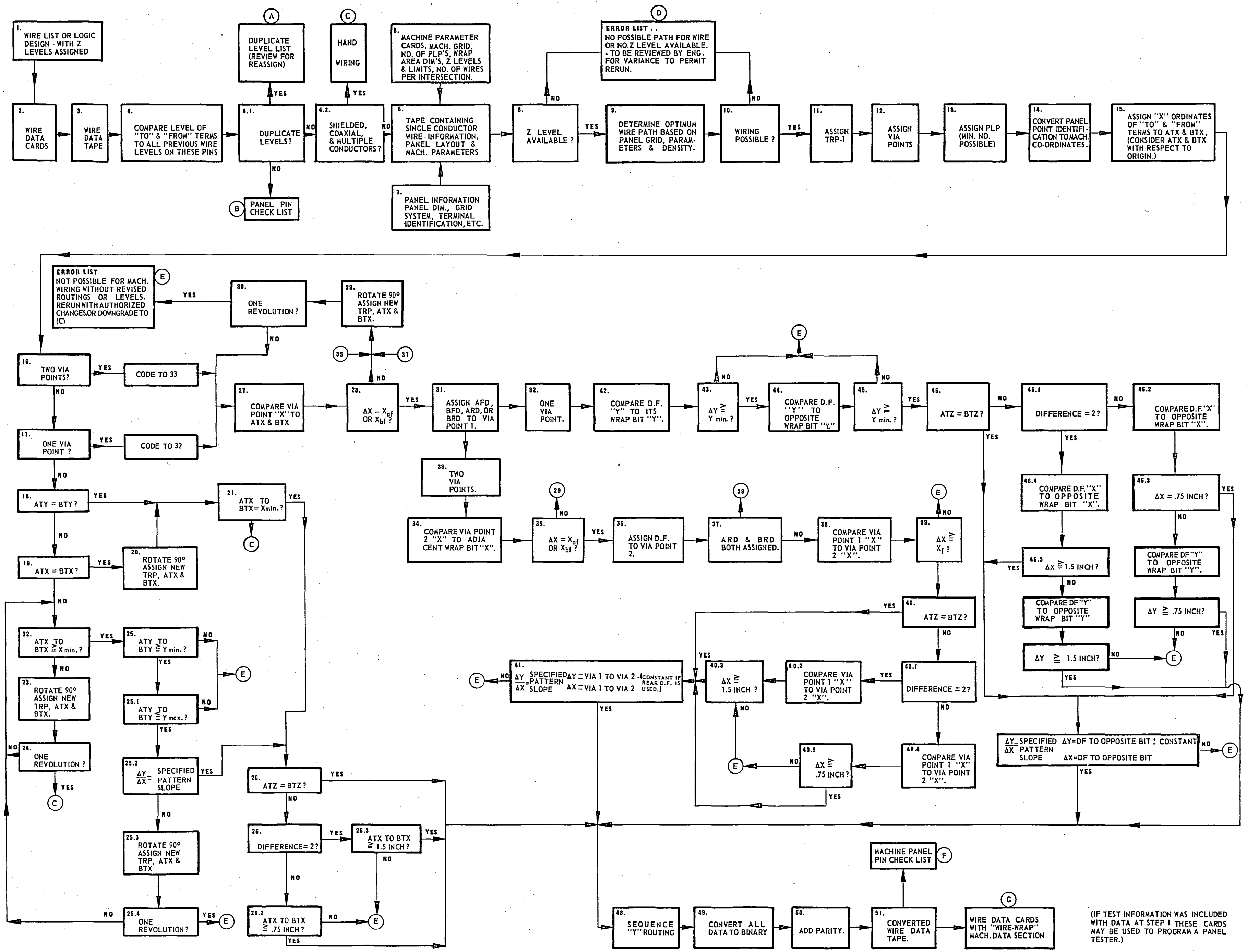
The chart on the next page is a generalized block diagram aimed at being a guide for the programmer, for any panel and machine combination. There are assumptions regarding the capacity of the computer used, the form of wire data available, and individual project procedures. In the case of some panels, certain steps in the block diagram may be minimized, specified directly, or eliminated.

CORRECTING THE PROGRAM

No program has been completely correct the first time through. It is not impossible, but realistically, it is improbable. The machine is complex in its operation and there are just too many facts that the programmer must know and keep in ready access that cannot be put into the computer. Also, there will be conditions on the panel which cannot be anticipated.

Watching the panel being wrapped is the best way to spot areas of improvement in sequencing the deck, and even in some cases, the selection of patterns to be used. Doing this will provide the final perfective touches to your program and make a smooth, efficient production facility of the "Wire-Wrap" machine.

New operators will not be able to provide such suggestions, but an experienced operator who applies himself can be an invaluable asset.


1. WIRE LIST OR LOGIC DESIGN - WITH Z LEVELS ASSIGNED
2. WIRE DATA CARDS
3. WIRE DATA TAPE
4. COMPARE LEVEL OF "TO" & "FROM" TERMS TO ALL PREVIOUS WIRE LEVELS ON THESE PINS
4.1. DUPLICATE LEVELS?
A
DUPLICATE LEVEL LIST (REVIEW FOR REASSIGN)
B
PANEL PIN CHECK LIST
4.2. SHIELDED, COAXIAL, & MULTIPLE CONDUCTORS?
C
HAND WIRING
5. MACHINE PARAMETER CARDS, MACH. GRID, NO. OF PLP'S, WRAP AREA DIM'S, Z LEVELS & LIMITS, NO. OF WIRES PER INTERSECTION.
6. TAPE CONTAINING SINGLE CONDUCTOR WIRE INFORMATION, PANEL LAYOUT & MACH. PARAMETERS
7. PANEL INFORMATION PANEL DIM., GRID SYSTEM, TERMINAL IDENTIFICATION, ETC.
8. Z LEVEL AVAILABLE?
D
ERROR LIST.. NO POSSIBLE PATH FOR WIRE OR NO Z LEVEL AVAILABLE. - TO BE REVIEWED BY ENG. FOR VARIANCE TO PERMIT RERUN.
9. DETERMINE OPTIMUM WIRE PATH BASED ON PANEL GRID, PARAMETERS & DENSITY.
10. WIRING POSSIBLE?
11. ASSIGN TRP-1
12. ASSIGN VIA POINTS
13. ASSIGN PLP (MIN. NO. POSSIBLE)
14. CONVERT PANEL POINT IDENTIFICATION TO MACH. CO-ORDINATES.
15. ASSIGN "X" ORDINATES OF "TO" & "FROM" TERMS TO ATX & BTX, (CONSIDER ATX & BTX WITH RESPECT TO ORIGIN.)
E
ERROR LIST NOT POSSIBLE FOR MACH. WIRING WITHOUT REVISED ROUTINGS OR LEVELS. RERUN WITH AUTHORIZED CHANGES, OR DOWNGRADE TO (C)
16. TWO VIA POINTS?
CODE TO 33
17. ONE VIA POINT?
CODE TO 32
18. ATY = BTY?
19. ATX = BTX?
20. ROTATE 90° ASSIGN NEW TRP, ATX & BTX.
21. ATX TO BTX = Xmin.?
22. ATX TO BTX ≧ Xmin.?
23. ROTATE 90° ASSIGN NEW TRP, ATX & BTX.
24. ONE REVOLUTION?
25. ATY TO BTY ≧ Ymin.?
25.1 ATY TO BTY ≦ Ymax.?
25.2 ΔY/ΔX = SPECIFIED PATTERN SLOPE
25.3 ROTATE 90° ASSIGN NEW TRP, ATX & BTX
25.4 ONE REVOLUTION?
26. ATZ = BTZ?
26. DIFFERENCE = 2?
26.2 ATX TO BTX ≧ .75 INCH?
26.3 ATX TO BTX ≧ 1.5 INCH?
27. COMPARE VIA POINT "X" TO ATX & BTX
28. ΔX = Xaf OR Xbf?
29. ROTATE 90° ASSIGN NEW TRP, ATX & BTX.
30. ONE REVOLUTION?
31. ASSIGN AFD, BFD, ARD, OR BRD TO VIA POINT 1.
32. ONE VIA POINT.
33. TWO VIA POINTS.
34. COMPARE VIA POINT 2 "X" TO ADJACENT WRAP BIT "X".
35. ΔX = Xaf OR Xbf?
36. ASSIGN D.F. TO VIA POINT 2.
37. ARD & BRD BOTH ASSIGNED.
38. COMPARE VIA POINT 1 "X" TO VIA POINT 2 "X".
39. ΔX ≧ Xf?
40. ATZ = BTZ?
40.1 DIFFERENCE = 2?
40.2 COMPARE VIA POINT 1 "X" TO VIA POINT 2 "X".
40.3 ΔX ≧ 1.5 INCH?
40.4 COMPARE VIA POINT 1 "X" TO VIA POINT 2 "X".
40.5 ΔX ≧ .75 INCH?
41. ΔY/ΔX = SPECIFIED PATTERN SLOPE ΔY = VIA 1 TO VIA 2 - (CONSTANT IF REAR D.F. IS USED.) ΔX = VIA 1 TO VIA 2
42. COMPARE D.F. "Y" TO ITS WRAP BIT "Y".
43. ΔY ≧ Y min.?
44. COMPARE D.F. "Y" TO OPPOSITE WRAP BIT "Y."
45. ΔY ≧ Y min.?
46. ATZ = BTZ?
46.1 DIFFERENCE = 2?
46.2 COMPARE D.F. "X" TO OPPOSITE WRAP BIT "X".
46.3 ΔX = .75 INCH?
COMPARE DF "Y" TO OPPOSITE WRAP BIT "Y".
ΔY ≧ .75 INCH?
46.4 COMPARE D.F. "X" TO OPPOSITE WRAP BIT "X".
46.5 ΔX ≧ 1.5 INCH?
COMPARE DF "Y" TO OPPOSITE WRAP BIT "Y"
ΔY ≧ 1.5 INCH?
ΔY/ΔX SPECIFIED PATTERN SLOPE ΔY=DF TO OPPOSITE BIT ± CONSTANT ΔX=DF TO OPPOSITE BIT
48. SEQUENCE "Y" ROUTING
49. CONVERT ALL DATA TO BINARY
50. ADD PARITY.
51. CONVERTED WIRE DATA TAPE.
F
MACHINE PANEL PIN CHECK LIST
G
WIRE DATA CARDS WITH "WIRE-WRAP" MACH. DATA SECTION
(IF TEST INFORMATION WAS INCLUDED WITH DATA AT STEP 1 THESE CARDS MAY BE USED TO PROGRAM A PANEL TESTER.)
YES
NO