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This manual may not be complete in all aspects of product maintenance and repair. **All products should be used only by qualified and properly trained personnel, following proper safety procedures.** All products should be regularly inspected and maintained, and their condition, application and use should be periodically evaluated by qualified personnel. Only qualified and properly trained technicians should perform maintenance, repair and replacement procedures. Attempting these procedures without proper training may cause machine damage or operator injury!

Products may be unsupported by The Challenge Machinery Company due to age or the unavailability of parts from their original manufacturer. No parts or product support will be available to repair or maintain unsupported products. Older products may not be UL listed (if the product does not have a UL label it is not a listed product), and may not comply with applicable installation or other regulations or requirements if relocated to a new facility. Many municipalities require a product to be UL listed before an electrician will connect power to them. Often the cost of updating an older product to comply with current safety regulations is greater than the value of the product.

\$10.00

SERIAL NO —

MODEL —

SAFETY ALERT



This safety alert symbol means CAUTION OR WARNING-PERSONAL SAFETY INSTRUCTION. Personal injury may result if safety precautions are not carefully read before attempting to operate or repair this machine. See SAFETY PRECAUTIONS, page 4.

- This machine is designed for **ONE PERSON OPERATION ONLY!**
- Always **DISCONNECT THE POWER** before working on this machine.
- **DO NOT OPERATE WITH ANY GUARDS REMOVED!** Replace all guards before operating.
- **CRUSH HAZARD** - Keep hands, hair, cleaning rags, & loose clothing away from drills.

Instruction and Parts Manual



MODEL MS-5 Paper Drilling Machine

**This manual covers serial numbers 73614 & up.
ALWAYS GIVE THE SERIAL NUMBER OF YOUR MACHINE WHEN WRITING.**

Sold and serviced by

THE CHALLENGE MACHINERY COMPANY

1433 Fulton Street / Grand Haven, Michigan 49417 U.S.A. / Phone: 616/842-8300/ Telex No. 228409

F. 300

INTRODUCTION

WELCOME to the family of Challenge® users. Challenge has been developing and manufacturing Graphics Arts Equipment for over 100 years and is today one of the world's leading producers and distributors of Paper Cutters, Paper Drills and Bindery Equipment.

THE CHALLENGE REPUTATION is important to you as a user for the continuous, ready availability of parts and service.

THIS MANUAL is designed to help you get the most from your Challenge equipment. Keep this manual in a safe, convenient place for quick reference by operators and service personnel.



SAFETY ALERT! This symbol means, **CAUTION OR WARNING: Personal safety instructions!** Pay special attention to the instructions in bold type. Personal injury may result if the precautions are not read and followed.

READ THIS MANUAL BEFORE OPERATING! Follow precautions and instructions given and you should have years of trouble-free operation. If after reading the manual questions still remain, contact your Authorized Challenge Dealer or the Challenge Service Department. For the dealer nearest you or for service questions, call (800) 866-7800; in Michigan, call (616) 842-8300.

FOR PARTS OR SERVICE contact the Authorized Challenge Dealer from whom you purchased your machine. Use the illustrations and parts lists at the back of this manual to identify the correct parts needed. **Always give the SERIAL NUMBER and MODEL** of your machine to insure that the correct parts are sent as soon as possible.

Take a few moments right now and **RECORD YOUR MACHINE SERIAL NUMBER** in the space provided on the front cover of this manual. Also be sure to fill out the warranty card accompanying this manual and return it **DIRECT TO CHALLENGE**.

If you bought a used machine, it is important to have the following information on record at Challenge. Copy this page, fill in the information and send it care of: The Challenge Service Department, 1433 Fulton St., Grand Haven, MI 49417. Phone (616) 842-8300.

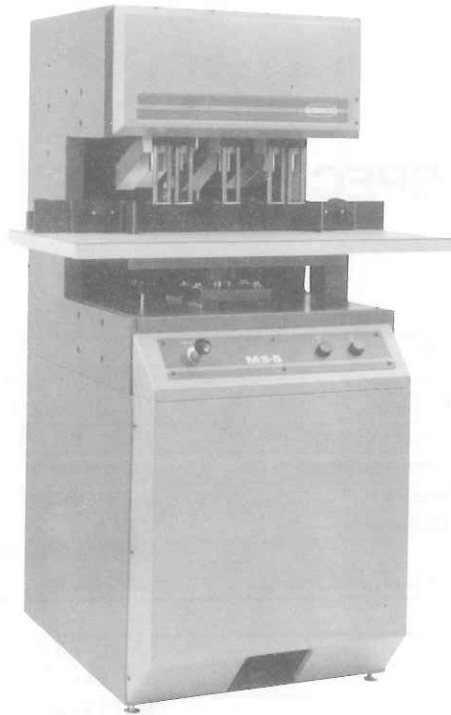
CHALLENGE MODEL	SERIAL NUMBER	
ATTN	COMPANY	
ADDRESS		
CITY	STATE	ZIP
PHONE	DATE INSTALLED	
DEALER'S NAME AND CITY		

LIMITED WARRANTY

*This equipment is guaranteed to be free from defects in workmanship or material for a period of **one year** from the date of installation, except components purchased by Challenge which carry the manufacturer's warranty.*

*We will repair or replace, at our option, any equipment proving defective, not caused by accident, misuse or improper maintenance, if returned to our factory, transportation charges prepaid. **This warranty does not include the cost of labor** to replace defective components. Check the purchase agreement from your Dealer for a statement of labor warranty.*

Should you find anything wrong, contact the dealer from whom the equipment was purchased. Challenge will not be responsible for any charges incurred without its specific written authorization.



(fig. 1)

PACKING LIST

Part No.	Description	Qty.
	Basic Machine	1
45149	Grease, 1 lb. can	1
S-1718	Grease Gun	1
W-105-1	Allen Wrench, 1/4" 'T' Handle	1
A-6588	Wrench, 'T' HandleDrill Drift	1
4688	Lubrication Stick, Drill-Ease	1
A-4950	Drill Sharpener, Hand	1
4687	Drill Drift (straight rod)	1
6564	Drill Block	3
45067	Backgage Filler Block Asm. (magnetic)	2

Drill Head(s) — as ordered includes as std: (per head)

CD-4-2-1/2	1/4" / 64 mm Hollow Drill	1
K-85	Drift Hole Cover	1

SPECIFICATIONS

Drilling

Number Of Drill Heads	2 to 5
Drill Bit Sizes Available	1/8" to 1/2" / 3 to 13 mm
Center To Center Maximum	15-1/2" / 39 cm
Minimum Distance Between Heads	1-7/8" / 8.7 cm
Minimum Distance Between Holes	Adjustable
Maximum Drilling Capacity	2-1/2" / 63 mm
Strokes Per Minute (Adjustable)	Up To 18
Backgage Adjustment	0 To 5" / 0 To 13 cm
Vertical Adjustment Of Individual Heads	1/4" / 6 mm

Dimensions

Table	17-3/4" x 34" / 45 cm x 86.4 cm
Table Height	37" / 94 cm
Overall Height	56" / 142 cm
Floor Space Needed	36" x 36" / 92 x 92 cm
Net Weight (Approximate)	830 lbs / 373.5 kg
Shipping Weight (Approximate)	1000 lbs / 453.6 kg

Electrical

208/230 Volts/18 Amps, 1 Phase, 60 Hz, AC. Service size 30 Amps.


Pump: 1/2 H.P. Spindle: 1-1/2 H.P.

Optional Motor: 208/230 Volts/10 Amps, 3 Phase, A.C. Service size 20 Amps.

460 Volts/ 5 Amps, 3 Phase, A.C. Service size 15 Amps.

Challenge reserves the right to make changes to any product or specification without notice and without incurring responsibility to existing units.

TABLE OF CONTENTS

	Page
Warranty	Inside Front Cover
Packing List	1
Specifications	2
 Safety Precautions	4
Installation Instructions	5
Setup Instructions	5
Operation	8
Routine Maintenance	9
Service Checklist (oil chart)	9
Trouble Shooting	11
Drilling Tips	12
Main Assembly 45000 Sheet 1	14
Main Assembly 45000 Sheet 2	16
Main Assembly 45000 Sheet 3	18
Hydraulic Power Unit H-378	20
Electrical Schematic E-2384	21
Power Panel Assembly (1 phase) EE-2385	22
Power Panel Assembly (3 phase) EE-2386	24
Drill Head Assembly 45094	26
Accessories	27

SAFETY PRECAUTIONS

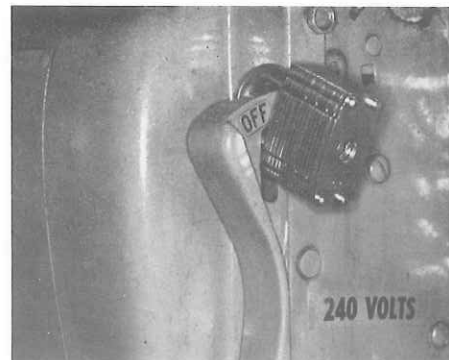


This safety symbol means **CAUTION/WARNING - PERSONAL SAFETY INSTRUCTION**. Read the instructions because it has to do with safety. Failure to comply with the following instructions may result in personal injury.

- This machine is designed and safeguarded for **ONE PERSON** operation. **NEVER** operate the machine with more than one person.
- Safety of this machine is the responsibility of the user and operator. Use good judgement and common sense when working with and around this machine.
- **READ** and understand all instructions thoroughly before using the machine. If questions still remain, call your Authorized Challenge Dealer - Failure to understand operating instructions may result in personal injury.
- Only trained and authorized persons should operate the machine.
- **DO NOT ALTER SAFETY GUARDS OR DEVICES**, they are for your protection and should not be altered or removed. Severe lacerations could result.
- **DISCONNECT POWER** before cleaning, lubricating, servicing or making adjustments not requiring power. Lock the disconnect switch in the **OFF** position, see Power Lockout Procedure below.
- **HIGH SPEED DRILL** - Keep rags, loose clothing and long hair away from rotating drill. Personal injury could result from items being caught on drill.
- Have your electrician make sure the machine is properly grounded, Power Hookup, page 5.
- Have your electrician check for sufficient power to operate the machine properly, page 5.
- **OBSERVE ALL CAUTION PLATES** mounted on this machine
- **KEEP FOREIGN OBJECTS** off table and away from drill.
- **BE EXTREMELY CAREFUL** when handling and changing the drills. Severe lacerations or dismemberment could result from careless handling procedure, see page 7.
- **KEEP THE FLOOR** around the machine free of trim, debris, oil and grease.
- When replacing hydraulic parts, loosen the connections slowly to release pressure. Never loosen connections with the machine running.
- If the machine sounds or operates unusually, turn it off and consult the Trouble Shooting section of this manual, page 11. If the problem cannot be corrected have it checked by a qualified service person or you Authorized Challenge Dealer.
- **CRUSH HAZARD**, keep feet off the pedal, page 8, when handling paper under the clamp. **DO NOT REST FOOT ON PEDAL** at any time!
- **DO NOT REACH UNDER THE DRILL AND CLAMP AREA!**
- **DO NOT OPERATE WITH ANY GUARDS REMOVED!** Replace all guards after adjusting, lubricating or servicing the machine.
- **SEVERE LACERATIONS** - Contact with high speed drill could cause severe injury. Always turn machine off and wait for drill to stop before removing drill bits. Keep hands away from drill(s) when operating.

CAUTION: POWER LOCK-OUT PROCEDURE

For maximum safety when making adjustments or repairs to your machine, be sure to lock out the main power control switch to which the machine is connected. The switch should be thrown to the **OFF** position and a padlock placed in the loop. The key should be held by the person servicing the machine.



(fig. 2)

INSTALLATION

Refer to the parts lists and drawings in the back of this manual for part identification and orientation, as necessary.

All guards and instruction plates are installed for your safety and information and must remain on the machine as shipped from the factory.

Unpacking


Unless otherwise specified, this machine is packaged for shipping completely assembled. The drill head(s) specified on the order are shipped already installed. The machine should be unpacked by carefully removing the packaging materials so as not to damage any of the machine parts.

Immediately after uncrating, check off parts received against the packing list. Also, examine for any physical signs of damage incurred during shipment. The machine is inspected before and after crating at our plant. The responsibility for filing a claim against the carrier for damages incurred during shipment rests with the receiver of the goods (FOB our factory).

The machine is held in place on its shipping skid with plastic strapping material. The machine weighs approximately 850 lbs. (380 kg.), be sure you have sufficient equipment and manpower to handle the machine safely. Contact your Authorized Challenge Dealer to arrange for installation.

Remove the protective coating of light oil from machined surfaces with a cleaning solvent, such as type wash. Clean all other surfaces with a solvent such as C.R.C.

Power Hook-up

 **WARNING: DISCONNECT POWER before cleaning, lubricating servicing, or making adjustments not requiring power. Lock the disconnect switch in the OFF position, see Power Lockout Procedure on page 4.**

The machine is factory wired to the customer's specification. It is the customer's responsibility to wire the motor for the current and voltage specified on the name plate. It is important that the line voltage specified be maintained. Failure to do so will result in improper operation of the machine (see trouble shooting section for specific problems). It may be

necessary to provide a dedicated line for the machine. A junction box is provided on the side of the machine for making the hookup to the power source. Remove one of the knockout plugs and run your power line into the box using a standard conduit connector. A ground lug is provided inside the junction box. Replace the junction box cover after the power connection has been made.

On three phase machines, check to see that the motor turns in the proper direction. Briefly turn the machine on and off then look into the vents in the motor. If the motor is turning in the direction opposite of the arrow, switch connection of any one wire with another. Again, check rotation of the motor to be sure it turns in the direction of the arrow.

The standard motor for this machine is a 208/230 single phase. This machine should be on a 30 amp circuit and wired with #10 gauge wire. Optional three phase motors are available also; 230/208 three phase, 20 amp circuit, #12 ga. wire; and 460 volt three phase, 15 amp circuit, with #14 ga. wire.

SETUP INSTRUCTIONS

Starting the Machine

The power for this machine is supplied by two motors; one is for the hydraulic power pack and the other is for the spindle. The hydraulic motor drives the pump directly while the spindle motor drives the drill heads. The two motors are started and stopped simultaneously by "on" and "off" pushbuttons located on the control panel. The pushbuttons are labeled by their function. The on button has a collar guard to reduce the possibility of accidental contact. Be sure both motors are operating before trying to drill paper.

NOTE: The MS-5 paper drill is equipped with a safety interlock system which prevents the machine from being started with the cover up. Also, if the cover is raised when the drill is in operation, the motors will shut off and must be restarted when the cover is back in place. This is a safety feature provided to prevent accidental contact with moving parts and must not be tampered with.

Lighting the Machine (factory option)

A table light may be purchased as optional equipment when the machine is ordered. If equipped with this option, the table light is controlled by the on/off buttons and comes on whenever the machine is turned on.

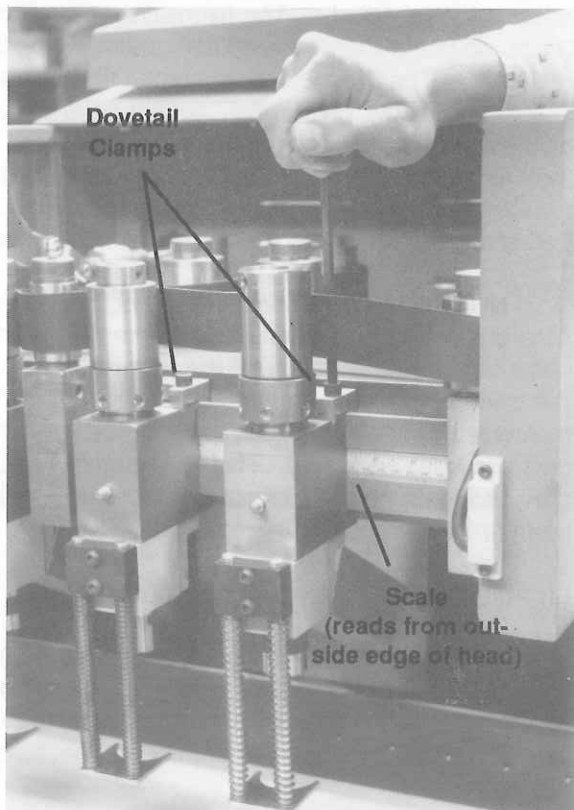
Hydraulic Check

Check the hydraulic oil supply for the proper level. This check is made by removing the rear panel and unscrewing the dip stick located on the hydraulic tank. The oil level should be no higher than 1/2" (13 mm) up from the bottom of the dip stick to allow room for expansion of the oil when running. Recommended oils and a cross-reference chart are found in the maintenance section of this manual.

Positioning Drill Heads

CAUTION: HOT. After running, drill heads become very hot (approx. 140°F). Be very careful when repositioning heads after the machine has been in operation.

Drill heads ordered with your machine have been installed at the factory. One 1/4" drill is supplied as standard equipment with each head unless otherwise specified. The MS-5 handles two to five drilling heads mounted on a dovetail. Each head is independently adjustable allowing a minimum center-to-center distance of 1-7/8" (47.6 cm) to a maximum center-to-center distance of 15-1/2" (394 mm). Any number of heads (up to five) or combination of drill hole sizes can be drilled at one time. However, when using 1/2" (13 mm) drills, it is recommended that no more than three heads be used at the same time.



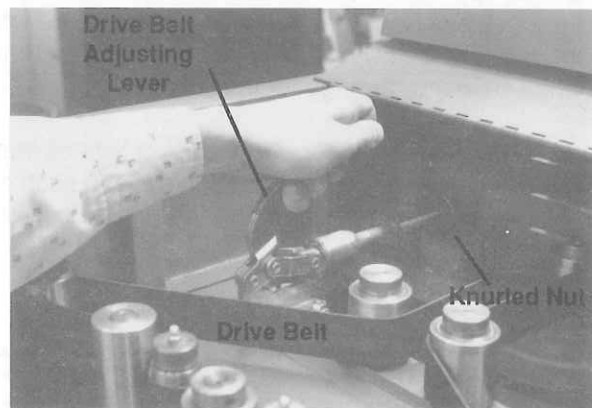
(fig. 3)

Always position heads so that the lift of paper being drilled is centered on the table. Drill heads are mounted on a dovetail and positioned by a scale mounted on the front of the dovetail, fig. 3.

To move heads; raise the front cover and release the drive belt tension by lifting the belt lever, loosen the socket head screws holding the head to the dovetail and position the heads according to the scale, fig. 3. The dovetail scale is calibrated from the center of the table and is setup to give readings to the center of the holes. The scale is read from the outside edge of the drill heads. (Heads mounted to the right of center read the scale from the right side, heads to the left of center are read to the left of the head.) Once heads are positioned as desired, retighten the socket head screws in the dovetail.

Positioning Idler Rollers

To keep proper tension on the drill head drive belt, two idler rollers are supplied with each machine. As a rule of thumb, an idler should be used whenever the space between heads is two inches (51 mm) or more (if two heads are used an idler should be mounted on one side of the drill head). Idlers keep the belt from slipping as the drills pass through the paper.



(fig. 4)

Drive Belt Adjustment

Whenever changing head configurations or repositioning heads, reset the drill head belt tension. This is done by backing off the knurled adjusting nut, fig. 4, with the belt lever in the up position. Lower the lever and turn the knurled nut out until it is tight. Raise the lever and turn the knurled nut out an additional 1-1/2 to 2 turns. Lower the lever and close the front cover.

Drill Installation



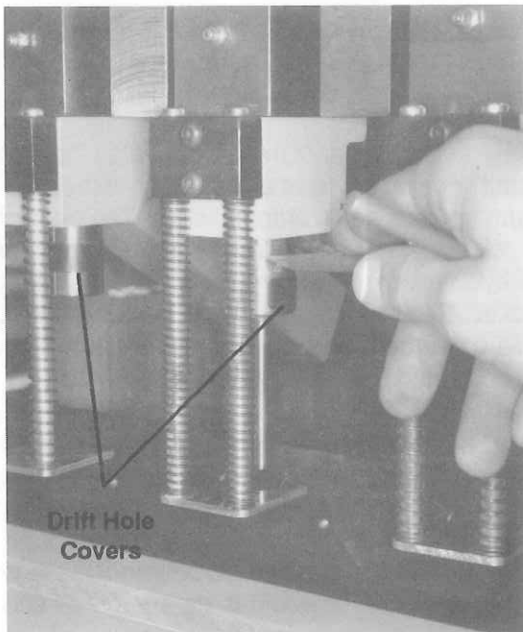
CAUTION: Always handle drills with care to avoid severe lacerations, even dull drills are sharp enough to cause lacerations.

Insert the tapered head of the hollow drills into the spindles. Press the drills firmly into place so they do not fall out when the motor is first started. To prevent drill chips from flying out be sure that the drift hole covers (black bands) are in place before operation (see fig. 5).

Make sure the cutting stick blocks are in position before trying to drill paper.

Drill Removal

After use drills may become seated so it is difficult to remove them. Use the T-handled drill drift to free stuck drills. Uncover the drill drift hole by sliding the cover down. Insert the drill drift with the flat

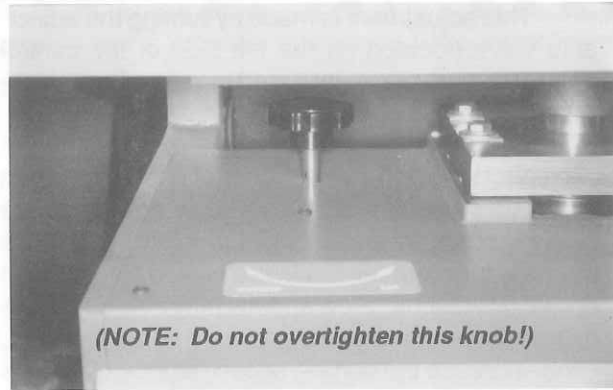


(fig. 5)

edge down and lift up to force the drill out of the head, fig. 5. Back off the drill head adjustment before starting the machine.

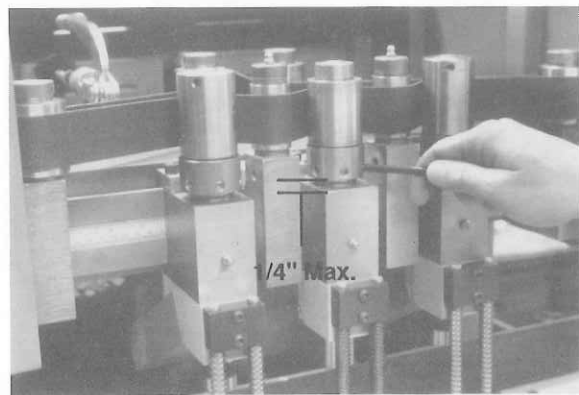
Stroke Adjustment

Whenever installing new or resharpened drills, the table stroke and drill height must be adjusted. To set these up, turn in (clockwise) the table height ad-



(fig. 6)

justment to lower the table, fig. 6. Next, lift the front cover and back off the drill head adjustment on each



(fig. 7)

head, fig. 7. Using the straight drill drift tool, back off each head adjustment to about 1/4" (6 mm). Place a single sheet of paper under the drills and raise the table with the foot treadle. Gradually raise the table height by turning the table height knob out (counter clockwise) and pressing the foot treadle to check the table height. Continue to do this until the first drill cuts through the paper. Once the table height has been set, adjust the drill heads individually until all the drills now cut through the paper. When cutting full lifts, any further stroke adjustment can now be made with the table height adjustment knob.

Adjusting the Stroke Speed

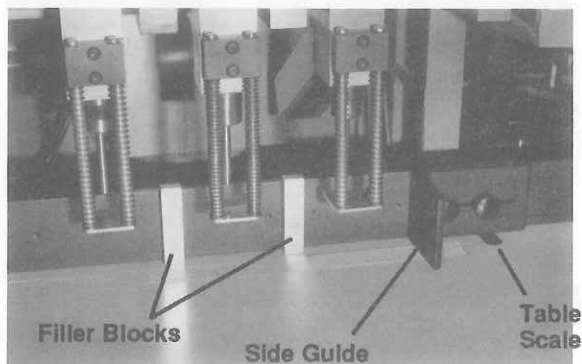
The hydraulic unit is equipped with an adjustable valve for regulating the table stroke speed (up and down travel). Maximum speed is 18 strokes per minute which is the speed used on the average run of work. Soft stocks such as mimeographs, NCR, etc., are apt to wrinkle at high speeds, and the speed should, therefore, be regulated to a point where the best results are obtained. This is found mostly by "trial and error."

This adjustment is made by turning the adjustable valve (located on the left side of the control panel) counter-clockwise to reduce speed and clockwise to increase speed.

Never turn the speed control knob more than 2-1/2 turns counter-clockwise (slow speed) as the drill will not bottom and engage the return cycle. Less than one turn counter-clockwise should suffice for all drilling operations. Slow speeds may also cause the drills to "burn" through the paper. If burning occurs, either increase the vertical speed, sharpen the drills or check for proper belt tension or idler arrangement.

Slower vertical speeds are recommended when drilling with the maximum number of heads.

Setting Up the Backgage



(fig. 8)

Scales are provided in the table for setting up the backgage. The scales read in inches/mm and will give you the dimension from the back of the sheet to the centerline of the holes. Two magnetic filler blocks are provided if it is necessary to drill within 1" of the edge of the sheet, fig. 8. The blocks are 1/2" (13 mm) thick and when used, 1/2" (13 mm) must be **subtracted** from the scale reading to give the set up dimension. Example: To drill 3/4"(19 mm) from the edge of the sheet, install the filler blocks and set the backgage to 1-1/4" (32 mm) on the scale.

Using the Side Guide(s)

The adjustment for the location of the holes to the top or bottom edge of the sheet is provided by a sturdy side guide. The backgage has a series of threaded holes to which the side guide is attached with two threaded knobs. In addition, the side guide is slotted to fine adjust the position of the paper. When setting up drill head positions and side guides,

always try to keep the paper centered on the table as much as possible.

Two side guides are provided as standard equipment so stock may be drilled to the left or right or for setting up multiple drilling sequences for more than five holes.

Emptying the Drill Chips

A large capacity chip bag attached to the rear of the machine, can be easily taken off and emptied by slipping it off the two hooks provided.

Removing the Drill Blocks

The drill blocks are removed by simply lifting them from their groove in the table. They should set flush with the table and may be shimmed if necessary. For best use and longest life, turn them end for end, top and bottom.

OPERATION

Pressing the foot treadle activates the hydraulic unit bringing the table and stock up to the drills and returning back again automatically. The pedal must be released and depressed again before the next drill cycle assuring full control and allowing no repeat stroke. Releasing the pedal at any time stops the table movement and returns it to its normal down position, thus preventing costly errors.

The vertical movement of the table is actuated by the hydraulic unit. Depressing the foot treadle sets the hydraulic unit into action. Keeping your foot on the treadle allows the drills to drill through the entire lift of stock and reach the bottom of their stroke. At this point, the solenoid is de-energized and the valve released, relieving the pressure off of the cylinder and allowing the table to return to the down position.



CAUTION: NEVER REST YOUR FOOT ON THE TREADLE WITHOUT INTENDING TO BRING UP THE TABLE.



CAUTION: NEVER put hands or fingers near the drill heads when operating the machine. Severe lacerations could result.

ROUTINE MAINTENANCE

General

Production losses can be reduced if good practices of maintenance are followed. The following suggestions may be helpful:

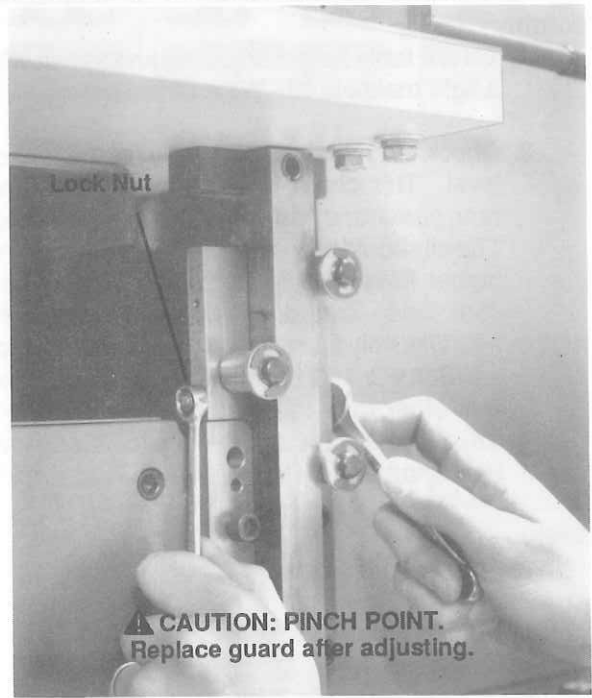
1. Recognize the fact that the user of hydraulic equipment has more control over maintenance than the manufacturer.
2. Operators should be familiar with use, care, and limitations of the equipment. **ALL OPERATORS SHOULD READ THIS MANUAL COMPLETELY.**
3. Use properly trained maintenance personnel.
4. Establish a program of systematic preventative care for your equipment or put this machine on an existing preventative maintenance program.
5. Analyze and isolate trouble before having any part of the equipment dismantled.
6. Be aware of how your machine should sound and perform. If the machine is not operating properly of it doesn't "sound right", stop running your job immediately and try to identify the problem.
7. Call the dealer for any problems that cannot be handled by your own personnel.

Vertical Table Guide

CAUTION: PINCH POINT. This adjustment requires a guard to be removed for adjustment and testing purposes only. Be very careful while adjusting. Replace all guards before operating. Do not operate machine with any guards removed.

The vertical table guide is located on the right side of the machine beneath the table and may need periodic adjustment to keep the table steady yet allow it and stock to fall away from the drills as rapidly as possible. The table down stroke is controlled by a return spring.

Remove the guide block cover guard. Tighten the two guide block lock nuts, fig. 9, and power the table up by pressing the foot treadle. Gradually back the locknuts off evenly until the



(fig. 9)

table releases freely. Re-test the upstroke and table return, and check the table for side play. Replace the guard.

SERVICE CHECKLIST

Daily

1. Keep drills sharp!
2. Lubricate the hollow drill frequently with the lubricating stick provided.
3. For better hollow drill life, remove the drills when not in use and soak in light oil. Wipe off excess oil before drilling.
4. Wipe off excess grease from the drill heads and idlers.

Weekly (or every 40 hours of operation)

1. Grease the drill heads and idlers with 3 pumps from the grease gun provided in the accessory kit. Wipe off excess grease around the pulleys.
2. Check belt wear/tension.
3. Oil the table lift rod between the table and stand with light oil.

Monthly

1. Oil the table height adjusting knob shaft with a light machine oil. Wipe off excess oil.
2. Check the hydraulic oil supply for the proper level. This check is made by removing the rear panel and removing the dip stick/plug. The oil should be visible on the dip stick but no higher than 1/2" up from the bottom when cool. This allows for expansion of the oil when hot. Use only one of the recommended oils or an ISO VG 100 Hydraulic Fluid equivalent. Oils other than the recommended type will cause seals, cups and O-rings to deteriorate. See Chart & CAUTION.

Yearly

1. Check all adjustments.
2. Tighten all screws.
3. Change hydraulic oil in reservoir. Oil may have to be changed more often if contamination of any kind gets in the oil.

Hydraulic

Through normal use, hydraulic systems gum up and seals wear. Signs of wear are hydraulic leaks and erratic operation of the vertical speed. Check with your Authorized Challenge Dealer for a current repair and/or replacement policy.

Drill Heads

Through normal use, bearings and bushings will wear and need replacing. Signs of wear are excessive noise, heat, or loose spindles.

Recommended Grease

Use a high quality National Lubricating Grease Institute, No. 1 consistency, extreme pressure grease (NLGI No. 1 EPG).



CAUTION: NEVER USE Automatic Transmission oil or brake fluid as a substitute! Oils other than the recommended type will cause seals, cups and O-rings to deteriorate. Unsafe operating conditions will result.

Recommended Oils


Oil Name


Rykon No. 100
Duro AW Oil 465
AW Machine Oil 100
Pacemaker XD No. 100
Super Hydraulic 100
Nuto H-100
Harmony 100 AW
HO 2A Hydraulic Oil
DTE No. 18
Pennzoil AW 100
Magnus A Oil 215
Tellus 100
Energol HLP 100
Industron 100
Sunvis 851 WR
Rando HD 100
Unax AW 100

Distributor

AMOCO
Arco
Chevron
Citgo
Conoco
Exxon
Gulf
Lubriplate
Mobil
Pennzoil
Phillips
Shell
Sohio
Std. Oil Indiana/Boron
Sunoco
Texaco
Union Oil Co.

TROUBLESHOOTING

 **WARNING: DISCONNECT THE POWER AND LOCK IT OUT** whenever working on the machine unless the directions specifically require the machine to be powered, see Power Lockout procedure, page 4. Several of the following tests may require the machine to be operational for checking and adjusting. Be very careful that tools and other people are clear of moving parts and that the drill is not accidentally operated while adjustments are being made.

 **CAUTION: Whenever repairing hydraulic components, loosen connections slowly to bleed off any trapped pressure.**

Problem	Area to Check	Solution
1. Lack of power	Relief valve in pump may be bad or have dirt in it.	Clean or replace relief valve or pump.
	Check oil level — may be low.	Add oil.
	Check voltage at machine — may be low.	Remove other machinery on line or provide a dedicated line.
2. Spindle motor stalls	Dull drills.	Sharpen drills
	Check for low voltage.	(See above.)
	Check drive pulley and belt for tightness.	(See main. section for adjustment.)
	Check for paper plugging drills.	Clean out hollow drills — We recommend cleaning and soaking drills in oil overnight.

DRILLING TIPS

Important! To prevent the drill from overheating, always avoid drilling too slowly. The table should be brought up as rapidly as possible allowing the drills to easily cut through the paper. Also, adjust the vertical table guide to return the table to the down position as rapidly as possible to avoid spinning the drills in the stock.

Slotted Holes - Instead of punching slotted holes for five and seven hole universal binding work, save time and cost by drilling a 1/2 inch diameter hole in place of the slot. The slot is only intended to allow the post or ring to be used in either location, and the large hole permits this.

Plastic Bindings -Drilling holes for plastic bindings, instead of punching them, is practical and saves a great deal of time, particularly on long run jobs.

Keep Drills Sharp - A dull drill is the major cause of drill breakage and production tie-ups. Usually after three hours of drilling, depending on the type of paper being processed, the drill should be sharpened. A dull drill results in poor quality work.

Keep Drills Clean - A dirty and rusty drill will not permit the free upward passage of the drill chips. Pressure built up by a clogged drill will split or break the drill. To keep it free from dirt or rust, clean the drill of all chips after each use and apply a light oil to the inside and outside. Drills should be cleaned out immediately after each use. This is particularly true if a coated or varnished stock has been drilled. On these jobs the coating on the chips frequently fuse the chips into one solid mass when the drill cools, causing breakage the next time the drill is used.

Lubricate Drills - Lubrication assists in the passage of the chips and helps avoid overheating of the drills. Use readily available stick lubricants for this purpose. Hold the end of the stick against the side of the rotating drill. Be sure to touch the cutting edge with the lubricant also. Wipe off excess oil before drilling. **CARE MUST ALWAYS BE TAKEN WHEN HANDLING DRILLS.**

Keep Spindle Clean - Clean out the drill spindle frequently. This will prevent any buildup in the spindle of the drill.

DRILLING TIPS

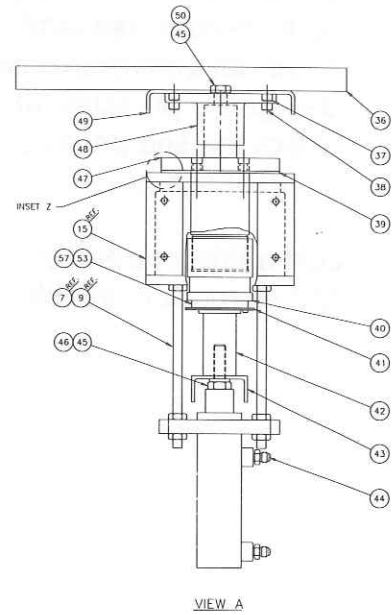
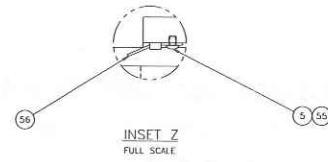
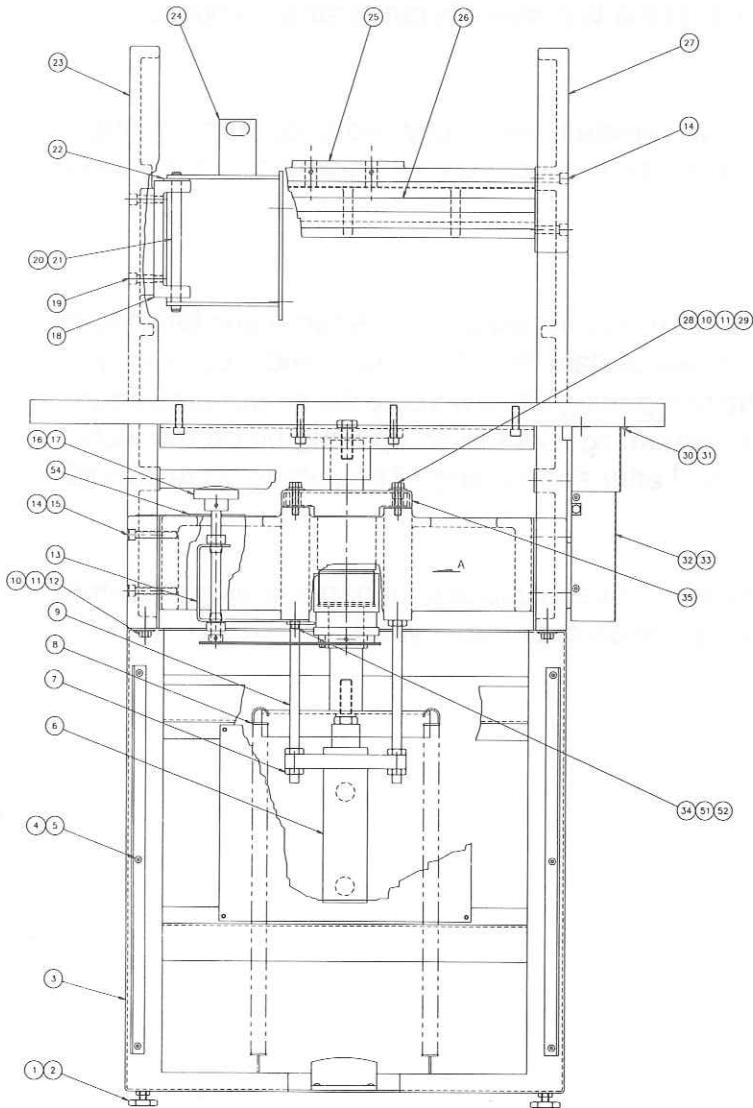
Set the Drills Correctly - Do not cut too deeply into the cutting block. The drill should just touch the block and cleanly cut through the bottom sheet. During drilling, do not set the drill deeper into the block but change the position of the block frequently. Drilling deeper into the block dulls the drills quickly. Use a piece of chipboard underneath your stock. This will make handling the stock easier and will ensure that the last sheet is cut cleanly through.

Check for Drill Wobble - If spindles are badly worn or bent through misadjustment, have them replaced immediately. A wobbly or loosely held drill will break.

Check Your Drill Sharpener - The cutting edge of the sharpening bit should be inspected frequently to make certain that it is sharp and free of nicks. Never let a drill drop onto the sharpening bit. It will chip the sharpening edge. Use gentle pressure when sharpening - let the sharpening bit do the work. Check the sharpness of the drill after sharpening. The cutting edge should be razor sharp.

Just a little time and effort taken with each use of your paper drilling machine should result in trouble free operation over many years.

MAIN ASSEMBLY 45000 SHEET 1

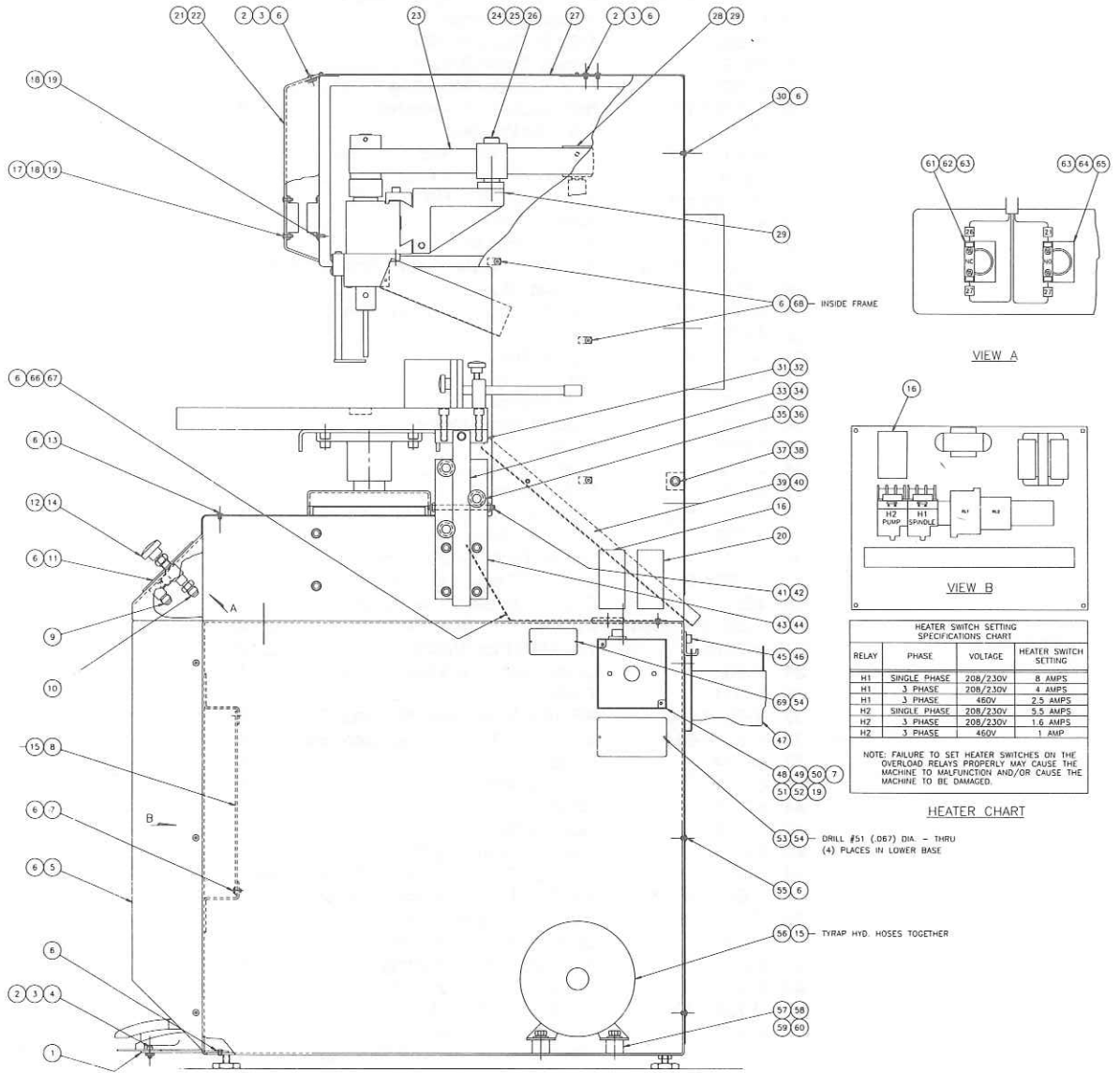


MAIN ASSEMBLY

45000 SHEET 1

Ref. Part No. No.	Part Name	Qty.
1. 16543	Leveler	4
2. H-5424-6	3/8-16" Hex Jam Nut	4
3. 45051	Base Assembly	1
4. 45049	Bracket, Lower Base Cover	2
5. H-6910-102404	#10-24 x 1/2" Butt. Hd. Soc. Cap. Scr. .	7
6. H-377	Hydraulic Cylinder	1
7. H-6424-8	1/2-13" Hex Jam Nut	12
8. 8843-1	Spring, Table Return	2
9. 45007	Rod, Cylinder Mounting	4
10. H-7327-12	3/8" Medium Lockwasher	8
11. H-7321-5	3/8" Flat Washer	8
12. H-6913-606	3/8-16 x 1" Hex Hd. Cap. Scr.	4
13. 45136	Table Adjustment Asm.	1
14. H-6918-616	3/8-16 x 2" Soc. Hd. Cap. Scr.	14
15. 45073	Brace, Cross	1
16. S-1753	Knob, Table Adj.	1
17. H-6939-103204	#10-32 NF x 1/4" CupPt.Soc. Set Scr. .	1
18. 45070	Bracket, Motor	1
19. H-6918-612	3/8-18 x 1-1/2" Soc. Hd. Cap. Scr.	2
20. 45001	Pin, Motor	1
21. S-1193-50	1/2" 'E' Ring	2
22. 11288	Washer, Nylon	1
23. 45077	Side Frame, L.H.	1
24. 45002	Bracket Asm., Motor	1
25. 45079	Dovetail	1
26. 45065	Scale, Drill Head	1
27. 45075	Side Frame, R.H.	1
28. H-6913-612	3/8-16 x 1-1/2" Hex Hd. Cap. Scr.	4
29. 11288-1	Washer, Nylon	4
30. 45117	Cover, Table Guide - Top	1
31. S-1088-5	#10 x 5/8" type AB Scr.	2
32. 45017	Cover, Vertical Table Guide	1
33. H-6910-102404	#10-24 x 1/4" Butt. Hd. Soc. Cap. Scr. .	4
34. H-7319-4	1/4" USS Flat Washer	2
35. 45092	Cover, Table Rod Guide	1
36. 45011	Table	1
37. H-6918-610	3/8-16 x 1-1/4" Soc. Hd. Cap. Scr.	4
38. H-6918-614	3/8-16 x 1-3/4" Soc. Hd. Cap. Scr.	4
39. 43084	Isolator	2
40. 45131	Nut, Adjusting	1
41. 45135	Chain	1
42. 45115	Rod, Table	1
43. 45037	Bracket, Return Spring	1
44. H-238-3	Adapter, 9/16-18" S.A.E. 'O' Ring Tube	2
45. H-6913-1012	5/8-11 x 1-1/2" Hex Hd. Cap. Scr.	2
46. H-7327-20	5/8" Med. Lockwasher	1
47. 45137	Guide Asm., Table Rod	1
48. 45116	Bracket, Table Mounting	1
49. 45120	Bracket, Table Support	1
50. H-7324-20	5/8" Int. Tooth Lockwasher	1
51. 45118	Stop, Table Travel	1
52. H-6918-405	1/4 -20 x 5/8" Soc. Hd. Cap. Scr.	2
53. 45138	Sprocket, Table Adj.	1
54. 45142	Decal, Table Adj.	1
55. H-7330-#10	#10 Ext. Tooth Lockwasher	1
56. EE-2425	Wire Asm., Auto Trip	ref.
57. H-6938-102404	#10-24 x 1/4" Soc. Set Scr.	2

MAIN ASSEMBLY 45000 SHEET 2



**HEATER SWITCH SETTING
SPECIFICATIONS CHART**

RELAY	PHASE	VOLTAGE	HEATER SWITCH SETTING
H1	SINGLE PHASE	208/230V	8 AMPS
H1	3 PHASE	208/230V	4 AMPS
H1	3 PHASE	460V	2.5 AMPS
H2	SINGLE PHASE	208/230V	5.5 AMPS
H2	3 PHASE	208/230V	1.6 AMPS
H2	3 PHASE	460V	1 AMP

NOTE: FAILURE TO SET HEATER SWITCHES ON THE OVERLOAD RELAYS PROPERLY MAY CAUSE THE MACHINE TO MALFUNCTION AND/OR CAUSE THE MACHINE TO BE DAMAGED.

HEATER CHART

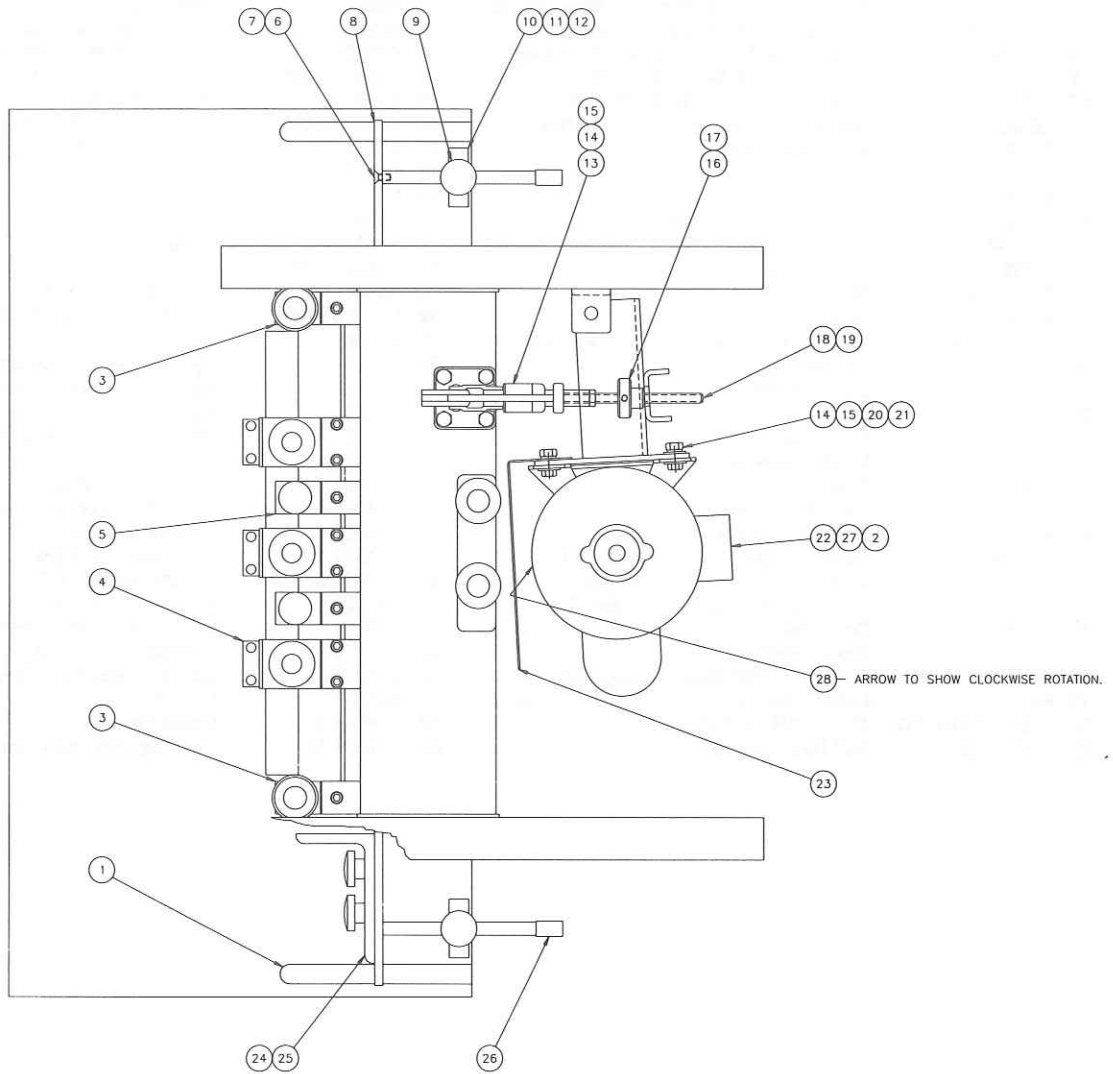
53 54 - DRILL #51 (.067) DIA. - THRU
(4) PLACES IN LOWER BASE

56 55 - TYRAP HYD. HOSES TOGETHER

MAIN ASSEMBLY 45000 SHEET 2

Ref. Part No. No.	Part Name	Qty.	Ref. Part No. No.	Part Name	Qty.
1. 45078	Bracket, Foot Treadle	1	36. A-10257-8	Bearing, Flanged (bronze)	
2. H-7324-#10	#10 Int. Tooth Lockwasher	10	37. H-6918-616	3/8-16 x 2" Soc. Hd Cap. Scr.	2
3. H-6423-#10	#10-24 Hex Nut	10	38. 45107	Tiebar	1
4. H-6918-102406	#10-24 x 3/4" Soc. Hd. Cap. Scr.	2	39. 45032	Chip Chute, Lower	1
5. 45048	Cover, Lower Base	1	40. H-5254-408	1/4-20 x 3/4" Soc. Shoulder Scr.	2
6. H-6910-102404	#10-24 x 1/2" Butt. Hd. Soc. Cap. Scr. 52		41. 45080	Stud, Table Guide	1
7. H-7330-#10	#10 Ext. Tooth Lockwasher	5	42. H-5247-4	1/4-20 Flex Lock Nut	2
8. EE-2385	Power Panel Assembly (single phase) .	1	43. 45012	Vertical Table Guide Assembly	1
9. H-237-5	Elbow 90°, 1/8 NPT x 9/16-18 Tube	1	44. H-6918-808	3/8-16 x 1" Soc. Hd. Cap. Scr.	4
10. H-241-5	Adapter, 1/8 NPT x 9/16-18" Tube	1	45. 5870	Hook, Chip Bag	2
EE-2386	Power Panel Assembly (three phase) ..	1	46. H-6918-504	5/16-18 x 1/2" Soc. Hd. Cap. Scr.	2
11. 45110	Panel, Console	1	47. 45061	Chip Bag Assembly	1
12. 4771-1	Valve	1	48. E-530-10	Fuse Holder	1
13. 45081	Cover	1	49. E-1075-1	Fuse, 1 Amp	1
14. H-7322-8	1/2" Polished Washer	1	50. E-640-1	Ground Lug	1
15. S-1694	Tyrap	2	51. E-1369-1	Cover, Junction Box	1
16. S-1781-12	Caution Label	2	52. H-6927-103204	#10-32 x 1/4" Rd. Hd. Mach. Scr.	1
17. H-6423-#8	#8-32 Hex Nut	2	53. 14050	Plate, Serial Number	1
18. H-7324-#8	#8 Int. Tooth Lockwasher	4	54. H-6924-004	#0 x 1/4" Rd. Hd. Drive Scr.	4
19. H-6910-83203	#8-32 x 3/8" Butt. Hd. Soc. Cap. Scr. ...	4	55. 45056	Cover, Rear	1
20. S-1781-15	Caution Label	1	56. H-407	Hyd. Power Unit Assembly (3 Ph 60 C) 1	
21. 45047	Cover, Front	1	H-408	Hyd. Power Unit Assembly (3 Ph 50 C) 1	
22. 45109	Label	1	H-379	Hyd. Power Unit Assembly (1 Ph 50 C) 1	
23. 45034	Drive belt	1	H-378	Hyd. Power Unit Assembly (1 Ph 60 C) 1	
24. 45129	Pulley Assembly (uncrowned)	2	57. 40016-2	Vibration Mount	4
25. 20075-7	Shim	2	58. H-7321-5	5/16" Flat washer	4
26. 45040-1	Pin, Idler Pulley	2	59. H-7327-10	5/16" Med. Lockwasher	4
27. 45043	Cover Assembly, Top	1	60. H-6423-5	5/16-18 Hex Nut	4
28. 45103-1	Drive Pulley (50 cycle machines)	1	61. E-2074-1	Pushbutton, Off (Red)	1
45103	Drive Pulley (60 cycle machines)	1	62. E-1839-8	Contact Block, N.C.	1
29. H-6938-404	1/4-20 x 1/4" Cup Pt. Soc. Set Scr.	3	63. 18520	Ring, Anti-rotation	2
30. 45145	Cover Assembly, Rear	1	64. E-2074	Pushbutton, On (Green)	1
31. 45015	Block, Guide	1	65. E-1839-9	Contact Block, N.O.	1
32. H-6918-612	3/8-16 x 1-1/2" Soc. Hd. Cap. Scr.	2	66. 45147	Cover, Power Base Top	1
33. 45016	Guide, Vertical	1	67. 8254-2	Grommet	1
34. H-21S-300-1750	1/2 x 1-3/4" Roll Pin	1	68. S-1694-2	Cable Tie	3
35. S-1073-30	1/2" Retaining Ring	3	69. E-1503-M	Fuse Specification Plate	1

MAIN ASSEMBLY 45000 SHEET 3

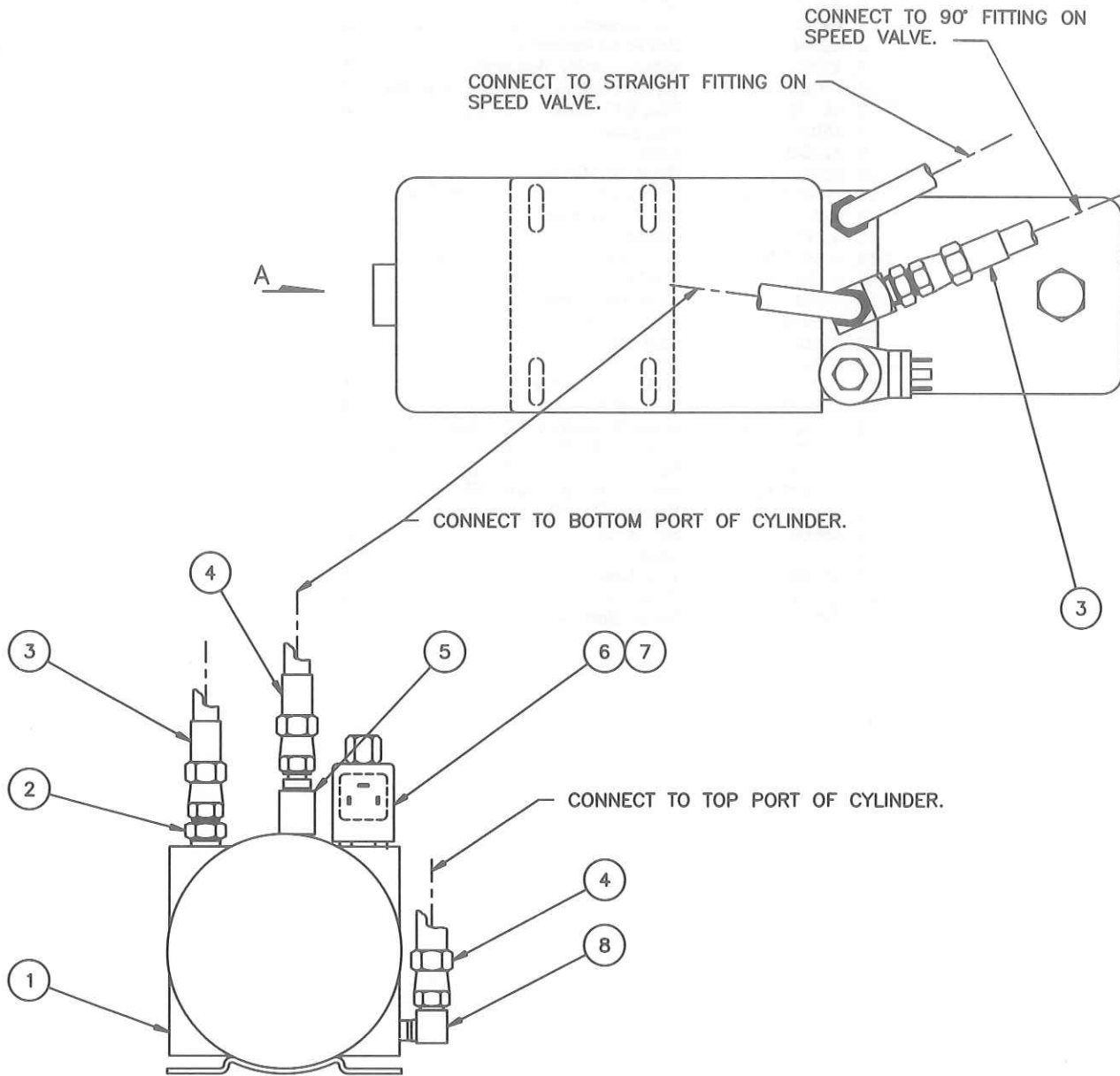


MAIN ASSEMBLY 45000 SHEET 3

Ref. Part No. No.	Part Name	Qty.
1. 4636-3	Scale, B/G Position	2
2. S-1781-12	Caution Label	1
3. 45035	Idler Assembly, Stationary	2
4. 45094	Drill Head Assembly	3
5. 45038	Idler Assembly, Adjustable	2
6. H-6909-405	1/4-20 x 5/8" Flat Hd. Soc. Cap. Scr.	2
7. 45018	Rod, B/G Guide	2
8. 45020	Backgauge	1
9. 8273-3	Knob	2
10. 45019	Block, B/G Guide	2
11. H-6913-614	3/8-18 x 1-3/4" Hex Hd. Cap. Scr.	4
12. H-7321-6	3/8" Flat Washer	4
13. 45006	Clamp	1
14. H-6913-506	5/16-18 x 3/4" Hex Hd. Cap Scr.	8
15. H-7327-10	5/16" Med. Lockwasher	8
16. 45060	Knob, Belt Tensioner	1
17. H-6964-404	1/4-20 x 1/4" Soc. Set Scr. (brass tip) .	1
18. 45059	Stud, Belt Tensioner	1
19. H-6423-8	3/8-16" Hex Nut	1
20. H-7321-5	5/16" Flat Washer	4
21. H-6423-5	5/16-18" Hex Nut	4
22. E-1600-190	Motor (208-230 V. 1PH. 50C.)	1
E-1600-189	Motor (200-230/380-415 V. 3PH. 50C.)	1
E-1600-192	Motor (208-230 V. 1PH. 60C.)	1
E-1600-191	Motor (208-230 /460V. 3PH. 60C.)	1
23. 45146	Bracket, Chip Deflector	1
24. 45066	Sideguide	2
25. 8278-4	Knob	4
26. 45143	Vinyl Cap	2
27. E-1237-2	Wire Nut	3
28. S-1106	Decal, Motor Arrow	1

HYDRAULIC POWER UNIT ASSEMBLY

H-378 (60HZ 1 PHASE); H-379 (50HZ 1 PHASE);
H-407 (60HZ 3 PHASE); H-408 (50HZ 3 PHASE)



VIEW A

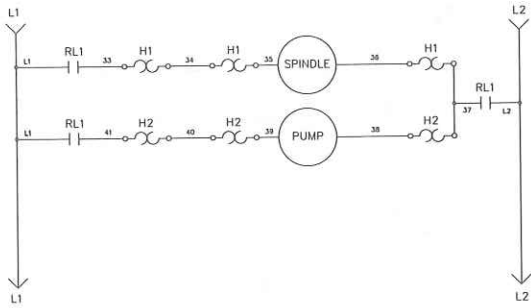
FITTINGS ROTATED FOR CLARITY

Ref. Part No. No.	Part Name	Qty.
1. H-372	Hyd. Power Unit, 208/230V 60C 1 Ph	ref.
H-373	Hyd. Power Unit, 208/230V 50C 1 Ph	ref.
H-405	Hyd. Power Unit, 208-230/460V 60C 3 Ph	ref.
H-406	Hyd. Power Unit, 208-230/380-415V 50C 3 Ph ..	ref.
2. H-241-6	Adapter, 3/8 NPT to 9/16" Tube	1
3. H-242-10	Hydraulic Hose Assembly 39" long	2
4. H-242-41	Hydraulic Hose Assembly 25" long	2
5. H-263-2	Tee	1
6. H-200-5	Solenoid Cartridge	ref.
7. E-1069-13	Coil	ref.
8. H-237-6	Elbow 3/8" NPT to 9/16" Tube	1

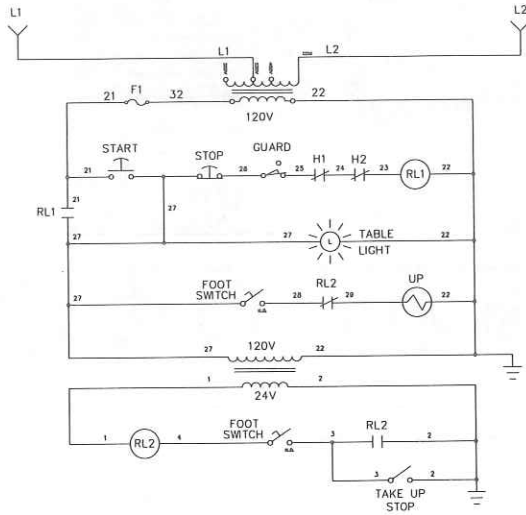
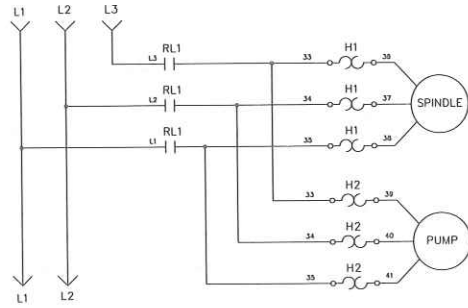
SCHEMATIC - BASIC MACHINE

E-2384

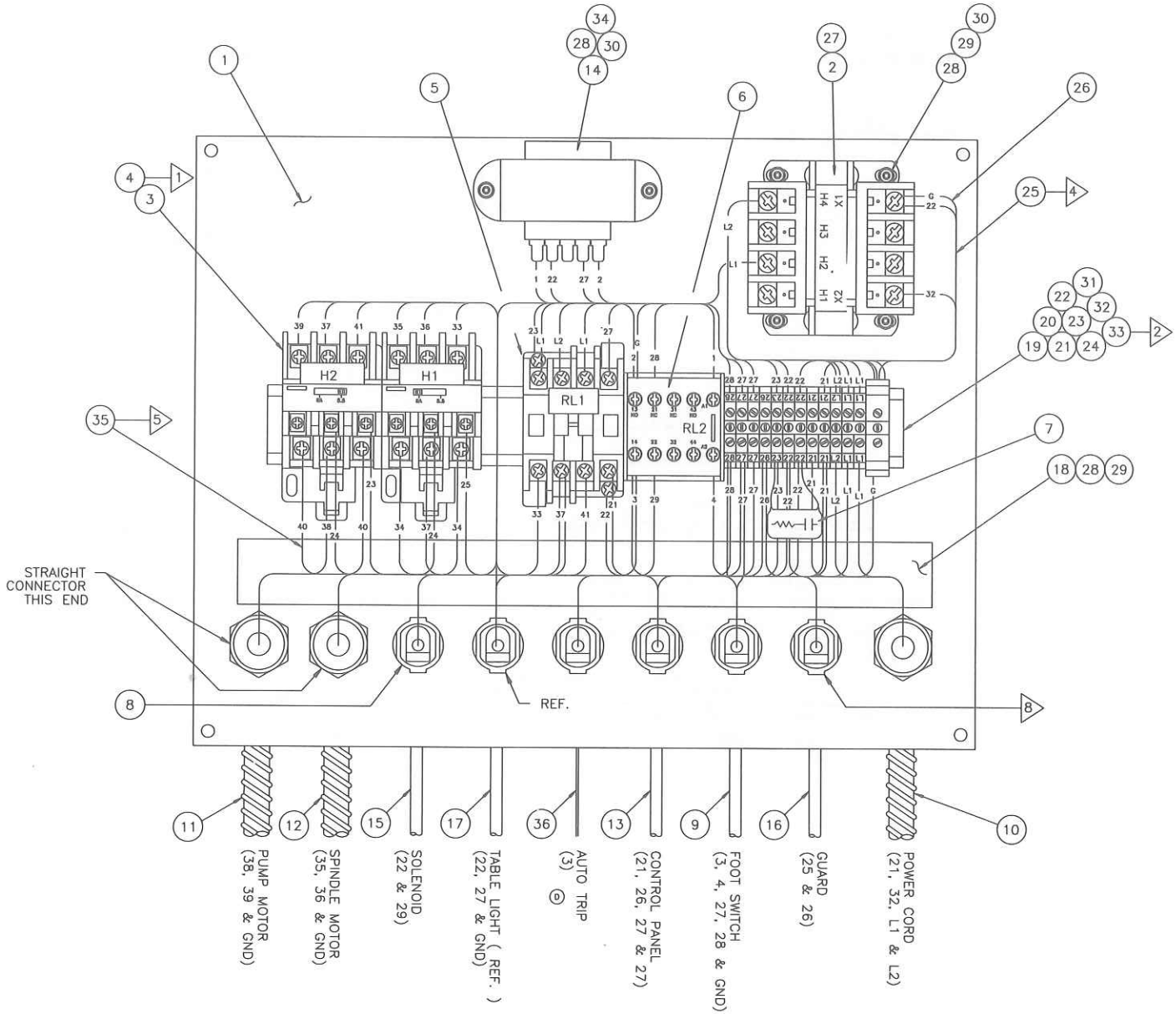
SINGLE PHASE
HOOK-UP



THREE PHASE
HOOK-UP



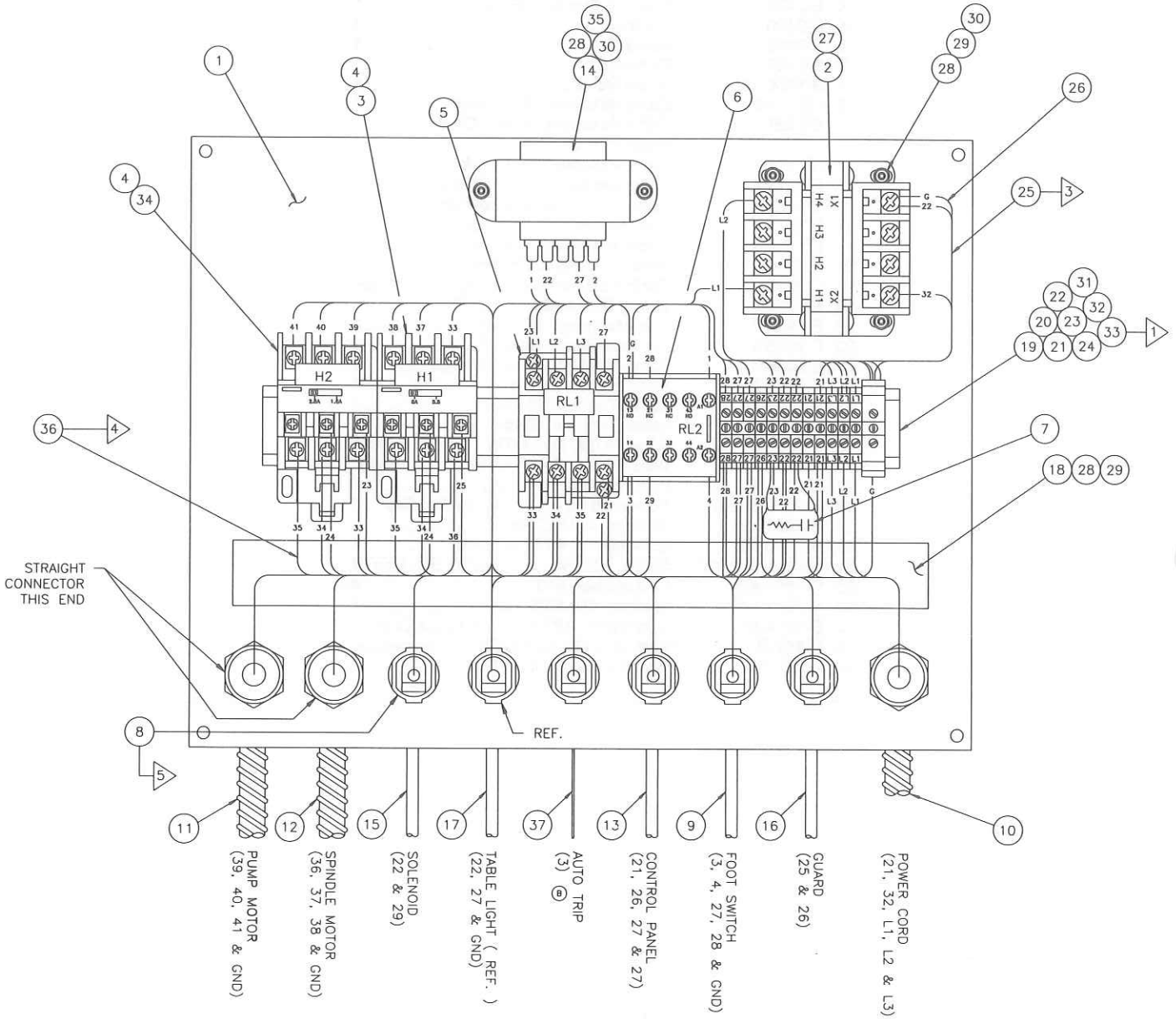
POWER PANEL ASSEMBLY EE-2385 SINGLE PHASE



POWER PANEL ASSEMBLY EE-2385 SINGLE PHASE

Ref. Part No. No.	Part Name	Qty.
1. 45119	Panel, Electrical	1
2. E-1089-33	Transformer	1
3. E-2401	Overload Relay	2
4. E-2402	Bracket, Overload Relay	2
5. E-2400	Starter	1
6. E-2403	Relay	1
7. E-1736	Quencharc	1
8. S-1350-16	Strain Relief	5
9. EE-2399	Cable Assembly, Footswitch	1
10. EE-2391	Cable Assembly, Power Cord /Fuse (1 Phase)	1
11. EE-2392	Cable Assembly, Pump Motor	1
12. EE-2393	Cable Assembly, Spindle Motor	1
13. EE-2394	Cable Assembly, Control Panel	1
14. E-1623-4	Transformer	1
15. EE-2396	Cable Assembly, Solenoid	1
16. E-2397	Switch, Magnetic Position	1
17. E-2398	Cable Assembly, Table Light	Ref.
18. E-1429-4	Wiring Duct and Cover (12" Long)	1
19. E-1977-7	Rail, Mounting (11" Long)	1
20. E-2068-3	Terminal Block, Ground	1
21. E-2068-4	Terminal Block, Feed Through	12
22. E-2071-2	Fixed Bridge, 2 Pole	4
23. E-1336-58	Label, Terminal Block	1
24. E-1356-57	Label, Terminal Block	1
25. E-709-R	Wire, 18 Ga. Red MTW	as needed
26. E-709-G	Wire, 18 Ga. Green MTW	as needed
27. E-1214-4	Fork, Insulated, Locking	7
28. H-6910-83202	Screw, #8-32 x 1/4" But Hd Soc Cap ...	9
29. H-7321-#8	Washer, #8 USS Flat	7
30. H-7330-#8	Lockwasher, #8 Shakeproof	6
31. H-6910-102402	Screw, #10-24 x 1/4" But Hd Soc Cap .	4
32. H-7330-#10	Lockwasher, #10	4
33. H-7321-#10	Washer, #10 USS Flat	4
34. E-1214-51	Connector, .187 Fully Ins. Quick Disc .	4
35. E-849-R	Wire, #18 Ga. Red MTW	as needed
36. EE-2425	Wire Assembly, Auto Trip	1

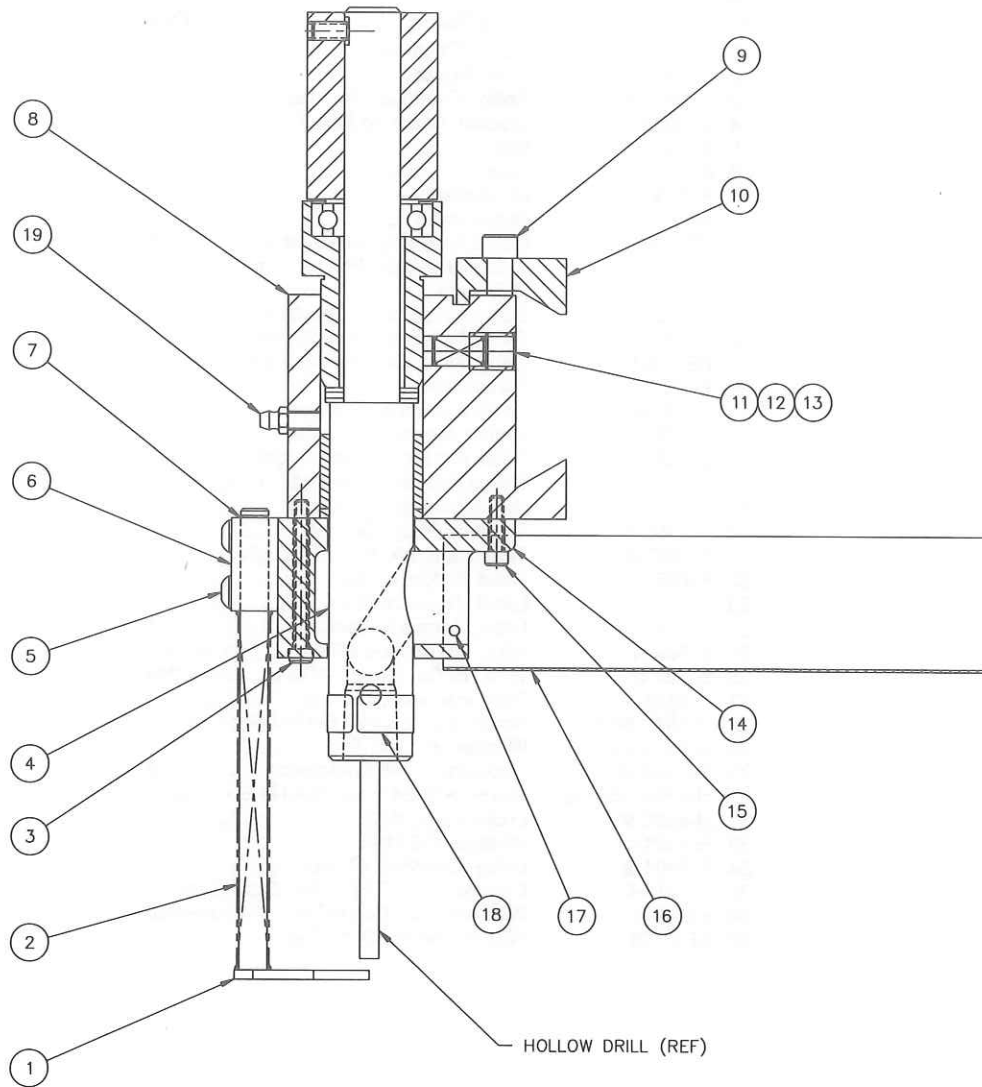
POWER PANEL ASSEMBLY EE-2386 THREE PHASE



POWER PANEL ASSEMBLY EE-2386 THREE PHASE

Ref. Part No. No.	Part Name	Qty.
1. 45119	Panel, Electrical	1
2. E-1089-33	Transformer	1
3. E-2401-3	Relay, Overload (Spindle)	1
4. E-2402	Bracket, Overload Relay	2
5. E-2400	Starter	1
6. E-2403	Relay	1
7. E-1736	Quencharc	1
8. S-1350-16	Strain Relief	5
9. EE-2399	Cable Assembly, Footswitch	1
10. EE-2391-1	Cable Assembly, Power Cord (3 Phase)	1
11. EE-2392-1	Cable Assembly, Pump Motor	1
12. EE-2393-1	Cable Assembly, Spindle Motor	1
13. EE-2394	Cable Assembly, Control Panel	1
14. E-1623-4	Transformer	1
15. EE-2396	Cable Assembly, Solenoid	1
16. E-2397	Switch, Magnetic Location	1
17. E-2398	Cable Assembly, Table Light	Ref.
18. E-1429-4	Wiring Duct and Cover (12" Long)	1
19. E-1977-7	Rail, Mounting (11" Long)	1
20. E-2068-3	Terminal Block, Ground	1
21. E-2068-4	Terminal Block, Feed Through	12
22. E-2071-2	Fixed Bridge, 2 Pole	3
23. E-1336-60	Label, Terminal Block	1
24. E-1356-61	Label, Terminal Block	1
25. E-709-R	Wire, 18 Ga. Red MTW	as needed
26. E-709-G	Wire, 18 Ga. Green MTW	as needed
27. E-1214-4	Fork, Insulated, Locking	7
28. H-6910-83202	Screw, #8-32 x 1/4" But Hd Soc Cap ...	9
29. H-7321-#8	Washer, #8 USS Flat	7
30. H-7330-#8	Lockwasher, #8 Shakeproof	6
31. H-6910-102402	Screw, #10-24 x 1/4" But Hd Soc Cap .	4
32. H-7330-#10	Lockwasher, #10	4
33. H-7321-#10	Washer, #10 USS Flat	4
34. E-2401-2	Relay, Overload (Pump)	1
35. E-1214-51	Connector, .187 Fully Ins. Quick Disc. .	4
36. E-849-R	Wire, #18 Ga. Red MTW	as needed
37. EE-2425	Wire Assembly, Auto Trip	1

DRILL HEAD ASSEMBLY 45094



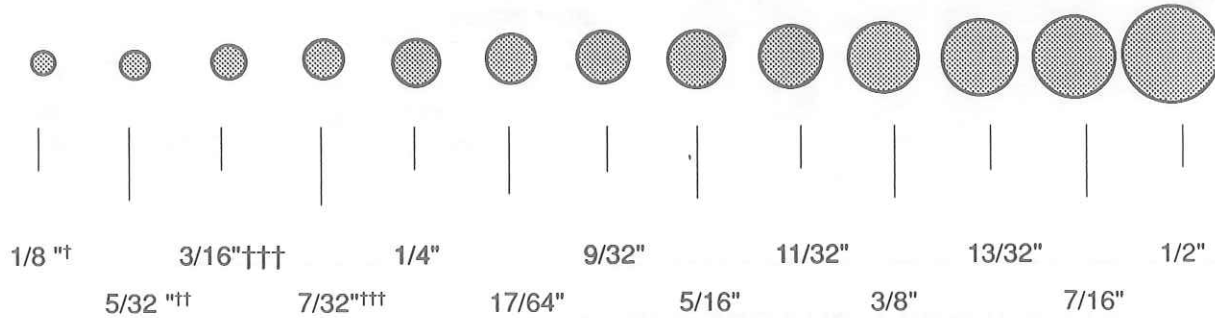
Ref. Part No. No.	Part Name	Qty.
1. 45128	Pressure Foot Assembly	1
2. 4629-1	Spring	2
3. H-6918-102416	Screw, #10-24 x 2" Soc. Hd. Cap	2
4. 45100	Sleeve Assembly	1
5. H-6910-408	Screw, 1/4-20 x 1" Butt. Hd. Cap	2
6. 45125	Block, Pressure Foot	1
7. S-1518-37	Ring, Retaining	2
8. 45099	Spindle Housing Assembly	1
9. H-6918-510	Screw, 5/16-18 x 1-1/4" Soc. Hd. Cap..	2
10. 45090	Clamp, Spindle Housing	1
11. 6609-2	Plunger	1
12. S-1255-1	Spring	1
13. H-6951-510	Set Screw, 1/2-13 x 1/2" Nylok	1
14. 45030	Chip Deflector	1
15. H-6918-102406	Screw, #10-24 x 3/4" Soc. Hd. Cap	1
16. 45095	Chip Chute	1
17. H-21S-125-0375	Pin, 1/8 x 3/8" Roll	2
18. K-85	Cover, Drill Drift Hole	1
19. S-1725	Fitting, Lubrication	1

ACCESSORIES FOR CHALLENGE PAPER DRILLING MACHINES

Genuine Challenge Hollow Drills

In 13 Standard Sizes For Every Drilling Need

(2" drill capacity unless otherwise noted.)



17/32" & 9/16" available by special order

Drill Capacity: †=5/8"; ††=1-1/8"; †††=1-5/8"

This wide range of standard drill sizes is available to meet your every ordinary drilling need. Carried in stock by local Challenge dealers.

Challenge Drill-Ease Lubricant Stick

Cat. No. 4688

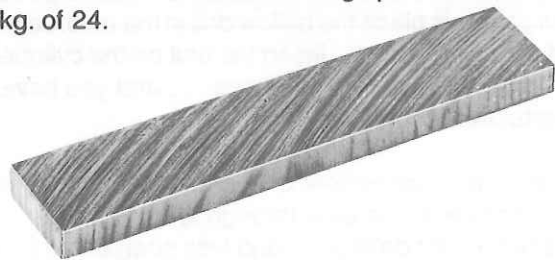
This lubricating stick provides a dry stainless lubricant which has many uses throughout the printing plant. It is specially recommended for use on hollow drills for easier drilling, particularly when drilling clay coated stock. It eliminates binding and excessive heating of the drill. Will not discolor the stock.

CARE MUST ALWAYS BE TAKEN WHEN USING STICK AND HANDLING DRILLS.

Challenge Drilling Blocks

Cat. No. A-6626-4

These Challenge 1-1/4 x 6" End-Wood Drilling Blocks are for round hole drilling operations. Sold in pkg. of 24.



Sharp-Eze II Drill Sharpener

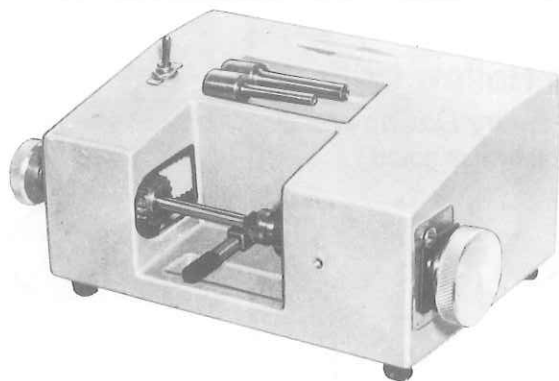
Cat. No. 11910

The rugged Sharp-Eze II drill sharpener is the perfect accessory for your MS-5 Drill. Durable, die-cast construction, this tool will sharpen 1/8" to 1/2" (3 to 13mm) bits without having to remove them from the drill. The lever actuated, diamond sharpening head provides the proper cutting angle and has a built-in chip removing pin. The Sharp-Eze comes with a layered component base to accommodate various length drills.

ACCESSORIES FOR CHALLENGE PAPER DRILLING MACHINES

Challenge Power Sharpener

Cat. No. A-6450



A new moderate-cost power drill sharpener. Plugs into any standard 115 volt, 60 cycle, AC outlet. Handles Challenge and other taper shank drills. Adaptors also available for handling practically all other makes.

Item	Cat. No.
Replacement Cutting Bit	6469
Resharpener Service - Your Old Bit	6469-R

HOLLOW DRILL SHARPENER *For fast . . . easy . . . drill sharpening*



CAUTION: Drills are sharp even after use. Be careful to keep edge away from your body. To prevent personal injury and/or damage to the drill, ALWAYS keep drills in protected area.

Here's a unit that really makes drill sharpening easy. All you do is place the hollow drill in the tapered end of the drill holder . . . insert the unit on the cylinder . . . then turn two or three times . . . and you have a perfectly sharpened drill.

This Challenge Hollow Drill Sharpener can pay for itself many times over through longer drill life . . . easier, faster drilling . . . and less sharpening time. All sizes of drills from 1/8 to 1/2 inch in diameter can be handled.

Important, too, the drill sharpener automatically puts just the right amount of bevel on the hollow drill for best drilling results. It's self centering, too, so that the center of the sharpening bit exactly meets the center of the hollow drill. The drill sharpener also has a replaceable sharpening bit.

Items	Part No.
Challenge Hollow Drill Sharpener	A-4950
Extra Cutting Bit	4952

Instructions:

NOTE: Always handle carefully

1. Be sure to wipe off all grease before using the sharpener.
2. Remove any paper chips from the hollow drill.
3. Place the hollow drill in the drillholder section. Insert the sharpening section, being very careful to bring the drill and cutting tool together without bumping.

CAREFUL: The cutting tool is made of a glass hard material and may be chipped by careless handling.

4. Turn the cutting unit clockwise, maintaining an even pressure until the hollow drill is sharpened (usually two or three turns). The cutting tool seldom requires regrinding, but when this does become necessary, the bit should be sent to the factory as regrinding must be done on a diamond wheel.

