INTRODUCTION

The Model MP37 Controller is a special purpose computer designed to control a sheet metal processing machine. The machine converts coiled stock material into cut parts with a variety of notch and hole patterns.

The MP37 Controller has been designed to work with two distinct types of machines. The first is a machine that makes heating,air conditioning, and ventalation (HVAC) ducting parts. The second is a machine or class of machines that make a variety of industrial parts.

The duct machine mode is designed to make it easy for the operator to program. THe operator only has to enter the type of duct construction and the finished length and width. The computer then calculates the required notch pattern based on this information and some internal dimensional constants.

The industrial machine can be generalized as having a notching pattern that is coincident with the shear and a secondary hole pattern that can be repeated along the length of the part. The end-notch press will place a pattern on the leading edge of one part and on the trailing edge of the previous part with one cycle of the press. THe hole press can be programed to cycle at up to 20 distinct locations or it can be set up to repeat an incremental movement between holes up the 50 times.

A simple diagram of the machine is shown in Figure 1. The rotopulser, or rotary pulse generator, transmits a pulse to the computer for each linear movement of the material. The computer keeps track of these pulses and then controls the driving rolls and the press solinoids in order to fabricate the patterns that were programed.

SPECIFICATION

Resolution	.012 in with 12 in wheel
Accuracy	Output turned on within 1 count (does not include errors of the machine)
Maximum Line Speed	200 FPM
Maximum Length Part	9999.99 inches
Maximum Batch Quantity	9999
Number of Batches	50
Pattern Types	9 (0-8)
Input Power	115VAC +/-10%,50-60Hz,1 Amp max 5-24VDC, 1 Amp (excluding loads)
Outputs	6 (FWD,REV,SLOW,SHEAR,P1,P2) 5-24VDC, 5 Amp max
Inputs	2 (JOG FWD and JOG REV)
Length Totalizer	999999 FT or Meters
Physical Size	6in X 9in X 10in with a 1in flange on the front panel
Weight	13 pounds

Figure 2 shows the layout of the front panel and keys. There is a 16 key keypad, 6 illuminated pushbutton switches, and a 12 digit LED display. The function of each switch and key is as follows:

MANUAL END NOTCH

The MANUAL END NOTCH key is used to manually cycle the END NOTCH output when the line is in the HALT mode. The lamp indicates when the END NOTCH output is on in both the HALT and RUN modes.

MANUAL VEE NOTCH

The MANUAL VEE NOTCH key is used to manually cycle the VEE NOTCH output (or HOLE output) when the line is in the HALT mode. The lamp indicates when the VEE NOTCH output is on in both the HALT and RUN modes.

MANUAL SHEAR

The MANUAL SHEAR key is used to manually cycle the SHEAR output when the line is in the HALT mode. The lamp indicates when the SHEAR output is on in either the HALT or RUN modes. The SHEAR key also causes a RESET condition in the controller. The RESET means that all parts in progress will be terminated and the controller will begin again from the END NOTCH press to process the uncompleted parts over again.

METRIC WHEN LIT

The METRIC WHEN LIT key is used to switch between metric and English units of measurements. When the lamp is lit, data is entered and displayed in centimeters (meters for accumulator). When the lamp is not lit, the data is displayed and entered in inches (feet for accumulator).

RUN

The RUN key is used to initiate an automatic run of the machine. The green lamp indicates when the controller is in the RUN mode.

HALT

The HALT key is used to abort an automatic run of the machine. The red lamp indicates that the controller is in the HALT mode.

SETUP

The SETUP key is used to enter the SETUP mode. The SETUP mode is used to enter semi-permanent data about the machine such as die spacing, cycle duration, die size, flow direction, etc.

END

The END key is used to exit the PROGRAM or SETUP mode and return to the HALT or RUN mode display.

PRG

The PRG key is used to enter the PROGRAM mode to enter batch data on the parts to be run.

ENT

The ENT key is the data ENTER key and it is used by the operator to indicate to the computer to take the data that is present in the display window.

CLR

The CLR key is the data CLEAR key and is used to erase key entry before the ENTER key. It is also the key that is used to set the total length accumulator to zero.

The display on the front panel is a 12 character 7-segment LED display that is used to show data and prompt the operator for information.

There are 6 outputs from the MP37. These are 5 ampere open collector transistors that switch load current to the DC ground. The function of each is as follows:

The FWD output is used to turn the machine drive rolls in the forward direction.

The REV output is used to turn the machine drive rolls in the reverse direction.

The SLOW is used to change the speed of the drive rolls. When the SLOW output is on, the rolls will turn at slow speed when either the FWD or REV outputs are on. When the SLOW output is off, the rolls will turn at fast speed when either the FWD or REV outputs are on. The SLOW output is

always on when FWD is off or in the HALT mode. The SLOW output will be off when the FWD is on and the distance to the next press function is greater than the programed SLOWDOWN DISTANCE (see SETUP).

The END NOTCH output is used to cycle the end notch press.

The VEE NOTCH output is used to cycle the vee notch or hole press.

The SHEAR output is used to cycle the shear or cutoff press.

There are two external input switches into the MP37. These are the JOG FWD and JOG REV switches. These inputs are only looked at by the computer in the HALT mode. When closed, the FWD or REV outputs respectively will turn on. The SLOW output will remain on so that all jogging (or inching) of the machine is done at slow speed.

Material movement is sensed by the MP37 through the rotopulser (rotary pulse generator) which is an incremental optical shaft angle encoder. This device generates a precise number of pulses for each revolution of its shaft. On the shaft is a precision measuring wheel which rides on the material. As the material moves through the machine, it turns this wheel and thus causes the potopulser to generate pulses. The computer counts these pulses and by knowing the counts per revolution of the rotopulser and the circumference of the wheel, the computer can detect the amount of material that has moved through the machine.

The heart of the MP37 is the microprocessor and its associated memory components. The operating program of the computer is contained in read-only-memory (ROM) and user data such as setup parameters and batch data is contained in random-access-memory (RAM) that normally would not retain the information when power is off except that there is a battery in the unit that that provides power to the RAMs at all times. This battery should last for about 5 years. Should the unit fail to retain memory on a consistant basis, the battery should be replaced.

MODES OF OPERATION

There are five modes of operation in the MP37- SETUP, PROGRAM, RUN, HALT, and ERROR. It is possible to be in two modes at the same time. It should be clearer to explain the two types of modes that one could encounter. On type can be called the display mode and the other can be called the machine mode. The display modes are SETUP, PROGRAM, RUN, or HALT. This refers to what the computer is showing on the display and what keys it will respond to. The machine modes are RUN and HALT and they refer to what the machine is doing. The ERROR mode can be entered from any type of mode depending on what the error is. By making this distinction between the two types of modes, an operator can put the machine in the RUN mode and then put the display in the PROGRAM mode and thus program new data while older batches are being run.

SETUP MODE

The SETUP mode is used to enter machine parameters and some seldom changed part parameters. The mode is entered by pressing the SETUP key and is exited by pressing the END key or by stepping through all of the parameters. Table 1 shows a table of these parameters with the prompts used, range of allowed values, with a place to write in the proper values for your machine. The setup parameters and their function in the machine are as follows:

LENGTH TOTALIZER

The LENGTH TOTALIZER or accumulator indicates the total amount of material that has passed through the machine since the accumulator was last cleared. The operator can only clear this amount to zero using the CLR key and he cannot set it to a number.

END NOTCH TO SHEAR DISTANCE

The END NOTCH to SHEAR DISTANCE is the distance from the center of the end notch die to the center of the shear die. This is usually determined by loading the machine up with material and manually cycling the shear and end notch presses without moving the material, running the material forward until the end notch pattern is past the shear, and measuring the distance from the leading edge of the sheet to the center of the end notch pattern. If the shear removes a slug of material then half of this slug width must be added to this measurement since the distance specified is from die center to die center.

VEE NOTCH TO SHEAR DISTANCE

The VEE NOTCH to SHEAR DISTANCE is the distance from the center of the vee notch die to the center of the shear die. This distance would be determined in a manner similar to the end notch distance.

SLOWDOWN DISTANCE

The SLOWDOWN DISTANCE is the length required for the machine to dependably shift from fast speed to slow speed so that

the material is moving at slow speed when a press operation occurs. If the distance is set to zero, then the computer sets the line up as a flying die machine with no stop at a press cycle.

SHEAR TIME

The SHEAR TIME parameter sets the time duration of the shear press cycle.

END NOTCH TIME

The END NOTCH TIME sets the time duration of the end notch press cycle.

VEE NOTCH TIME

The VEE NOTCH TIME sets sthe time duration of the vee notch press cycle.

PAUSE TIME

The PAUSE TIME is a time delay after the shear press cycle that will allow a spacing between parts as they exit the machine.

BATCH HALT

The BATCH HALT function allows the operator to select either an automatic return to the HALT mode after each batch is run or a continuing run of the next batch. In either case the next batch may have been started by the machine with partial patterns being produced but no complete parts will made if the BATCH HALT is set to YES. This may be required in some installations to allow for packaging of the previous batch

or for a required change of some downstream machinery because of a dimensional change in the parts being run.

LEADING EDGE SCRAP LENGTH

The LEADING EDGE SCRAP LENGTH or CONS 1 is the distance required on the leading edge of a part to allow for an orderly transition from an end notched part to a shear only part. Since an end notch normally puts a pattern on both the trailing edge of one part and the leading edge of the next part, when the last end notched part was completed, there would be a pattern on the leading edge of the next part. If that part were to be a shear only part, this parameter will force an automatic double shear so that a piece of scrap will be produced and the first part of shear only batch will not have a notch pattern.

TRAILING EDGE NOTCH DISTANCE

This dimension is similar to the previous except that it applies to the scrap required at the transition from a shear only to an end notched part.

LEADING EDGE ALLOWANCE

The LEADING EDGE ALLOWANCE is a distance that is automatically added to the front edge of a part, indepentent of the part data programed. In the case of the duct machine, this would be the leading edge lock allowance that would be required.

TRAILING EDGE ALLOWANCE

The TRAILING EDGE ALLOWANCE is the amount of material that is automatically added to the trailing edge of each part.

CORRECTION FACTOR

The CORRECTION FACTOR is a constant that allows for the correction of the length of a part due to wear of the measuring wheel.

MINIMUM LENGTH

The MINIMUM LENGTH parameter allows for a limit to be set for the smallest part that could be run through the machine. This may be necessary because a short part may become jammed in the machine.

START LENGTH

The START LENGTH is used for non-stopping lines and is the distance required to get a line up to speed before a press operation can take place.

SLUG LENGTH

The SLUG LENGTH is the width of the slug that the shear may remove when it is cycled. This is automatically added to each part run with half being added to the front edge and half added to the rear edge.

DIRECTION

In different machines, the rotopulser can be mounted so that forward motion of the material can produce either an up or a down count in the computer depending on whether the shaft

turns clockwise or counterclockwise. The DIRECTION parameter allows for an easy direction change.

PROGRAM MODE

The PROGRAM mode is used to enter batch information on the parts that are to be run. A batch is defined as a quantity of a particular part that the operator wishes to produce by the machine. There are 50 batches that can be programed at any one time. As batches are completed, new batch data can be entered in the place of completed batches.

The PROGRAM mode is entered by pressing the PRG key and is exited by pressing the END key. The first entry required is the batch number. It is initially set to the first empty batch number after the batch that is currently being run. If you are running batch 1 and batches 2 through 10 have been programed, then it will begin with batch 11. If this is the batch desired, then press the ENT key. IF another batch is desired, enter that number. The display will then prompt for the TYPE which can be from 0 to 8. After entering the TYPE, the display will prompt for the number of pieces required. this can be from 0 to 9999. Entering 0 will delete that batch. The display will then go through a sequence of prompts, asking for the data required for each particular type.

TYPE 0 is a shear only part. The only prompt is for LA which is the total length.

TYPE 1 through TYPE 4 are primarily used the duct machine. The type number refers to the number of notch operations in the part. TYPE 1 has only and end notch and would be used where four pieces

would be used to make one cross section of duct. TYPE 2 has an end notch and one vee notch. This would form an L-shaped section. TYPE 3 has an end notch and 2 vee notches that would form a U-shape. TYPE 4 would have an end notch and three vee notches and would form a box-shape when bent.

In TYPE 1 only the LA is asked for which is the finished overall length. In types 2 through 4, both LA and Lb are asked for which represent the finished length and width of the duct. This is the only information required. THe computer can add the leading and trailing lock allowances and calculate the entire notch pattern from this information. Figure 3 shows the pattern for these types.

TYPE 5 and TYPE 6 are used in industrial applications where a large number of holes or notches are evenly spaced on the part. The overall length of the part is entered as LA. Lb is the incremental distance to the first hole. LC is the incremental distance of the repeated holes and rPt is the number of times LC is to be repeated (1-50). TYPE 5 has no end notch and TYPE 6 has an end notch pattern. See Figure 4 for a description of these types.

TYPE 7 and TYPE 8 are also industrial application types that are used when up to 20 individually spaced holes are required. LA is the overall length of the part. The next prompts are for P1 through P20 which are the distance from the leading edge of the part that the holes are to be placed. The order of the dimensions is not important. They cannot be greater than LA.

When all of the holes are entered, entering a dimension of 0 will terminate the entry and all following holes will be deleted. If only P1 to P5 are used then make P6 equal to 0 and P7 to P20 will automatically be deleted. TYPE 7 is used if no end notch is required and TYPE 8 is used if there is an end notch. See Figure 5 for details.

RUN MODE

The RUN mode is used to actually produce the parts. The mode is entered by pressing the RUN key and is exited by pressing the HALT key or at the completion of the required batches.

There are two conditions in which the RUN mode can be entered. The first is the RESET condition which means that the computer will begin processing the material from the furthest required press and that the material from that point to the shear will be scrapped. The second condition is NON-RESET which means that the computer will pick up from where it last left off and no scrap will be generated.

If in the RESET condition, the display will prompt for a batch number to be run. If the number is correct then press RUN a second time. If a different batch is desired, enter the new number and then RUN. If in the NON-RESET condition, no prompt will be given and the line will continue normally.

The RESET condition occurs under the following conditions:

1. From the first time the unit is turned on.
2. When any manual cycle of a press occurs.
3. When all programed parts have been run.
4. When the length counter is greater than the next shear length.

Once set running, batches will be run in numerical order provided that they are programed. The programed batches are searched for

in ascending order until batch 50 is reached. Then the search is begun over starting at batch 1.

When the computer starts into the RUN mode, it sets up all of the operations that are required from a point 24 inches before the end notch press to the shear. These operations are placed in memory in a place called the work stack. Since memory in the computer is not infinite, there is a finite number of operations that can be placed in the work stack. This finite number is 200. This means that for a large machine there could be many parts between the shear and the end notch. If the number of operations in these parts times the number of parts between these points exceeds 200 then an Error 9 will occur.

SETUP DATA SHEET

PARAMETER	PROMPT		RANGE
LENGTH COUNTER	Accu	_____	0-999999 (CLEAR ONLY)
END NOTCH-SHEAR	P1 LEN	_____	.01-999.99 IN
VEE NOTCH-SHEAR	P2 LEN	_____	.01-999.99 IN
SLOWDOWN LENGTH	LE SLO	_____	0-999.99 IN
SHEAR TIME	SH SEC	_____	.01-99.99 SEC
END NOTCH TIME	P1 SEC	_____	.01-99.99 SEC
VEE NOTCH TIME	P2 SEC	_____	.01-99.99 SEC
PAUSE TIME	PAUSE	_____	.01-99.99 SEC
BATCH HALT	bA HALt	_____	yES or No (TOGGLE)
LEADING EDGE SCRAP	CONS 1	_____	0-999.99 IN
TRAILING EDGE SCRAP	CONS 2	_____	0-999.99 IN
LEAD EDGE ALLOWANCE	CONS 3	_____	0-999.99 IN
TRAIL EDGE ALLOWANCE	CONS 4	_____	0-999.99 IN
CORRECTION FACTOR	corr	_____	.5-1.50000 (NO UNITS)
MINIMUM LENGTH	LEASt	_____	0-999.99 IN
START LENGTH	StArt	_____	0-999.99 IN
SLUG LENGTH	LE SLU	_____	0-999.99 IN
DIRECTION	dirEction	_____	0 or 1 (TOGGLE)

Table 1. Setup Mode Data

ERROR MODE

The MP37 computer can detect certain operational errors and it displays a message that shows 'Error N' where N is the error number. The MP37 will only respond to the CLR key in order to clear the error message. The description of each error is as follows:

Error 0	Number entered is out of range
Error 1	Zero entry is not allowed
Error 5	Direction number not 0 or 1
Error 6	Type number error
Error 9	More than 200 operations in work stack

ENTERING A NUMBER

Throughout this document references to entering a number are made. In this section, this procedure will be explained in detail one time so that the rest of the manual can be simplified.

Numerical data refers to such things as a length of a part, spacing between holes on a part, time duration of a press cycle, etc. In order to tell the computer what these values are, the operator must enter or key in these numbers through the keyboard in a manner that the computer can understand. This same procedure is used for all numerical data.

Before describing this procedure, a definition of some terms may be necessary. The following terms and their meaning will be seen throughout this manual:

PROMPT--There is two-way communication between the computer and the operator. The operator tells the computer what a certain value is but the computer must tell the operator what data item the operator is to key in next. This message from the computer is called a "prompt" and it appears on the left hand side of the display. Each prompt is unique so that the operator should know exactly what piece of data the computer is asking for by the prompt.

ENTER--When the operator keys in a piece of data, he must tell the computer when he is finished. This is done with the ENTER key and it is like the period at the end of a sentence. Pressing the ENTER key tells the computer "I am

finished with this line of data. Store it away and go to the next line of data."

CLEAR--Before the ENTER key is pressed, the operator has the chance to check what he has entered to see if it is correct. If he finds that he has made a mistake, he can erase what he has entered so far by pressing the CLEAR key. THis will cause the display to revert back to showing the value that was present before any keys were present. Also, for any error that may occur, the display will show the error and the CLEAR key must be pressed before any other action can take place.

FORM--For each data item there is a form or shape associated with it. This consists of the number of digits above and below the decimal point. An example of this might be a length whose form is defined as XXX.XX. This means that there are allowed to be three digits above the decimal point and two digits below the decimal point. Thus the largest number that could be entered would be 999.99 and the smallest increment would be 0.01 units. When the maximum number of digits above the decimal have been entered, the decimal point is automatically inserted.

RANGE--For each data item there is a range of acceptable values that can be entered. Values entered outside of this range will cause an error message to be shown. A data item whose form may be XXX.XX may have a range of 100.00 to 10.00

because of some machine constraint. Values entered outside of this range will result in an error message.

With an understanding of these terms we can proceed to explaining the data entry procedure.

The best way to explain this process is with an example. The example's data items are as follows:

DATA ITEM	Length from the center of the shear die to the center of a punch die.
PROMPT	LEN S-P
FORM	XX.XX
UNITS	INCHES
RANGE	12.00 TO 50.00
OLD VALUE	24.56
NEW VALUE	25.87

DISPLAY BEFORE KEY	KEY
LEN S-P 24.56	2
LEN S-P 2.	5
LEN S-P 25.	8
LEN S-P 25.8	7
LEN S-P 25.87	ENT

(next data item and old value)

A mistake and subsequent correction sequence would be as follows:

DISPLAY BEFORE KEY	KEY
LEN S-P 24.56	2
LEN S-P 2.	6
LEN S-P 26.	CLR
LEN S-P 24.56	2
LEN S-P 2.	5
LEN S-P 25.	8
LEN S-P 25.8	7
LEN S-P 25.87	ENT

(next data item and old value)

Leading and trailing zeroes do not have to be entered. An example would be the entry of a value of 10.00 inches.

DISPLAY BEFORE KEY	KEY
LEN S-P 24.56	1
LEN S-P 1.	0

LEN S-P	10.	ENT

(next data item and old value)

An out-of-range example would be:

DISPLAY BEFORE KEY		KEY
LEN S-P 24.56		1
LEN S-P	1.	ENT
Error		CLR
LEN S-P 24.56		1
LEN S-P	1.	0
LEN S-P	10.	ENT

(next data item and old value)

LENGTH CALIBRATION

The computer detects the movement of material through the machine by means of an optical shaft encoder which is also called a rotary pulse generator or rotopulser. It is a device that generates electrical pulses as the shaft is rotated. It can detect the direction of rotation and it generates a precise number of pulses for each revolution of its shaft. The computer detects these pulses and counts the net number of up and down pulses in order to know the shaft position.

The computer only knows the angular displacement of the shaft. In order to translate this angular movement into actual material movement, a precision measuring wheel is attached to the shaft of the encoder. The wheel rides on the material and is carefully aligned so that in one revolution of the shaft, an amount of material equal to the circumference of the wheel moves through the machine.

The resolution of the system (smallest measured increment) is equal to the circumference of wheel divided by the number of counts generated in one revolution of the encoder shaft. If the circumference of the wheel is 10 inches and there are 1000 pulses per revolution on the encoder, then the resolution would be 10 inches/1000 or 0.01 inches. If a 12 inch wheel were used then the resolution would be 0.012 inches.

In this system, the computer has a setup parameter called the correction factor. The correction factor is used to set the

nominal resolution of the system and to compensate for small errors due to measuring wheel diameter errors. The initial value of the correction factor is computed by dividing 0.01 by the system resolution. Thus, a 10 inch wheel would have an initial correction factor of 0.01/0.01 or 1.00000 and the 12 inch wheel would have a correction factor of 0.01/0.012 or .83333.

Using this initial value of correction factor, the system can then be fine tuned in order to give optimum accuracy. Length inaccuracies consist of two distinct elements, the repeatability error and the linearity error. The repeatability error results from variations in the mechanics of the machine from one operation to the next. This variation would be the same for 1 inch long parts or 100 inch long parts. The linearity error is due to slight errors in the size of the measuring wheel. This error grows as the length of the part grows. It is not noticable on short parts and can get quite significant on long parts. These two error elements must be separated in order to properly calibrate the system.

The repeatability error can be determined by running a large number of short parts and measuring the total variation in length from the shortest part to the longest part. This total variation should be within the machine's specified tolerance. Further tests should not be attempted until this variation tolerance is met. Once the variation is determined, a part as long as possible should be run and its length carefully measured. A new value for correction factor can be calculated as follows:

NCF = OCF X PL/AL

where NCF is new correction factor

OCF is old correction factor

PL is the programed length

AL is the actual measured length

As an example, with the old correction factor at 1.00000, a 100 inch part was programed with the result being a 100.25 inch long part made. The new correction factor (NCF) would be:

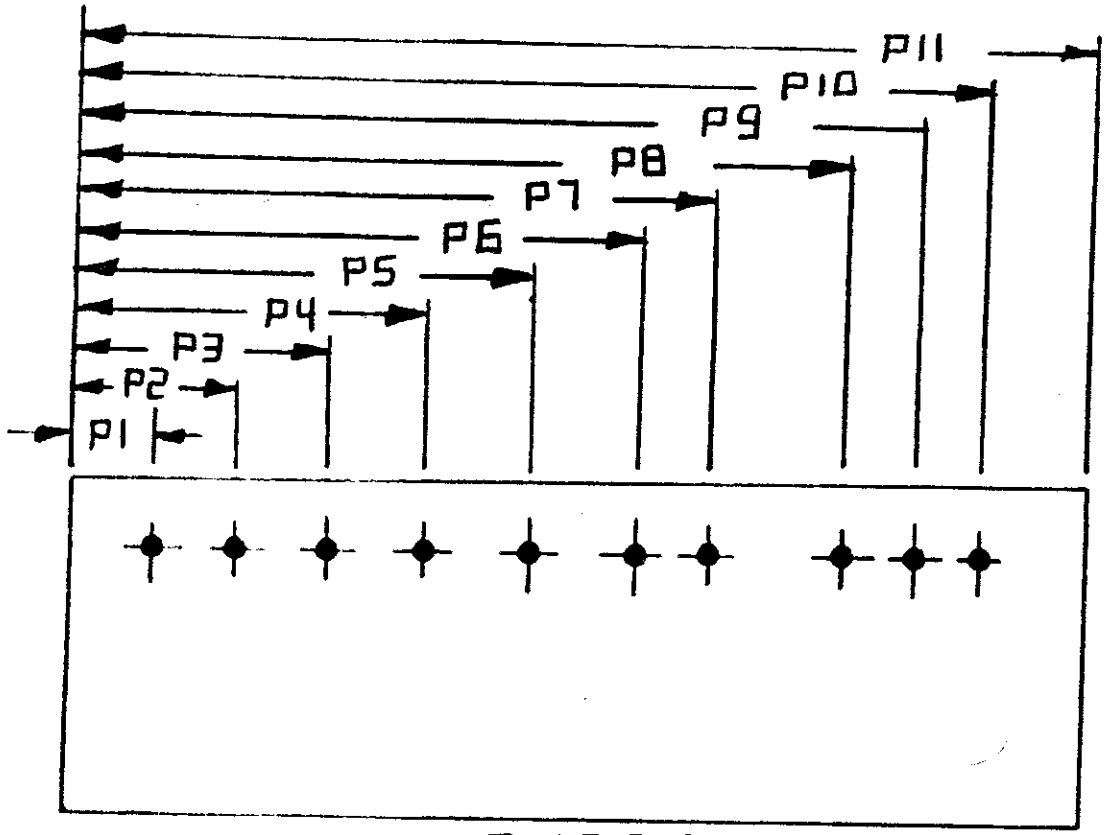
NCF = 1.0000 X 100/100.25 = .99751

This new value for correction factor should be entered into the computer. If the resultant error was less than the allowable tolerance, the previous step should not be done.

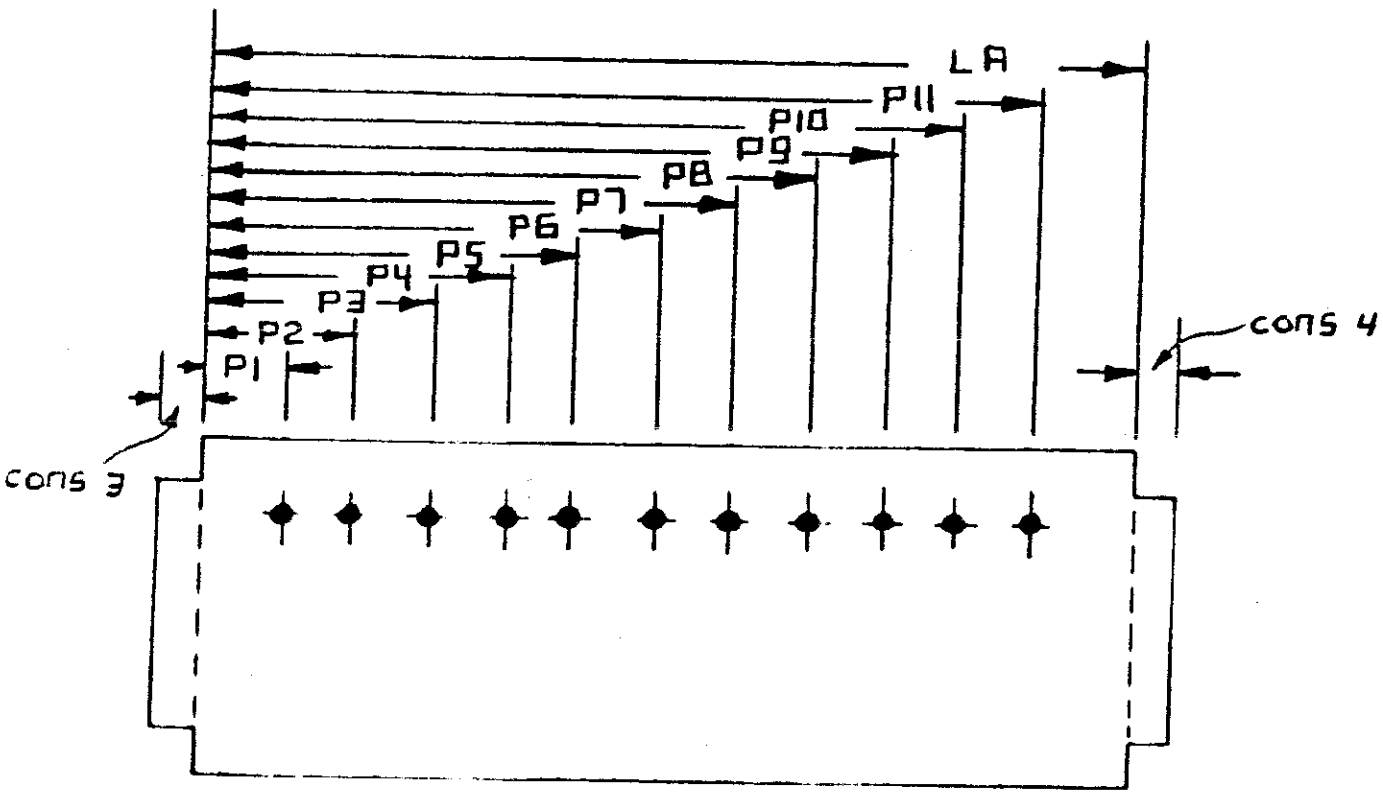
At this point, the machine should be reasonably well calibrated. However, a portion of the linear error detected could have been due to a repeatability error. Further calibration can be done be running a large sample of long parts and carefully measuring each part and finding the mean value. The previous calculation can be repeated using the mean value as the measured length to further refine the correction factor. If in the previous example, the correction factor of .99751 were entered and a new run of 100 inch parts resulted in a spread of 1000.00 to 100.06, the mean value would be 100.03 and the new calculation would be:

NCF = .99751 X 100/100.03 = .99721

This should then yield parts that are within the specified allowable length variation, centered around the length programed. Further adjustments can be made using this same procedure should the wheel begin to wear.

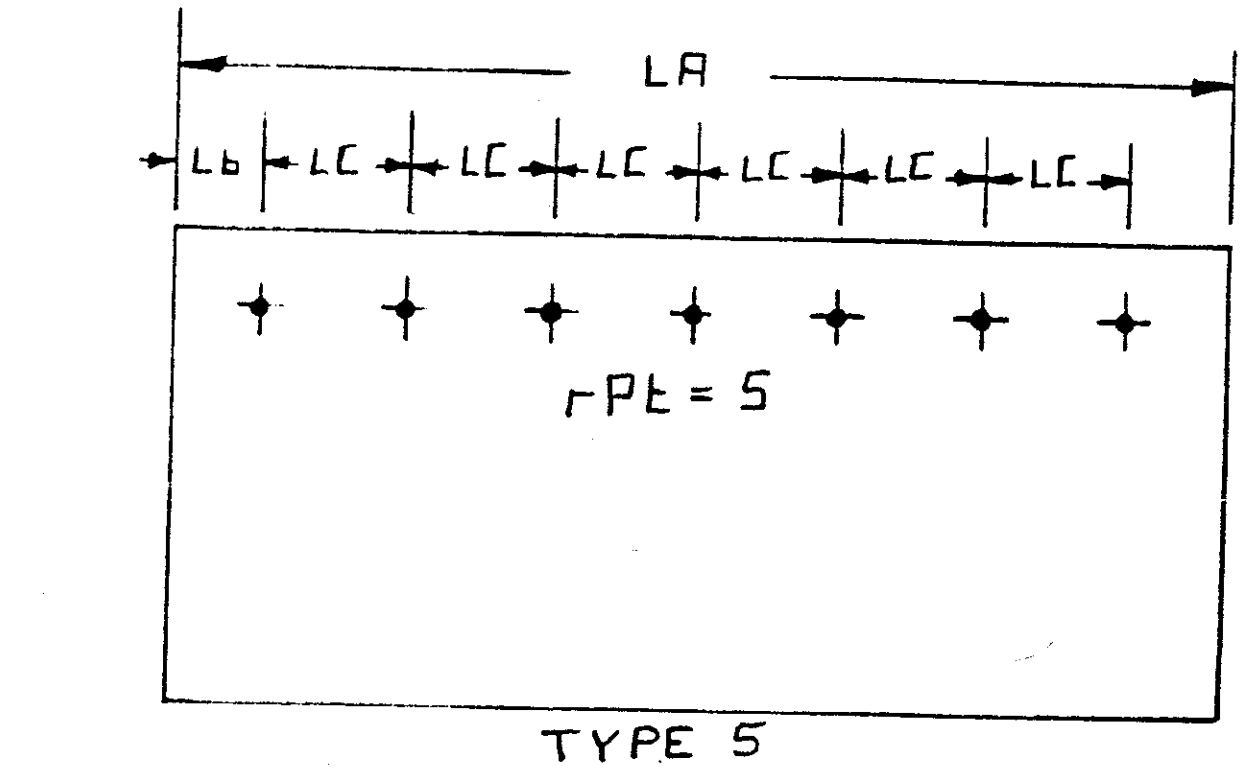


TYPE 7

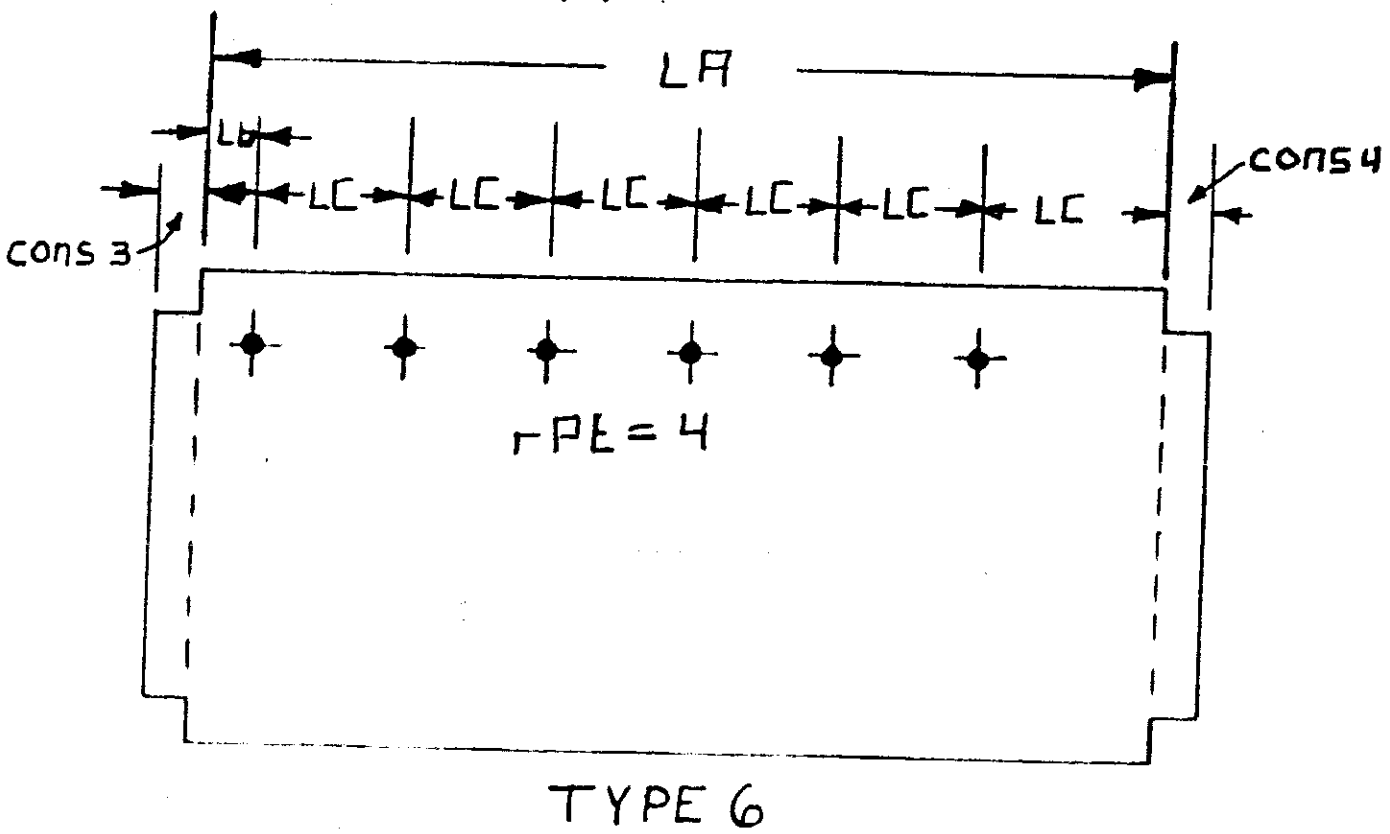


TYPE 8

FIGURE 5. TYPES 7+8



TYPE 5



TYPE 6

FIGURE 4. TYPES 5+6

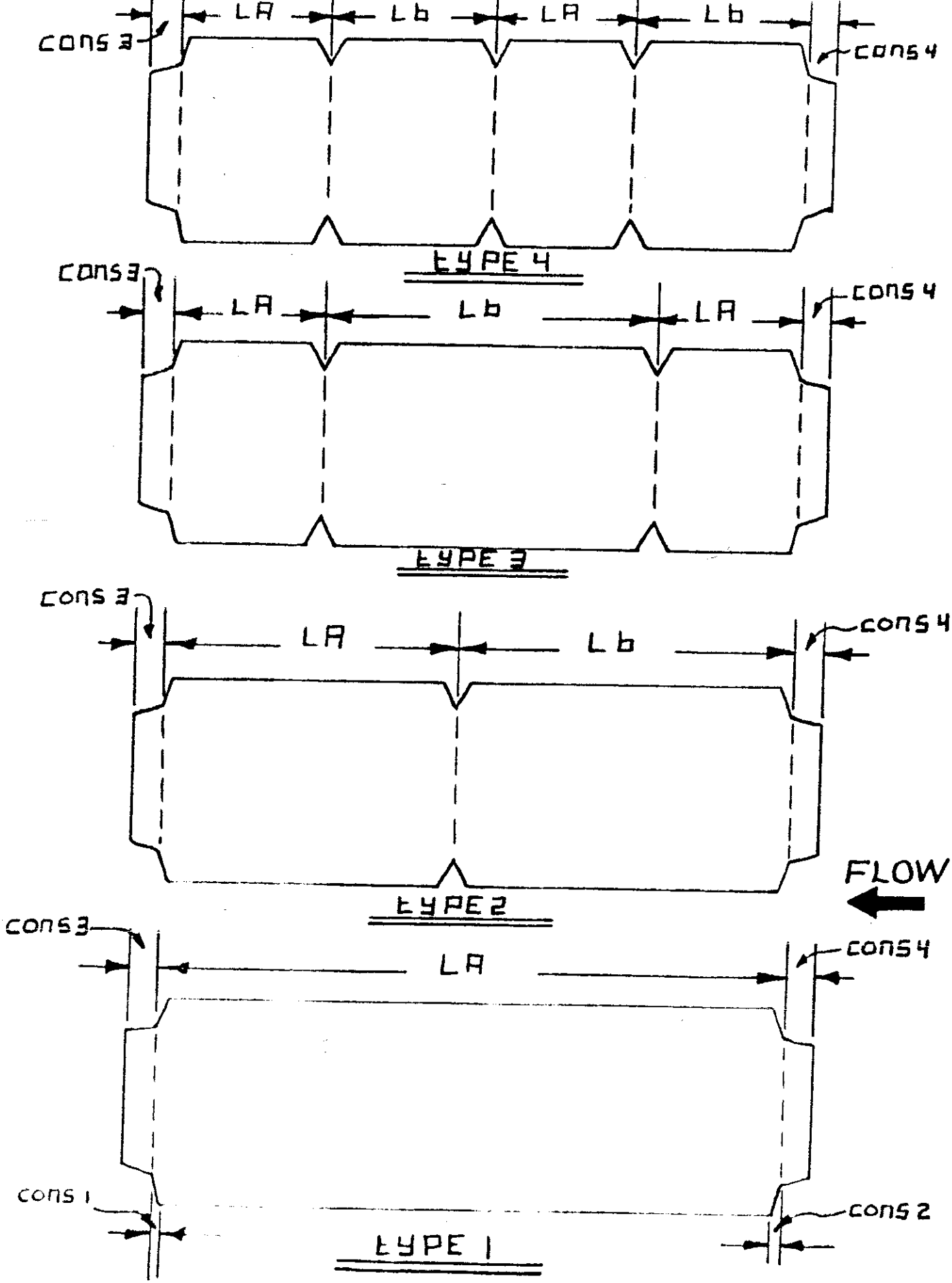


FIGURE 3. TYPES 1-4

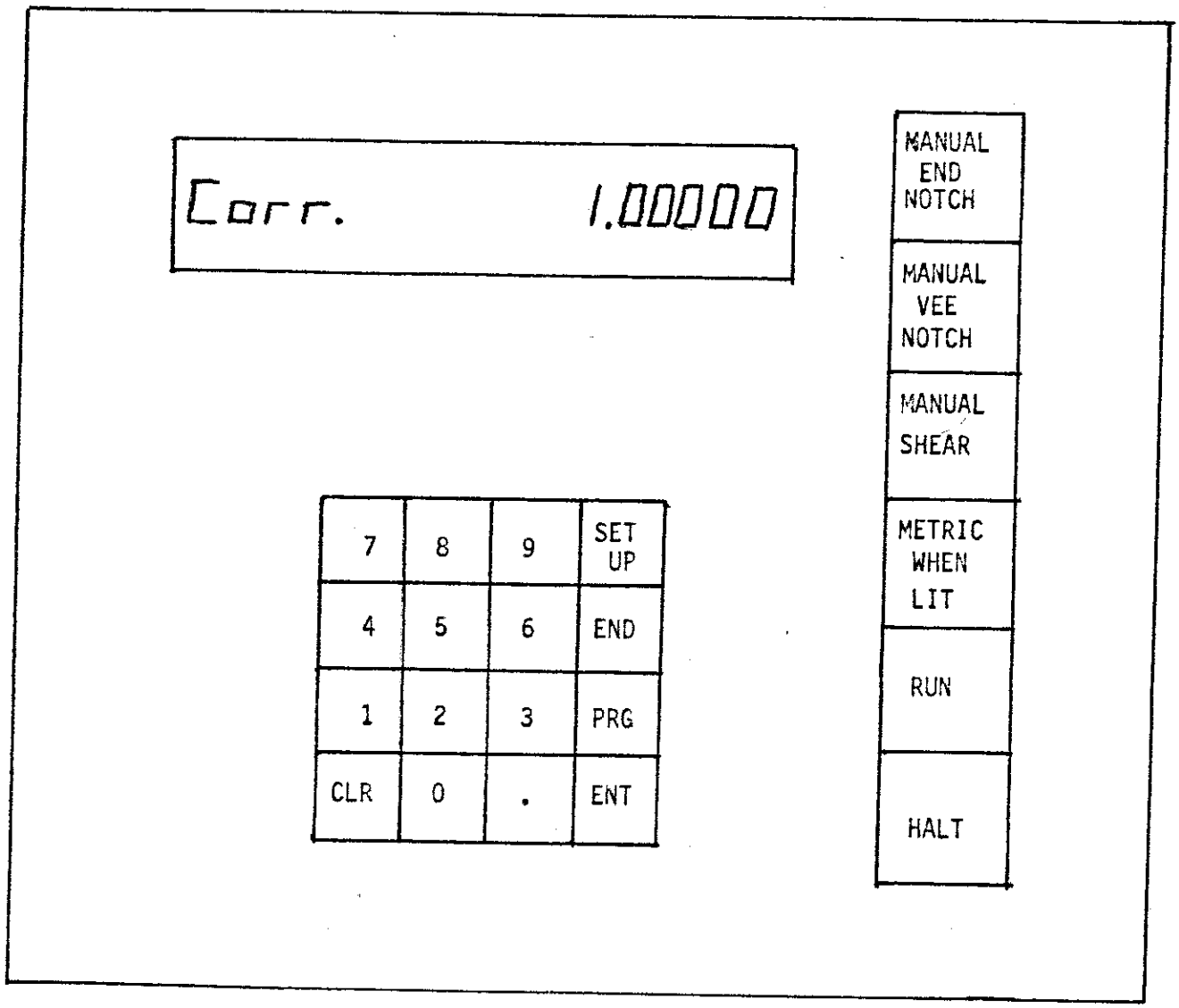
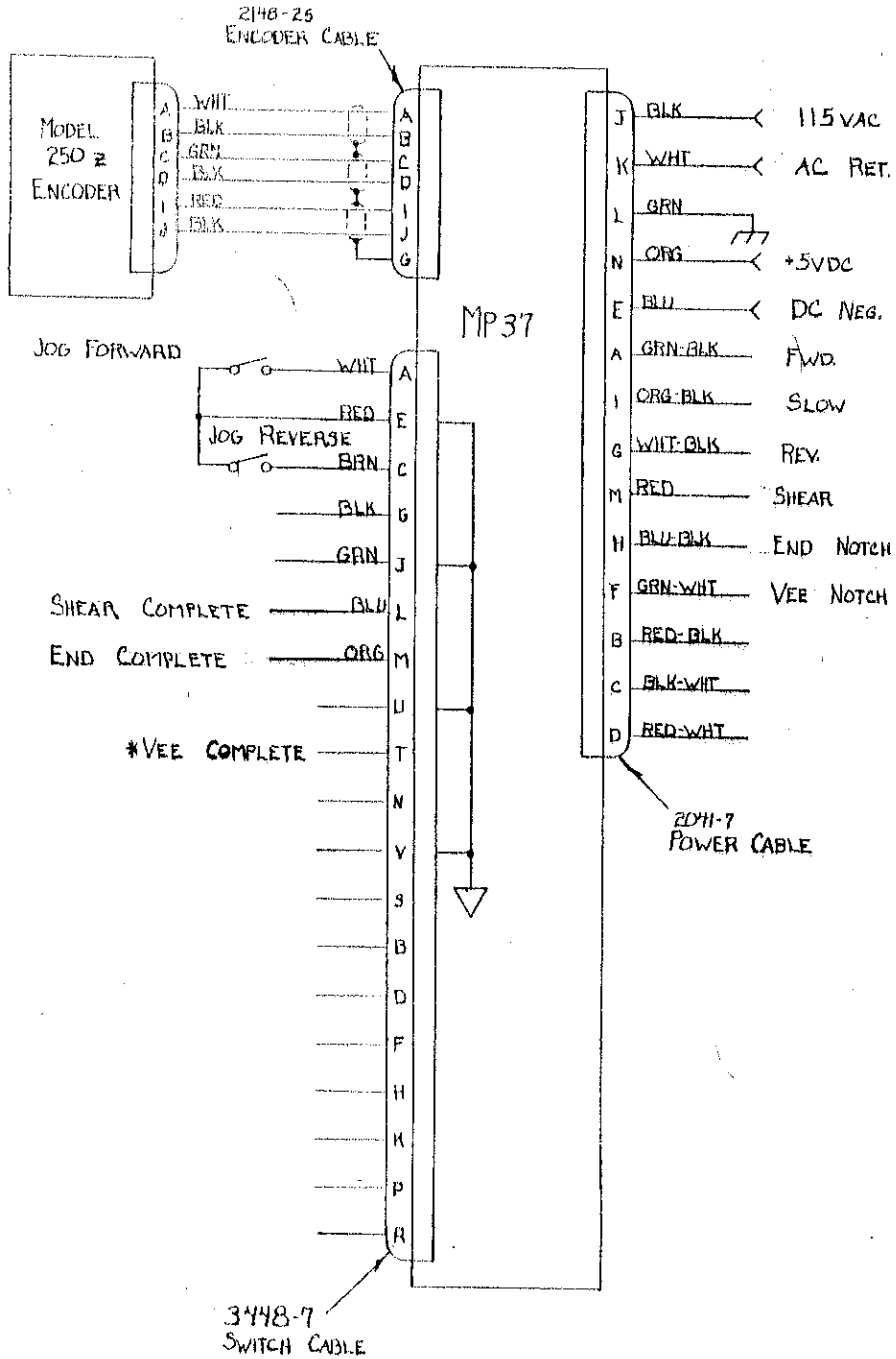


FIGURE 2. MP37 FRONT PANEL

REV	ECR#	DESCRIPTION	DWN BY	DATE
	324	DELETE NOTES		1-17-8
A		ECR# 324 INCORPORATED		1-18-8



NOTES:

* OPTIONAL INPUT, NOT WIRED IN WIRING HARNESS PROVIDED.

ENGEL STD. COMPACT

TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY
DECIMAL ±			
FRACTIONAL ±			
ANGULAR ±			

APPLIED MICROSYSTEMS INC.

MACHINE INTERFACE ENGEL

DRAWN BY	SCALE	MATERIAL
CHK'D	DATE 5-4-84	DRAWING NO. MP37
TRACED	APP'D	