THE DESIGN OF A PORTABLE PIPE THREADING MACHINE

Thesis by

Richard A. Wallace

In Partial Fulfillment of the Requirements

For The Professional Degree of

INDUSTRIAL DESIGNER

California Institute of Technology

Pasadena, California

1949

ACKNOWLEDGMENTS

The designer wishes to thank the members of his thesis reviewing committee: Mr. J. P. Youtz, Dr. D. S. Clark, and Mr. B. Morant, for the valuable suggestions and assistance which they offered.

To the faculty and the class members of the Industrial Design Section, the designer is most appreciative for the creative stimulus which their frank and honest criticism provided.

Many manufacturers, salesmen, and consumers of pipe threading machinery have graciously given of their time and effort, and the designer sincerely thanks each of them.

ABSTRACT

This thesis is the presentation of the design of a portable pipe threading machine having improved operational usefulness and increased sales advantage over present machines.

An investigation of the present portable pipe threading machine market has been conducted including a product study, a survey of consumer preference in a sample market, an analysis of the present market, and a patent investigation.

Technical research has been done consisting of tests to determine operating torque loads, an investigation of chaser form and threading speed, development of automatic chucking systems, and an investigation of suitable materials and new processes for portable pipe threading machine manufacture.

Design studies have been made of an ideal portable pipe threading machine, of portable rotary-tool machines, and of portable rotary-pipe machines.

The final design offers the following improved features over present portable machines: (1) separate threading assemblies for each pipe size, but only one opening mechanism; (2) a power-driven cut-off mechanism; (3) a reamer mounted behind the diehead; (4) a positive gripping automatic chucking system. A stress analysis, a cost analysis, a weight analysis, a market estimate, sales and advertisement features, maintenance and service considerations, and assembly drawings have been prepared for this machine.

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INTRODUCTION AND SCOPE

There are three general types of pipe threading machines in use today:

(1) Automatic and semi-automatic production machines which will thread all sizes of pipe from 1/16" to 12".

(2) Portable field machines which will thread, ream, and cut-off pipe below 2" diameter by tools attached to a carriage sliding on ways.

(3) Power vises which rotate pipe below 2" diameter and use hand tools to thread, ream, and cut-off.

The Rotamatic pipe threading machine developed in this thesis is a portable field machine. Its design is the result of careful consideration of the sales, production, and operational requirements which present day portable pipe threading machines must meet.

The thesis is composed of four major parts: a market investigation, technical research, design studies, and the final design description.

The market investigation includes a survey of present portable pipe threading machines, a field survey of consumer preference in the Southern California area, an analysis of the extent and condition of the present pipe threading machine market, and an investigation of threading machine patents.

The technical research consists of operational tests to determine threading and cut-off torques, an investigation of chaser form and threading speeds, research and development of two automatic chucking systems, and an investigation of suitable materials and new processes for use in the manufacture of the Rotamatic.

The design studies include a visualization of an ideal pipe threading machine, preliminary designs of five portable rotary-tool machines, and a design analysis of the component parts of portable rotary-pipe machines.

The final design of the Rotamatic pipe threading machine is based on the results and conclusions of the market investigation, the technical research, and the design studies. It consists of a detailed description of the construction and operation of the machine.

The appendices include engineering, market, and sales data pertaining to the Rotamatic; a tabular summary of the specifications of present day portable pipe threading machines; and the designer's suggestions for future pipe threading machine design.

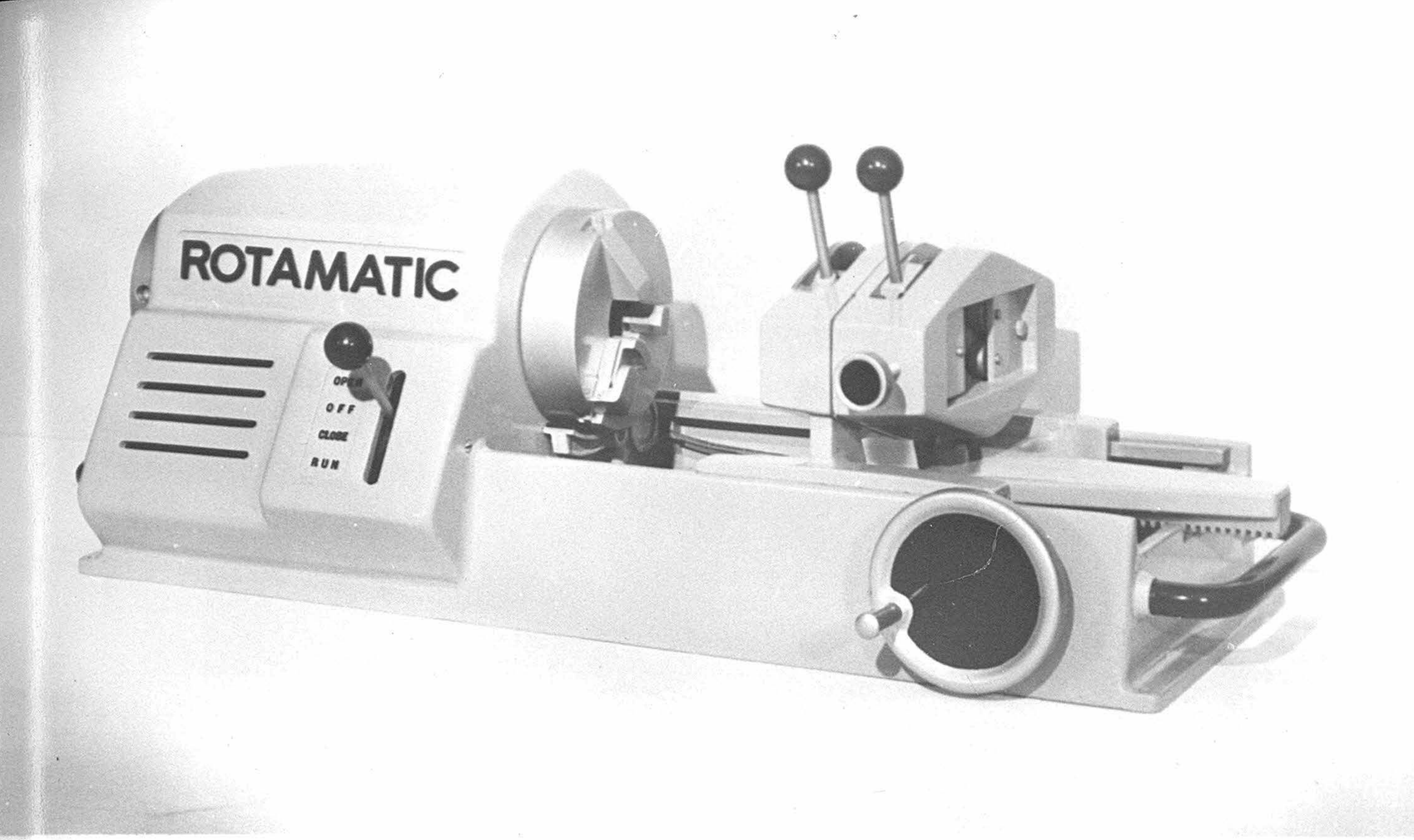
FINAL DESIGN SUMMARY

The Rotamatic pipe threading machine designed in this thesis is shown in Illustration 1. Its general specifications are: size - 38.50" long, 14.75" wide, 14.35" high; weight - 220#; standard range of pipe - $\frac{1}{2}$" - 2"; spindle speed - 40-55 rpm, variable with load; price - $625.00 (with 6 threading assemblies.)

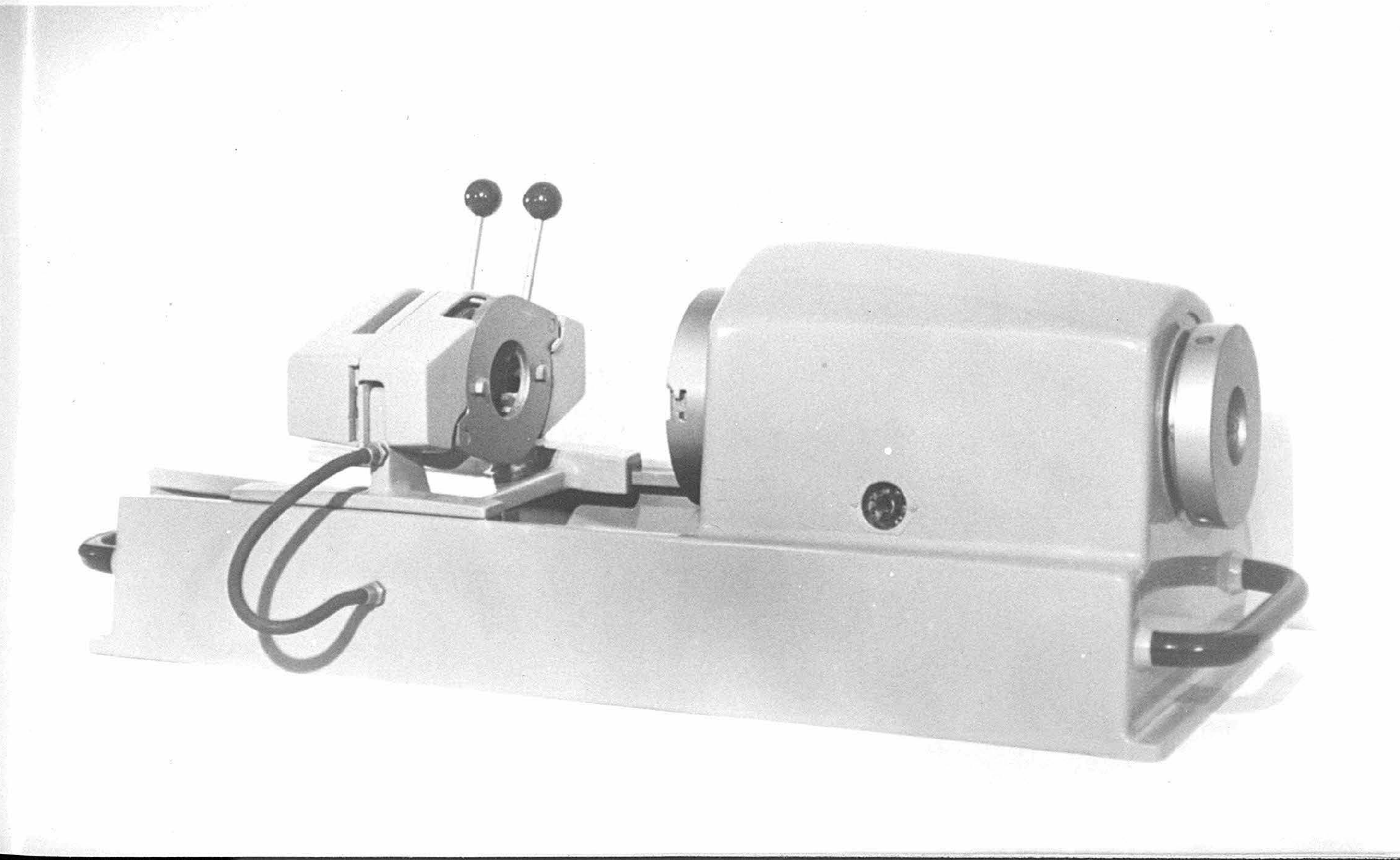
The Rotamatic is painted a warm, light grey with black trim. The operating handle knobs are red plastic.

The threading mechanism consists of separate threading assemblies for each size pipe, but of only one scroll opening mechanism operated by the handle mounted on top of the diehead. A downward motion of the handle closes the chasers and locks the threading assembly in place, while an upward motion opens the chasers and allows the threading assembly to be removed. Provision is made in the threading assemblies for adjustment for cutting oversize and undersize threads.

The cut-off mechanism is power driven by a friction drive from the pipe. Operation is by the handle mounted on top the mechanism. A downward motion of the handle causes the cut-off wheel to move against the pipe, while an upward motion backs the cut-off wheel away from the pipe at high speed. The cut-off mechanism will slide to align itself about any size pipe.



1. THE ROTAMATIC PIPE THREADING MACHINE



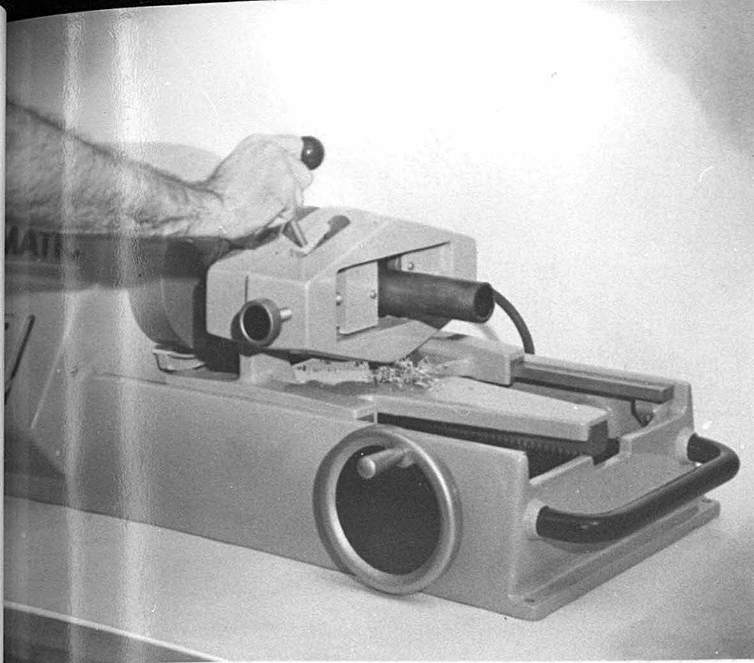
A cone reamer is mounted on the rear of the cut-off mechanism, and is moved into position behind the diehead chasers by sliding the cut-off mechanism towards the operator.

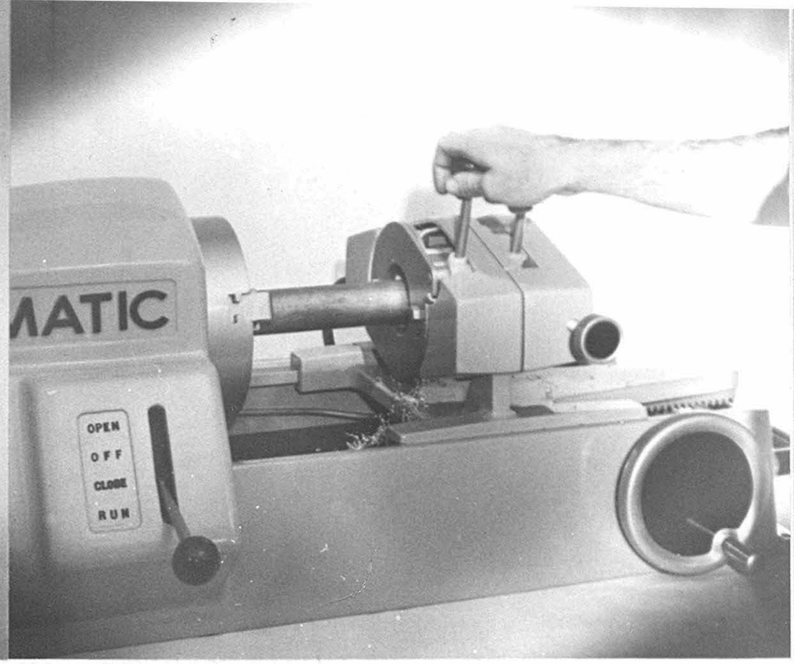
The carriage which carries the threading and cut-off mechanisms is moved by a rack and pinion gear feed by the positioning wheel mounted on the frame of the machine. The threading and cut-off mechanisms may be swung away from the carriage for making-up fittings.

The chucking system driving the pipe is fully automatic. There is a front gripping chuck and a rear aligning chuck which open and close simultaneously. Operation is by the handle mounted on the front of the driving head. A downward motion of the handle starts the motor which closes the jaws. A further downward motion lifts the closing force. An upward motion reverses the motor and opens the jaws. Positive gripping of the front chuck jaws is insured by a master torque jaw which grips tighter as the torque load increases.

The motor is a $\frac{1}{2}$ HP, sealed, gear-in-head, series motor, driving a spur pinion gear which meshes with the spindle gear. The motor mounts are fiber to reduce noise and vibration. The motor switch is operated by the chuck operating handle.

A vane type oil pump, driven from the spindle gear, supplies





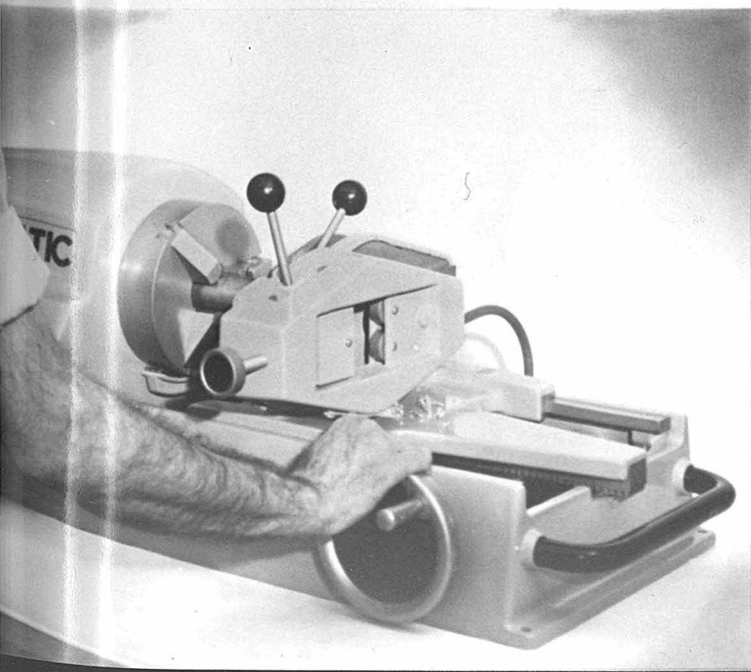
CUTTING - OFF

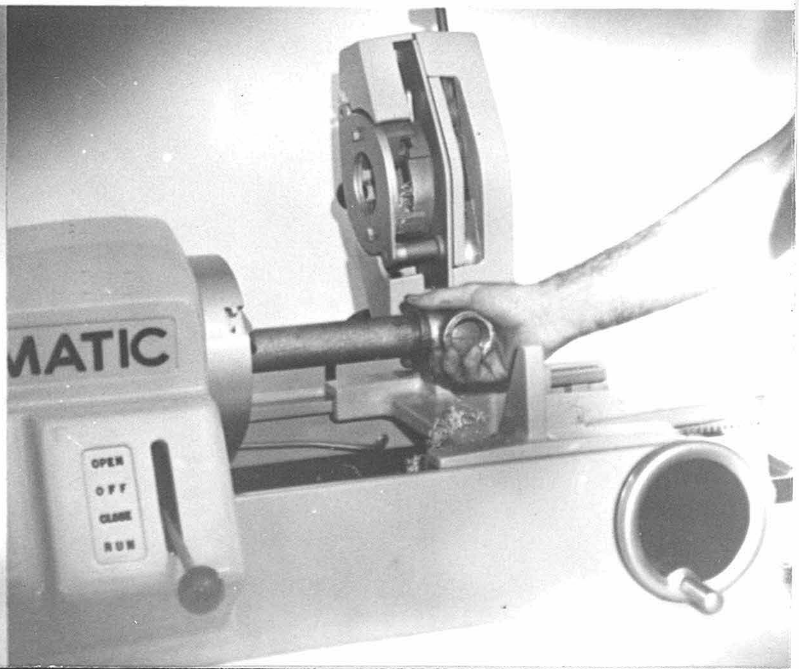
THREADING

2. ROTAMATIC OPERATION SEQUENCE

REAMING

MAKING - UP





cutting oil to the threading mechanism. The oil is automatically shut off when the threading and cut-off mechanisms are in make-up position. Chips are caught on a removable metal tray.

The frame is a one-piece aluminum casting. Ball bearings are used to support the spindle. The carriage guides are ground, heat-treated steel.

The operation sequence of the Rotamatic cutting-off, threading, reaming, and making-up a piece of pipe is shown in Illustration 2. Estimated operation times for 2" pipe are: Cutting-off, 6 sec.; Threading, 20 sec.; Reaming, 4 sec.; Making-up, 15 sec.

Patent rights on novel features of the Rotamatic are reserved by the designer.

PRODUCT SURVEY

Thirty five letters were written in October 1948 to the pipe threading machine manufacturers listed in Thomas Register. The purpose of these letters was twofold: (1) to obtain manufacturers' reaction to the initial concept of the design of a portable pipe threading machine (a machine having a maximum pipe capacity of 1", weighing approximately 50 pounds, costing around $300, and rotating the tools rather than the pipe); and (2) to collect sales data and engineering specifications of the present portable machines manufactured and sold by these companies.

The significant information contained in the replies to these letters was as follows:

(1) The capacity of the machine to meet the full need of the present market would need to be large enough to handle 2" pipe.

(2) The weight was lower than necessary. To be so light would necessitate the use of too many high-cost, high precision parts. The machine might weigh as much as 100 pounds and still be more portable than present day machines.

(3) The retail cost should be in the vicinity of $3.00 per pound if the machine is made chiefly of aluminum, or $2.00 per pound if made chiefly of ferrous materials.

(4) The construction of the machine must be durable enough to withstand excessive abuse and prolonged overloads.

The principal manufacturers of portable pipe threading machines as indicated by this survey are:

(1) American Die and Tool Co., Reading, Penna.

(2) Beaver Pipe Tools, Inc., Warren, Ohio

(3) The Oster Manufacturing Co., Cleveland, Ohio

(4) Quijada Tool Co., Inc., Los Angeles 32, Cal.

(5) The Toledo Pipe Threading Machine Co., Toledo, O.

The portable machines manufactured by these companies are shown in Illustrations 36 to 44 inclusive. Specifications of these machines are tabulated in Appendix I.

The power vises and large pipe threading machines manufactured by these companies and other companies were not considered as being of sufficient informative value for this thesis study and were not investigated.

CONSUMER FIELD SURVEY

A consumer field survey was conducted during the first three months of 1949. The purpose of this survey was (1) to determine consumer likes and dislikes of present pipe threading machines, and (2) to become acquainted with portable pipe threading machine operational requirements.

A total of 32 interviews made up the survey. Names were selected according to a predetermined sequence from the local telephone directories. The primary area was Pasadena (18 interviews), chosen because of its easy access. The Los Angeles area (9 interviews) and the Long Beach area (5 interviews) were used as checks against the Pasadena area. The interviews consisted of four major groups of consumers.

Plumbers were the largest group interviewed. This included 13 of the Pasadena interviews, 5 of the Los Angeles interviews, and 4 of the Long Beach interviews. All sizes of plumbing establishments from large heating and plumbing contractors employing approximately 100 people to one-man shops were included in this group. An effort was made to speak with men on all levels of employment. Owners, estimators, master plumbers, shop men, and apprentice plumbers were interviewed. The head plumbing instructor of the Pasadena City College, where an off-job training course in plumbing is given, was interviewed.

Plumbing supply shops included 2 of the Pasadena interviews, 4 of the Los Angeles interviews, and 1 of the Long Beach interviews. These shops varied in size and volume of business from large departmental businesses to small 2 or 3-man shops.

Pipe threading machine jobbers included 3 of the Los Angeles interviews. One of these jobbers was also the largest rebuilder of pipe threading machinery in Southern California.

Electrical contractors included 3 of the Pasadena interviews. All of these concerns employed over 50 people.

The technique of the interviews varied with the different groups. With plumbers the individual was first acquainted with the nature and scope of this thesis project. No set pattern of questions was asked. The conversation was cast in such a direction as to ascertain what he liked most about his machine, what he liked least, and what he would like to see incorporated in a machine which he might buy in the future. With plumbing supply shops the purpose was to learn the requirements which they placed upon pipe threading machines. Questions concerning present supply channels of plumbing supplies were also asked. With pipe threading machine jobbers the purpose was to determine sales features, selling problems, and repair problems of threading machinery. The conversations were more concerned with economic considerations than with mechanical features of the machines. With electrical contractors the technique was the same as with the plumber interviews. The questions asked were modified to fit their special interest in iron pipe for solid conduit work.

The time spent on each interview varied from approximately 15 to 45 minutes. An effort was made to be as brief as possible.

A general summary of the information obtained from the four groups of consumers interviewed is as follows:

(1) Portable pipe threading machines were used by approximately half the establishments interviewed. Power vises were used in the remainder.

(2) Increased speed was desired by practically all plumbers. This interest was more pronounced in large contracting shops using several portable machines than in small shops using power vises.

(3) A light-weight machine would be very desirable if it would be strong enough to withstand the usual abuse and overload presently incurred.

(4) The price of present-day machines was considered reasonable, although any reduction would be welcome.

(5) The uses of portable machines varied from being used entirely in the shop to being used entirely on the job. Most machines were used in both capacities.

(6) The cut-off operation should either be speeded up on the threading machine, or be done on special machines. Several contracting shops were using carborundum-wheel cut-off machines. Wheel and roller hand cut-off was preferred to blade cut-off for general work.

(7) Separate opening dieheads for each size pipe were desired for greater speed, convenience, and

dependability. Any design which would lower the high initial cost of these mechanisms without sacrificing operational accuracy and efficiency would be highly desirable.

(8) Reaming by the use of burr reamers or some similar device was thought desirable to increase speed.

(9) An automatic chuck which would hold 2" pipe without slipping, and not wear out quickly would be very desirable.

(10) Bent or curved pipe handling ability by a portable pipe threading machine would be very helpful for some jobs.

No significant difference in machine working requirements or in consumer preference was noted in the three areas surveyed. However, it was felt that the Southern California requirements for portable pipe threading machines are not entirely representative of the requirements of other areas of the United States. For a definite, conclusive survey of this sort, a large number of people in several areas of the country would need to be interviewed, and the results tabulated and compared.

The information thus assembled was used as a basis of reference for the design of the Rotamatic pipe threading machine developed in this thesis.

MARKET ANALYSIS

The pipe threading machine industry is a small section of the machine tool industry. There are 37 companies listed in Thomas Register under the general heading of Pipe Threading Machinery. This list is composed of manufacturers, jobbers, and rebuilders of all types of pipe threading machinery and equipment.

The size of the five companies manufacturing portable pipe threading machines can be approximated by the capital rating assigned them by Thomas Register:

(1) American Die and Tool Co.--over $1,000,000

(2) Beaver Pipe Tools, Inc.--between $500,000 and $1,000,000

(3) The Oster Manufacturing Co.--over $1,000,000

(4) Quijada Tool Co., Inc.--between $100,000 and $300,000

(5) The Toledo Pipe Threading Machine Co.--over $1,000,000

The distribution of portable machines is direct from the factories to the jobbers. These jobbers may be machine tool retailers, plumbing supply retailers, pipe supply companies, or hardware and metal supply companies. Factory representatives call on these retail outlets for sales orders. Plumbers buy through the retail outlets. There is a small auxiliary market of rebuilt machines sold by machine shops which specialize in rebuilding machine tools.

The life of portable machines varies with the make of machine and the manner of use. Some makes of machines, if used carefully and periodically overhauled, will last until antiquated by design evolution. Other makes are less durable and need replacemnt of parts after several hundred hours of operation. The average life as indicated by the Southern California market is approximately six years. For individual machines the life may be as low as three years and as high as ten.

The volume of portable pipe threading machines manufactured and sold per year is not available in any government or private publication, and the manufacturers of these machines are unwilling to release any production figures. However, the annual volume may be established with reasonable accuracy in the three following ways:

(1) Estimations of men associated with the industry fix the total volume manufactured per year at approximately 5000 machines.

(2) The Statistical Abstract of the United States 1948[1] lists a total of 37,112 heating and plumbing establishments recorded in the census of 1939. Of these establishments 4,686 have over $25,000 capital while 32,426 have under $25,000 capital. On the basis of the consumer survey made by the designer of Southern California, it appears safe to allow three portable machines for each of the plumbing establishments of over $25,000

capital, and one portable machine for half of the establishments under $25,000. By this distribution there are a total of 30,000 portable machines in use in the United States. Assuming that the present market is essentially the same as the 1939 market, and that the average life of each machine is six years, there is an average annual market of 5000 machines. This figure does not represent sales of portable machines to factories and institutions for repair work. It can be assumed that this market would add as many as 500 machines per year to the market, giving a total annual volume in this case, of 5500 portable machines.

(3) The Census of U. S. Manufacturers 1939[2] lists the total value of pipe threading machines of all types manufactured in 1937 as $1,529,383, and in 1939 as $1,073,489. Assuming 80% of this value to be portable machines at an average cost of $300 each, and assuming the volume to be essentially constant each year, the annual volume is approximately 4500 portable machines.

An annual market of approximately 5000 portable pipe threading machines may be assumed with reasonable accuracy on the basis of these calculations. No attempt has been made to determine either the volume or the value of the market of rebuilt portable machines.

PATENT SITUATION

A search of the patent files in Washington, D. C. was made by the designer in December 1948. Appropriate classes of Divisions 10, 29, 74, and 82 were searched. The patents noted as being of interest in the design of a portable machine are listed in Appendix J.

Manufacturers' sales literature was checked for patents issued and applied for on present portable pipe threading machines. These patents are also listed in Appendix J.

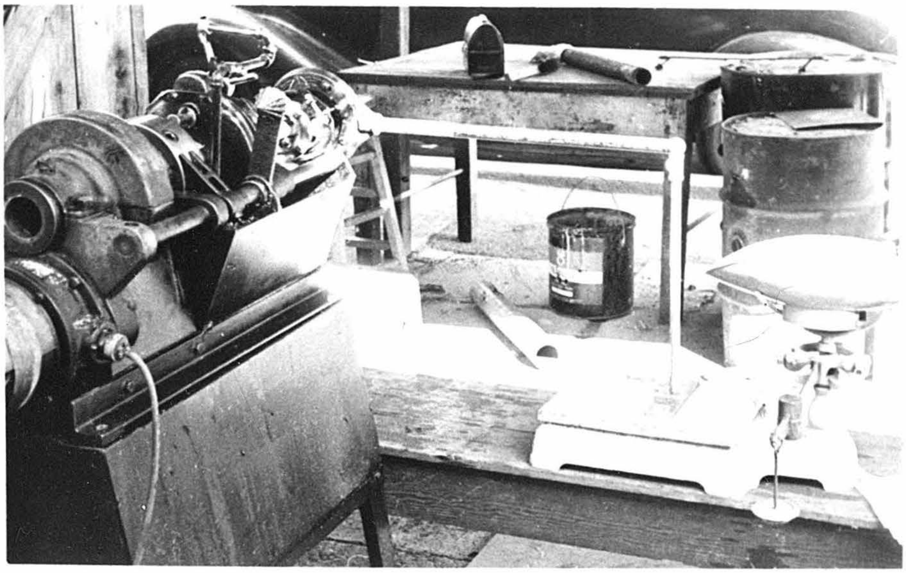
Copying patented elements on the Rotamatic was avoided. An effort was made to use mechanisms upon which there are no patent restrictions and to develop mechanisms which are sufficiently different from present design to be patentable in their own right.

THREADING AND CUT-OFF TORQUE TESTS

Operational threading and cut-off torque loads were obtained by a series of tests using a Toledo 999 pipe threading machine, Rigid 11-R and 65-R hand threading dies, and a Rigid wheel and roller hand cut-off tool. This equipment is owned by the Department of Buildings and Grounds of the California Institute of Technology.

The threading torque test was conducted as follows: The pipe threading machine was set up adjacent to a set of platform scales. The hand threading dies were used for threading instead of the machine dieheads. The lever arm of the hand threading dies was made to bear upon the platform scales while the thread was being cut by the machine. The test set-up is shown in Illustration 3. Care was taken to achieve point contact between the threading die lever arm and the platform scales support. Rigid 11-R threading dies were used to thread 1/2", 3/4", and 1" wrought iron pipe. A Rigid 65-R die set was used to thread 1", $1\frac{1}{4}$", $1\frac{1}{2}$", and 2" wrought iron pipe. The depth of the 11-R chasers was 1", and the thickness, 3/16". The depth of the 65-R chasers was 1", the thickness, 1/4". Three runs were made using different pieces of each diameter pipe. All chasers were sharp and a sulphur base cutting oil was used during all runs.

The cut-off torque test was conducted as follows: The Rigid



3. THREADING TORQUE TEST SET-UP.

4. CUT-OFF TORQUE TEST SET-UP.

hand cut-off tool was set up to cut off pieces of black iron pipe turned by the machine as shown in Illustration 4. Loads were read on a spring scale. Care was taken to keep the spring scale at right angles to the cut-off tool handle. Several readings were made on each size pipe. No cutting oil was used.

A plot of the average threading torques obtained is shown in Figure 5. It was felt that the difference in the torque to thread 1" pipe with the 11-R die set and the 65-R die set was caused by the difference in the thickness of the chasers.

The average cut-off torque for wheel and roller cut-off was found to be 80"#. There was no appreciable variation in this value for the different pipe diameters tested.

Pipe threading torques are not listed in any handbooks or engineering publications available to the designer. Letters sent to the five major manufacturers of portable pipe threading machines and to the Rigid Tool Company asking for this information were completely futile. Inasmuch as cutting torques, milling torques, and drilling torques are included in standard handbooks, the designer feels that companies who have this information would do the engineering and machine tool profession a needed service by making threading torque values publicly known.

The tangential forces acting upon the chasers can be

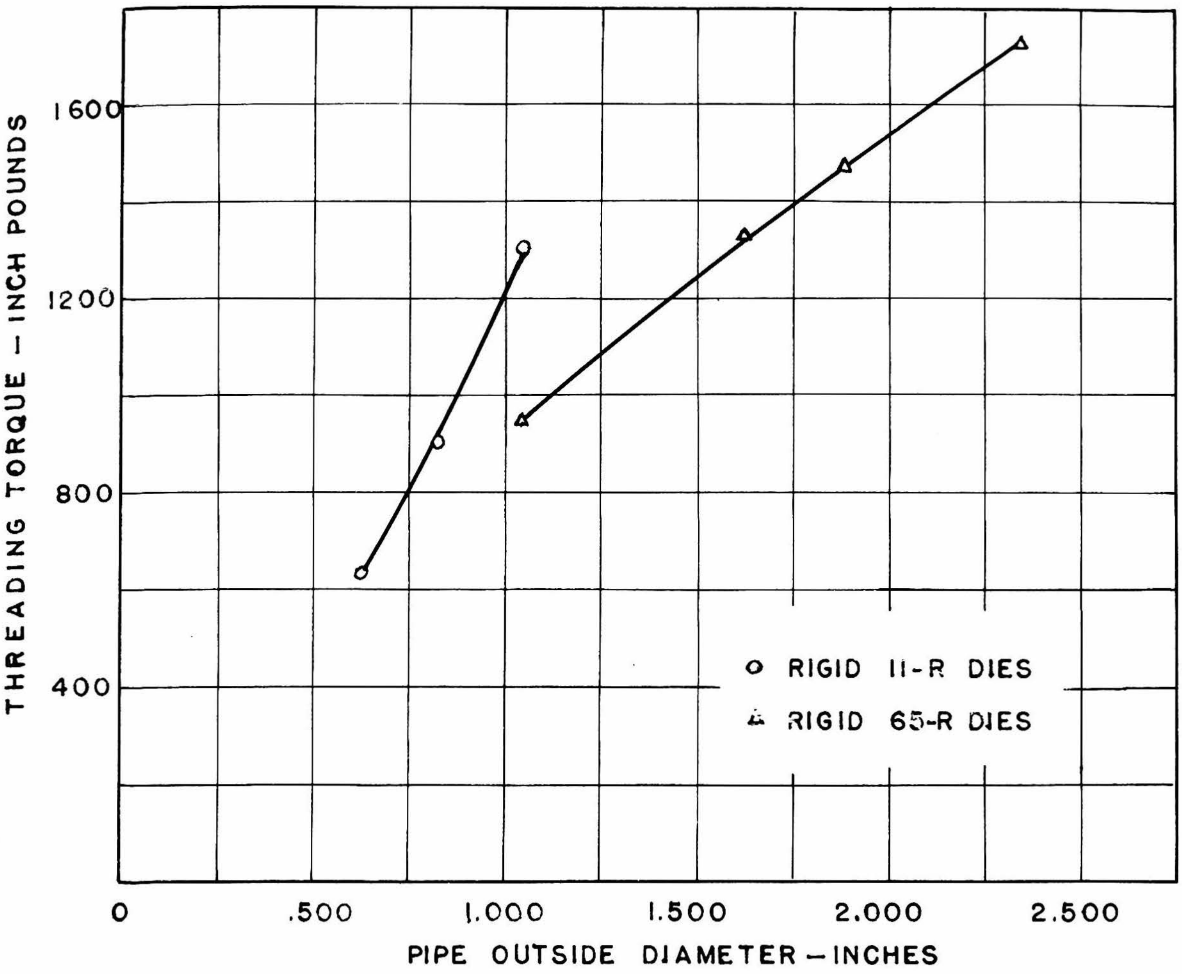


FIG. 5 - PIPE THREADING TORQUES.

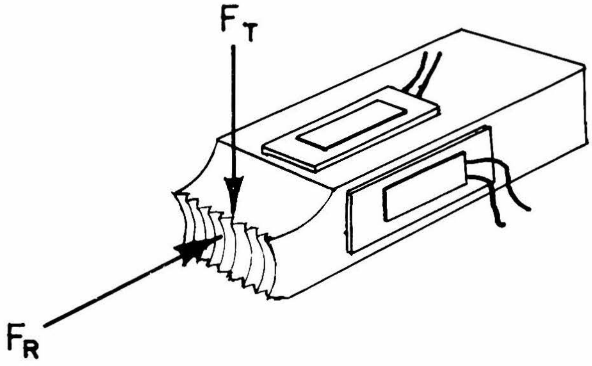


FIG. 6 - THREADING CHASER WITH SR-4 STRAIN GAGES ATTACHED.

calculated from the threading torque values obtained. The radial forces however, can not be determined from these data.

A test for accurately determining both the tangential force and the radial force exerted on a threading chaser may be made by gluing four standard SR-4 strain gages on each side of a chaser as shown in Figure 6. The chaser could be clamped, and calibrated under static load in both the tangential and radial directions. Threading loads could be measured by a galvanometer and bridge circuit.

The total work done in cutting metal is known to be composed of the following parts: (1) friction work caused by the chip sliding over the tool face; (2) plastic strain energy to curl the chip; (3) work to separate the chip from the work-piece. Merchant[3], Zlatin[4], and Alim[5] have made determinations of work done and have developed force relationships for the orthogonal cutting of metal with a continuous chip. However, no work has yet been done using v-profile cutters or threading chasers. The further investigation of the work done to thread metal would be the subject of a separate research and is outside the scope of this thesis.

CHASER FORM AND THREADING SPEED INVESTIGATION

Threading chasers are made of carbon and of high-speed steel. Carbon steels for this purpose contain approximately 1.10 to

1.30 per cent carbon with little or no alloying elements. Standard high-speed steels may be high-tungsten low vanadium, low-tungsten high-vanadium, molybdenum, or molybdenum-tungsten steel alloys. Special high-speed steels may be high-tungsten high-vanadium, low-tungsten cobalt, or high-tungsten cobalt steel alloys.[6]

There are four general forms of chasers as illustrated in Figure 7:

(1) Circular chasers are used on production pipe threading machines were their increased cost is offset by their increased speed and precision.

(2) Tangent chasers are used interchangeably with circular chasers on production machines.

(3) Milled chasers, because of their tendency to chatter after a few sharpenings, are not generally used on portable pipe threading machines.

(4) Hobbed chasers are the usual form used on portable pipe threading machines and on hand pipe dies.

The recommended form for sharpening hobbed chasers for cutting wrought iron or SAE 1010-1035 steel is with a hook angle of 5° as illustrated in Figure 8.[7] This angle may be cut by hand, but should be done on a grinding fixture for best results. The chaser may be sharpened as often as required until too weak to withstand threading torques.

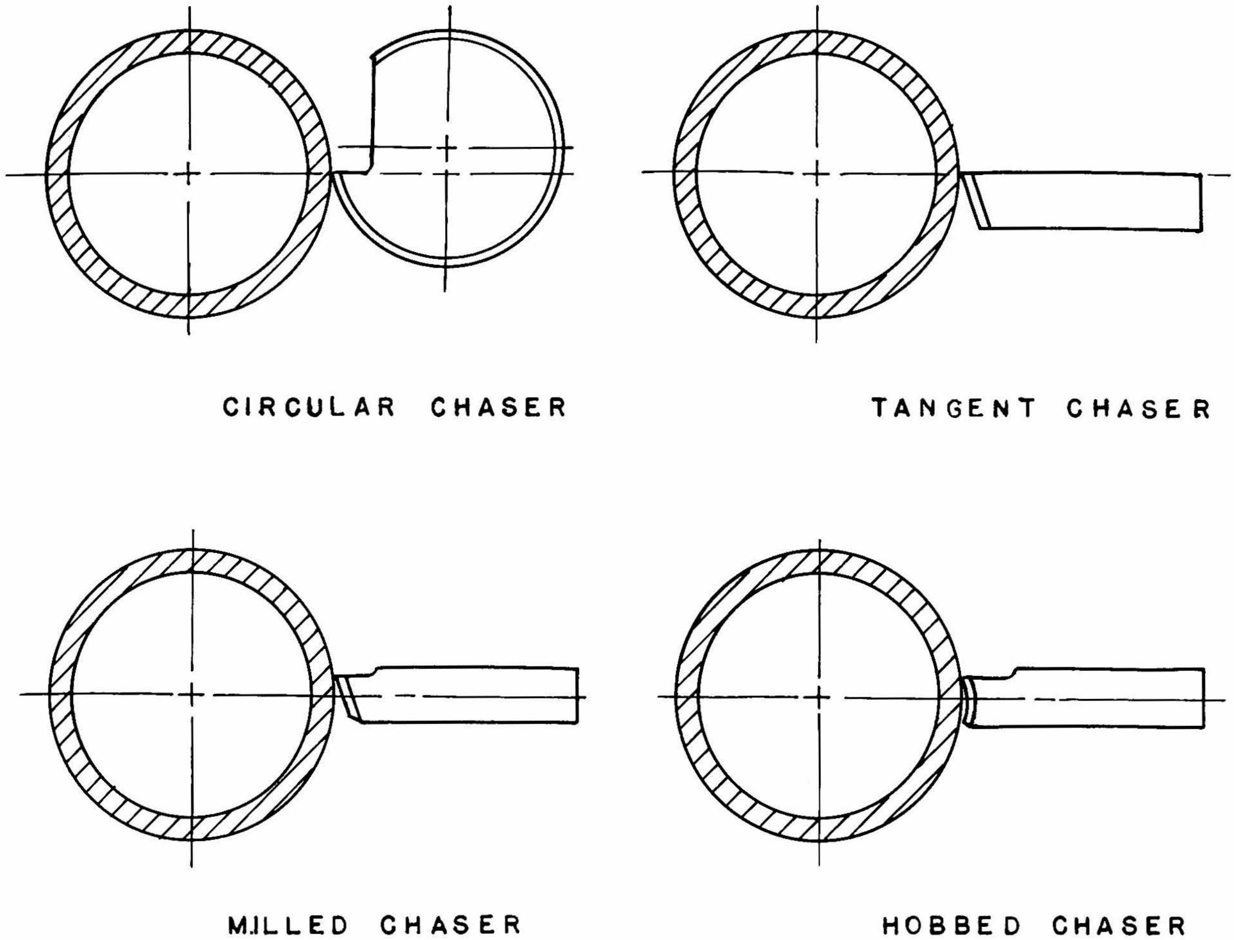


FIG. 7 - THREADING CHASER FORMS.

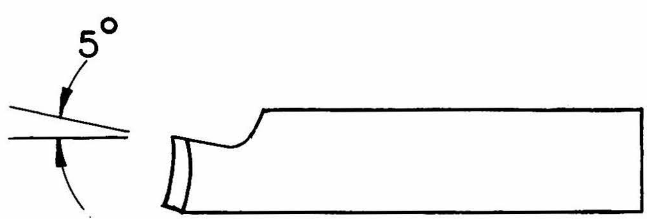


FIG. 8 - HOBBED CHASER FORM FOR CUTTING IRON AND MILD STEEL.

The surface speed at which a pipe may be threaded depends upon the following variables: (1) the hardness of the pipe metal; (2) the kind of steel of which the chasers are made and their heat treatment; (3) the sharpness and the cutting face angles of the chasers; (4) the depth of the thread being cut; (5) the rigidity and resonant characteristics of the threading machine; (6) the cutting oil being used.

Threading speeds are determined on the basis that the chasers remove the same amount of metal in a given time for all thread pitches. The recommended surface speed using carbon or high-speed chasers, for threading between 8 to 10 threads per inch, standard taper pipe threads produced by a jam cut, is 15 fpm for wrought iron and 22.5 fpm for SAE 1010-1035 steel.[7]

The principal functions of a cutting oil when used with threading chasers is: (1) to carry off heat developed by the separation of the chips from the pipe; (2) to lubricate the chips as they are removed from the pipe; (3) to improve the surface finish of the thread; (4) to increase the life of the chaser; (5) to flush out the threading area and wash out small chips.

The lubricant recommended for threading wrought iron is soluble oil, and for threading SAE 1010-1035 steel is mineral lard (20% lard) oil.[7] In general practice petroleum or lard oil with a sulphurized base have proven very satisfactory.

AUTOMATIC CHUCKING SYSTEM DEVELOPMENT

Present demands for speed in threading pipe have made practical the development of automatic chucks. As a part of the design of the automatic chuck used on the Rotamatic, research on automatic methods of chucking pipe was done.

A chuck is basically a friction clutch in which one element is the power-driven machine and the other the working-piece. To hold, a chuck must exert a friction force on the surface of the working-piece which will overcome any working torque load. A wedge action is usually used in the chuck to create this friction force. It is desirable that a chuck be self-holding by being constructed so that the working torque load will tend to increase the friction force. Such a self-holding feature should also be easily and instantly releasing upon opening the chuck. It is desirable that a chuck be self-locking and need no further application of locking force to hold the jaws against the working-piece after the initial tightening.

In an automatic chuck the initial tightening force comes from a source other than the operator. This force may be applied by the driving motor, or by a separate power mechanism. The most economical method is by the use of the driving motor and a friction drag mechanism. Unless the friction drag is removed after the working-piece has been gripped tightly, it will cause an additional load on the driving motor and wear to the friction drag mechanism.

Two types of automatic chucks, which use the power of the driving motor to operate them, were investigated: (1) a rotating-wedge chuck, and (2) a sliding-wedge chuck.

An automatic rotating-wedge chuck has three jaws (usually) attached to the spindle by rotating means. The jaws are rotated by planetary gears attached to them. The motor may (1) be connected to the planetary gears by an internal gear and have a spindle restrained by friction drag, or (2) be directly connected to the spindle and have an external gear engaging the planetaries which is restrained by friction drag.

The friction force which a rotating-wedge chuck can exert is dependent upon the following three major factors:

(1) The pressure angle of contact between the chuck jaws and the pipe determine the profile of the rotating jaw. This profile may be generated by a tangent envelope similar to the way in which an involute gear tooth profile is generated. Figure 9 shows a 10°, 15°, and 20° pressure angle jaw for comparison of profile. It can be seen that as the pressure angle decreases, the jaw becomes fuller, and the angle through which it rotates increases. A 0° jaw is a segment of an Archimedes spiral. Handbooks give 15° as a maximum wedge angle for a self-

locking fit. The exact angle to be used on these jaws would need be determined by experiment. If the angle is too small the jaw will tend to lock too tightly in place and be difficult to open. If too large, the jaw will not be self-locking enough to overcome centrifugal force, and will not remain in place against the pipe without a constant closing moment applied to it.

(2) The shear strength of the pipe determines for a given jaw tooth penetration the torque load which will cause the pipe to slip. If the magnitude of the torque and the penetration of the jaw tooth is such that the load rises above the ultimate shear strength of the pipe, the jaw tooth will become a shaving tool and remove a cutting from the surface of the pipe.

(3) The jaw teeth shape determines the self-holding characteristics of the chuck. The shape must be such that there is no unlocking force transmitted to the jaw by the pipe as the working torque is applied. If the shape of the jaw teeth are as shown in Figure 10, as torque is applied, the jaw will tend to lock tighter against the pipe. For this action to occur the jaw teeth must have sufficient initial contact with the pipe surface so that the stress in the pipe is kept below shear ultimate.

The main advantage of a rotating-wedge chuck is its self-

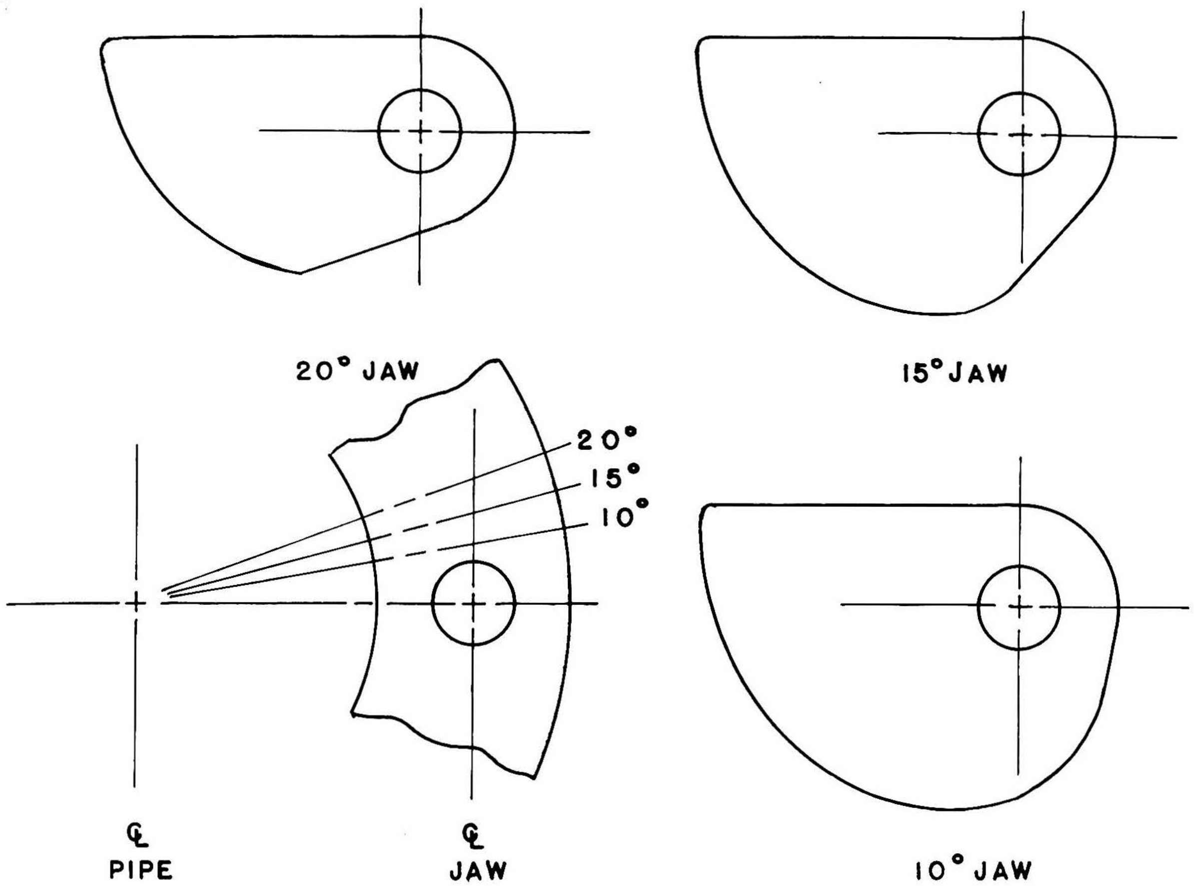


FIG. 9 - ROTATING-WEDGE CHUCK JAW PROFILES.

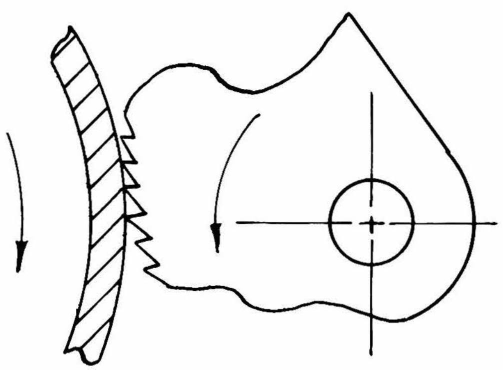


FIG. 10 - ROTATING-WEDGE CHUCK JAW TEETH SHAPE.

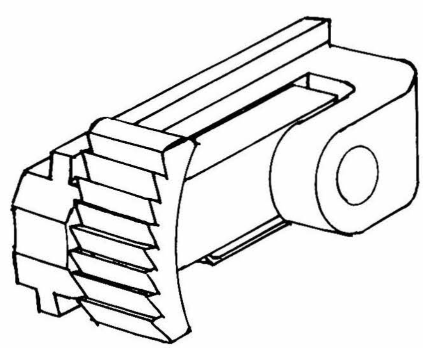


FIG. 11 - SELF-HOLDING SLIDING-WEDGE CHUCK JAW.

holding characteristics. The use of rotating parts also tends to simplify and lighten the structure.

The major disadvantage of a rotating-wedge chuck is that it is not inherently self-locking. A constant moment needs to be kept upon the jaws to keep them in contact with the pipe. This moment imposes an extra load upon the motor. This type chuck has several design disadvantages. The jaws must be cantilevered from the spindle, requiring heavy construction of parts. If an internal gear is used to rotate the jaws, the spindle gear must be mounted on a very short bearing axis. If an external gear is used, the housing construction is complicated.

An automatic sliding-wedge chuck has three jaws (usually) attached to the spindle by sliding means. The jaws are slid by the rotation of a scroll plate having a spiral thread machined on it. The motor may be connected (1) to the scroll plate and have the spindle restrained by friction drag, or (2) to the spindle and have the scroll plate restrained by friction drag.

The friction force which a sliding-wedge chuck can exert is dependent upon the following three major factors:

(1) The magnitude of the tightening force. Since this type chuck is not inherently self-holding, the initial tightening force must be great enough to drive the jaw

teeth deep enough into the pipe to overcome all working torque loads.

(2) The shear strength of the pipe has the same effect on this type chuck as on the rotating-wedge chuck.

(3) The jaw teeth shape must be such that a maximum amount of penetration is achieved by a given tightening force. The strength and wearing characteristics of the jaw metal, the amount of pipe surface scarring permissible, and the radii of the maximum and minimum size pipe to be gripped determine the final shape and area.

The main advantage of a sliding-wedge chuck is its self-locking characteristics.

The major disadvantage of a sliding-wedge chuck is that it is not inherently self-holding. This type chuck has several design disadvantages. The use of sliding parts tends to make the structure heavy and the machining difficult.

The self-holding characteristic of a rotating-wedge chuck may be added to a sliding-wedge chuck by modifying one of its jaws as shown in Figure 11. The rotating-jaw is a segment of a 0^{o} rotating-jaw. It is attached to the sliding-jaw by a pin and flat spring as shown. The initial tightening force will drive the rotating-jaw teeth into the pipe. As the working torque load is applied, the rotating-jaw will roll tighter against the pipe. Experimental design will be necessary to determine (1) the exact profile of the rotating-jaw to make it hold sufficiently and yet not bind the scroll plate too tightly to prevent easy opening, and (2) the jaw teeth shape so that the pipe may rotate but have no axial motion relative to the jaws. The addition of the rotating-jaw will reduce the magnitude of the initial tightening force needed to overcome a given working torque.

SUITABLE MATERIALS AND NEW PROCESSES FOR PORTABLE PIPE THREADING MACHINE MANUFACTURE

The materials investigated for use in the Rotamatic pipe threading machine were:

(1) Aluminum may be used for sand cast parts such as the frame, the carriage, and the diehead and cut-off mechanism frames. The characteristics which these parts should have are: (a) high impact resistance, (b) good corrosion resistance, (c) good machinability, (d) good castability, (e) good bearing qualities, and (f) high strength. No one aluminum casting alloy has all these features. An aluminum-copper alloy containing 4% copper plus magnesium and nickel is somewhat hot short, but has high physical and bearing qualities and good machinability. It is generally used in a heat treated condition. An aluminum-magnesium alloy containing 10% magnesium combines high strength and

elongation with good shock and corrosion resistance. Its machinability is good; its castability only fair. It is generally used in a heat treated condition. An aluminum-copper-silicon alloy containing 7.5% copper, 2.5% silicon plus zinc can easily be made from scrap and combines fair corrosion resistance, very good castability, and excellent machinability. It is generally used as cast. An aluminum-silicon-copper alloy containing 5.5% silicon, 4.5% copper plus zinc is a general purpose alloy having all-around characteristics and is heat treatable.

(2) Malleable iron may be used where part size is limited and high strength is needed for such parts as the spindle and chuck housings. Malleable iron castings have high shock resistance, excellent machinability, good castability, good wearing qualities, and high strength.

(3) Steel may be used in cast or rolled form. Alloy steel castings can be used in place of malleable iron castings for higher strength weight ratios. High-speed tool steel is used for the chasers, reamer, and cut-off wheel. The carriage guides may be made of high carbon or alloy steel.

(4) Thermo-plastic plastics generally have limited use on a portable pipe threading machine. Cellulose acetate or polystyrene, however, are very suitable for operation

handles. Thermo-setting plastics may be used in the form of fabric impregnated with phenolic as mounting blocks for the motor to reduce vibration and noise. Parts of the electrical insulation of the motor and motor switch are made of various forms of molded phenolic plastic.

New processes investigated for use in the manufacture of the Rotamatic were as follows:

(1) Casting small steel inserts in aluminum castings for increased wearing strength can be done with decided success. If the inserts are large, machining needs to be done on them after casting to insure correct alignment of mating parts.

(2) Powder metallurgy forming of gears[8] has the following advantages: (a) lower production cost than cut and heat treated SAE 1040 gears, and (b) self-lubrication qualities of gears so formed. The gears used in the power cut-off mechanism of the Rotamatic are well adapted to being formed by this method.

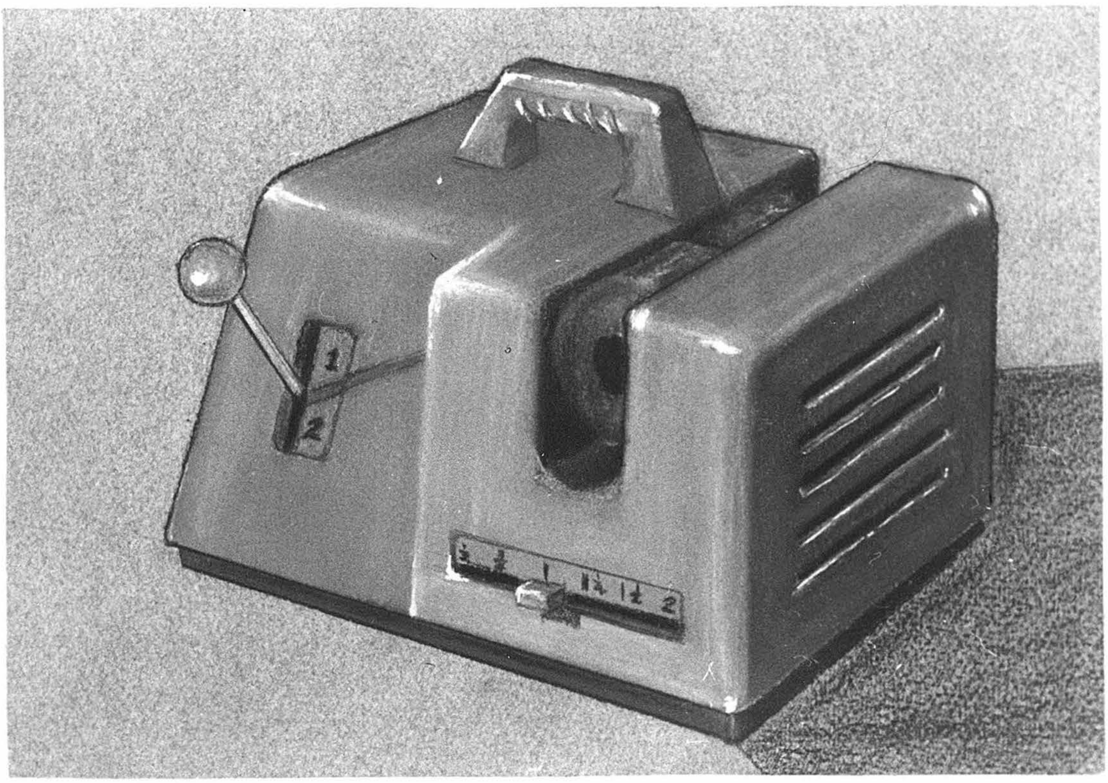
(3) Shot-peening of the chuck scroll plates, the diehead scroll, the motor gears, and the spindle for increased wear and fatigue resistance could be expected to raise the expected life of these parts several times over their life when not peened.

DESIGN OF AN IDEAL PORTABLE
PIPE THREADING MACHINE

The ideal portable pipe threading machine visualized by the designer is shown in Illustration 12.

The construction of the machine would be light enough for one man to carry, yet there would be sufficient stability for operation when sitting unattached to a surface. The tools would be electric-power driven; the pipe would be held stationary. The machine would handle any pipe size from 1/8" to 2", and any pipe length above 2". All dies would be self-contained and could be selected by turning a dial on the outside of the machine. The appearance of this machine would be simple and suggest the nature of its work. There would be a minimum of protruding surfaces and controls. It would be amply-powered, of durable construction, be safe and simple to operate, and be easy to adjust and maintain. Its price would be around $600.

The operation of this machine would be as follows: After a length of pipe has been indexed in the slot, the control arm is tripped to Position 1. The machine would then commence a cycle of gripping the pipe, cutting-off the unwanted length, threading and reaming the end, releasing the grip on the pipe, and coming to a stop. The threaded piece of pipe could then be removed from the machine. If it is desired only to thread an end, the end of a length of pipe could be indexed in the



12 - AN IDEAL PORTABLE PIPE THREADING MACHINE

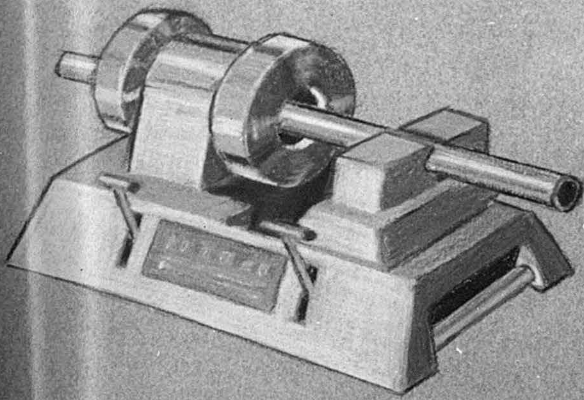
slot, and the control arm tripped to Position 2. The machine would then commence a cycle of gripping the pipe, threading and reaming the end, releasing the grip on the pipe, and coming to a stop. The threaded piece of pipe could then be removed from the machine.

This concept of an ideal portable pipe threading machine was used as a basis of further design and development.

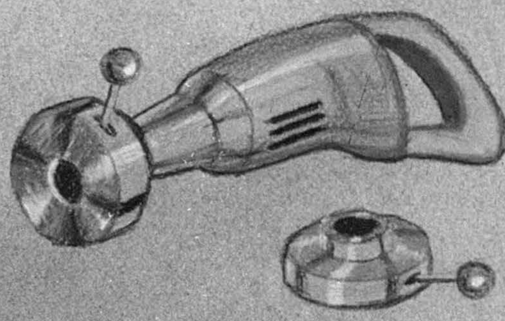
DESIGNS OF PORTABLE ROTARY-TOOL PIPE THREADING MACHINES

Preliminary design studies were conducted of five portable rotary-tool pipe threading machines.

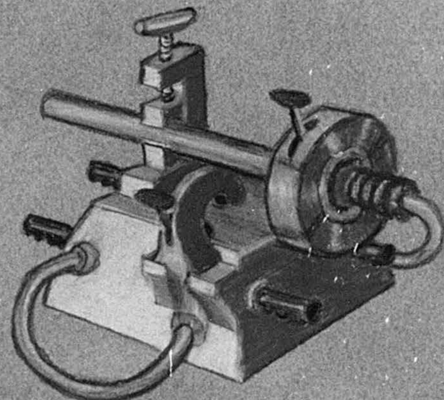
A turret machine having two turret positions is shown in Illustration 13a. It has a combination rotary self-opening diehead and reamer, and a rotary power cut-off tool mounted on the turret. The pipe is held stationary in a vise, and the turret is mounted to rotate and slide on the machine bed. Fully automatic, this machine is a working version of the ideal machine previously described. With hand controls to indes the turret it is an exceedingly fast machine. However, the mechanical difficulties involved in getting power to the turret tools makes this machine unable to compete pricewise with present portable machines. Future development was therefore not attempted.



A



B



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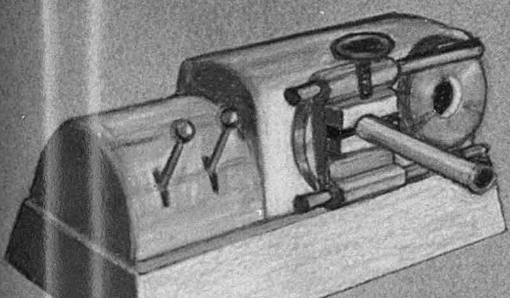

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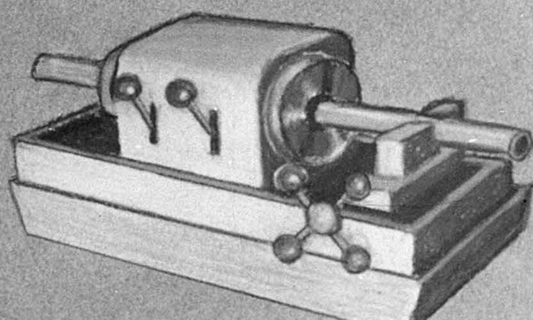


E

13 - PORTABLE ROTARY TOOL PIPE THREADING MACHINES

A light-weight hand machine similar in appearance to an electric drill is shown in Illustration 13b. It has an automatic opening diehead. The threading torque is restrained by clamping an extension of the machine frame to the pipe. A reamer may be mounted behind the diehead, or can be rotated by an electric drill. The hand threading machine could also be fitted with a rotary power cut-off tool for cutting off pipe. The main advantage of this machine is that it will replace hand tools in places where the work can not be done on ordinary machines. The limited market which it would have was considered too small for further development.

A machine rotating its tools by flexible shafts is shown in Illustration 13c. It can be placed on any convenient surface and the pipe clamped to it by an ordinary pipe vise. One of the flexible shafts drives the rotary diehead and reamer combination; the other drives the power cut-off tool. Both these tools can be clamped onto the pipe to relieve the operator from restraining the torque. The chief disadvantages of this system are the difficulties in using a flexible cable drive to deliver the high torque loads needed, and the necessity of the operator having to mount the tools by hand. For these reasons this design was not considered further.

A bench-mounted machine having two spindles is shown in Illustration 13d. The pipe is held stationary in a sliding vise which moves between the two spindles. One spindle threads and reams; the other cuts off the pipe. The obvious disadvantages of this machine are the expense of the two spindles needed, and the necessity of having to move the pipe between them. For these reasons this concept of a portable pipe threading machine was not considered practical for further development.

A bench-mounted machine having a single spindle is shown in Illustration 13e. The pipe is held stationary in a vise and is inserted either into the spindle for threading and reaming, or through the spindle for cutting-off. This machine was considered suitably workable for a more comphrensive engineering design. The following disadvantages were discovered: (a) The method of removing the reamer for cut-off was extremely clumsy. Either it had to be inserted and removed by hand each time it was needed, or a rather elaborate retracting mechanism was needed to move it out of the way of the pipe. (b) The power cut-off mechanism as designed needed several impact elements in it. (c) A time analysis to cut-off, thread, and ream showed no great saving in time over present rotary-pipe machines. (d) Consumer preference in the sample market surveyed showed no great demand for this type machine.

These design studies proved conclusively that in spite of the ability of a rotary-tool pipe threading machine to thread bent or curved pipe, it would be very difficult to produce a machine which rotated the three tools which could compare in price or simplicity with a machine which rotated only the pipe. For this reason, design studies of portable rotary-pipe pipe threading machines were undertaken.

DESIGNS OF PORTABLE ROTARY-PIPE PIPE THREADING MACHINES

A rotary-pipe pipe threading machine resembles a lathe in over-all configuration. The pipe is rotated by a chucking device mounted on the headstock. The cut-off mechanism, the reamer, and the diehead are mounted on a carriage which slides on ways attached to the bed. This configuration is dictated by function, and the major variations possible are primarily in the design of the component parts, and to a lesser extent in their location.

The design of a rotary-pipe threading machine logically begins with the design of the diehead mechanism, the reamer, and the cut-off mechanism. The configuration and placement of these mechanisms determine the carriage dimensions and the bed width. The motor, the spindle, and the pipe chucking device determine the dimensions of the headstock. A cutting oil system is required for the threading and reaming assemblies. The frame is designed to mount the carriage and tools, to support the spindle and chucking device, to house the motor, and to include the cutting oil system.

Following is a discussion of the design features of the parts of rotary-pipe pipe threading machines.

Dieheads. There are three types of opening dieheads as illustrated in Figure 14: (1) a self-contained diehead which has all of the chasers needed for threading any size pipe mounted in it; (2) a chaser and scroll diehead which uses a spiral scroll to open the chasers; and (3) a quick-opening diehead which is hinged in two pieces. The advantage of a self-contained diehead is that all the chasers are in one unit eliminating the necessity of changing dieheads or chasers. The advantage of a chaser and scroll diehead is the simultaneous opening and closing ability of the chasers. The advantage of a quick-opening diehead is the simple construction. With machines using chaser and scroll or quick-opening dieheads the greatest convenience is to have a separate mechanism for each size pipe.

Reamers. There are two general designs of reamers as illustrated in Figure 15: (1) burr, and (2) cone. A burr reamer is mounted behind the diehead and reams while threading. Depth of ream depends upon the length of thread. A different burr reamer is needed for each pipe size. Cone reamers are usually mounted ahead of the diehead and swung or slid out of place

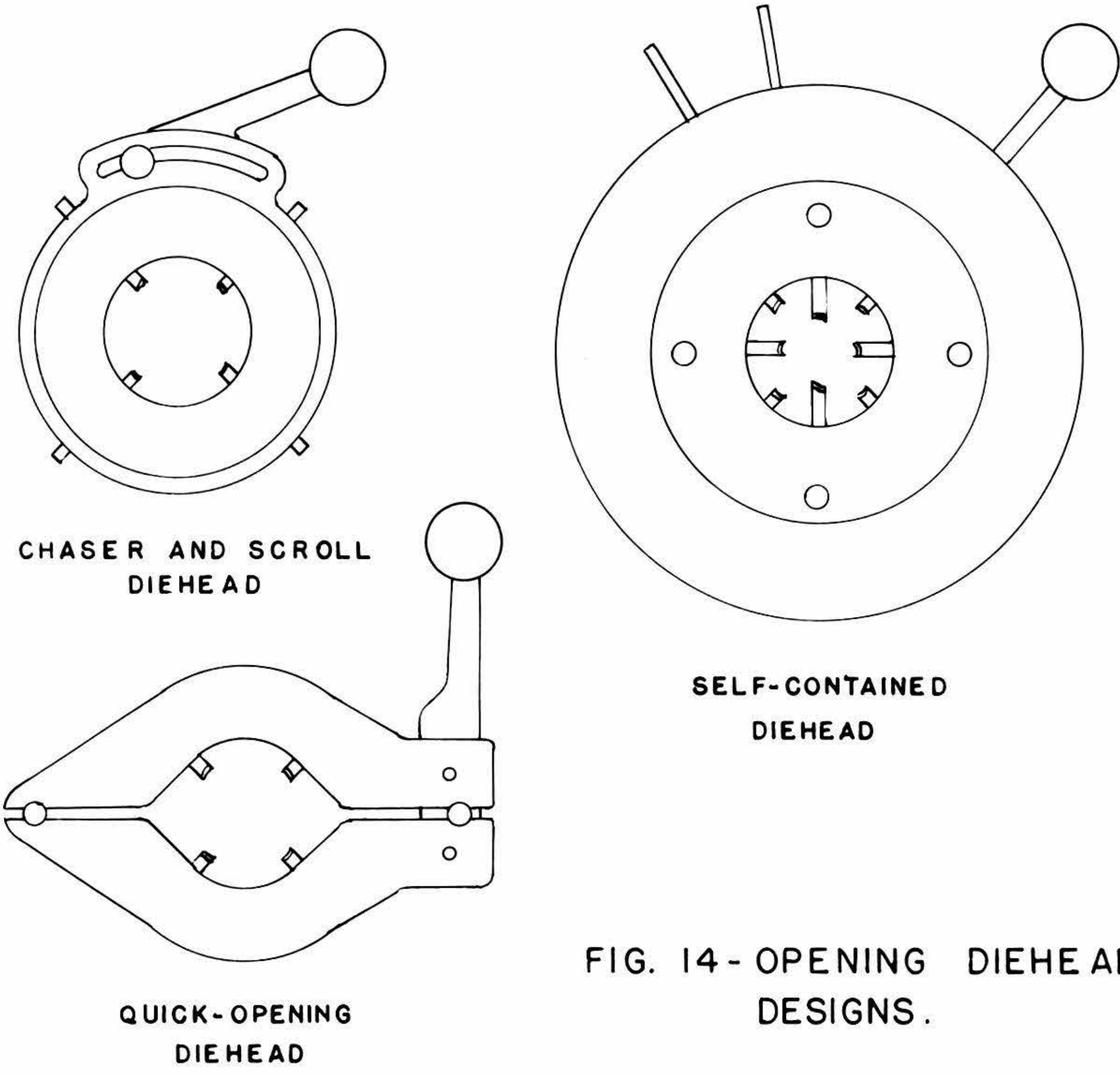


FIG. 14 - OPENING DIEHEAD DESIGNS.

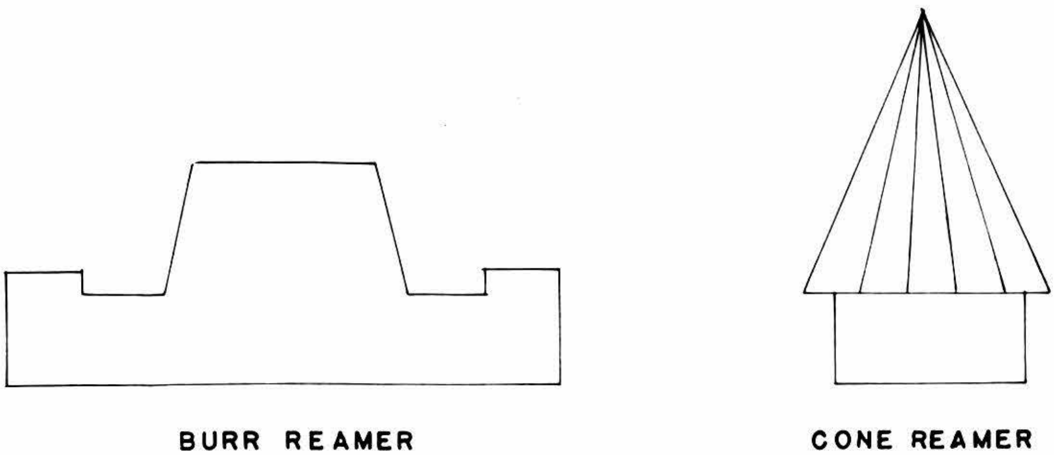
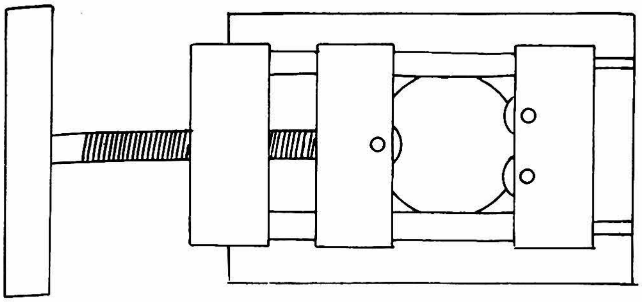


FIG. 15 - REAMER DESIGNS.

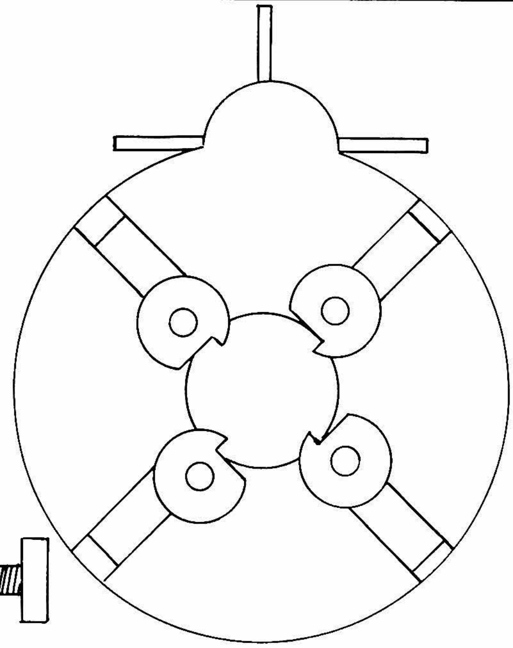
when not in use. They vary in angle from 60° to 30°, and may be multi-fluted or have a replaceable blade.

Cut-Off Mechanisms. There are two types of cut-off mechanisms as illustrated in Figure 16: (1) a wheel and roller cut-off in which a tool-steel cutting wheel pierces the pipe by a rolling and wedging action; and (2) a blade cut-off in which a single or multiple blades cut the pipe by removing metal. The advantage of a wheel and roller cut-off is its simple and durable construction. The advantage of a blade cut-off is its clean cut requiring a minimum of reaming. A cut-off mechanism may be made self-aligning about a pipe by mounting it on sliding guides. If it is mounted rigidly on the carriage, adjustment for different pipe diameters must be made by hand.

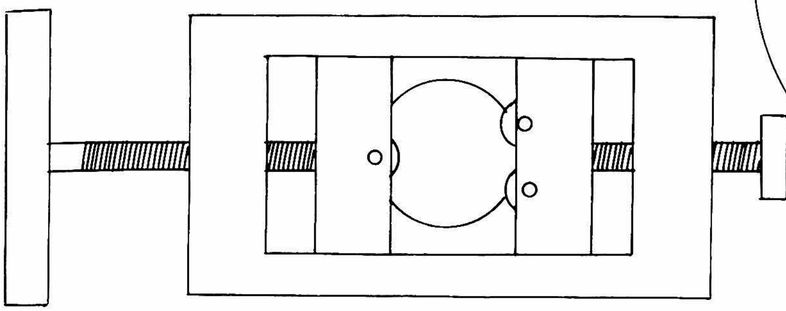
Carriages. The carriages of portable pipe threading machines usually hold the cut-off mechanism, the reamer, and the diehead mechanism. They may slide on flat or round cross-section ways, and may be moved by a rack and pinion or by a lever. If the tools are attached to the carriage in such a way that they may be rotated or slid out of the way, making-up fittings can be conveniently done. It is not desireable to attempt make-up work through the diehead because of danger of damage to the chasers. Make-up work can also be done outside the back end of the spindle by running the motor in reverse.



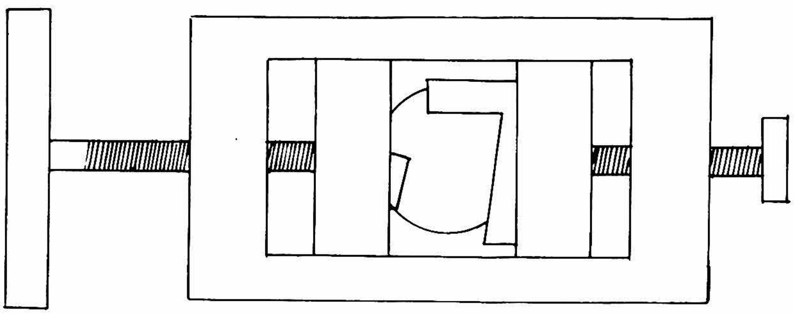
SELF-ADJUSTING WHEEL & ROLLER CUT-OFF



MULTIPLE BLADE CUT-OFF

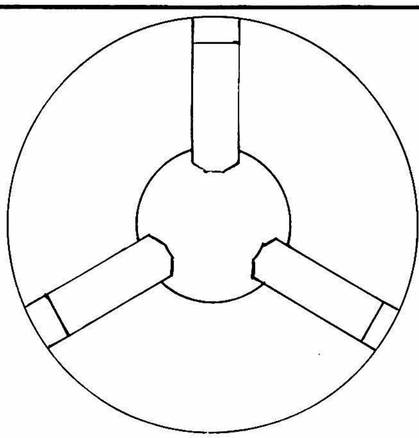


MANUAL-ADJUSTING WHEEL & ROLLER CUT-OFF

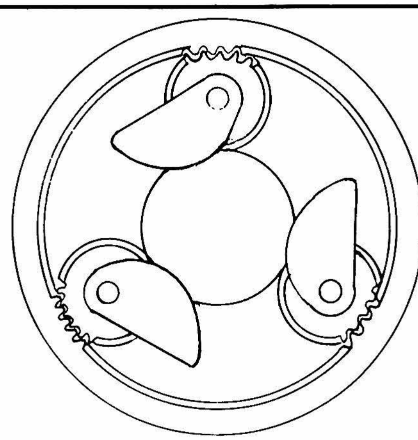


MANUAL-ADJUSTING SINGLE BLADE CUT-OFF

FIG. 16 - CUT-OFF MECHANISM DESIGNS.



SLIDING-WEDGE CHUCK



ROTATING-WEDGE CHUCK

FIG. 17 - CHUCK DESIGNS.

Chucks. There are two general types of chucks as illustrated in Figure 17: (1) a sliding-wedge chuck operated by a scroll plate which slides the gripping jaws, and (2) a rotating-wedge chuck operated by gears which rotate the gripping jaws. The three-jaw universal chuck, tightened by a key wrench, is the most common form of sliding-wedge chuck available. A universal chuck may be made semi-automatic by extending the scroll plate beyond the circumference of the chuck housing and providing it with finger grips. The operator can then tighten the chuck by grasping the scroll plate while the motor rotates the housing. Rotating-wedge chucks are not in wide use at the present. They are readily adaptable to automatic chucking using the motor as a source of power. For holding long pipe a rear chuck or a bracket holder is desirable to keep the pipe in correct alignment with the spindle.

Motors. There are two general types of motors which are adaptable for use on portable pipe threading machines: (1) series wound, and (2) induction. Compensated series, 110 volt, 15 ampere maximum input are the most common type. Induction motors are usually 3 phase, 110-220 volts and are used on high speed machines. Motors may be gear-in-head, gear connected, worm connected, belt connected, or chain connected to the spindle. Transmissions, while desirable for speed are expensive, and are not in general use on portable machines.

Cutting Oil Systems. A cutting oil system consists of a gear or vane type oil pump driven by a belt or gear from the main motor, an output line leading to the working tools, a screening system to retain cuttings and strain the cutting oil, a resevoir of cutting oil, and a suction line from the resevoir to the pump.

Frames. Frames for portable pipe threading machines may be cast, or built-up welded structure. The use of cast aluminum is desirable to lighten weight. Handles are usually provided for ease in carrying.

Accessories. There are various accessories made for use with portable machines. Among them are collapsible pipe stands, wheeled stands, auxiliary supports for long pipe, nipple chucks, and universal drive shafts to drive geared dieheads for threading pipe up to 12" nominal diameter.

The above studies of the design features of portable rotary-pipe pipe threading machines indicate that a wide variation in structure is possible. The exact combination of features selected is a choice based on the economic and engineering requirements under which the machine is being designed.

BASIS

The design of the Rotamatic pipe threading machine is based on the results and conclusions of the market investigation, the technical research, and the design studies performed. Production, sales, and operation requirements of portable pipe threading machines were considered simultaneously throughout the design.

The final design of each of the parts of the Rotamatic is the result of consideration and compromise between the following elements:

(1) Sufficient strength and power requirements.

(2) Low material and fabrication costs.

(3) Simple maintenance and accessibility.

(4) Essential safety considerations.

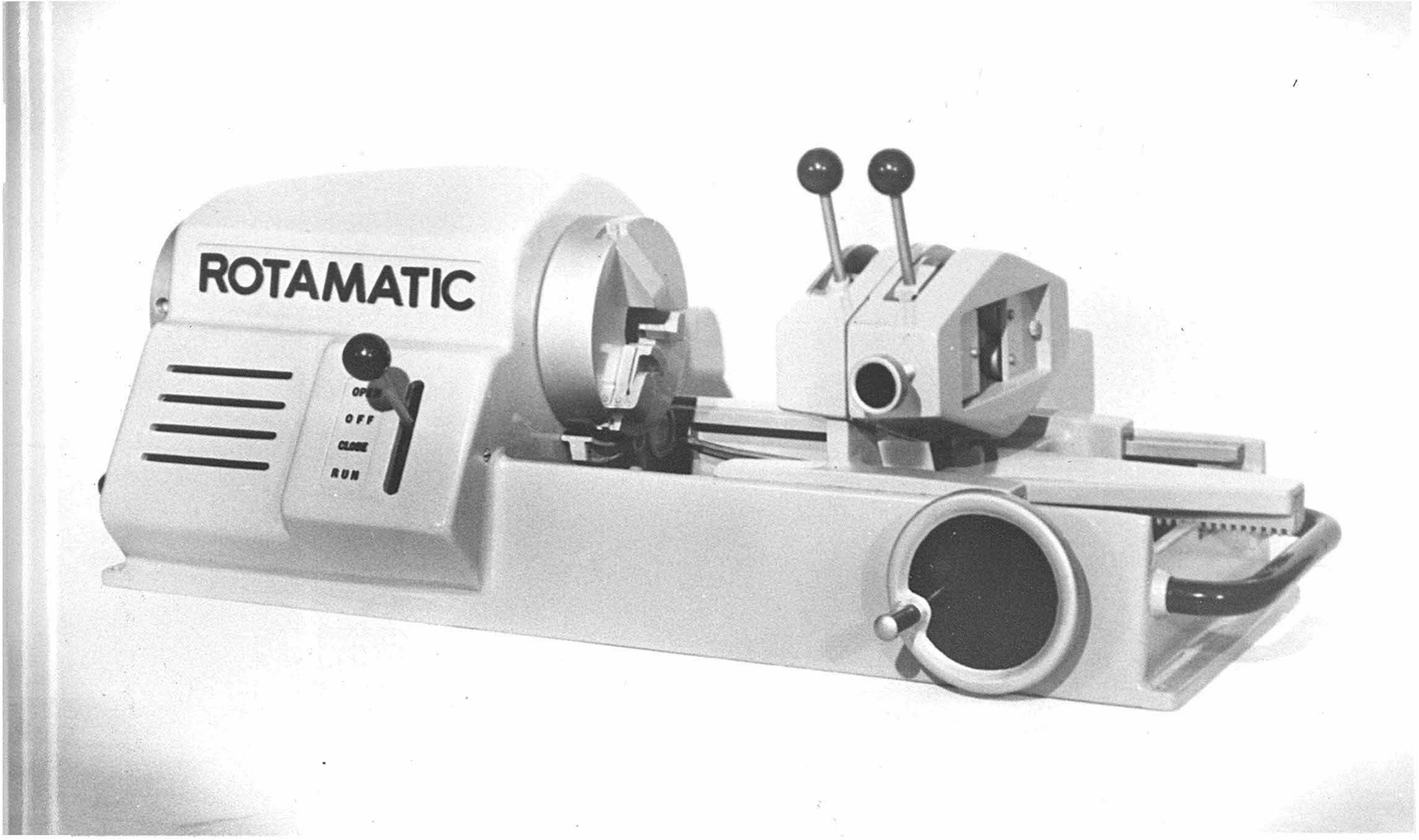
(5) Over-all utility and operation convenience.

(6) Inherent attractiveness of form and surfaces.

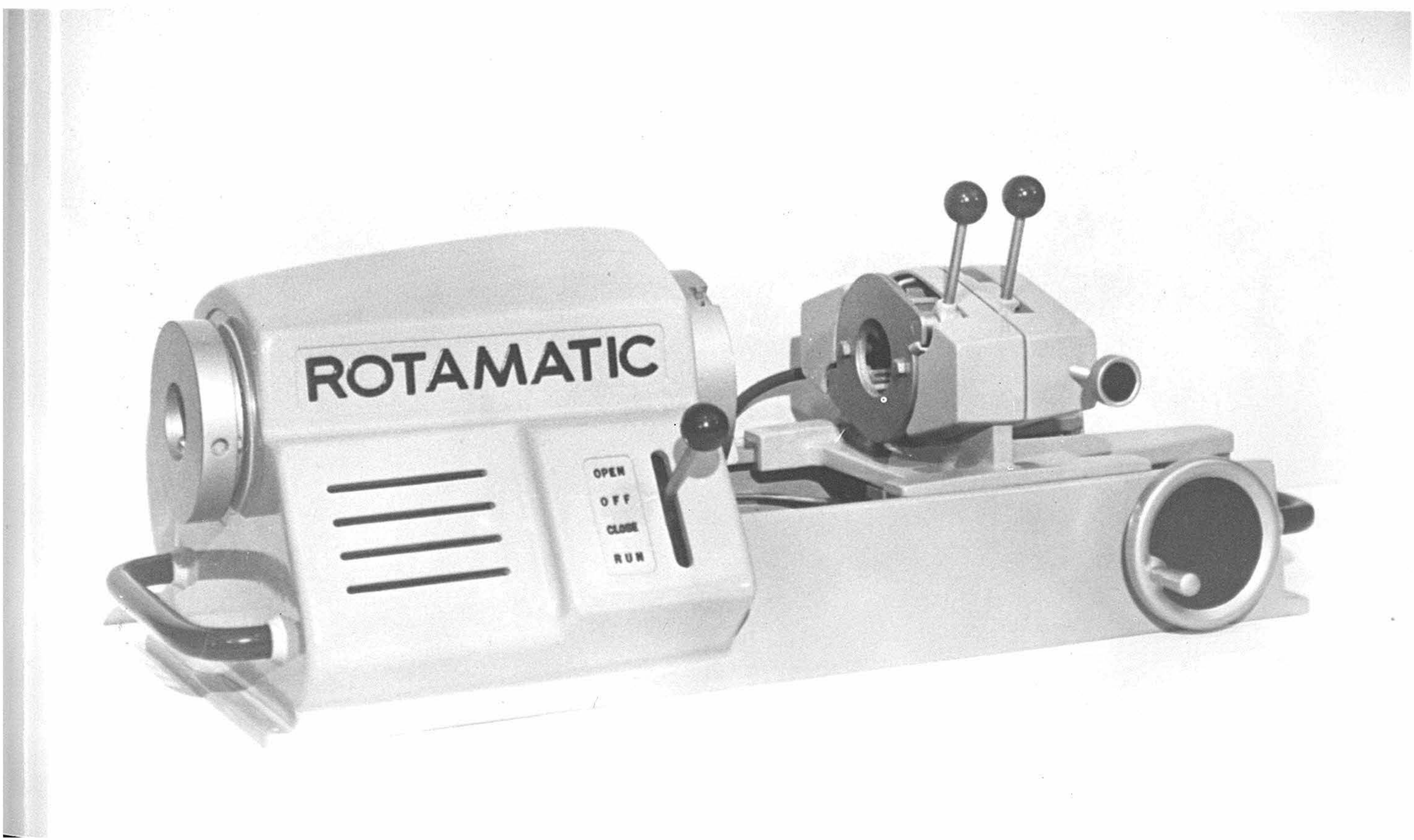
(7) Special sales and advertising features.

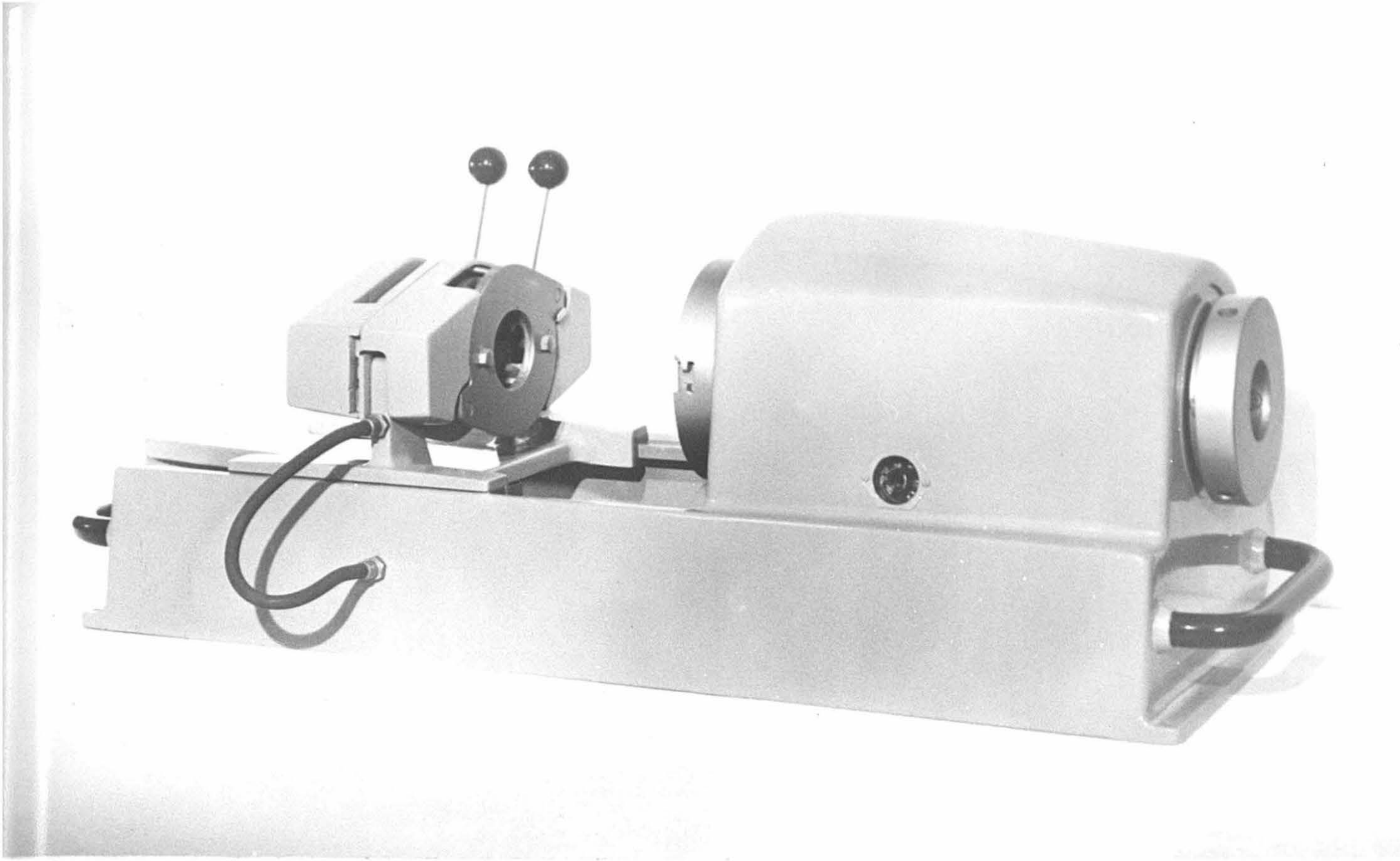
CONSTRUCTION

The Rotamatic pipe threading machine is shown in front views in Illustration 18, in rear views in Illustration 19, and in pictorial orthographic in Figure 20. The machine is composed of the seven mechanisms described in the following paragraphs. A schedule of the drawing numbers referred to is tabulated in Appendix B.

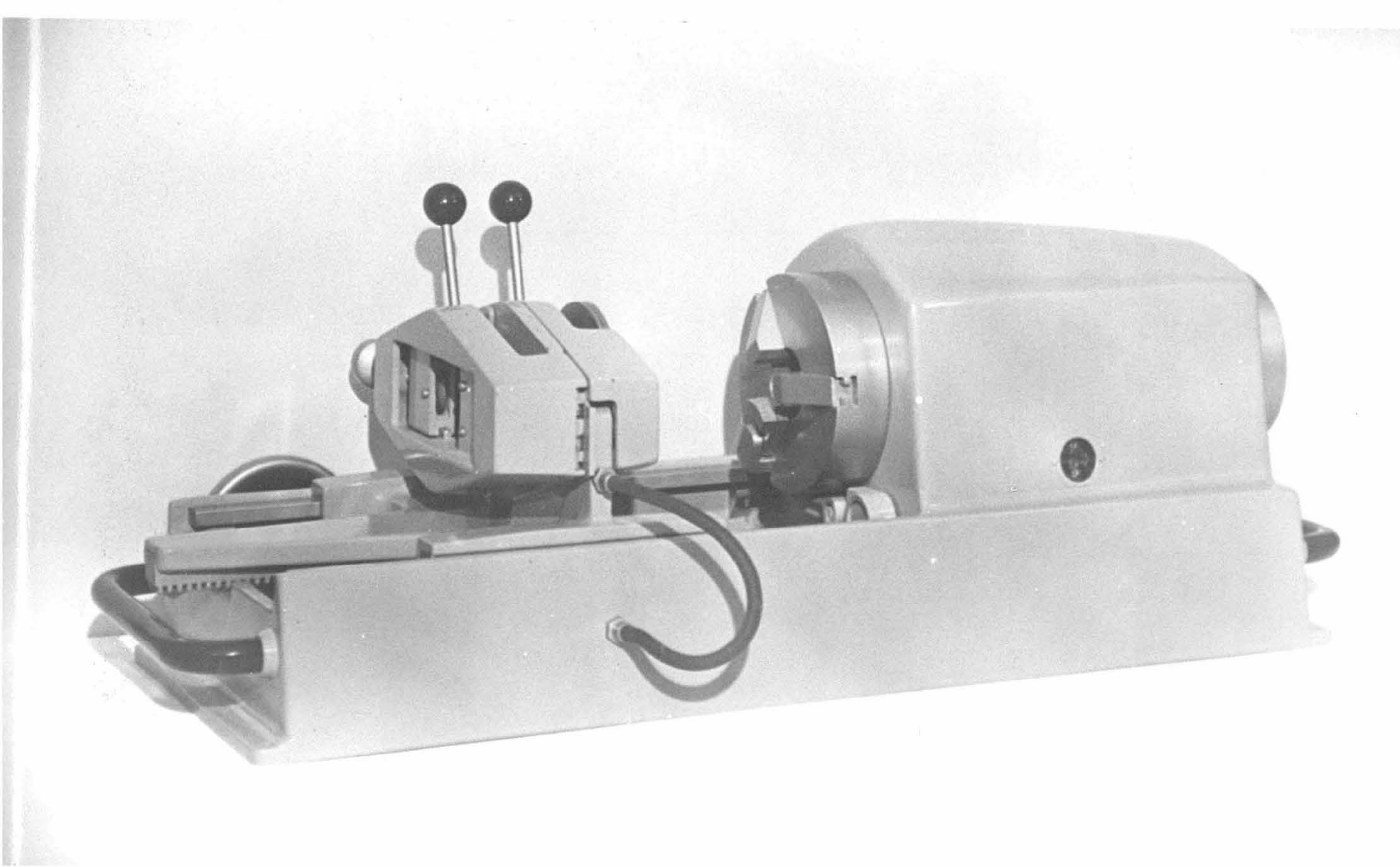


18. ROTAMATIC — FRONT VIEWS





19. ROTAMATIC — REAR VIEWS



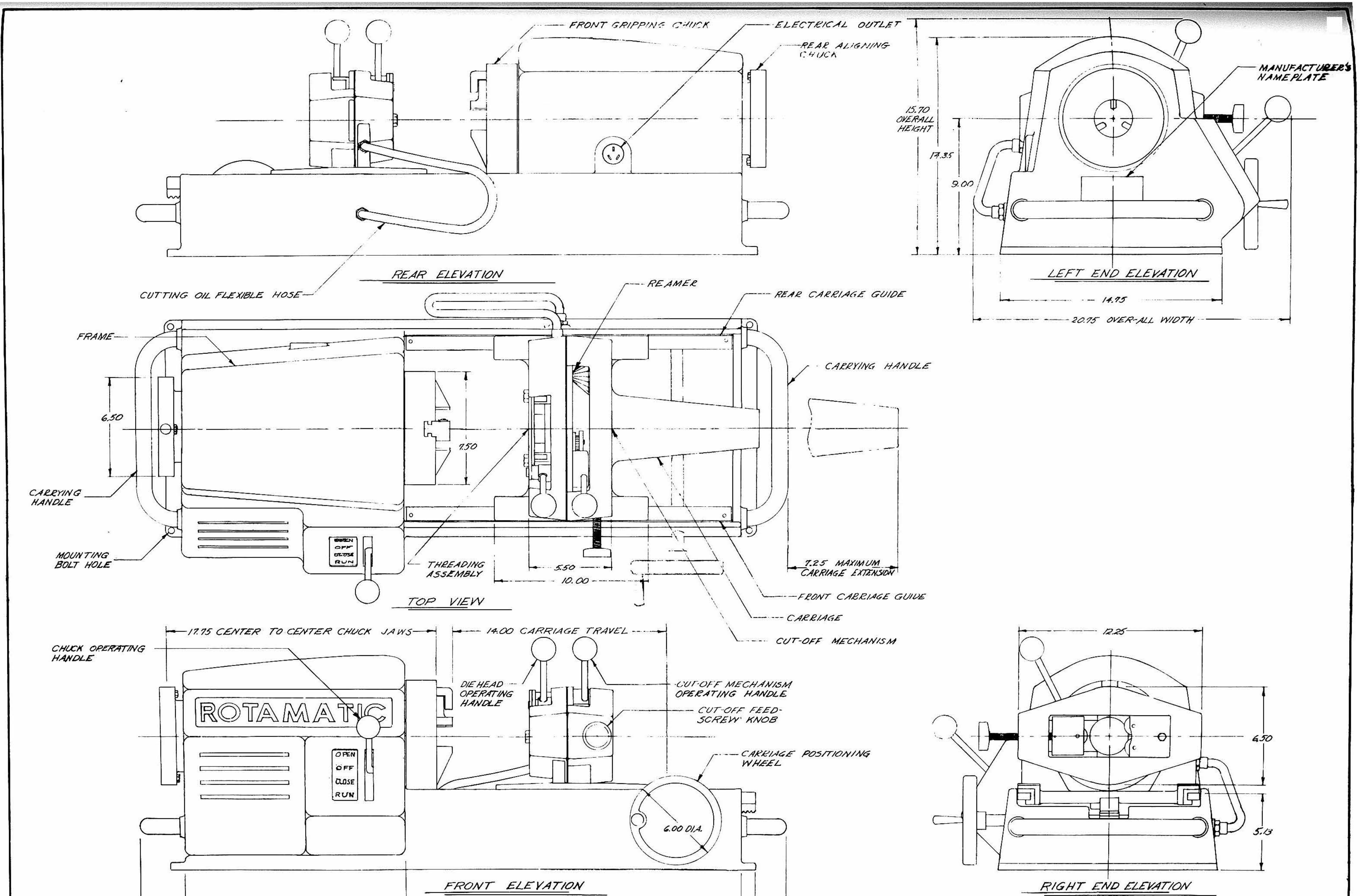


FIGURE 20.

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ROTAMATIC PICTORIAL

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APPROVED BY
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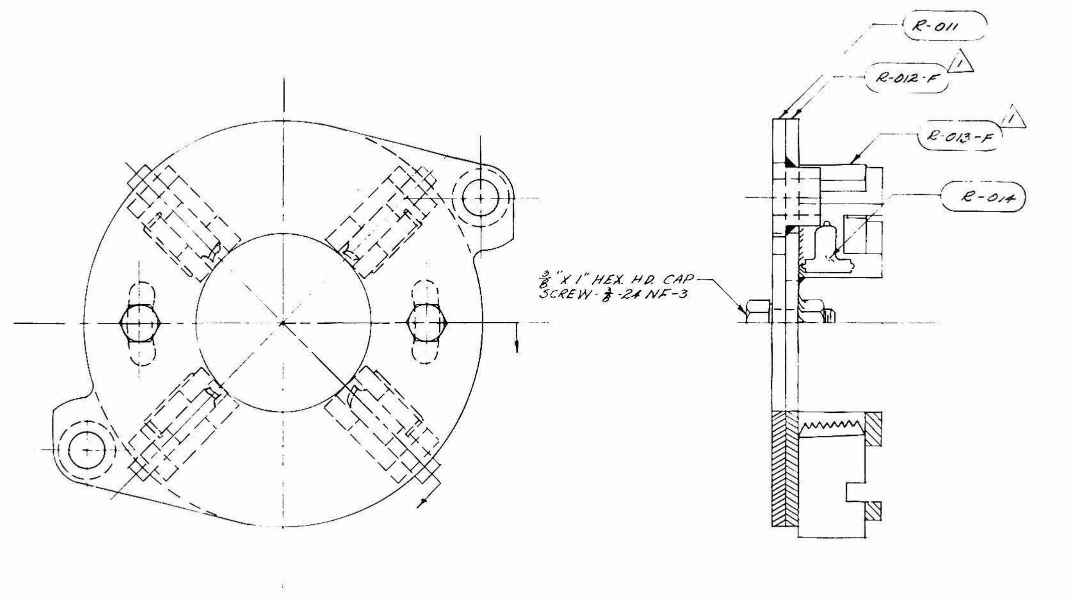
R-000

The threading mechanism is composed of two major assemblies, the diehead threading assembly (Drawing R-010) shown in Figure 21, and the diehead frame assembly (Drawing R-020) shown in Figure 22.

Six threading assemblies are furnished with the Rotamatic to thread pipe from $\frac{1}{2}$" to 2" in diameter. Bolts up to $1\frac{1}{4}$" in diameter may be threaded by the use of bolt chasers mounted in the threading assemblies. The 2" pipe diehead threading assembly is shown in Figure 21. It consists of a steel stamping front plate; a steel stamping back plate; 4 steel chaser guides; 4 hobbed, high-speed tool steel chasers; and 4 spring steel chaser springs. The chaser guides are welded to the back plate. The chasers slide easily in the guides, but are held in an open position by the chaser springs when the threading assembly is not mounted on the machine. The cantilever construction of the chaser guides prevents clogging by chips such as occurs in quick-opening dieheads. The front plate is connected to the back plate by two 3/8" cap screws to allow for varying the thread diameter by rotating the back plate in respect to the front plate, which will allow the chasers to engage the operating scroll at a different point when the threading assembly is mounted on the torque pins. Bushings are provided around the front plate mounting holes to add rigidity. The radius of metal around these holes allows the threading assembly to be locked onto the



△1 "F" DESIGNATE 2" PIPE SIZE. OTHER SIZE NUMBERS SHOWN ON SCHEDULE.

PART NO.	NAME	NO. REQ.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT
	3/8" Cap Screw	2			
R-014	Chaser Springs	4	Sprg.-Stl.		
R-013F	2" Chasers	4	Too.-Stl.		
R-012F	2" Base Plate Assem.	1	Steel		
R-011	Front Plate	1	Steel		

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DIEHEAD THREADING ASSEMBLY

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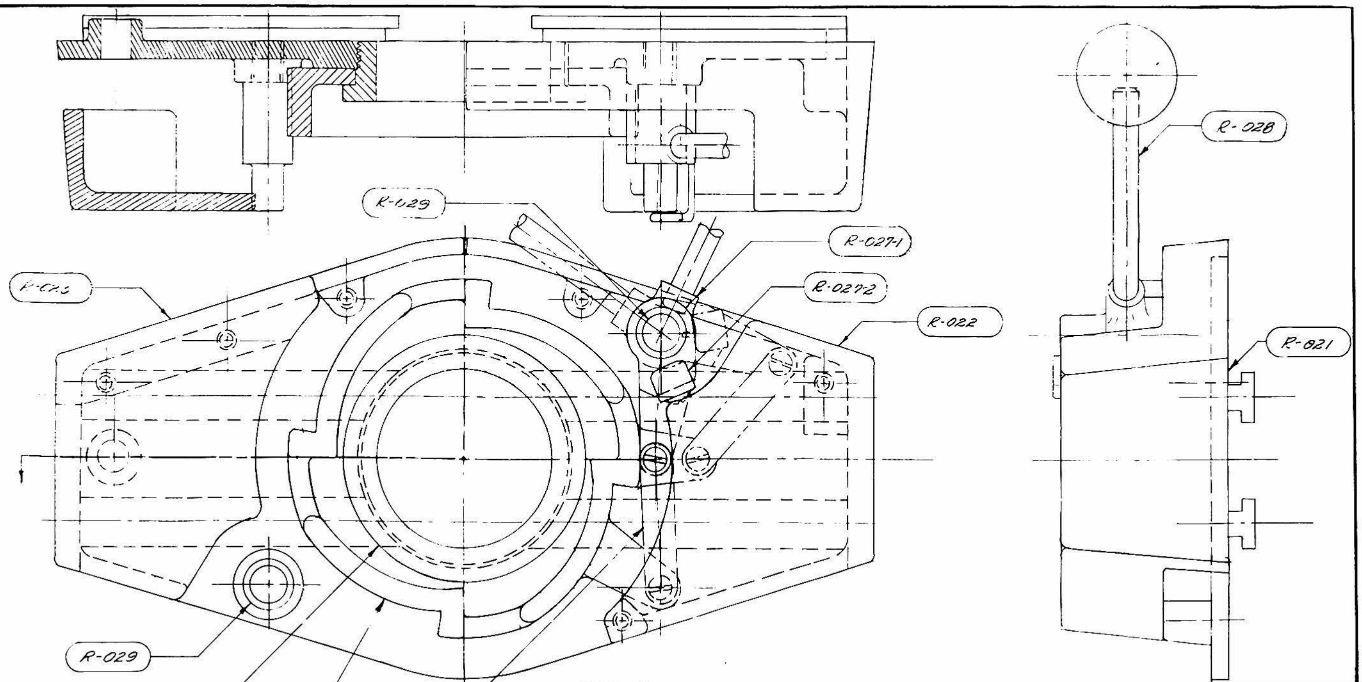
R-010-F

FIGURE 21.



PART NO.	NAME	NO. REQ.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT
R-029	Torque Pin	2	Stl.		
R-028	Handle	1	Stl. & Plas.		
R-027-2	Locking Lug	1	Steel		
R-027-1	Toggle Arm	1	Steel		
R-026	Toggle Link	1	Steel		
R-025	Scroll Washer	1	Steel		
R-024	Oper. Scroll	1	Steel		
R-023	Rear Cover	1	Aluminum		
R-022	Front Cover	1	Aluminum		
R-021	Back Plate	1	Aluminum		

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DIEHEAD FRAME ASSEMBLY

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R-020

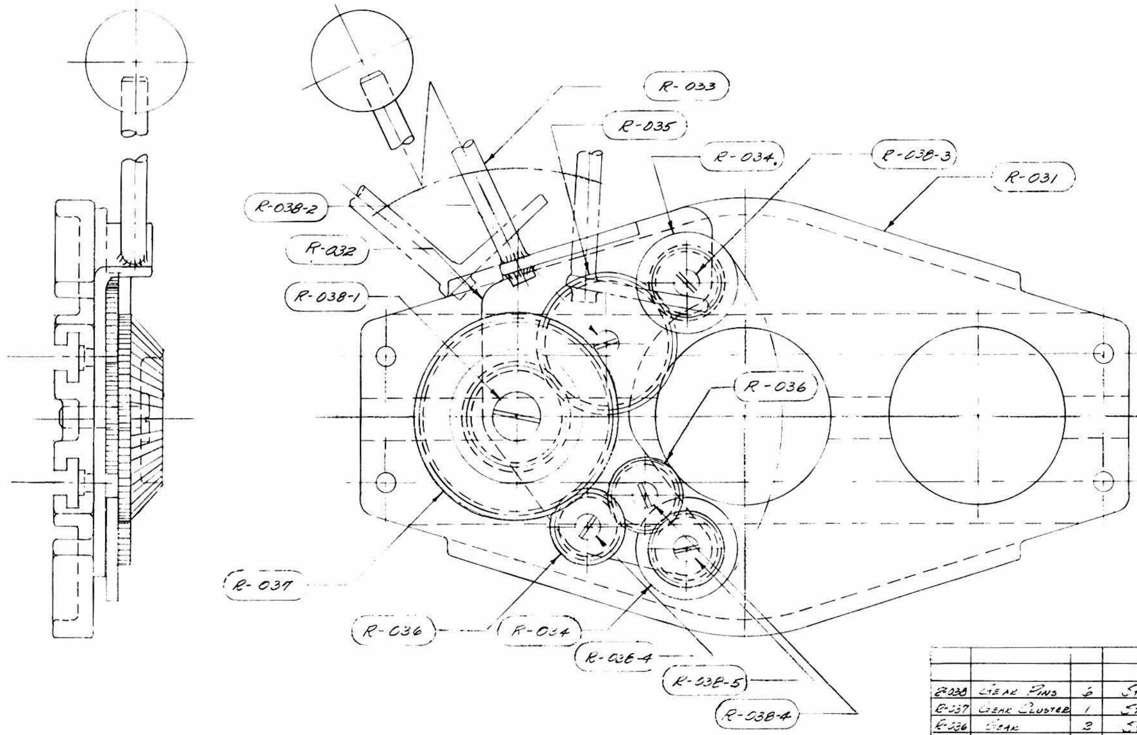
FIGURE 22.

diehead frame assembly when the chasers are closed.

The diehead frame assembly shown in Figure 22 consists of a cast aluminum back plate, a cast aluminum front cover plate, a cast aluminum rear cover plate, a cast steel operating scroll, a cast steel scroll washer, a steel stamping toggle link, a cast aluminum toggle arm, a steel stamping locking lug, a steel and plastic operating handle, and two steel torque pins. The toggle linkage which raises and lowers the chasers of the six threading assemblies is mounted on the diehead frame assembly. An 80° rotation of the operating handle rotates the scroll through 33° and moves the chasers .210". The lobes of the scroll are interrupted for ease in fitting the threading assemblies onto the torque pins. The lobes are rounded on their interrupted ends so that when closed, they will easily engage the chasers, and push away any chips which might be in the chaser slots. A locking lug is attached to the toggle arm which rotates in front of the threading assemblies and holds them in place on the torque pins when the chasers are closed. The bushings on the threading assemblies' front plates will not allow them to slip off the torque pins even though they are held at only one pin. The front cover plate adds rigidity to the attachment of the diehead frame assembly to the carriage. The rear cover plate is used as a stop for the diehead mechanism when raised in make-up position. There is sufficient cut out in the cover plates for full visibility of the pipe and for chip disposal while threading. The torque pins are screwed into the back plate and carry the threading torque load from the diehead threading assembly to the diehead frame back plate. The toggle arm rotates about the front torque pin and is restrained from sliding off it by a shear pin. The male guides machined on the back of the back plate engage the cut-off mechanism female guides. The scroll washer is threaded into the back plate.

The cut-off and reaming mechanism is composed of two major assemblies, the cut-off tumble gear assembly (Drawing R-030) shown in Figure 23, and the cut-off frame assembly (Drawing R-040) shown in Figure 24.

The cut-off tumble gear assembly shown in Figure 23 consists of a cast aluminum back plate, a steel stamping tumble plate, a steel and plastic operating handle, 2 gear and roller combinations, 1 large steel intermediate spur gear, 2 small intermediate spur gears, a steel spur and bevel gear cluster, and steel pins for these gears. The tumble gear assembly uses the torque of the rotating pipe to drive the cut-off wheel into the pipe. When the operating handle is moved downward the bottom roller contacts the rotating pipe. This sets in motion the lower gear train which drives the cut-off wheel against the pipe at a rate of .052" for each revolution



PART NO.	NAME	NO. RQD.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT
R-038	Gear Pins	6	Stl.		
R-037	Gear Cluster	1	Stl.		
R-036	Gear	2	Stl.		
R-035	Gear	1	Stl.		
R-034	Gear & Roller	2	Stl.		
R-033	Handle	1	Stl. & Plas.		
R-032	Tumble Plate	1	Steel		
R-031	Base Plate	1	Aluminum		

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CUT-OFF TUMBLE GEAR ASSEMBLY

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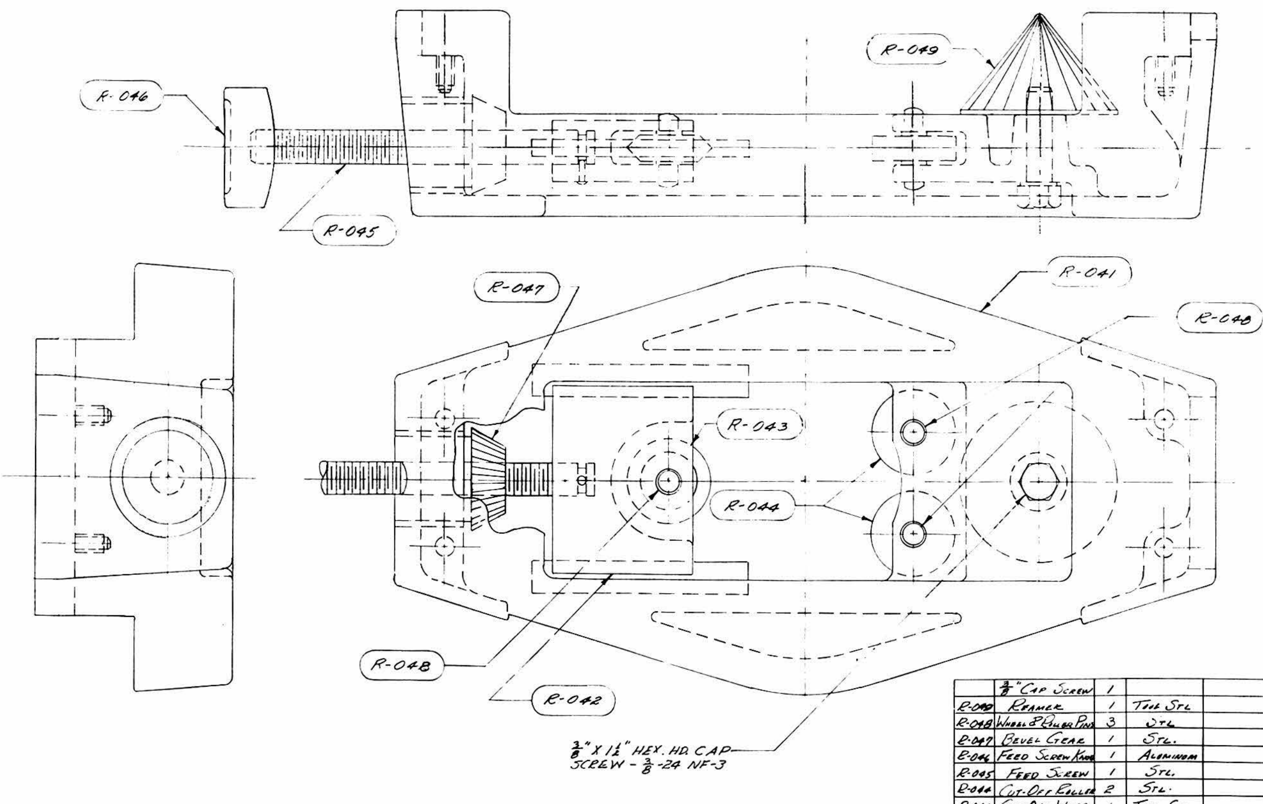
R-030

FIGURE 23.



PART NO.	NAME	NO. RQD.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT
	3/8" Cap Screw	1			
R-049	Reamer	1	Tool Stl		
R-048	Wheel & Roller Pins	3	Stl		
R-047	Bevel Gear	1	Stl.		
R-046	Feed Screw Knob	1	Aluminum		
R-045	Feed Screw	1	Stl.		
R-044	Cut-Off Roller	2	Stl.		
R-043	Cut-Off Wheel	1	Tool Stl.		
R-042	Sliding Block	1	Aluminum		
R-041	Cut-Off Frame	1	Aluminum		

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CUT-OFF FRAME ASSEMBLY

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CHECKED BY
APPROVED BY
DATE 4-28-49 SCALE

R-040

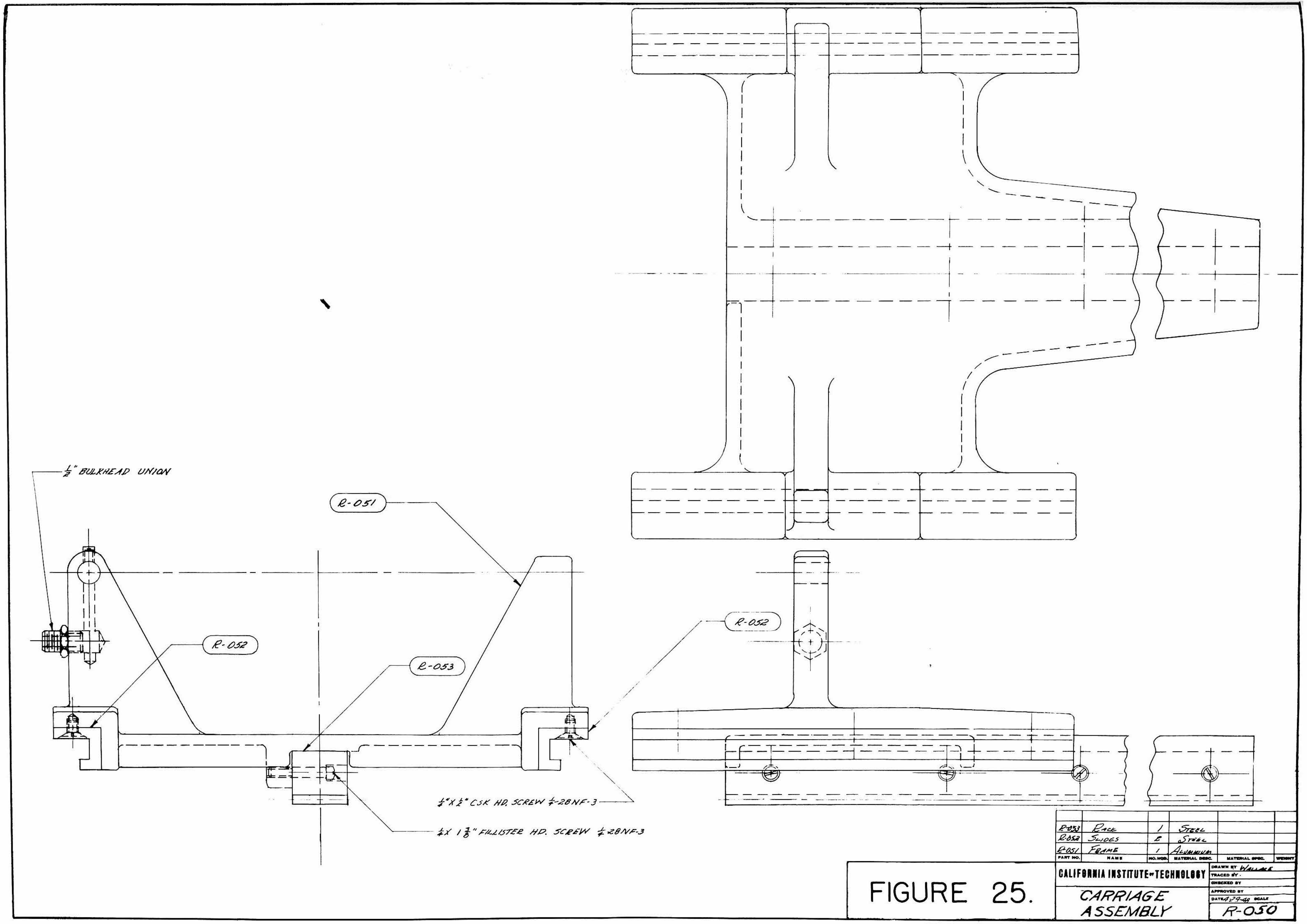
FIGURE 24.

of the bottom roller. When the operating handle is moved upward, the top roller engages the pipe, setting in motion the upper gear train which moves the cut-off wheel away from the pipe at a rate of .104" for each revolution of the top roller. A small ball bearing mounted in the back plate keeps the tumble plate in a neutral position when not in use. The female guides on the back of the back plate engage the male guides on the back of the diehead mechanism. The center hole in the back plate is to allow pipe to pass through it for cutting-off, and the rear hole is to allow the pipe to pass through it for reaming.

The cut-off frame assembly shown in Figure 24 consists of a cast aluminum frame, a cast aluminum sliding block, a tool steel cut-off wheel, 2 steel cut-off rollers, a steel feed screw, a cast aluminum feed screw knob, a steel feed screw bevel gear, steel wheel and roller pins, and a tool steel cone reamer. The steel guides for the sliding block and the steel insert bushing for the feed screw bevel gear are cast as inserts in the frame. The two rollers align the cut-off mechanism about the pipe. The feed screw has a $\frac{1}{2}$" NC thread. The feed screw bevel gear threads onto the feed screw and engages the bevel gear of the tumble gear assembly. The feed screw knob is used for three purposes: (1) to move the sliding block by hand if it is not open far enough to allow a pipe to be inserted through the cut-off frame; (2) to rotate the cut-off and diehead mechanisms out of the way of the pipe for make-up work; and (3) to slide the reamer into place for reaming. The reamer has a 60° included angle and is mounted on the rear of the cut-off frame. When slid in place it is approximately $1\frac{1}{2}$" behind the threading chasers. This position in rear of the chasers enables it to be used with more convenience and speed than if it were mounted in front of the diehead. There is sufficient clearance for full visibility of the reamer when in cutting position.

The carriage assembly (Drawing R-050) shown in Figure 25 consists of a cast aluminum frame, 2 steel carriage slides, and a steel carriage rack. It supports the diehead and cut-off mechanisms by a bolt connection in the rear and a locking block in front. The slides slide on the top and grip on the bottom of the main frame guides. The rack is 15" long to allow 14" of carriage travel. The bolt attaching the tools to the carriage is on the same horizontal center line as the spindle to avoid a force couple which would tend to twist the tools relative to the carriage.

The automatic chucking device (Drawing R-060) shown in Figure 26 consists of a cast steel front chuck housing, a cast steel front chuck scroll plate, a forged steel front chuck master jaw, 2 steel front chuck jaws, a cast aluminum rear chuck housing, a cast aluminum rear chuck adjustment plate, a cast

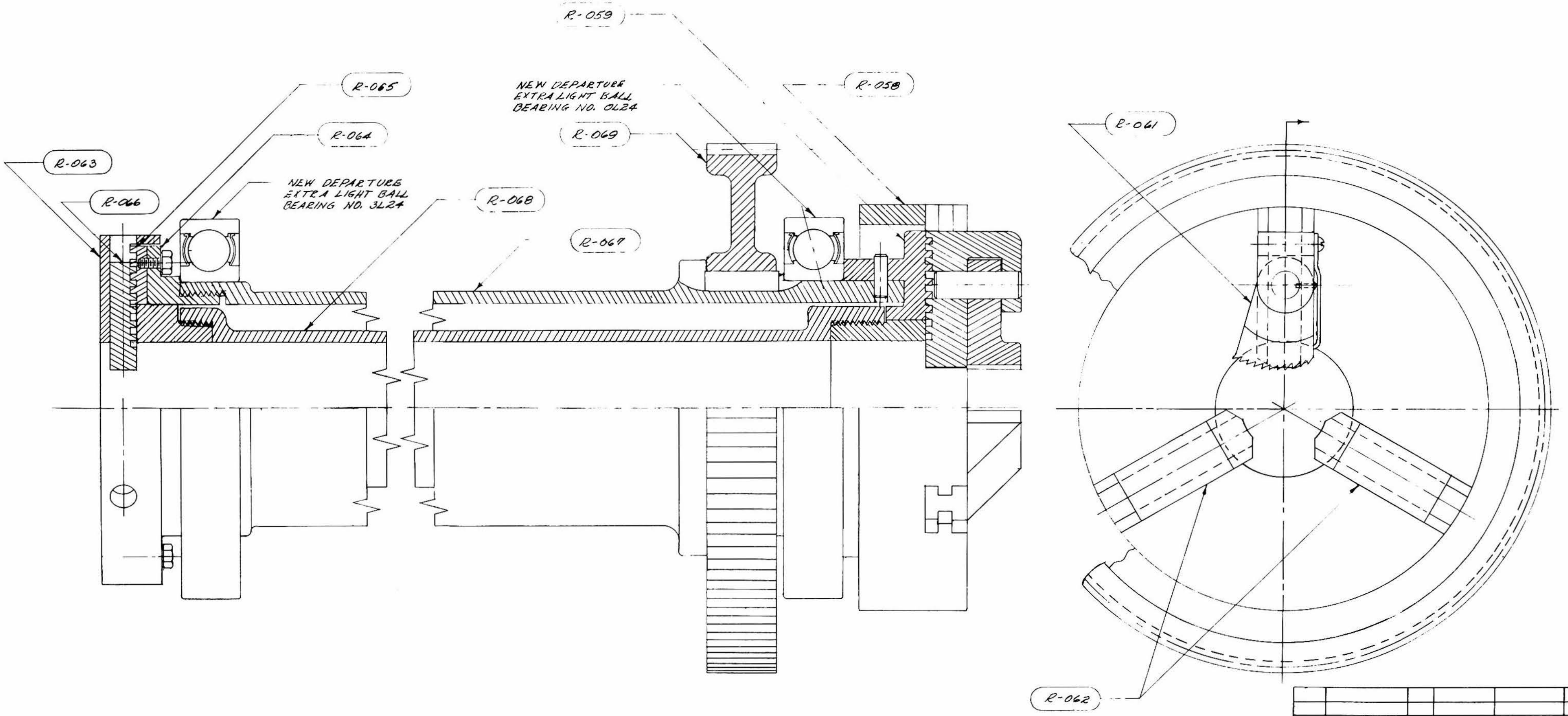


1/2" BULKHEAD UNION
R-051
R-052
R-053
R-052
1/4"X1/2" CSK HD. SCREW 1/4-28NF-3
1/4X 1 7/8" FILLISTER HD. SCREW 1/4 28NF-3
R-053 RACK 1 STEEL
R-052 SLIDES 2 STEEL
R-051 FRAME 1 ALUMINUM
PART NO. NAME NO. REQD. MATERIAL DESC. MATERIAL SPEC. WEIGHT
CALIFORNIA INSTITUTE OF TECHNOLOGY
CARRIAGE ASSEMBLY
DRAWN BY WALLACE
TRACED BY
CHECKED BY
APPROVED BY
DATE 4-29-49 SCALE
R-050

FIGURE 25.

steel rear chuck scroll plate, 3 steel rear chuck jaws, a cast steel outer spindle, a cast steel inner spindle, a cast steel spindle gear, and 2 extra-light ball bearings. The front 3-jaw sliding wedge chuck grips the pipe while the rear chuck keeps it concentric with the inner spindle. The housings of the two chucks are connected to the inner spindle. The scroll plates are connected to the outer spindle. The spindle gear is keyed to the outer spindle. The outer spindle rotates on extra-light ball bearings which have seal rings and can be lubricated by fittings provided on the frame. Thrust is carried by the front bearing. An adjustment plate is provided on the rear chuck scroll plate to allow the setting of the rear jaws to be the same as the front. The driving torque is transmitted from the spindle gear, through the key to the outer spindle, through three shear pins to the front chuck scroll plate, through the teeth to the front chuck jaws, and through the jaw serrations to the pipe. The transmission of torque through the front chuck is different from conventional universal chucks which transmit the torque from the spindle, to the chuck housing, to the jaws, and to the pipe. The inner spindle carries no torque loads.

The action of the chucks and spindle for chucking pipe is as follows: After a piece of pipe has been inserted through the inner spindle, the operating handle is moved to the "close" position which starts the motor. The friction drag linkage



	Ball Bearing	2	Extra Light		
R-069	Spindle Gear	1	Steel		
R-068	Inner Spindle	1	Steel		
R-067	Outer Spindle	1	Steel		
R-066	Rear Jaw	3	Steel		
R-065	Rear Scroll	1	Steel		
R-064	Adjustment Plate	1	Aluminum		
R-063	Rear Housing	1	Aluminum		
R-062	Minor Jaw	2	Steel		
R-061	Master Jaw	1	Steel		
R-059	Front Scroll	1	Steel		
R-058	Front Housing	1	Steel		
PART NO.	NAME	NO. REQ.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT

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SPINDLE & CHUCK ASSEMBLY

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APPROVED BY
DATE 4-30-46 SCALE

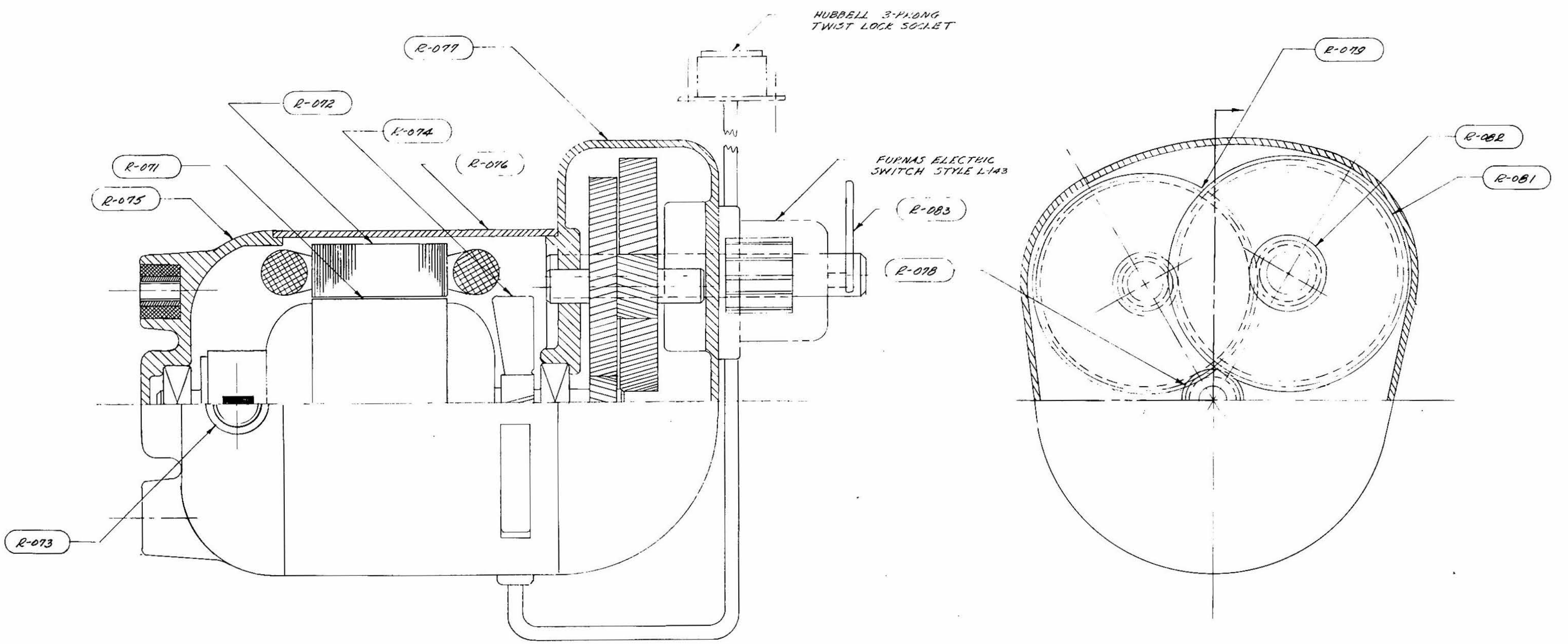
R-060

FIGURE 26.

shown in Figure 29 (Drawing R-090) will restrain the front chuck housing from rotation, allowing the spindle gear to rotate only the outer spindle and scroll plates, which will cause the front and rear chuck jaws to close. When the front chuck jaws are tightly closed upon the pipe the brake will begin to slip as the inner spindle rotates. This will impose a load on the motor, and the spindle will slow down. The operating handle is then moved to the "run" position which causes a cam to lift the brake shoe and allows the full power of the motor to rotate the pipe. The rotating pawl on the master jaw of the front chuck will grip tighter as the working torque load upon the pipe increases. The action of this type jaw is described in detail on page 25.

The action of the chucks and spindle for unchucking pipe is as follows: When the operating handle is moved to "open" the brake shoe is allowed to bear against the front chuck housing and the motor is reversed. The scroll plates will rotate in reverse and open the front and rear chuck jaws. When the jaws are sufficiently clear of the pipe, the operating handle is moved to "off" and the pipe can be removed from the inner spindle. If it is desired to stop the machine and not remove the pipe, the operating handle can be moved from "run" to "off". This will cause the brake to bear against the front chuck housing, and the motor to be turned off. The front chuck will not release its grip on the pipe.

The motor assembly (Drawing R-070) shown in Figure 27 consists of a series armature, a series field, 2 brush assemblies, a cast aluminum fan, a cast steel motor end bell, a cast steel motor housing, a cast steel gear case, a steel helical motor pinion gear, a steel helical cluster gear, a steel helical final gear, a steel spur pinion gear, 2 steel gear shafts, 4 gear shaft ball bearings, 2 motor armature ball bearings, a steel stamping switch lever, a Furnas electric switch Style L-143, and a Hubbell 3-prong 15 amp. twist lock socket. The motor specifications are: 2-pole compensated series winding, 110 volts, 3.5 amp. no-load current, 15 amp. full-load current, 7500 rpm no-load speed, 5400 rpm full-load speed, 65"# starting torque. Heat-treated steel, helical gears are used in the gear case which give an overall reduction of 17-1 in two steps of 4-1 and 4.25-1. The spindle gear reduction is 8-1 giving a total reduction of 136-1, which makes the no-load spindle speed 55 rpm and the full-load speed 40 rpm. The motor armature and the gear shafts are mounted on ball bearings. The motor and gear case are sealed and require no lubrication in service. The spur pinion which engages the spindle gear requires only occasional greasing. The rear motor mounts which restrain the motor torque have fiber bushings to minimize vibration and noise. The front motor mount is a steel bushing which fits on the spur pinion gear shaft. The electric switch is an on-off-



PART NO.	NAME	NO. REQ.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT
	3-Prong Socket	1	Hubbell		
	Electric Switch	1	Furnas		
R-083	Switch Lever	1	Steel		
R-082	Spindle Pinion	1	Steel		
R-081	Final Gear	1	Steel		
R-079	Cluster Gear	1	Steel		
R-078	Motor Pinion	1	Steel		
R-077	Gear Case	1	Steel		
R-076	Housing	1	Steel		
R-075	End Bell	1	Steel		
R-074	Fan	1	Aluminum		
R-073	Brush Assem.	2	—		
R-072	Field	1	Iron		
R-071	Armature	1	Iron		

FIGURE 27.

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MOTOR ASSEMBLY

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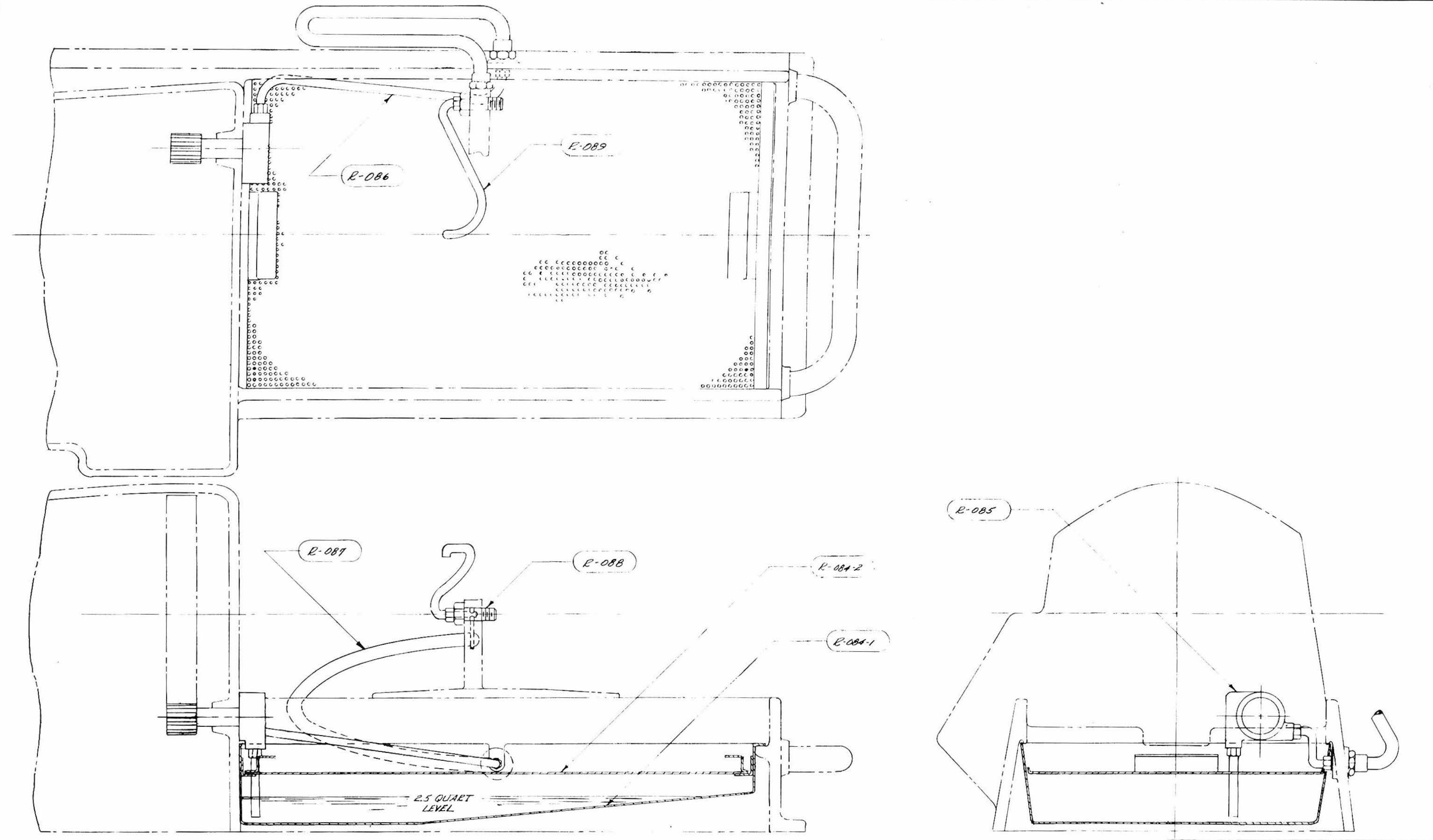
CHECKED BY	
APPROVED BY	
DATE 1-28-49	SCALE
R-070	

reversing switch of $\frac{1}{2}$ HP rated capacity. It has a total throw of 60° from reverse to forward. It is mounted on the gear case where it is fully shielded against any oil which the pinion might throw on it, and is operated by an extension of the chuck operating handle. The 3-pronged twist lock electrical socket for connecting the power cord is located on the rear of the machine where it is out of the operator's way.

<u>The cutting oil system</u> (Drawing R-080) shown in Figure 28 consists of a sheet metal sump, a perforated metal tray, a vane oil pump, a pinion gear, a suction line, an output line, a neoprene flexible hose, a valve bolt, and a diehead line. The sheet metal sump has a 2.5 quart capacity of cutting oil. A ridge is cast in the frame where it meets the sump to restrict the flow of cutting oil down the insides of the frame. The perforated metal tray is fitted with handles for convenience in removing for cleaning. The vane pump is driven by a pinion gear meshing with the spindle gear. Cutting oil is picked up from the sump through the suction line. The output line extends from the pump to a bulkhead union on the frame midway between the extremes of the carriage travel. A piece of neoprene tubing with fittings on each end runs from the frame bulkhead union to the carriage bulkhead union. The carriage is drilled, and the bolt which connects the diehead mechanism to the carriage is hollow and equipped with a union



PART NO.	NAME	NO. REQD.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT
R-089	Diehead Line	1	Cu. Tubing		
R-088	Valve Bolt	1	Steel		
R-087	Flexible Hose	1	Neoprene		
R-086	Output Line	1	Cu. Tubing		
R-085	Pump Assem	1	—		
R-084	Sump & Tray	1	Sheet Stl.		

FIGURE 28.

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CUTTING OIL SYSTEM

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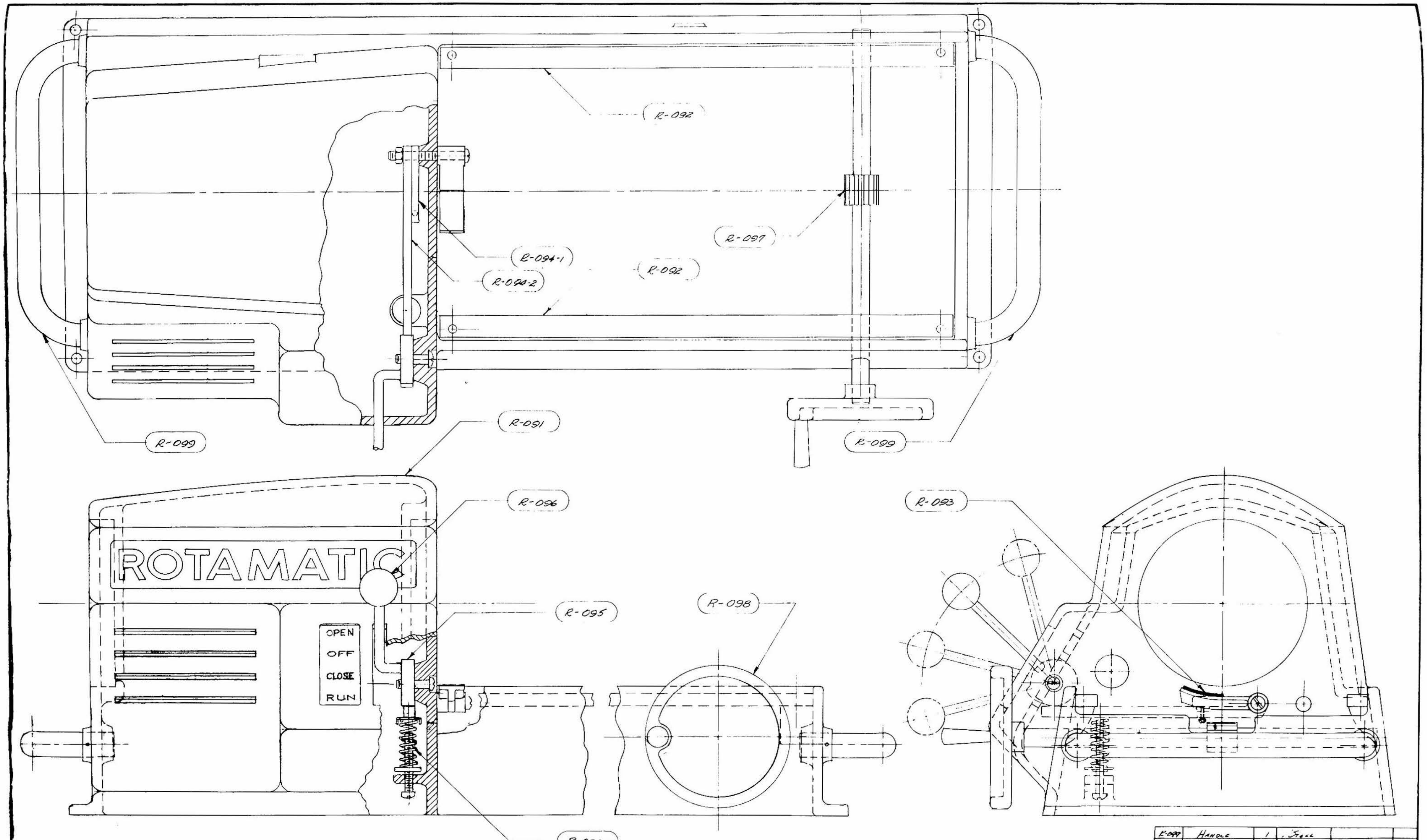
APPROVED BY
DATE 5-4-44 SCALE

R-080

on its head. The diehead line extends from the head of the bolt inside the rear cover plate to a point directly over the chasers. When the diehead and cut-off mechanisms are rotated to make-up position the bolt will rotate with them and stop the supply of cutting oil to the chasers.

The frame assembly (Drawing R-090) shown in Figure 29 consists of a cast aluminum frame, 2 steel carriage guides, a cast aluminum brake shoe, molded asbestos brake lining, a steel stamping brake adjusting link, a steel stamping brake tripping link, a steel cam, a steel and plastic operating handle, a spring steel brake spring, a steel spur gear and shaft, an aluminum carriage positioning wheel, and two tubular steel carrying handles. The frame is cast in one piece with the parting line along the vertical center line of the spindle. The name of the Machine, the chuck operating handle positions and slot, and the motor cooling slots are part of the casting. The brake shoe is located so as to bear on the front chuck housing, and is rigidly connected by a bolt to the adjusting link. The molded asbestos lining is unaffected by the cutting oil. A set screw in the tripping link bearing against the adjusting link varies the angle between the brake shoe and the tripping link to compensate for wear of the lining. The compression spring pushes against the tripping link so as to keep the brake shoe tight against the front chuck housing. Spring pressure may be varied by adjusting the length of the



Part No.	Name	No. Req.	Material Desc.	Material Spec.	Weight
R-099	Handle	1	Steel		
R-098	Control Wheel	1	Aluminum		
R-097	Gear & Shaft	1	Steel		
R-096	Handle	1	Stl. & Plas.		
R-095	Cam	1	Steel		
R-094	Brake Linkage	1	Steel		
R-093	Brake Shoe	1	Aluminum		
R-092	Guides	2	Steel		
R-091	Frame Casting	1	Aluminum		

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FRAME ASSEMBLY

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Date 5-4-49 Scale

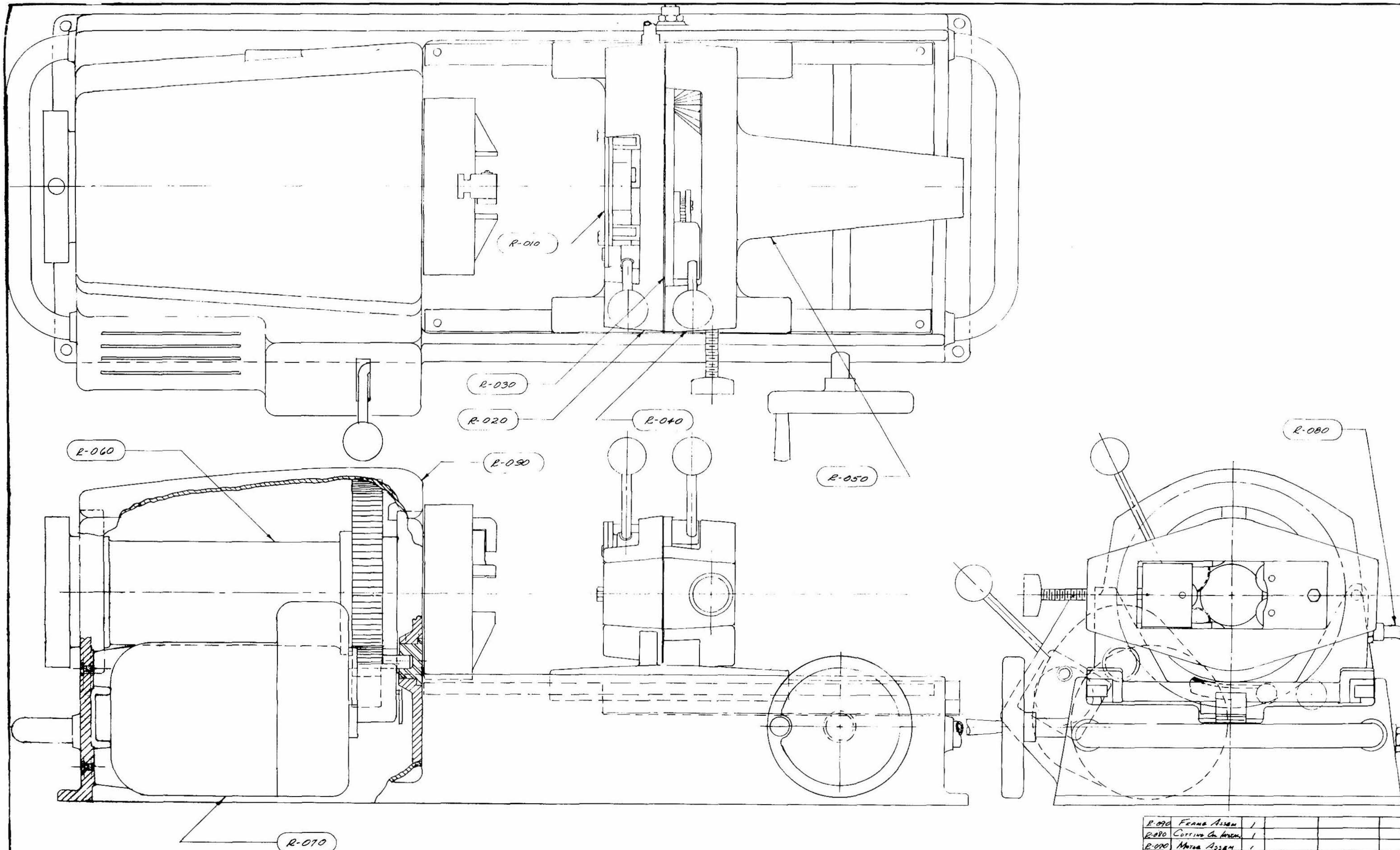
R-090

FIGURE 29.

bolt running through its center. The chuck operating lever is welded to the cam. The motor switch lever engages two lugs on the cam. A 30° downward movement of the operating lever will turn the motor on. An additional 30° downward movement will cause the cam to bear against the tripping lever and the brake shoe to lift off the front chuck housing. The center of the cam is displaced from the center of the motor switch to allow for this overtravel. The chuck operating lever moves through a total arc of 90°. By having the operating lever lift the brake there is less wear to the brake lining, and a large proportion of the motor torque may be used to close the chuck jaws.

The carriage guides are heat-treated ground steel whichare bolted on both ends to the frame. The length of the guides allows 14" of carriage travel. The carriage positioning pinion, shaft, and wheel are mounted on the frame. Tubular steel handles are provided on each end of the machine for carrying by two men. Mounting bolt holes are provided in the horizontal feet on each end of the machine.

<u>The Rotamatic final assembly</u> (Drawing R-100) shown in Figure 30 consists of 6 diehead threading assemblies, a diehead frame assembly, a cut-off tumble gear assembly, a cut-off frame assembly, a carriage assembly, a spindle and chuck assembly, a motor assembly, a cutting oil system, and a frame assembly.



Part No.	Name	No. Req.	Material Desc.	Material Spec.	Weight
R-090	Frame Assem	1			
R-080	Cutting Oil Assem.	1			
R-070	Motor Assem	1			
R-060	Spindle & Chuck Assem.	1			
R-050	Carriage Assem.	1			
R-040	Cut-Off Frame Assem	1			
R-030	Cut-Off Gear Assem	1			
R-020	Thr. Frame Assem	1			
R-010	Threading Assem.	1			

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ROTAMATIC
FINAL ASSEMBLY

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Traced by
Checked by
Approved by
Date 7-5-49 Scale

R-100

FIGURE 30.

The inside and outside surfaces of the frame, carriage, diehead mechanism, and cut-off mechanism are sprayed with grey lacquer primer. The outside surfaces of these parts are given two coats of a light warm grey lacquer. The machine name, the chuck operating handle positions, the front of the cut-off feed screw knob, the front of the carriage positioning wheel, and the two carrying handles are painted black. The manufacturer's name plate is attached to the left end of the machine.

The diehead threading assembly is mounted on the torque pins of the diehead frame assembly which is bolted to the carriage assembly by the special oil valve bolt. The cut-off tumble gear assembly is bolted to the cut-off frame assembly. The cut-off mechanism will slide against the back of the diehead mechanism. The spindle and chucks are assembled through the frame bearing holes with the frame in an upside-down position. The motor is fitted into place from the bottom of the frame and held by two bolts in the rear and by the pinion shaft bushing in the front. The motor wiring is passed under the spindle and connected to the twist lock socket. The oil pump is mounted in the frame and the suction and output lines connected. The oil sump and tray are fastened to the frame. The carriage is fitted on the guides and the flexible oil line is attached between it and the frame. This completes the assembly of the Rotamatic pipe threading machine.

OPERATION

The Rotamatic may be operated on a bench, on a wheeled stand, on the bed of a truck, or on any convenient working surface. For best results the surface should be smooth and level, and the machine should be fastened to it with care that there is no twist in the bed. Height of the carriage positioning wheel should be between 30" and 36" above floor height for maximum comfort and ease of operation.

Electric power may be obtained from any 110 volt line fused for 15 amperes or higher. For maximum safety a ground connection should be made if the circuit does not provide it. The electric power cord may be disconnected from the back of the machine for convenience in moving.

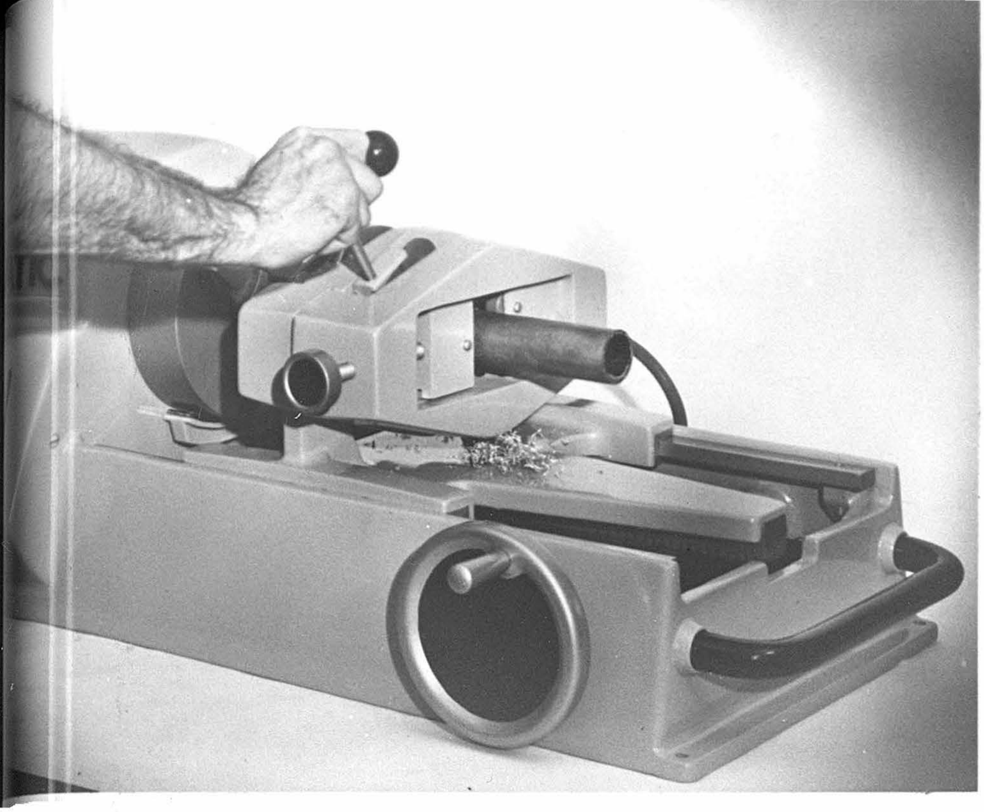
Approximately 2.5 quarts of cutting oil should be in the oil sump for operation. The perforated metal tray should be clean of chips.

A pipe support should be used whenever a long length of pipe projects from either end of the machine. Very short nipples can be threaded by using a nipple chuck. Pipe up to 12" nominal diameter may be threaded and cut off by use of geared tools driven by a universal extension shaft.

Chucking is done by placing a piece of pipe in the spindle so that the position where it is to be cut off falls approximately midway between the ends of the carriage guides. The chuck is closed and the motor turned on by pulling the chuck operating handle downward to the "close" position. After the jaws have gripped the pipe tightly, it will begin to rotate and the motor will slow down. The chuck operating handle is then moved to the "run" position which will remove the load from the motor.

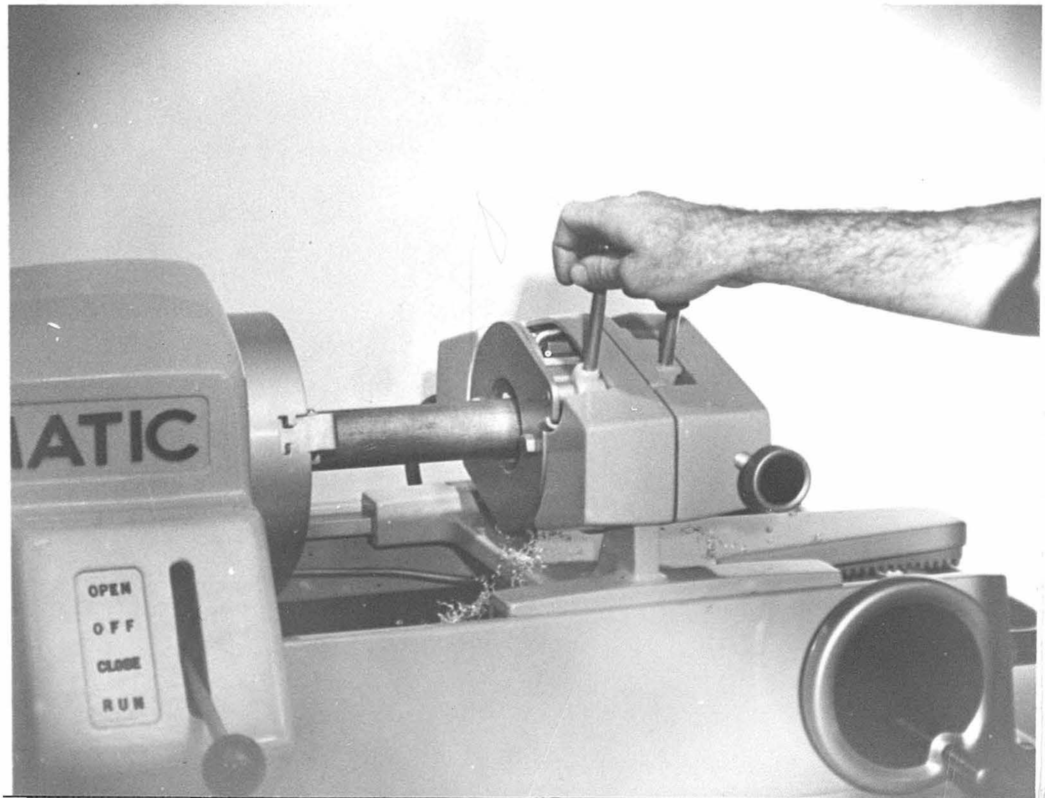
Cutting-off is done by moving the carriage so that the cut-off wheel is at the position desired. The cut-off operating handle is pulled towards the operator. This motion will contact the bottom roller of the tumble gear train to the pipe and the cut-off wheel will move towards the pipe. The Rotamatic is shown performing the cut-off operation in Illustration 31. Time for cutting off 2" pipe is 6 seconds. For pipe sizes below $1\frac{1}{2}$" the gear train will drive the cut-off wheel into the pipe without having to lift the operating handle. For $1\frac{1}{2}$" and 2" pipe the operating handle will have to be lifted periodically as the wheel is cutting off to avoid stalling the motor. After the pipe has been cut-off the cut-off operating handle is moved away from the operator. This contacts the top roller of the tumble gear train against the pipe and backs the cut-off wheel away at high speed.

Threading is done by moving the carriage away from the end of the pipe far enough to clear the diehead. The chasers are



31. CUTTING-OFF

ROTAMATIC OPERATION

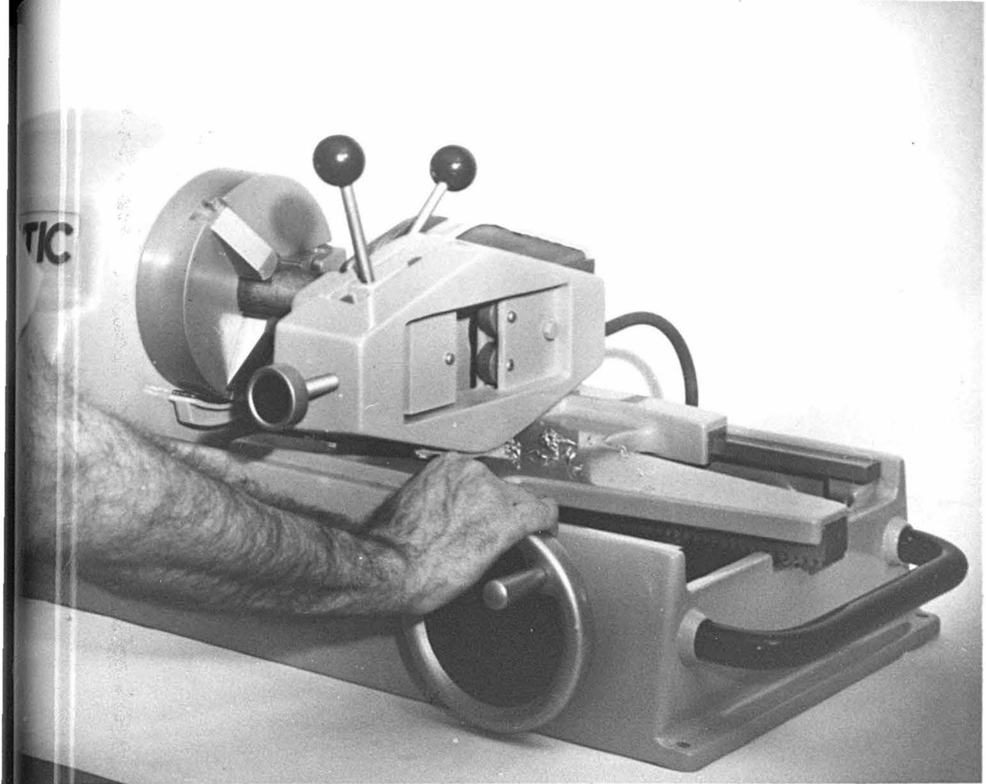


32. THREADING

closed by pulling the diehead operating handle towards the operator, and are started threading by moving them against the end of the pipe by means of the carriage positioning wheel. Once started, the chasers alone will move the carriage. Cutting oil is fed in a steady stream directly over the chasers. The Rotamatic is shown performing the threading operation in Illustration 32. Time for threading 2" pipe is 20 seconds. When sufficient thread has been cut, the chasers are lifted by moving the diehead operation handle away from the operator.

Reaming is accomplished by sliding the cut-off mechanism towards the operator by grasping the cut-off feed screw knob. The reamer is then moved against the end of the pipe by the carriage positioning wheel, until it has cut away a sufficient amount of pipe metal. The Rotamatic is shown performing the reaming operation in Illustration 33. Time for reaming 2" pipe is 4 seconds.

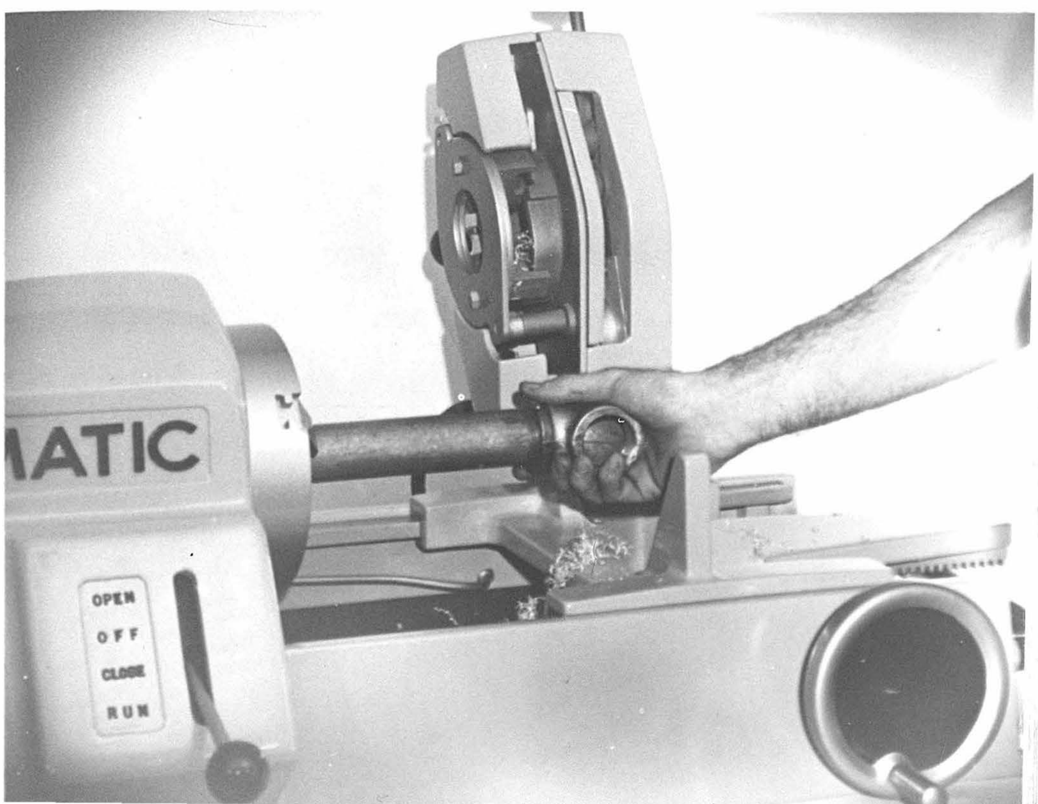
Making-up a fitting is done by moving the carriage away from the pipe far enough for the reamer to clear, and rotating the diehead and cut-off mechanisms away from the carriage, by lifting the cut-off feed screw knob. When in this position the flow of cutting oil to the diehead will stop. Caulking may be applied to the thread of the rotating pipe and a fitting screwed on by hand. The Rotamatic is shown performing the



33. REAMING

ROTAMATIC OPERATION

34. MAKING-UP



making-up operation in Illustration 34. Time for making-up 2" pipe is 15 seconds. After the fitting is on finger tight, the chuck operating handle is moved to the "off" position and the fitting is tightened with a wrench.

Unchucking the pipe is accomplished by moving the chuck operating handle to the "open" position. When the jaws have opened sufficiently, the chuck operating handle is moved to "off". The motor will stop and the pipe with the fitting on it may be removed from the front of the machine. The diehead and cut-off mechanisms are rotated back into place on the carriage and the Rotamatic is ready for another piece of pipe.

Changing dieheads may be done by merely pulling the diehead threading assembly off the torque pins when the diehead operating handle is in an open position, and slipping another size diehead in place on the pins. Closing the chasers locks the threading assembly onto the diehead frame.

CONCLUSIONS

The pipe threading machine designed as a result of this thesis study fulfills a large portion of the present need for portable pipe threading machines. The Rotamatic is an attractive, durable, light-weight, high-speed machine which is convenient to operate, easy to clean, and simple to maintain. It is capable of threading, reaming, cutting-off, and making-up fittings for pipe between $\frac{1}{2}$" and 2" diameter. It can thread bolts up to $1\frac{1}{4}$" diameter, and thread and cut-off pipe up to 12" diameter by the use of a universal extension shaft.

The Rotamatic offers the following improved features over present portable pipe threading machines:

(1) Separate threading assemblies for each size pipe, but only one diehead operating mechanism mounted on the machine. This arrangement substantially lowers the cost of the threading assemblies.

(2) A cut-off mechanism which is power-driven by the rotating pipe for increased ease and speed in cutting off pipe.

(3) A reamer which is mounted behind the diehead for increased speed and convenience of use.

(4) A positive gripping automatic chucking system which simultaneously grips and aligns the pipe saving operator time and effort.

The design of the parts of the Rotamatic were determined by the designer as being the best for the job required without regard to any particular manufacturing plant facilities. With minor modifications the machine could be adapted to be made by most of the present day portable pipe threading machine manufacturers.

The final design, as presented, is free of mechanical interferences that could be checked by the building of the wooden appearance model . The structure is sufficiently strong to carry the design loads chosen as a result of test and reasoning. Before actual production, an experimental working model will need to be built to eliminate the mechanical and structural difficulties which will surely arise.

APPEARANCE DESIGN CONSIDERATIONS

The appearance design of the Rotamatic was done simultaneously with the engineering design. The basic characteristics which the designer considered the Rotamatic needed appearance-wise were:

(1) A form suggestive of a light-weight, yet sturdy and powerful machine.

(2) Surfaces with a minimum of protruding parts.

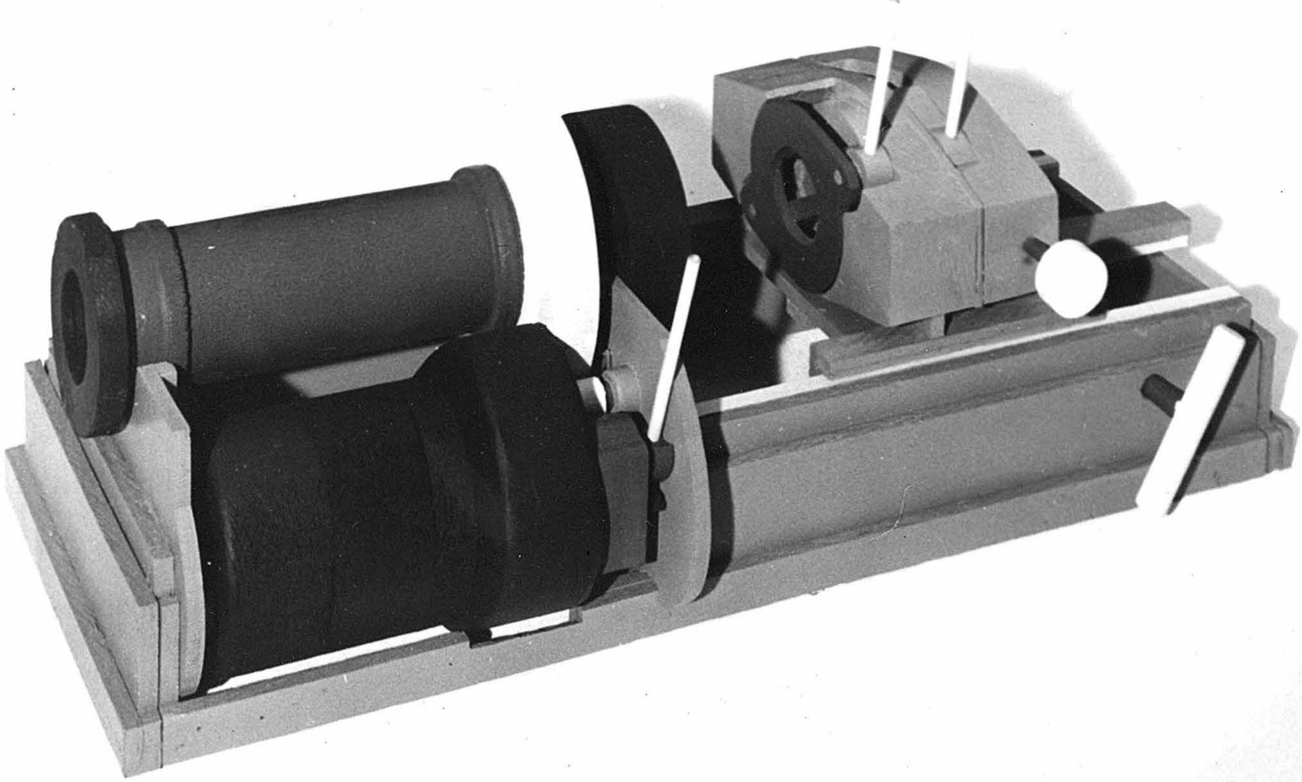
(3) A durable surface finish suggestive of precision of design and construction.

(4) As few controls as possible organized into convenient groups for operation.

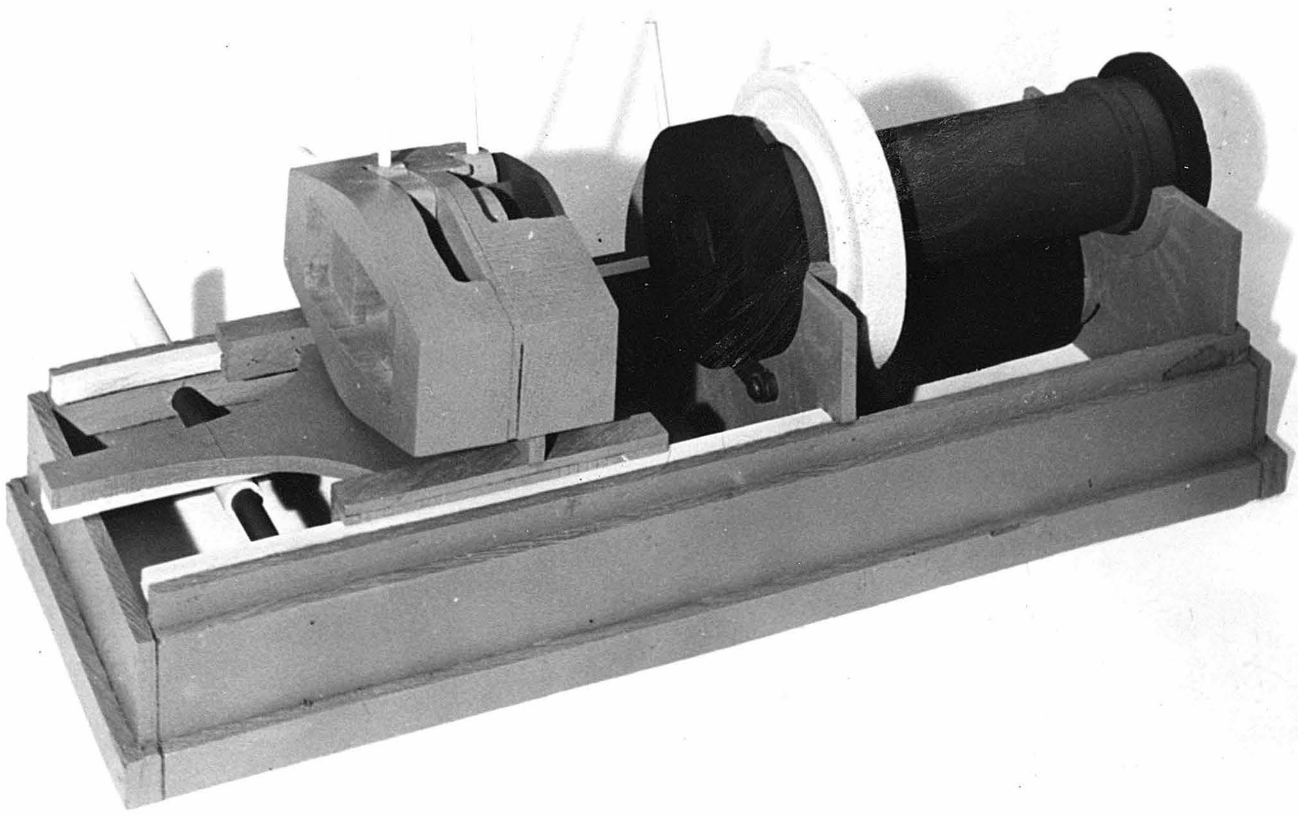
The design of the diehead and cut-off mechanisms began by assuming them to be housed within a rectangular form. This shape was modified to reduce the mass and to save material. The diehead and cut-off frame castings were tapered both for ease of drawing when being cast and to further lighten the mass. They were designed so that when closed, the guides between them are invisible. This was possible with no complication to either casting. The diehead toggle linkage and the cut-off tumble gear assembly were designed to fit within the outside form. Placing the reamer inside the cut-off frame was a convenient way of organizing it within the basic form. Ample cutouts were made in the top of the castings for vision. The diehead and cut-off mechanism operating handles were organized so that when the diehead was closed and the cut-off mechanism was in neutral position, the handles would be parallel and at an angle of approximately 65° to the horizontal for ease in grasping. A thermo plastic knob was used for the knobs for warmth and color. Because of the relatively low production of the machine a spherical knob was used. However, a more comfortable form could be designed if thought economically feasible. The cut-off feed screw knob was rounded in the back for comfort in pulling, and knurled on the surface for friction in turning.

The carriage was designed in a straight-forward way to carry the diehead and cut-off mechanisms. Its dimensions were determined by the dimensions of these mechanisms and the length of travel desired. The center extension which holds the rack was made with straight lines to avoid giving a feeling of direction away from the carriage.

The frame design was begun after the dimensions of the motor, the spindle, and the chucks had been definitely determined. The half-scale visualization model shown in Illustration 35 was constructed. It contained the motor, spindles, chucks, carriage, and diehead and cut-off mechanisms. Since the diehead and cut-off mechanism operating handles were asymetrical elements about the center line of the spindle, it was considered best to mount the motor asymmetrically towards the front. If



35. ROTAMATIC HALF-SCALE VISUALIZATION MODEL.



the motor were placed above or below the spindle the over-all height of the machine would be raised, which would require more metal, increase the weight, and raise the silhouette. If the motor were placed to the rear of the machine the operating handles would cause asymmetry in one direction and the motor in the other. Half-scale elevations of the frame were made, and perspective sketches were made from photographs of the model. Finally, the visualization model was covered with modeling clay to the form desired to check the sketches.

In the final form of the frame the headstock was tapered to lighten the mass and to form a pleasing transition from the large front chuck to the small rear chuck. Small radii were used on horizontal plane intersections, while larger radii were used for vertical plane intersections to accent the horizontal lines of the machine. The angle of slope of the bed sides was made the same as the angle of slope of the headstock sides. The large protrusion which was needed for the motor gear case was used to mount the chuck operating handle. The off-center position of this handle was balanced by the position indications cast into the metal. The handle was made to operate in the same direction, and of the same dimensions and material as the diehead and cut-off mechanism operating handles. The minor protrusion to clear the motor housing was textured with horizontal cooling slots. The name of the machine was cast into the metal and placed on a prominent part of the headstock. The manufacturer's name plate was mounted on the left end of the machine underneath the rear chuck. The twist-lock electrical outlet was placed in the rear of the machine out of the way of the operator. The carriage guides were dropped $\frac{1}{4}$" from the top of the frame ways so the carriage would appear to be well consolidated with the frame. The carriage positioning wheel was made to repeat the cut-off feed screw knob and was provided with finger grips on the back to give positive gripping action for reaming. Handles were provided at both ends of the machine for two-man carrying since, because of the asymmetrical position of the motor, it could not be carried satisfactorily by a pipe through the spindle. A horizontal foot running the width of the machine was provided for its support and fastening.

The color scheme was chosen because it is attractive in any setting, and does not show grease stains excessively. The frame, the carriage, and the diehead and cut-off mechanisms are painted a light, warm grey. The carrying handles, the inside of the feed-screw knob, the inside of the carriage positioning wheel, the chuck operating handle positions, and the name of the machine are painted black. The spherical knobs on the chuck, diehead, and cut-off mechanism operating handles are dark red. The rear chuck, the front chuck, the diehead threading assemblies, the stems of the three operating handles, and the rims of the feed screw knob and carriage positioning wheel are natural metal finish.

ROTAMATIC DRAWING NUMBER SCHEDULE

R-000 Rotamatic Pictorial - (Figure 20)

R-010-A-F Diehead Threading Assembly, $\frac{1}{2}$"-2" - (Figure 21)
- R-011 Diehead Front Plate
- R-012-A-F Diehead Back Plate Assembly, $\frac{1}{2}$"-2"
- R-013-A-F Threading Chasers, $\frac{1}{2}$"-2"
- R-014 Threading Chaser Spring

R-020 Diehead Frame Assembly - (Figure 22)
- R-021 Diehead Frame Back Plate
- R-022 Diehead Frame Front Cover Plate
- R-023 Diehead Frame Rear Cover Plate
- R-024 Diehead Operating Scroll
- R-025 Diehead Operating Scroll Washer
- R-026 Diehead Toggle Link
- R-027 Diehead Toggle Arm
- R-028 Diehead Operating Handle
- R-029 Diehead Torque Pins

R-030 Cut-Off Tumble Gear Assembly - (Figure 23)
- R-031 Cut-Off Back Plate
- R-032 Cut-Off Tumble Plate
- R-033 Cut-Off Operating Handle
- R-034 Cut-Off Gear and Roller Combination
- R-035 Cut-Off Intermediate Gear, Large
- R-036 Cut-Off Intermediate Gear, Small
- R-037 Cut-Off Bevel and Spur Gear Cluster
- R-038 Cut-Off Gear Pins

R-040 Cut-Off Frame Assembly - (Figure 24)
- R-041 Cut-Off Frame
- R-042 Cut-Off Sliding Block
- R-043 Cut-Off Wheel
- R-044 Cut-Off Roller
- R-045 Cut-Off Feed Screw
- R-046 Cut-Off Feed Screw Knob
- R-047 Cut-Off Feed Screw Bevel Gear
- R-048 Cut-Off Wheel and Roller Pins
- R-049 Reamer

R-050 Carriage Assembly - (Figure 25)
- R-051 Carriage Frame
- R-052 Carriage Slide
- R-053 Carriage Rack

R-060 Spindle and Chuck Assembly - (Figure 26)
- R-058 Front Chuck Housing
- R-059 Front Chuck Scroll Plate
- R-061 Front Chuck Master Jaw Assembly
- R-062 Front Chuck Minor Jaw
- R-063 Rear Chuck Housing
- R-064 Rear Chuck Adjustment Plate
- R-065 Rear Chuck Scroll Plate
- R-066 Rear Chuck Jaw
- R-067 Outer Spindle
- R-068 Inner Spindle
- R-069 Spindle Gear

R-070 Motor Assembly - (Figure 27)
- R-071 Motor Armature
- R-072 Motor Field
- R-073 Motor Brush Assembly
- R-074 Motor Fan
- R-075 Motor End Bell
- R-076 Motor Housing
- R-077 Motor Gear Case
- R-078 Motor Armature Pinion Gear
- R-079 Motor Cluster Gear
- R-081 Motor Final Gear
- R-082 Motor Spindle Pinion Gear
- R-083 Motor Switch Lever

R-080 Cutting Oil System - (Figure 28)
- R-084 Oil Sump and Tray
- R-085 Gear Pump Assembly
- R-086 Pump Output Line
- R-087 Flexible Hose
- R-088 Diehead Valve Bolt
- R-089 Diehead Line

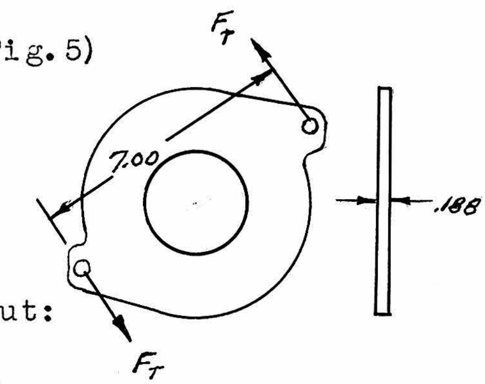
R-090 Frame Assembly - (Figure 29)
- R-091 Frame Casting
- R-092 Carriage Guides
- R-093 Chuck Brake Shoe
- R-094 Chuck Brake Linkage
- R-095 Chuck Brake Lifting Cam
- R-096 Chuck Operating Handle
- R-097 Carriage Positioning Pinion Gear and Shaft
- R-098 Carriage Positioning Wheel
- R-099 Machine Carrying Handle

R-100 Rotamatic - Final Assembly - (Figure 30)

ROTAMATIC STRESS AND LOAD ANALYSIS

1. R-010 Diehead Threading Assembly

Design Torque, T = 2000"# (Fig. 5)



a. Load at the mounting holes:

F_T = T/1 = 2000/7.00 = 286#

b. Right mounting hole in tearout:

S = 286/.188 x.25 = 6100 psi

f.s. = 60,000/6100 = 9.7 Ample.

.25 = length of tearout
f.s.= factor of safety
60,000= shear ultimate mild steel
2.375 = diameter 2" pipe

c. Forces on chasers:

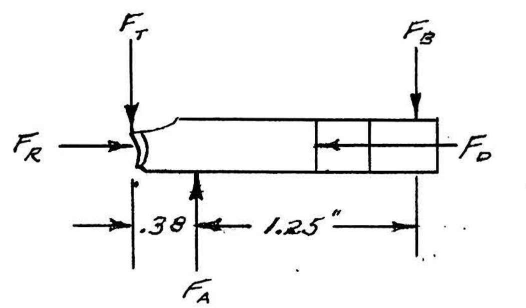
F_T = 2000/2.375 x 2 = 421#

d. Forces on chaser guides:

F_A = 421 x 1.63/1.25 = 550#

F_B = 550 - 421 = 129#

Assume F_T = F_R = 421#



e. Force against scroll slot of chaser:

F_D = F_T = 421#

f. Shear in weld between chaser guide and back plate:

S = P/.24 x 1 x t

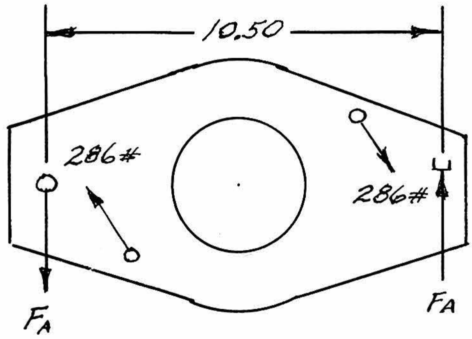
= 550/.24 x 1.5 x.25

= 6100 psi

P = load
.24 = welding constant
1 = Length of weld
t = Thickness of weld
60,000 = Shear ultimate of weld

f.s. = 60,000/6100 = 9.7 Ample.

2. R-020 Diehead Frame Assembly



a. Load on mounting bolt and stop pad:

F_A = 2000/10.50

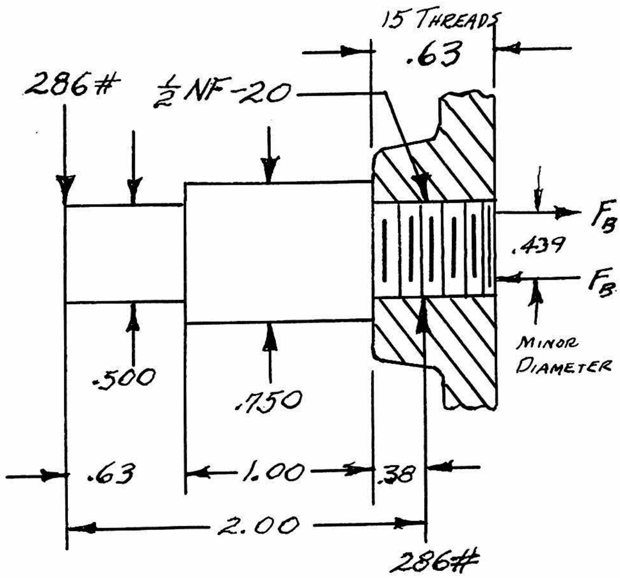
= 191#

b. Load on torque pin threads:

F_B = 286 x 2.00/.439

= 1300#

c. Shear on back plate threads:



Load/thread =

1300/15 = 87#

Assume tension load carried by 90° arc of the thread.

$$S_S = \frac{87 \times 4}{.439\pi \times .05}$$

= 5050 psi

f.s. = 40,000/5050 = 7.9 Ample.

d. Bending in the torque pin:

S = Mc/I

= 286 x 2.00 x .25/.00307

= 5000 psi

M = bending moment
c = pin radius
I = moment of inertia of pin

f.s. = 60,000/5000 = 12.0 Ample.

3. R-030 Cut-Off Tumble Gear Assembly

Design Torque = 80"# at 50 rpm

a. Gear velocity:

$V = 50 \times 2.375\pi/12 = 31$ fpm — 2.375" = diameter of 2" pipe

b. Force on gear teeth:

$F = 80/1.00 = 80\#$ — 1.00" = pitch radius of feed screw bevel gear

c. Gear allowable tooth stress:

$$S = \frac{90,000}{3} \times \frac{600}{600 + 31} = 28,600 \text{ psi}$$

90,000 = tension ultimate for 1040 heat-treated steel

d. Gear face width:

$$b = \frac{P_d F}{\pi s y} = \frac{24 \times 80}{\pi \times 28,800 \times .095}$$

$= .224"$

P_d = diametrical pitch
F = load on teeth
s = allow. tooth stress
y = form factor

Use standard 24 pitch, $14\frac{1}{2}^{\circ}$ involute, SAE 1040 heat-treated spur gears with $\frac{1}{4}$" face.

4. R-040 Cut-Off Frame Assembly

a. Load on the feed screw:

$$F = \frac{M}{r\left(\frac{f \times \cos\alpha}{\cos\frac{\beta}{2}} + \tan\alpha\right)}$$

feed screw thread is $\frac{1}{2}$ NC-13

(Formula for sharp threaded screw)

$$= \frac{80}{.217\left(\frac{.09 \times .99}{.866} + .154\right)}$$

$= 1450\#$

M = turning moment
f = coef. of friction
α = angle of pitch
β = angle between faces

b. Shear on the feed screw threads:

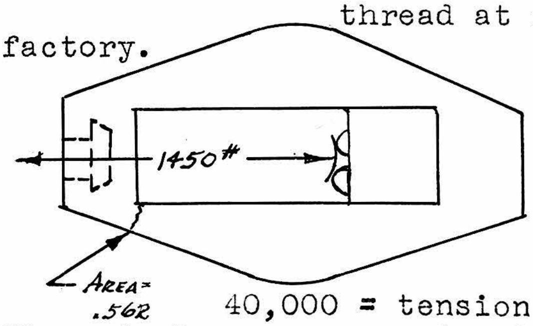
Load/thread = 1450/1.5 x 13 = 75#

$$S_S = \frac{75}{.416\pi \times .077}$$

.416 = Root dia. screw
.077 = Thickness of thread at root

= 745 psi Satisfactory.

c. Frame in tension:



F_T = 1450/2 x .562

= 1290 psi

f.s. = 40,000/1290 = 31 Ample.

40,000 = tension ultimate aluminum

d. Bevel gear face width:

$$b = \frac{P_d F}{\pi s y} = \frac{12 \times 80}{\pi \times 28800 \times .095}$$

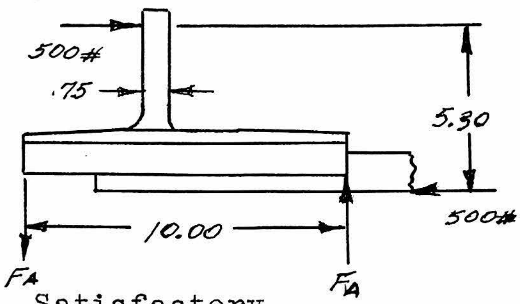
= .448"

(Velocity, forces, and allowable tooth stresses same for bevel gear as for spur gears in tumble gear assembly.)

Use standard 12 pitch, $14\frac{1}{2}^o$ involute, SAE 1040 heat-treated bevel gears with 5/8" face.

5. R-050 Carriage Assembly

a. Diehead supports in bending:



S = Mc/I

$$= \frac{500 \times 5.30 \times .375}{2.75 \times .75^3/12}$$

= 10,300 psi

f.s. = 40,000/10,300 = 3.88 Satisfactory.

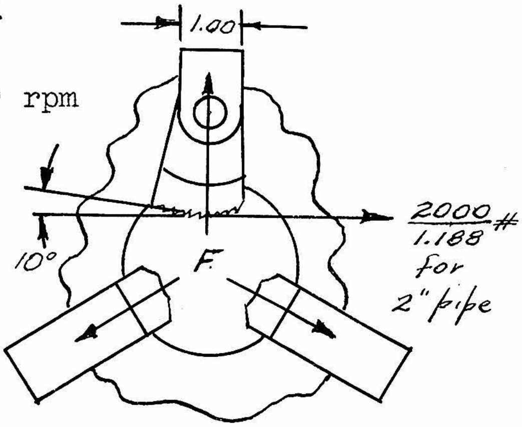
b. Load on carriage guides:

Note: For derivation of 500# load see 9-e Page 71

F_A = 500 x 5.30/10.00 = 266#

6. R-060 Spindle and Chuck Assembly

Design Torque = 2000 "# at 50 rpm



6 active teeth per jaw

a. Load on front chuck jaws:

$F = 2000/1.188 \times \tan 10^{\circ}$

= 9520#

Load/tooth = 9520/6

= 1590#

b. Shear in scroll plate teeth:

$S_S = 1590/1.00 \times .10$

= 15,900 psi

f.s. = 45,000/15,900 = 2.83 Satisfactory.

1.00 = width of chuck jaw
.10 = thickness of jaw tooth
45,000 = shear ultimate cast steel

c. Shear on aluminum shear pins:

$$S_S = \frac{2000}{\frac{2.38 \times 3}{.094^2 \pi}} = 10,100 \text{ psi}$$

f.s. = 20,000/10,100 = 1.98

.188 = dia. of shear pins
2.38 = outside radius of outer spindle

Pins will shear at 4000"# torque load on pipe.

d. Spindle gear velocity:

$V = 50 \times 9.60 \pi/12$

= 125 fpm

9.60 = pitch dia. spindle gear

e. Force on spindle gear teeth:

F = 2000/4.800

= 417 #

f. Spindle gear tooth allowable stress:

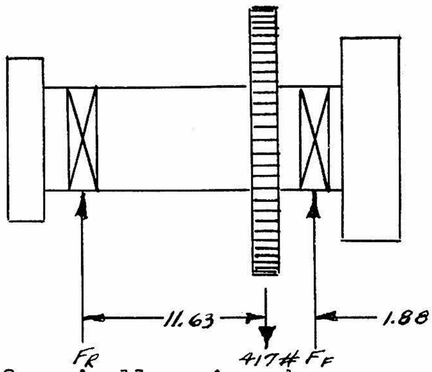
$$S = \frac{45,000}{4} \times \frac{600}{600 + 125} = 9300 \text{ psi}$$

g. Spindle gear face width:

$$b = \frac{10 \times 417}{\pi \times 9300 \times .117} = 1.22''$$

Use standard 10 pitch, $14\frac{1}{2}^{\circ}$ involute, cast steel, spur gear with $1\frac{1}{4}''$ face.

h. Load on spindle bearings:



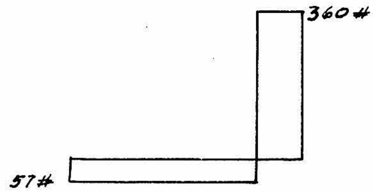
F_F = 11.62/13.50 x 417

= 360#

F_R = 417 - 360 = 57#

New Departure extra-light bearings N-OL24 used because of spindle size have rating of 11,700# for 50 rpm.

i. Stress in outer spindle from combined torsion and bending:



Shear Diagram

M_B = 360 x 1.88 = 675"#

M_T = 2000"# (design)

$$S = \frac{\sqrt{M_B^2 + M_T^2}}{.8\left(\frac{\pi\, D_o^4 - D_i^4}{16\, D_o}\right)}$$

M_B = max. bending moment
M_T = max. torsional moment
D_o = outside dia. spindle
D_i = inside dia. spindle

(.8 factor for keyway)

$$= \frac{\sqrt{675^2 + 2000^2}}{.8\left(\frac{\pi\, 4.75^4 - 4.00^4}{16 \times 4.75}\right)} = 1160 \text{ psi}$$

f.s. = 45,000/1160 = 39 Ample.

7. R-070 Motor Assembly

Design Torque = 250"# at 400 rpm

a. HP output at design conditions:

$$HP = \frac{2\pi Mn}{33{,}000} = \frac{2\pi \times 250 \times 400}{33{,}000} = 2.08 \text{ hp}$$

b. Spur pinion gear velocity:

$V = 400 \times 1.200\pi/12 = 125$ fpm   1.200" = pitch dia. of pinion gear

c. Force on spur pinion gear teeth:

$F = 250/.600 = 417\#$

d. Spur pinion gear allowable tooth stress:

$$S = \frac{90{,}000}{4} \times \frac{600}{600 + 125} = 18{,}600 \text{ psi}$$

e. Spur pinion gear face width:

$$b = \frac{10 \times 417}{\pi \times 18{,}600 \times .067} = 1.07"$$

Use standard 10 pitch, $14\frac{1}{2}^{\circ}$ involute, SAE 1045 steel spur gear with $1\frac{1}{4}$" face.

f. Cluster small gear velocity:

$V = 400 \times 4.25 \times 1.00\pi/12$

$= 535$ fpm

4.25 = ratio of cluster gear to spur pinion gear
1.00 = dia. small gear

g. Force on cluster small gear teeth:

$F = 250/\ 4.25 \times .500$

$= 118\#$

h. Cluster small gear allowable tooth stress:

$$S = \frac{90,000}{3} \times \frac{600}{600 + 535} = 17,400 \text{ psi}$$

i. Cluster small gear face width:

$$b = \frac{16 \times 118}{\pi \times 17,400 \times .067}$$

$$= .515''$$

Use standard 16 pitch, $14\frac{1}{2}^{\circ}$ involute, SAE 1045 steel, helical gear with $\frac{1}{2}''$ face.

j. Motor armature pinion gear velocity:

$$V = 400 \times 17.00 \times 1.00\pi/12$$

$$= 2140 \text{ fpm}$$

17.00 = ratio of armature to pinion gear speed

1.00 = pitch dia. armature gear

k. Force on motor armature pinion gear teeth:

$$F = 250/\ 17.00 \times .500$$

$$= 29\#$$

l. Motor armature pinion gear allowable tooth stress:

$$S = \frac{90,000}{3} \times \frac{600}{600 + 2140}$$

$$= 6580 \text{ psi}$$

m. Motor armature pinion gear face width:

$$b = \frac{20 \times 29}{\pi \times 6580 \times .090}$$

$$= .312''$$

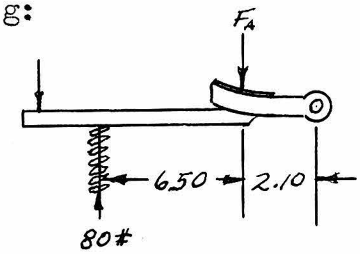
Use standard 20 pitch, $14\frac{1}{2}^{\circ}$ involute, SAE 1045 steel, helical gear with 3/8" face.

8. R-080 Cutting Oil System

No stress check made.

9. R-090 Frame Assembly

a. Brake load on front chuck housing:



Spring Force = 80#

F_A = 6.50 x 80/2.10 = 260#

b. Friction force on brake lining:

F = fN

= .5 x 260 = 130#

f = coef. of friction
N = normal load

c. Pressure on brake lining: $1.75''^2$ = brake area

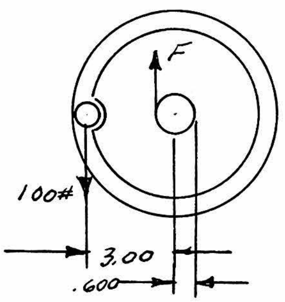
P = 130/1.75 = 74 psi Satisfactory.

d. Braking moment on spindle: 3.75" = front chuck radius

M = 130 x 3.75 = 488"# Satisfactory.

e. Force on carriage positioning gear teeth:

F = 3.00 x 100/.60 = 500#



f. Carriage positioning gear face width:

$$b = \frac{10 \times 500}{\pi \times 22{,}500 \times .067}$$

= 1.06"

Use standard 10 pitch $14\frac{1}{2}^{\circ}$ involute, SAE 1045 steel, spur gear with $1\frac{1}{4}$" face.

ROTAMATIC WEIGHT ANALYSIS

The following weight analysis was made by calculating the volume of each of the parts of the Rotamatic. The specific weight of the steel was assumed to be .278#/cu. in., and the specific weight of the aluminum was taken as .100#/cu. in.

A summary of the weight of each of the major assemblies of the Rotamatic is as follows:

	Assembly	Weight #
R-010	Diehead Threading Assembly	4.48
R-020	Diehead Frame Assembly	6.49
R-030	Cut-Off Tumble Gear Assembly	5.21
R-040	Cut-Off Frame Assembly	6.14
R-050	Carriage Assembly	13.60
	Carriage - Total Weight	35.72
R-060	Spindle and Chuck Assembly	69.17
R-070	Motor Assembly	40.21
R-080	Cutting Oil System	11.80
R-090	Frame Assembly	60.11
R-100	Final Assembly - Total Weight	217.01

On the basis of the above calculations the nominal net weight of the Rotamatic with one threading assembly is 220 pounds.

A tabular summary of the volume and weight of the detail parts is presented on pages 73 and 74.

Part Number	Part Name	No. Req	Mat'rl	Volume cu.in.	Weight lbs.
R-011	Front Plate	1	Steel	5.14	1.68
R-012-F	Back Plate Assem. 2"	1	"	7.64	2.02
R-013-F	Chasers, 2"	4	"	2.62	.73
R-014	Chaser Spring	4	"	.18	.05
R-010	Diehead Threading Assem.				4.48
R-021	Back Plate	1	Alum.	12.41	1.24
R-022	Front Cover Plate	1	"	6.88	.69
R-023	Rear Cover Plate	1	"	6.45	.65
R-024	Operating Scroll	1	Steel	7.00	1.95
R-025	Scroll Washer	1	"	3.04	.84
R-026	Toggle Link	1	"	.50	.14
R-027	Toggle Arm	1	"	1.35	.38
R-028	Operating Handle	1	"	.45	.13
R-029	Torque Pin	2	"	1.68	.47
R-020	Diehead Frame Assembly				6.49
R-031	Back Plate	1	Alum.	13.22	1.32
R-032	Tumble Plate	1	Steel	2.27	.63
R-033	Operating Handle	1	"	.45	.13
R-034	Gear & Roller Combin.	2	"	1.28	.36
R-035	Intermed. Gear, Large	1	"	.78	.22
R-036	Intermed. Gear, Small	2	"	.81	.23
R-037	Bevel & Spur Cluster	1	"	6.51	1.81
R-038	Gear Pins	1	"	1.83	.51
R-030	Cut-Off Tumble Gear As.				5.21
R-041	Cut-Off Frame	1	Alum.	41.25	4.13
R-042	Sliding Block	1	"	4.33	.43
R-043	Cut-Off Wheel	1	Steel	.29	.08
R-044	Cut-Off Roller	2	"	.64	.18
R-045	Feed Screw	1	"	.98	.27
R-046	Feed Screw Knob	1	Alum.	1.80	.18
R-047	Feed Screw Bevel Gear	1	Steel	.91	.25
R-048	Wheel and Roller Pins	3	"	.21	.06
R-049	Reamer	1	"	2.01	.56
R-040	Cut-Off Frame Assembly				6.14
R-051	Carriage Frame	1	Alum.	47.56	4.76
R-052	Carriage Slide	2	Steel	10.60	2.94
R-053	Carriage Rack	1	"	21.15	5.90
R-050	Carriage Assembly				13.60

Part Number	Part Name	No. Req	Mat'rl	Volume cu.in.	Weight lbs.
R-058	Front Chuck Housing	1	Steel	38.87	10.80
R-059	Front Scroll Plate	1	"	22.38	6.21
R-061	Master Jaw Assembly	1	"	5.59	1.56
R-062	Minor Jaw	2	"	6.26	1.74
R-063	Rear Chuck Housing	1	Alum.	33.02	3.30
R-064	Rear Adjustment Plate	1	"	9.44	.95
R-065	Rear Scroll Plate	1	Steel	4.93	1.37
R-066	Rear Chuck Jaw	3	"	1.18	.33
R-067	Outer Spindle	1	"	52.88	14.65
R-068	Inner Spindle	1	"	36.55	10.18
R-069	Spindle Gear	1	"	35.60	9.90
	Ball Bearings	2	"	29.40	8.18
R-060	Spindle & Chuck Assem.				69.17
R-071	Motor Armature	1	-	-	8.75
R-072	Motor Field	1	-	-	9.90
R-073	Brush Assembly	2	-	-	2.00
R-074	Motor Fan	1	Alum.	5.20	.52
R-075	Motor End Bell	1	Steel	19.85	5.32
R-076	Motor Housing	1	"	13.15	3.66
R-077	Motor Gear Case	1	"	29.60	8.22
R-078	Armature Pinion Gear	1	"	.39	.11
R-079	Cluster Gear	1	"	7.46	2.08
R-081	Final Gear	1	"	7.34	2.06
R-082	Spindle Pinion Gear	1	"	1.39	.38
R-083	Motor Switch Lever	1	"	.14	.04
	Ball Bearings	6	"	11.22	3.22
	Motor Switch	1	-	-	1.20
	3-prong Socket	1	-	-	.75
R-070	Motor Assembly				40.21
R-084	Oil Sump and Tray	1	Steel	25.40	7.07
R-085	Gear Pump Assembly	1	"	6.77	1.88
R-086	Output Line	1	Copper	-	.78
R-087	Flexible Hose	1	Neoprne	-	1.39
R-088	Valve Bolt	1	Steel	.21	.06
R-089	Diehead Line	1	Copper	-	.62
R-080	Cutting Oil System				11.80
R-091	Frame Casting	1	Alum.	479.90	47.99
R-092	Carriage Guide	2	Steel	19.26	5.35
R-093	Brake Shoe	1	Alum.	3.22	.32
R-094	Brake Linkage	1	Steel	2.66	.79
R-095	Brake Lifting Cam	1	"	1.62	.45
R-096	Chuck Operating Handle	1	"	.45	.13
R-097	Carr. Positioning Gear	1	"	7.18	2.00
R-098	Carr. Positioning Wheel	1	Alum.	14.37	1.44
R-099	Carrying Handle	2	Steel	5.92	1.64
R-090	Frame Assembly				60.11

ROTAMATIC COST ESTIMATE

The following cost estimate was made by computing material and labor cost for each part of the Rotamatic. $.075/lb. was used for the cost of all steel parts, and $.240/lb. was used for the cost of all aluminum parts. In the quanities needed, ball bearings were estimated at $1.00/lb. The motor armature and field were estimated at $.70/lb. Other electrical items were estimated on the basis of their present cost. All labor was estimated at $4.50/hour which included overhead. Labor time was estimated on the basis of jig set ups. $100,000 has been estimated as the tooling cost, and prorated over 5000 units. The selling cost was calculated by multiplying the manufacturing cost by three.

The cost of each of the major assemblies is as follows:

R-010	Diehead Threading Assembly (6)		$ 30.38
R-020	Diehead Frame Assembly		10.66
R-030	Cut-Off Tumble Gear Assembly		10.53
R-040	Cut-Off Frame Assembly		8.67
R-050	Carriage Assembly		6.33
R-060	Spindle and Chuck Assembly		32.21
R-070	Motor Assembly		32.22
R-080	Cutting Oil System		10.84
R-090	Frame Assembly		31.92
	Assembly	80 min.	6.75
	Finishing	80 min.	6.75
	Packing	20 min.	1.50
	Tooling Cost		20.00
R-100	Total Manufacturing Cost		$208.76
	Total Selling Cost		$625.00

A tabular summary of the cost of the detail parts of the Rotamatic is presented on pages 76, 77, 78 and 79.

Part Number	Part Name	No. Req	Mat'rl	Weight #	Mat'rl Cost $	Labor Time min.	Labor Cost $	Total Cost $
R-011	Front Plate	1	Steel	1.68	.126	12	.900	1.026
R-012-F	Back Plate Assem., 2"	1	"	2.02	.152	40	3.000	3.152
R-013-F	Chaser, 2"	4	"	.73	.055	8	.600	.655
R-014	Chaser Spring	4	"	.05	.004	2	.150	.154
	Assembly					2	.150	.150
R-010	Diehead Threading Assem.				.337		4.725	5.062
R-021	Back Plate	1	Alum.	1.24	.296	35	2.625	2.921
R-022	Front Cover Plate	1	"	.69	.165	8	.600	.765
R-023	Rear Cover Plate	1	"	.65	.156	8	.600	.756
R-024	Operating Scroll	1	Steel	1.95	.146	33	2.475	2.621
R-025	Scroll Washer	1	"	.84	.063	10	.750	.813
R-026	Toggle Link	1	"	.14	.011	4	.300	.311
R-027	Toggle Arm	1	"	.38	.029	8	.600	.629
R-028	Operating Handle	1	"	.13	.010	8	.600	.610
R-029	Torque Pin	2	"	.47	.035	8	.600	.635
	Assembly					8	.600	.600
R-020	Diehead Frame Assembly				.911		9.750	10.661
R-031	Back Plate	1	Alum.	1.32	.317	30	2.250	2.567
R-032	Tumble Plate	1	Steel	.63	.047	10	.750	.797
R-033	Operating Handle	1	"	.13	.010	8	.600	.610
R-034	Gear & Roller Combin.	2	"	.36	.027	22	1.650	1.677
R-035	Intermed. Gear, Large	1	"	.22	.017	8	.600	.617
R-036	Intermed. Gear, Small	2	"	.23	.017	13	.975	1.092
R-037	Bevel & Spur Cluster	1	"	1.81	.135	25	1.875	2.010
R-038	Gear Pins	1	"	.51	.038	10	.750	.788
	Assembly					5	.375	.375
R-030	Cut-Off Tumble Gear Assem				.608		9.625	10.533

Part Number	Part Name	No. Req	Mat'rl	Weight #	Mat'rl Cost $	Labor Time min.	Labor Cost $	Total Cost $
R-041	Cut-Off Frame	1	Alum.	4.13	.198	42	3.150	3.348
R-042	Sliding Block	1	"	.43	.103	10	.750	.853
R-043	Cut-Off Wheel	1	Steel	.08	.006	5	.375	.381
R-044	Cut-Off Roller	2	"	.18	.014	6	.450	.564
R-045	Feed Screw	1	"	.27	.020	6	.450	.470
R-046	Feed Screw Knob	1	Alum.	.18	.014	6	.450	.464
R-047	Feed Screw Bevel Gear	1	Steel	.25	.019	9	.675	.694
R-048	Wheel and Roller Pins	3	"	.06	.005	3	.225	.230
R-049	Reamer	1	"	.51	.042	8	.600	.642
	Assembly					15	1.125	1.125
R-040	Cut-Off Frame Assembly				.421		8.250	8.671
R-051	Carriage Frame	1	Alum.	4.76	1.142	23	1.725	2.867
R-052	Carriage Slide	2	Steel	2.94	.220	14	1.150	1.370
R-053	Carriage Rack	1	"	5.90	.442	10	.750	1.192
	Assembly					12	.900	.900
R-050	Carriage Assembly				1.804		4.525	6.329
R-058	Front Chuck Housing	1	Steel	10.80	.810	30	2.250	3.060
R-059	Front Scroll Plate	1	"	6.21	.465	17	1.275	1.740
R-061	Master Jaw Assembly	1	"	1.56	.117	20	1.500	1.617
R-062	Minor Jaw	2	"	1.74	.131	25	1.875	2.006
R-063	Rear Chuck Housing	1	Alum.	3.30	.792	17	1.275	2.067
R-064	Rear Adjustment Plate	1	"	.95	.228	8	.600	.828
R-065	Rear Scroll Plate	1	Steel	1.37	.103	16	1.200	1.303
R-066	Rear Chuck Jaw	3	"	.33	.025	25	1.875	1.900
R-067	Outer Spindle	1	"	14.65	1.100	30	2.250	3.350
R-068	Inner Spindle	1	"	10.18	.764	30	2.250	3.014
R-069	Spindle Gear	1	"	9.90	.675	25	1.875	2.550
	Ball Bearing	2	"	8.18	8.180			8.180
	Assembly					10	.750	.750
R-060	Spindle & Chuck Assem.				13.390		18.975	32.365

Part Number	Part Name	No. Req	Mat'rl	Weight #	Mat'rl Cost $	Labor Time min.	Labor Cost $	Total Cost $
R-071	Motor Armature	1	-	8.75	6.120	--	-	6.120
R-072	Motor Field	1	-	9.90	6.920	--	-	6.920
R-073	Brush Assembly	2	-	2.00	1.400	--	-	1.400
R-074	Motor Fan	1	Alum.	.56	.125	6	.450	.575
R-075	Motor End Bell	1	Steel	5.32	.400	8	.600	1.000
R-076	Motor Housing	1	"	3.66	.274	8	.600	.874
R-077	Motor Gear Case	1	"	8.22	.617	15	1.125	1.742
R-078	Armature Pinion Gear	1	"	.11	.008	10	.750	.758
R-079	Cluster Gear	1	"	2.08	.156	22	1.650	1.806
R-081	Final Gear	1	"	2.06	.154	12	.900	1.054
R-082	Spindle Pinion Gear	1	"	.38	.029	10	.750	.779
R-083	Motor Switch Lever	1	"	.04	.010	2	.150	.160
	Ball Bearings	6	"	3.22	3.220			3.220
	Motor Switch	1	-	1.20	2.900			2.900
	3-prong Socket	1	-	.75	1.190			1.190
	Assembly					23	1.725	1.725
R-070	Motor Assembly				23.613		8.600	32.213
R-084	Oil Sump and Tray	1	Steel	7.07	.530	13	.975	1.505
R-085	Gear Pump Assembly	1	"	1.88	.142	45	3.375	3.517
R-086	Output Line	1	Copp.	.78	.390	4	.300	.690
R-087	Flexible Hose	1	Neop.	1.39	1.025	10	.750	1.775
R-088	Valve Bolt	1	Steel	.06	.016	4	.300	.316
R-089	Diehead Line	1	Copp.	.62	.310	8	.600	.910
	Assembly					15	1.125	1.125
					2.413		8.425	10.838

Part Number	Part Name	No. Req	Mat'rl	Weight #	Mat'rl Cost $	Labor Time min.	Labor Cost $	Total Cost $
R-091	Frame Casting	1	Alum.	47.99	11.518	125	9.375	20.893
R-092	Carriage Guide	2	Steel	5.35	.401	25	1.875	2.276
R-093	Brake Shoe	1	Alum.	.32	.077	16	1.200	1.277
R-094	Brake Linkage	1	Steel	.79	.059	12	.900	.959
R-095	Brake Lifting Cam	1	"	.45	.034	8	.600	.634
R-096	Chuck Operating Handle	1	"	.13	.010	8	.600	.610
R-097	Carr. Positioning Gear	1	"	2.00	.150	17	1.275	1.425
R-098	Carr. Positioning Wheel	1	Alum.	1.44	.346	17	1.275	1.621
R-099	Carrying Handle	2	Steel	1.64	.123	8	.600	.723
	Assembly					20	1.500	1.500
R-090	Frame Assembly				12.718		19.200	31.918

ROTAMATIC MARKET ESTIMATE

The present market for portable pipe threading machines consists primarily of heating and plumbing shops for construction and repair work, and to a lesser extent of institutions and factories for repair work. Demand for these machines tends to be inelastic. It is influenced largely by the business cycle, and in particular by the building and construction cycle. At the present time the demand for portable machines appears high, although lessening.

The estimated total annual production of portable pipe threading machines in the United States, as discussed on pages 13 and 14 is approximately 5000 units. The average life of these machines was estimated to be approximately six years.

The market for the Rotamatic will come from the following sources: (1) the new market consisting of new plumbers entering the trade, of present plumbers who are not using portable pipe threading machines, and of institutions and factories not now using this type equipment for repairs; and (2) the replacement market consisting of plumbing shops, institutions, and factories whose machines have worn out.

The number of annual sales of the Rotamatic will depend upon the reputation of the manufacturer who produces the machine; his plant, distribution, and advertising facilities; the business cycle, and the state of competition. A market advantage will be gained from the patenting of the automatic chucking device, the threading mechanism, and the cut-off and reaming mechanism. It appears reasonable to assume a first year production of 1000 units. Since the cost of tooling has be prorated over 5000 units, a five year production at this rate will be required to amortize this cost.

Assuming the average life of the Rotamatic to be approximately six years, if its production is scheduled on a five year program, there will be a replacement market ready at the end of that time for a redesigned, improved version of the machine.

ROTAMATIC SALES AND ADVERTISING FEATURES

Distribution of the Rotamatic will be through the usual portable pipe threading machine channels, from factory to jobber, to consumer. Advertising and sales literature will be needed at both the jobber and consumer level.

Jobber advertising will need to consist of an outline of increased profits and new sales opportunities offered by the Rotamatic, and of instructions for its sales display.

Profits and sales opportunities can be dramatized on standard $8\frac{1}{2}$" x 11" single sheets, or 17" x 11" folded sheets so the factory salesman can conveniently carry them, and the jobber conveniently file them. This publicity will show by printed and pictorial means the difference and superiority of the Rotamatic. Such well recognized slogans as "Newest Design" and "The Most For Your Money", or special slogans like "Let The Rotamatic Turn Profits Your Way" can be used satisfactorily in this form of jobber advertising.

Instructions for sales display of the Rotamatic will include directions for window and interior displays, and for store demonstration of the machine. A counter card to setup behind or beside the machine bearing the name, Rotamatic, the trademark of the manufacturer, and an eye-catching legend such as "Power + Precision = Perfect Performance," can be suitable for a wide variety of displays. A length of pipe can be furnished the jobber to aid him in fully demonstrating the operation of the Rotamatic. The factory salesman can be coached on details of lighting and layout to be able to give helpful suggestions and advice to fit each jobber's special display problems.

Consumer advertising will need to be written for two major classes of consumers, (1) small shops, and (2) large contracting shops, institutions, and factories.

Small shop advertising will stress the convenience, the flexibility, and the appearance of the Rotamatic. Half-tone cuts of the machine and of the detail parts, as well as the operation sequence will need be shown. A tabular operation time chart, over-all specifications, and the price of the machine should be included.

Large shop, institution, and factory advertising will be an extension of the small shop advertising, and will contain more comphrensive machine time and cost charts of interest to the management group who estimate jobs and purchase equipment. These charts will present in tabular and graph form precise information showing how the Rotamatic will change estimations of job time, and lower costs. A factory salesman with an understanding of engineering and plumbing-job estimating should be available to further promote the sale of the Rotamatic to interested consumers of this class by personal calls.

All Rotamatic sales publicity should be written so as to be useful for other classes as well as the specific one for which it is intended. The advertising should be sufficiently different from other portable pipe threading machine literature to make it stand out in the minds of jobbers and consumers alike. The color and layout of the copy, and the size and fold of the paper are important to make the advertising carry punch. Black and red ink on grey paper might be used to harmonize with the actual color of the machine.

The following sales points of the Rotamatic should be included in all advertising copy:

(1) The Name--as being suggestive of a modern, fast, precise machine, and different from existing names.

(2) The Advanced Design--emphasizing speed and ease of operation.

(3) The Improved, Clean-Line Appearance.

(4) The New Mechanical Features--the simplified diehead design, the improved reamer location, the new power cut-off mechanism, the fully automatic chuck, and the flexible carriage arrangement.

For continuing factory-consumer advertising, a file system could be kept for purchasers of the Rotamatic, and convenient operating suggestions and announcements of new designs could be mailed to them periodically.

ROTAMATIC MAINTENANCE AND SERVICE REQUIREMENTS

Lubrication which the Rotamatic requires for ordinary service which can be done by the owner is as follows:

(1) Cut-off mechanism--oil gears once a month

(2) Spindle gear--grease with heavy grease once a month

(3) Front and rear chuck scroll plates and jaws--oil with SAE 10 or 20W oil once a month

(4) Carriage guides--oil with SAE 10 or 20W oil once daily

(5) Spindle bearings--oil with SAE 10 or 20W oil once daily

Miner adjustments which the Rotamatic requires which can be done by the owner are as follows:

(1) Threading mechanism--sharpen chasers when dull, and adjust threading assemblies for exact thread diameter.

(2) Cut-off mechanism--replace cut-off wheel when dull

(3) Reamer--sharpen when dull

(4) Automatic chucking device--adjust rear chuck scroll plate for front jaw wear, adjust brake spring for brake force, and adjust brake linkage for wear of brake lining.

Major servicing such as motor burn-out, carriage guide wear, chuck breakage, threading or cut-off mechanism breakage will require factory or factory supervised servicing.

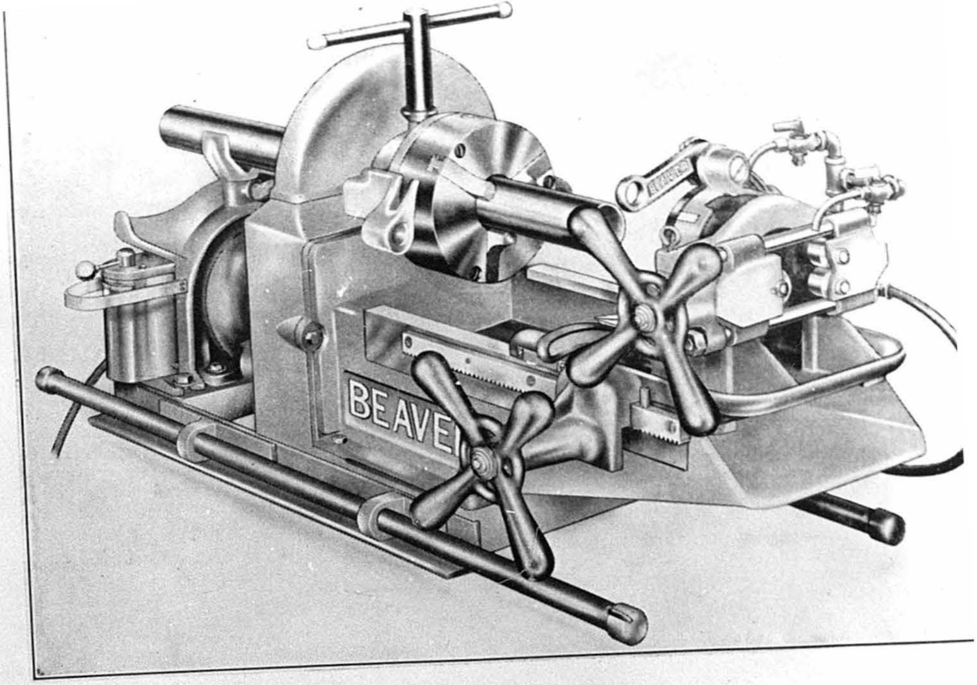
SPECIFICATIONS OF PRESENT-DAY
PORTABLE PIPE THREADING MACHINES

Specification	Am.T'l & Die R-E-H	Beaver Mod. A	Beaver Mod. B	Oster #502	Oster #531-A	Oster #582	Qui'da 3A	Toledo 999	Toledo Hi-Spd
Size - " Length Width Height	 - - -	 - - -	 36 18 $13\frac{1}{2}$	 46 $19\frac{1}{2}$ 18	 40 $20\frac{1}{4}$ 28	 42 21 $24\frac{1}{2}$	 33 12 18	 36 14 20	 45 31 47
Weight - #	-	435	265	375	450	525	185	371	850
Standard Range of Pipe	$\frac{1}{2}$-2	$\frac{1}{2}$-2	$\frac{1}{2}$-2	$\frac{1}{2}$-2	$\frac{1}{2}$-$1\frac{1}{4}$	$\frac{1}{2}$-2	$\frac{1}{2}$-2	$\frac{1}{2}$-2	$\frac{1}{2}$-2
Spindle Speed rpm	trans. 20,35 & 70	37-50	25-36	16-30	60-90	30-50	40-54	-	trans. 40-335
Price $ with 6 dieheads	796	580	520	427	695	698	545	550	1400
Operating time Chucking Threading Reaming Cutting-off (2" pipe in seconds)	Com- plete Opera- tion 100	 - - - -	 - - - -	 10 42 6 15	 5 20 0 --*	 9 27 5 15	 0 19 0 8	 - 22 - 10	 - 15 - 6

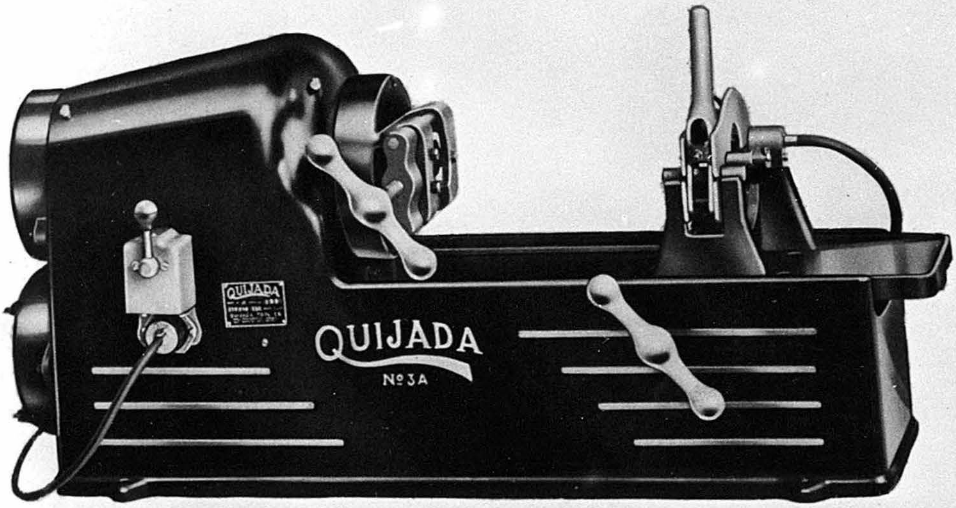
* Machine will not cut-off, times are for $1\frac{1}{4}$" pipe.

\- Indicates lack of data. (All data from company sources.)

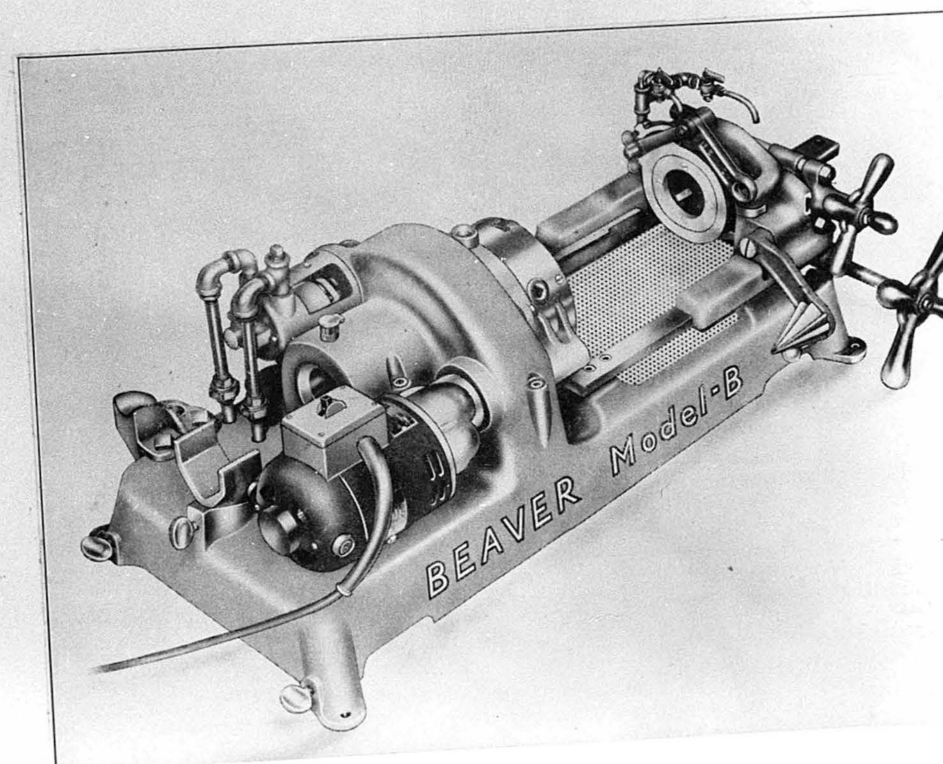
36. BEAVER
MODEL-A

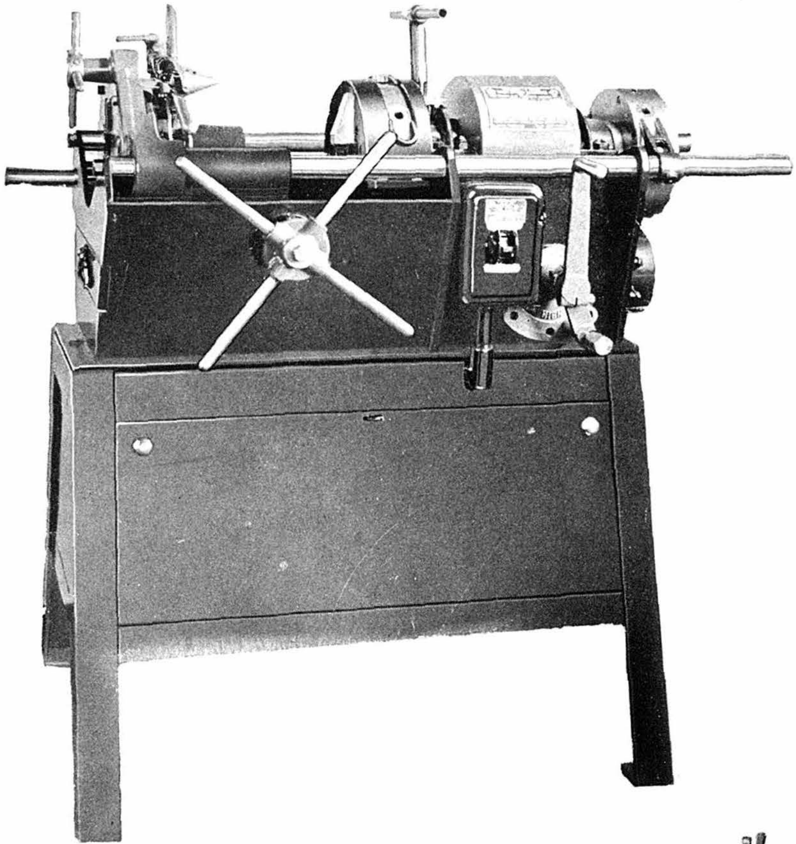


37. QUIJADA
No. 3A

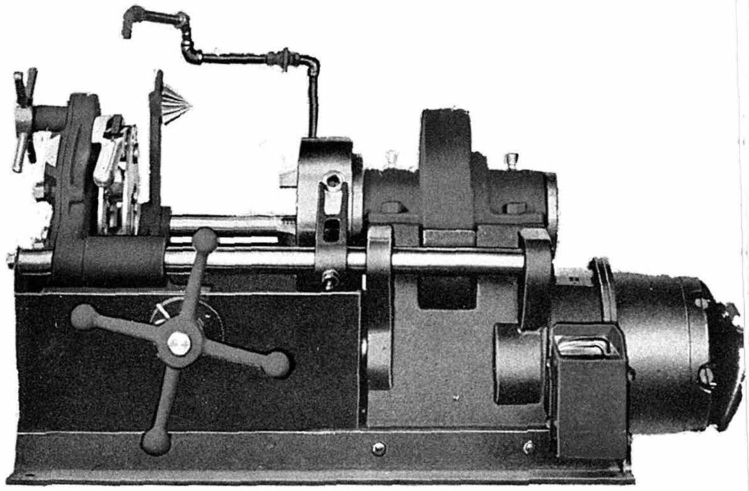


38. BEAVER
MODEL-B

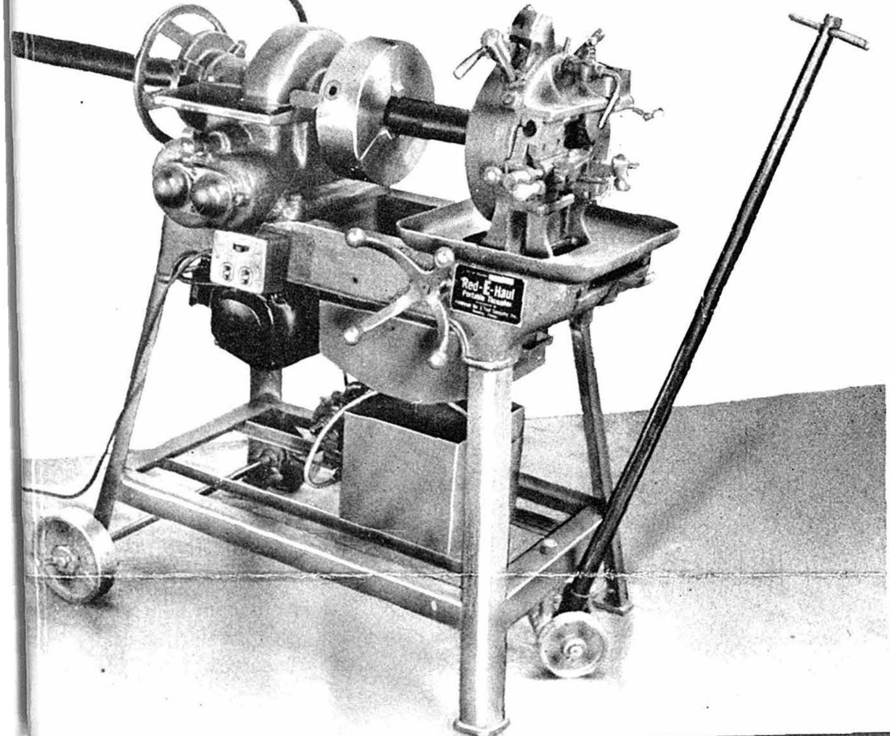




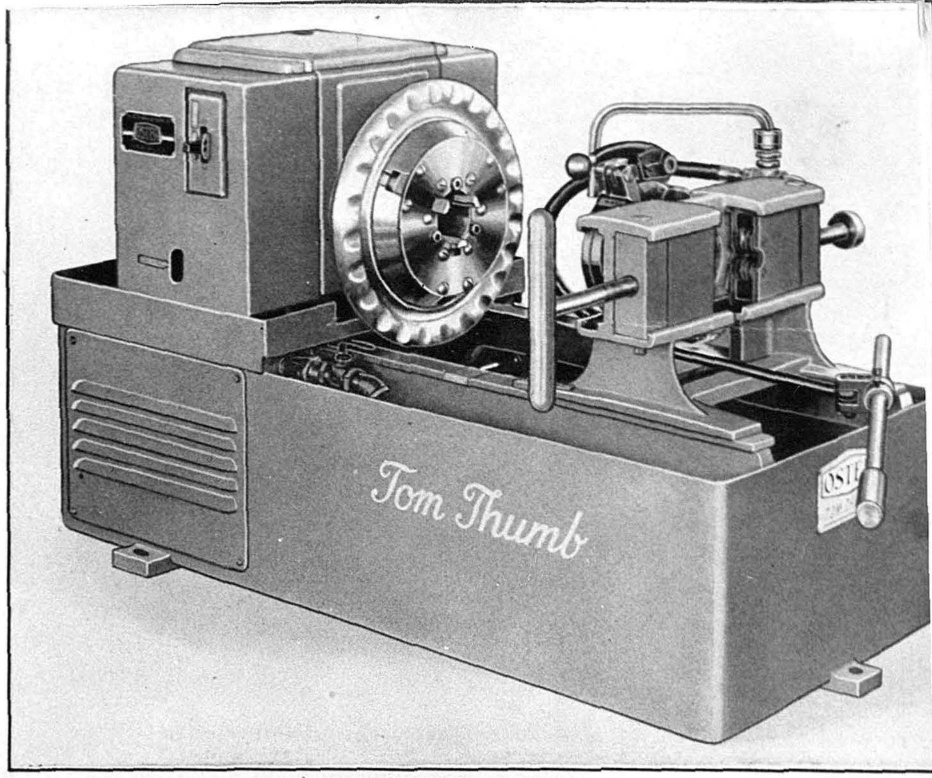
39. TOLEDO
HIGH SPEED



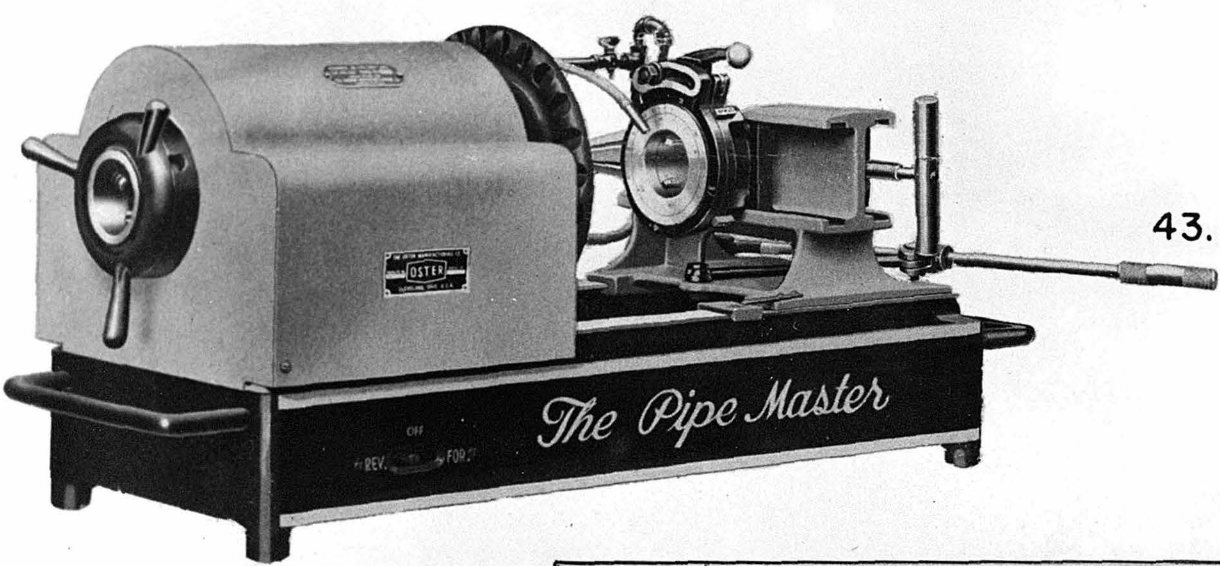
40. TOLEDO
No. 999



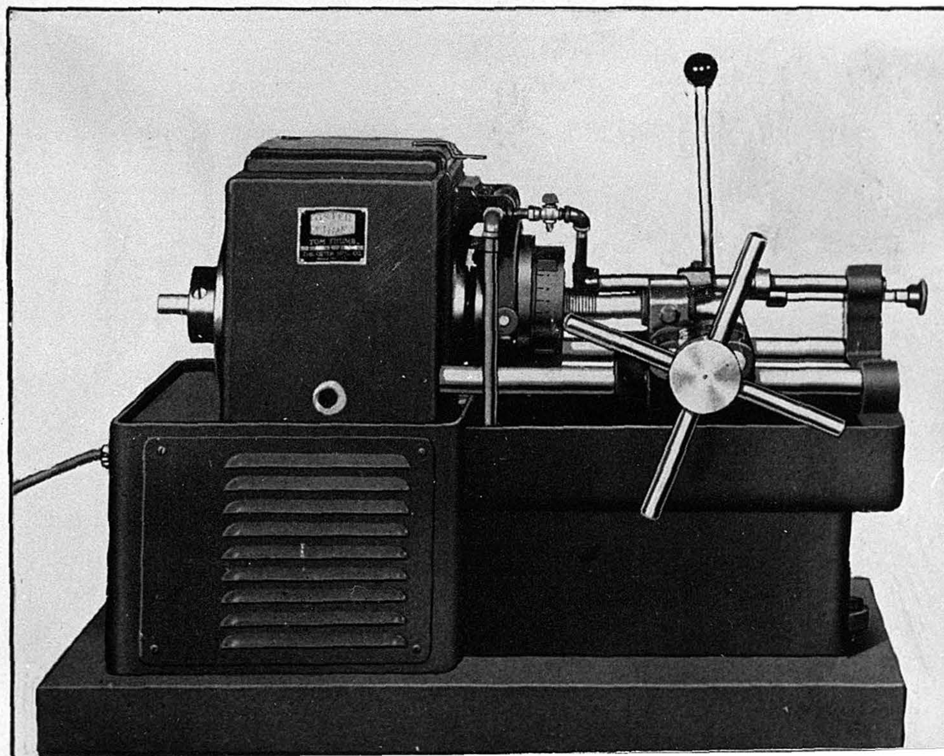
41. RED-E-HAUL



42. OSTER
No. 582



43. OSTER
No. 502



44. OSTER
No. 531A

PIPE THREADING MACHINE PATENTS

Patents of interest in the design of pipe threading machines:

(1) Patent No. 1,199,917 - H. W. Oster, 1916, portable tool turning machine.

(2) Patent No. 1,789,412 - H. W. Oster, 1931, variable speed device.

(3) Patent No. 1,814,675 - F. W. Erikson, 1931, power cutter for round objects using two rotating motors and two routers.

(4) Patent No. 1,883,728 - J. F. Haas, 1932, portable electric-powered self-opening diehead.

(5) Patent No. 1,871,732 - H. M. Olmstead, 1932, adapter for using electric drill for threading.

(6) Patent No. 2,195,578 - A. M. Hexdall, 1940, hand tool which rotates die to thread but rotates pipe to cut-off and ream.

Patents issued and applied for on present portable pipe threading machines:

(1) Beaver Pipe Tools, Inc. Patents issued: perforated removable chip tray; ball-bearing, self-centering wheel and roller cut-off assembly.

(2) The Oster Manufacturing Co. Patent applied for: "Spinfast" wrenchless chuck.

(3) Quijada Tool Co., Patents applied for on entire Model 3A.

SUGGESTIONS FOR FUTURE PORTABLE PIPE THREADING MACHINE DESIGN

Future design of portable pipe threading machines can be divided into three classifications: (1) Rotary-tool machine development, (2) Rotary-pipe machine development, (3) Thread rolling machine development.

The development of a rotary-tool pipe threading machine would progress from the preliminary design studies conducted as a part of this thesis and discussed on pages 30 to 33. A semi-automatic turret machine having carbide tipped tools and enough power to thread in one half to one quarter the present time could conceivably be economical in large contracting shops. On the other hand, light, power-driven hand tools, if cheap and rugged enough, could compete with present day hand tools.

The design of rotary-pipe machines has many aspects which the designer believes need further development. Automatic chucking systems are still in their infancy. It should be possible to develop an automatic chucking system which would not be much more heavy or complex than a present-day universal chuck. A further step in the development of opening dieheads is to mount the reamer so that pressure upon it opens the chasers as is now done on production pipe threading machines. With modifications and simplification, this system could be adapted to portable machines. By the use of carbide tipped chasers and the installation of more powerful,lighter motors present operating speeds can be halved. The cut-off assembly might be power-driven by a lead screw. Some investigation was done on allowing the cut-off tool to toggle into the pipe using the pipe torque to feed it. This method of power feeding the cut-off tool which would eliminate all gear drives would be worthy of further investigation. With the growing availability of light, high-strength alloys a portable pipe threading machine weighing around 100 pounds as fast and durable as any today should soon be commercially practical.

A portable pipe thread-rolling machine might be practical as a very rapid method of threading. A mandrel would have to be inserted inside the pipe to prevent crushing. The development of such a threading machine would involve extensive experimentation.

The goal of all future research and development of portable pipe threading machines will be towards more speed, precision, and flexibility, and less cost, weight, and complexity.

BIBLIOGRAPHY

1. Statistical Abstract of the United States, U.S. Department of Commerce, Number 67, 1946, pp. 811-813

2. Census of U.S. Manufacturers 1939, U.S. Department of Commerce, Vol II, part II, pp. 433

3. M. E. Merchant, "Basic Mechanics of Metal Cutting Process," Journal of Applied Mechanics, Sept. 1944, pp A-168 to A-175

4. M. E. Merchant and N. Zlatin "New Methods of Analysis of Machining Processes," Experimental Stress Analysis, Vol. III, No. 2, 1946

5. S. P. Alim, "Machinability" Engineering Thesis, University of California, 1948

6. Manual of Cutting of Metals, prepared by ASME Committee of Metal Cutting Data, 1939

7. Screw Thread Cutting Manual, The Geometric Tool Co., 1946

8. H. R. Clauser, "Metal Powder Parts Replace Those Produced by Other Methods", Material & Methods, November 1948

9. W. H. Clapp and D. S. Clark, Engineering Materials and Processes, International Textbook Company, Scranton, 1948

10. R. J. Roark, Formulas for Stress and Strain, McGraw-Hill Book Company, New York, 1943

11. C. A. Norman, E.S. Ault, I. F. Zarobsky, Fundamentals of Machine Design, The Macmillan Company, New York, 1938

12. Ben Nash, Developing Marketable Products and Their Packagings, McGraw-Hill Book Company, New York 1945