THE PENNSYLVANIA RAILROAD

LOCOMOTIVE MAINTENANCE INSTRUCTIONS NO. L-59

ISSUED PHILADELPHIA, PA.
AUGUST 1, 1947

Instructions for the Maintenance of American Multiple-Valve Throttles

GENERAL

Since the first steam locomotive was built, a steam dome on the top of the boiler has been used in order to obtain steam as dry as possible. In recent years, however, as locomotive boilers have increased in size, the height of the steam dome has necessarily decreased with the result that the dome is no longer a suitable place for the throttle. Also the introduction of the superheater added considerable steam space between the throttle and the cylinders, resulting in delayed response to the movement of the throttle.

In view of the above, it has been concluded that the smokebox location offers the most advantageous position for the throttle. In addition to eliminating the disadvantages of the dome throttle, the smokebox throttle has the following advantages:

1. Full use of the additional steam space afforded by the superheater header, units, and dry pipe.
2. Instant response of locomotive to movement of the throttle.
3. Availability of superheated steam for the auxiliaries at all times with resultant economy.
4. Protection for the superheater units.

OPERATION

The valves of the American throttle open in sequence. The sequence and the intervals between valve movements are established by the graduated contours of the cams on the camshaft. The main valves, other than the "A" valve, are all identical in construction, but are assigned designations "B", "C", "D", etc., which relate to the position of each valve in the throttle and the sequence in which each valve is set in motion in opening the throttle, see Fig. 1, page 9. The number of main valves varies with the size of the boiler and range from three to seven.

The first movement of the throttle operating lever, from the closed position to the open position, raises the pilot valve and permits steam to pass from the upper chamber of the throttle to the balancing chamber at the bottom. The main valves are then in balance. Further movement of the throttle lever opens the "A" valve, followed at the established intervals, by valves, "B", "C", "D", etc. The flow of steam from the upper chamber to the middle chamber and thence to the steam pipes and cylinders begins at the moment the "A" valve is opened, and increases in volume as the other valves are subsequently set in motion until full throttle opening is attained.

When the throttle lever is moved from the open position to the closed position, the valves will close in reverse order, the pilot valve closing last. As the throttle lever approaches the closed position, the lower side of each cam exerts force upon the bottom portion of the valves and closes each valve tightly. Leakage past the balancing pistons permits escape of the steam from the balancing chamber.

ADJUSTMENT OF THROTTLE RIGGING

Careful adjustment of the throttle rigging is very important and should be made while the locomotive is cold. The following procedure is to be used in the adjustment of the throttle rigging.

1. Remove camshaft crank arm pin and rotate crank arm on the outer end of the camshaft until the bottoms of the cams are in contact with stirrups of the valves.
2. Then, with the cab lever in the closed position, adjust length of the rods so as not to spring the camshaft. The adjustment should assure that the compensating lever will move an equal distance each side of its vertical center line. All lost motion should be removed from the rigging.
3. After the adjustment has been properly made, see that the lock nuts are securely tightened.

CAUSES FOR A HARD WORKING THROTTLE

1. Binding in throttle rigging, due to a misalignment. Throttle connecting rods tight in guides or moving parts of rigging not free to move readily. These faults are corrected by proper adjustment of rigging.
2. Lack of lubrication in the rigging.
3. Packing gland on camshaft drawn up too tight or packing dried out.
4. Excessive end play of camshaft, causing the cams to bind against the valve spindles or stirrups.
5. Incorrect intervals caused by wear of the cams or valves.
6. Excessive clearance between balancing piston and balancing piston guide in throttle.

REMOVAL OF THROTTLE VALVES

Remove the smokebox cover plate and disconnect throttle rod end from the camshaft crank arm. After the throttle has cooled, wash off the top of the throttle box with hot water to remove soot and cinders. Remove the valve covers and gaskets, rotate the camshaft in the direction for opening the valves and lift out the valves. The valve covers should then be replaced temporarily to prevent dirt or other foreign substances from dropping into the throttle.

Before replacing the valves, all scale and accumulation should be cleaned from the throttle box. The valve parts should be thoroughly cleaned and the valves ground to their seats. To replace the valves, rotate the camshaft to the position it occupied when the valves were removed. First apply the pilot valve, then rotate the camshaft sufficiently to permit the application of the "A" valve, which is the nearest main valve to the pilot valve. The remaining valves may now be applied. Before applying the gaskets and covers, operate the camshaft and see that the valves are lifted properly.

REMOVAL OF CAMSHAFT BEARING AND CAMSHAFT

If the camshaft is to be removed, first take out all throttle valves; then take off the camshaft nut and crank arm; and then remove the gas joint packing gland and flange, the steam packing gland and the bearing stud nuts. The exposed portion of the camshaft should be thoroughly cleaned and the bearing removed with the bearing puller, Fig. 2, page 10. The camshaft can now be removed through the hole in the neck of the throttle casting.

RE-APPLYING CAMSHAFT AND BEARING

Before re-applying a camshaft it should be thoroughly cleaned. The ball bearing and adjusting sleeve should likewise be thoroughly cleaned. When the camshaft is inserted, care must be taken that it does not strike and dislodge the camshaft plug bearings in the balancing chamber, and the end of the camshaft must enter the camshaft bushing at the opposite end of the header. The gasket recess in the throttle neck should be clean and, if necessary, should be given a light grinding with a suitable ring grinder. The old gasket should be replaced with a new one, annealed immediately before application.

Camshaft bearing gaskets are furnished with a suitable inside diameter, so that the gasket can be placed on the shoulder of the bearing, after which the bearing and gasket may be brought into position against the throttle neck at the same time.

The camshaft bearing may now be secured in place and the inner camshaft sleeve applied, followed by the ball bearing ring and the outer sleeve, etc. The camshaft nut is then applied and tightened and the glands and gland nuts replaced.

REPACKING STUFFING BOX

If stuffing box gland packing is leaking and leak cannot be eliminated by tightening the gland just enough to allow camshaft to turn freely, apply a new set of packing.

Before applying packing, clean box of old packing, dirt or scale, be sure camshaft packing zone is in good condition and oil hole to lantern gland is free of any obstruction.

The first packing ring should be firmly seated with convex side of ring toward inner end of box and pressure. Each following ring should then be separately compressed into place with the joints staggered. Apply lantern gland after second ring. Seat packing rings with a split metal bushing with inner end beveled to fit back face of packing ring; or a packing tool can be used, with leading edge having proper shape to conform to back face of packing ring. Tighten gland to seat rings firmly and then loosen slightly.

A suitable high temperature lubricant such as Keystone Lubrication Grease No. .007 or equivalent, to be provided to the lantern gland. This is important as it helps to prevent leakage and provides easy throttle operation.

VALVE COVERS AND GASKET SEATS IN HEADER

Main valve covers must not be faced off in a lathe. If bearing surface of cover and gasket recess in throttle header do not present a clean appearance, use a scraper or a lapping tool, Fig. 3, page 10, with a medium grade grinding compound and the handles used to turn it may be reversed, permitting it to be used on either the cover or the gasket recess in the throttle header.

A reamer for cleaning gasket recess in the header is shown in Fig. 4, page 11. The design of this reamer permits its use where one or more gasket recesses require attention. The throttle valve need not be removed and adjacent valve covers may remain in place. This tool can be made up in our shops, or purchased from the American Throttle Company to Piece No. 14263.

The reamer is assembled by first applying the clamping bracket, Ref. 8, Fig. 4, page 11, after which two ¼″ diameter pins are screwed into the clamping bracket. The reamer, Ref. No. 6, and the pilot Ref. No. 7, are then put on over the ¼″ pins. The driving shaft assembly, Ref. No. 5, then goes on over the ¼″ pins. Next, the shaft feed assembly, comprising Ref. Nos. 1, 2, 3 and 4, is applied. The clamping bracket, Ref. No. 8, is lifted by means of the two ¼″ pins, permitting the feed shaft to be locked in place in the clamping bracket, and then nut, Ref. No. 2, is screwed down.

The ¼″ pins are then removed and the tool is ready for use. A wrench with handles at opposite ends should be fitted to the square at the top of the driving shaft assemly, Ref. No. 5. One or two revolutions of the reamer should suffice.

To remove the reamer, first loosen nut, Ref. No. 2, and turn the shaft, Ref. No. 1, in a counter-clockwise direction to disengage the shaft from the clamping bracket. One of the ¼″ pins inserted through the hole in the reamer will prevent the clamping bracket from revolving with the shaft in this step.

When a number of gasket recesses are to be dressed, the 1/4" pins will be unnecessary as the clamping bracket can be reached through the next cover hole.

All valve cover gaskets should be of solid copper, 1/16" thick and properly annealed. Graphite and oil on the valve cover studs will facilitate future removal.

MAIN VALVE SEATS AND PILOT VALVE SEATS

Fig. 7, page 12, illustrates the main valve seats in use and gives the principal dimensions of the seats as well as their position with reference to the header casting. Dimension "E" shows the distance from the valve seat counterbore to the finished top of the throttle box. This dimension should be identical for all valve seats in any throttle. The valve seat counterbores may be reamed, if necessary, to produce this condition, but, in no case should dimension "E" be permitted to exceed the given figure by more than 1/32". When this condition prevails, new seats must be applied.

Replacement valve seats furnished by the manufacturer will be oversize at the point where they are fitted into the header casting. The diameter of the valve seat should be turned to .004" minimum to .006" maximum in excess of the hole in the header casting in order to provide a press fit.

Wear on pilot valve seats should not exceed 1/32".

Fig. 5, page 12, shows a tool for removing pilot valve seats. A similar tool for main valve seats is illustrated in Fig. 6, page 12. Valve seats should be thoroughly soaked with penetrating oil before they are pulled. Light tapping with a hammer may help to break any seal caused by corrosion.

When applying a new seat, the seat should be started into the bore, then forced into place by means of a tool shown in Fig. 9, page 14.

A tool for refinishing main valve seats is shown in Fig. 8, page 13. This tool can be used where one seat or more requires attention. A two-piece top guide is applied in place of the valve cover. Two dowel pins within the guide retain the feed nut. Pressure is maintained by turning the handles at the top of the feed screw and the arbor is turned, using a wrench having handles at opposite ends. The bottom guide shown is suitable for seats used with 3 9/16", 4 1/8" and 4 1/2" valves. One cutter will service 3 9/16" and 4 1/8" valves. A larger cutter is shown for 4 1/2" valves.

CAMSHAFT BEARING PLUGS AND BEARINGS

Fig. 10, page 14, illustrates the present standard camshaft bearing plug assembly used to support the camshaft. The bearing fits into the plug and is easily removed for repairs or replacement without disturbing the plug. After the camshaft is replaced, be sure and check to see that bearings are in place.

It has been found that camshafts supported only at each end will sag and when this occurs the valve lift intervals will be adversely affected. The camshaft bearing plug and bearings should, therefore, be set up so as to support the camshaft and eliminate any sagging. The amount of sag can be determined by carefully measuring the distance from the finished top surface of the throttle box down to the top of the camshaft at each end and also at a point lined up as closely as possible with the bearing plug. These measurements are made through the valve openings. To take up sag, the joint surface "X" on the plug can be machined off to suit, thus permitting the plug bearing surface to be raised the desired amount.

Before making any adjustment to the camshaft bearing plug and plug bearing, the camshaft bushing as shown in Fig. 16, page 17, should be examined for wear. If undue wear is found in the bushing, it should be replaced.

GRINDING VALVES AND CHECKING VALVE INTERVALS

If it is necessary to grind the throttle valves, first remove the smokebox cover plate and disconnect the throttle rod at the camshaft arm. Wash off all deposit, then remove all valve covers and gaskets, rotate the camshaft in the direction for opening the valves, and lift the valves.

Valve intervals should be checked after the valves are ground. Fig. 11, page 14, shows a depth gage with which the valve intervals may be checked as follows:

1. Remove the valve covers and gaskets and disconnect the throttle rod so that the camshaft can be turned by the shaft arm. If necessary, loosen camshaft packing gland so as to permit easy turning of shaft.

2. Place the depth gage above the pilot valve as shown in Fig. 11, page 14, and measure the distance to the top of the pilot valve.

3. Turn the camshaft until the "A" cam is just touching the lifting surface of the "A" valve.

4. Then measure with the depth gage the distance to the top of the open pilot valve. The difference between the first measurement taken and the latter, will be the interval between the pilot and "A" valve. Proceed in the same manner to determine the intervals between the "A", "B", "C", "D", "E", "F" and "G" valves.

To determine the moment the cam touches the lifting surface of the valve, rest the fingers on top of the valve spindle. The slightest pressure of the cam against the lifting shoulder can be detected in this manner.

If the intervals are found not to be correct, attention should be given to the valves, valve seats and cams. Present standard intervals are as follows:

Pilot Valve to "A" Valve—¼"
"A" Valve to "B" Valve—¼"
"B" Valve to "C" Valve—⅛"
"C" Valve to "D" Valve—⅛"
"D" Valve to "E" Valve—0
"E" Valve to "F" Valve—⅛"
"F" Valve to "G" Valve—0

MODIFYING AND MAINTAINING CAM CONTOURS

Fig. 13, page 15, shows the dimensions of the cam contours for locomotives equipped with compensating levers. Fig. 13 also shows the sequence of the cams on the camshaft. When camshafts from these locomotives are repaired, the cam contours should be finished as shown here.

The cam lifting-surfaces should not be permitted to wear in excess of 1/16". When this amount has been exceeded, the cam contour should be built up as described herein by the addition of Haynes-Stellite. Fig. 12, page 14, illustrates the use of a gage for checking cam contours.

Sufficient stellite material must be added to permit finishing the cams to the given contour dimensions. The distance from the top of the cam lifting-surface to the top of the cam neck must also conform to the dimensions shown. If the thickness of the neck on the C, D, E, F and G cams is reduced to less than a minimum of ⅜", it will be satisfactory to build up the lower side of the cam neck by welding with sufficient material to maintain the minimum thickness. Following the application of Haynes Stellite to the cam lifting-surfaces, as shown in Fig. 15, page 16, and as described below, the following steps should be observed:

A. The camshaft must be swung in a lathe and straightened.

B. The excess metal must be removed from the sides and the slot in the cam jaw by grinding. This is done with a thin cutting stone 6" x ½" x 1¼" bore.

C. In the roughing operation, the shaft is set up in a grinder and the desired contour of cams approximately roughed out with a small flat beveled stone 6" x ½" x 1¼" bore.

D. The finishing operation may be done with stones made with grinding surface to conform to cam contours. Such stones can be furnished by the American Throttle Company.

Fig. 14, page 16, illustrates the use of a cam grinding stone used for the finishing operation.

APPLYING STELLITE TO THROTTLE VALVES AND CAMS

Haynes Stellite No. 1 welding rod is a hard metal which will retain its hardness up to a temperature of 1500° F. Referring to Fig. 15, Haynes Stellite No. 1 should be applied as follows:

1. Use an oxyacetylene welding torch. Correct results are obtained by using an excess acetylene flame at all times. The excess bushiness of the flame should be twice as long as the inner sharply defined cone.

2. The surface to be Stellited must be clean. It is preferable to machine face before applying Stellite. The thickness of Stellite to be allowed on finished valve is shown in Fig. 15.

3. Heat the surface of the steel until it begins to sweat cleanly. See note below regarding special procedure to be followed for Stelliting cams.

4. Place Stellite rod into flame and when molten on the point, allow Stellite to flow onto the sweating steel.

5. At all times keep the steel just ahead of the Stellite weld up to a clean sweating condition, and in finishing the weld, carry the heat beyond the junction of the start and finish.

6. Do not allow Stellite to flow onto surface which is not sweating cleanly.

7. If the surface to be welded scales badly from heat and the Stellite will not flow readily onto it, increase the amount of acetylene in the flame. In rare cases the slightest amount of Oxweld Brazo flux will help for this operation.

8. It is important to make weld as smooth as possible to save excess grinding. Stellite can be machined only by use of a Carboloy tool—and then ground to finish.

9. On completion of welding operation, the parts should be ground to dimensions shown in Fig. 15.

10. The following wheels are recommended for grinding Haynes Stellited surfaces:

    Carborundum Co. 46 N Aloxite vitrified
    Detroit—Star 46 M Staralox vitrified
    Norton 46 M Alundum vitrified
    Precision 46 M vitrified
    Sterling 46 M vitrified

Note: Additonal procedure for Stelliting Cams—The thin neck section which joins the cam to the shaft proper should be air cooled to prevent overheating during the Stelliting operation so that maximum hardness and strength may be maintained in this section. To accomplish this, a low-velocity jet of compressed air should be directed against the underside of the cam neck section during the Stelliting operation.

LATERAL ADJUSTMENT OF CAMSHAFT

Fig. 16, page 17, should be followed for the lateral adjustment of camshafts. Use the tool, Fig. 17, page 17, to center the cams and adjust the length of the inner sleeve to equal the distance from the camshaft shoulder to the inner face of the ball bearing (see Fig. 16). The outer sleeve should be of equal length. With all parts of the ball bearing assembly in place there will be no end play.

REPAIRS TO CAMSHAFT (Packing Zone)

If the camshaft becomes corroded or badly pitted in the zone covered by the packing, the shaft must be sent to the Altoona Works for reclamation by the metal spray process, using stainless steel wire.

MAINTENANCE OF VALVES

Pilot Valves

Pilot valves, together with dimensions for their maintenance, are shown in Fig. 18, page 17.

These valves are subject to wear on the surface of the valve face and upon the surface lifted by the cam. The wear on the valve face should not exceed 1/16". Wear in excess of this amount should be replaced as described herein. The diameter of the valve must also be maintained.

Wear on the surface of the valve lifted by the cams should not exceed 1/32" and when worn in excess of that amount, it should be restored by the application of Stellite to a depth of 3/32" as described in Fig. 15.

Main Valves

The "A" valves in use are shown in Fig. 19, page 18. Large main valves are illustrated in Fig. 20, page 19. Dimensions are given with other information for their maintenance.

The permissible limit of wear on the face of these valves is 1/16". Wear in excess of this amount should be replaced as described herein. The diameter of these valves must also be maintained.

Welding Procedure for Repairing Valves

Pilot valves and main valves are alloy steel and the following procedure should be employed in welding:

1. Preheat to 500° F.
2. Arc or gas welding may be used and the following welding rods are recommended:

Arc Welding

Metal and Thermit, "Molex"
General Electric, W-52
A. O. Smith, SW-75

Gas Welding

Air Reduction Co.
"Airco Carbon Moly"

3. Cool slowly after welding.
4. Hold at 1000° F. for at least 30 minutes.
5. Air Cool.

After valves have been welded, they should be refinished to the original dimensions and checked to insure correct alignment.

Wear may also be expected at the point where these valves are lifted by the cam. This wear should not exceed 1/32" and when this figure is exceeded, the worn material should be restored by the application of Stellite.

In the case of the valve design, Fig. 19-C, page 18, and 20-C, page 19, the Stellited lifting surface is applied to a small cylindrical steel insert, which is pressed into the valve stirrup and locked in place by a rivet, as shown. When the Stellite becomes worn 1/32" a new insert should be applied. To remove the worn insert, take out rivet and remove insert, using tool Fig. 25, page 24. After new insert is applied, lock it in position with new rivet.

All large main valve pistons are so dimensioned that the inside diameter of the guide in the header exceeds the outside diameter of the piston by .018" minimum. The same is true of "A" valve pistons when used with 4½" main valves. The maximum allowable difference between the two diameters is .031". On "A" valves, used with 4⅛" main valves, the inside diameter of the guide in the header exceeds the outside diameter of the piston by .058" minimum. In this case the maximum allowable difference in the diameters should not exceed .071".

When the difference of these diameters exceeds the limitations given, due to wear of balancing piston, the piston should be repaired and restored to original diameter. If the difference is due to wear in the piston guide, the guide should be bushed. If the wear cannot be taken care of by either one of these two operations, it will be necessary to restore the pistons to original diameter and also bush the guide. Never increase the diameter of the piston greater than its original dimension.

Fig. 24-A, page 23, shows the manner in which valves (piece Nos. 12154, 12155, 12156, 12157 and 12158) are assembled by means of a welded pin securing the valve body to the balancing piston. Fig. 24-B, page 23, shows the ring lock which retains the valve stirrup ring on these valves.

Fig. 24-C, page 23, shows the valve assembly as used on valves to piece Nos. 13594, 13596, 13597 and 13598. The balancing piston sleeve is attached to the valve body by means of a shrink fit. It has a lip at the top which is rolled over to form an extra interlock with the valve body. To remove a worn sleeve, machine off the rolled lip and heat evenly with a torch until it drops away from valve body. To apply new sleeve, heat to approximately 1200° F., and shrink on to valve body with stirrup in place. Be sure that valve shoulders against sleeve as shown. After shrinking parts together, chuck the assembly in a lathe and roll lip over as shown, using a roller or burnishing tool. Spare sleeves are furnished by the American Throttle Company with the shrink fit diameter finished to the required standard size.

When repairs have to be made to the balancing pistons or stirrups on the foregoing valves, Fig. 24-C should be followed. Replacement parts can be obtained from the American Throttle Company.

Stirrup valves (piece Nos. 7061 and 7056) shown in Fig. 20-A are of an early design and may be repaired by replacing the stirrup, body or balancing piston sleeve.

When balancing pistons, valve bodies or sleeves for any of the above mentioned valves are purchased from the American Throttle Company, these parts will be furnished over-size to permit the assembled valves to be turned in a lathe to the finished dimensions. This will insure the correct alignment of valve and piston.

The balancing pistons of "A" valves and large main valves are manufactured with sleeves and are repaired by applying new sleeves. The method of bushing balancing piston guides is illustrated in Fig. 21, page 20, Fig. 22, page 21, Fig. 23, page 22. Fig. 21 gives dimensions and other data regarding the guide and bushing. The lower ends of the bushings may be flared by using a split tapered plug, which can be expanded by means of a center bolt through the valve opening.

Fig. 22 shows a tool for rough-boring and finishing the guide and for finishing the bushing after its application. The same tool, fitted with a suitable cutter is used for counter-boring the guide.

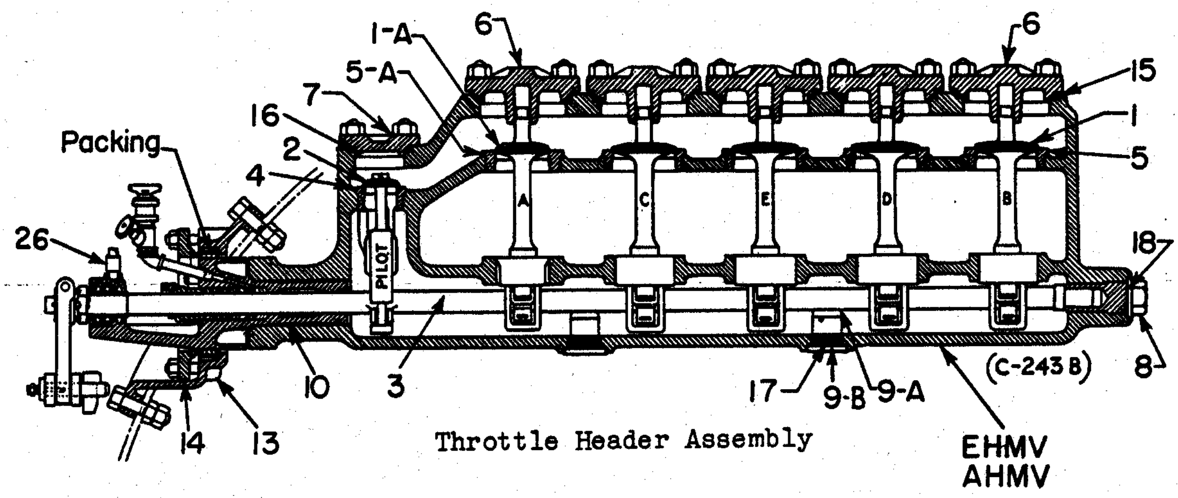
The top guide and feed nut are the same as those used with the Reseating Tool, Fig. 8, and it is similarly applied and operated, except that in this case the arbor is shown with a shank suitable for use with an air motor. A square end can be applied and the tool operated by hand if desired.

A tool for flaring the bushing is shown in Fig. 23, page 22.

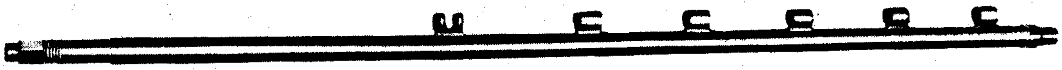
CLEANING OF THROTTLE HEADER ASSEMBLY

In bad water districts one of the most frequent causes of failures of this type of throttle is the accumulation of mud or sediment carried over when the locomotive foams, which prevents the proper functioning of the valves. Therefore, flush out the throttle header at frequent intervals through the throttle washout arrangement as required.

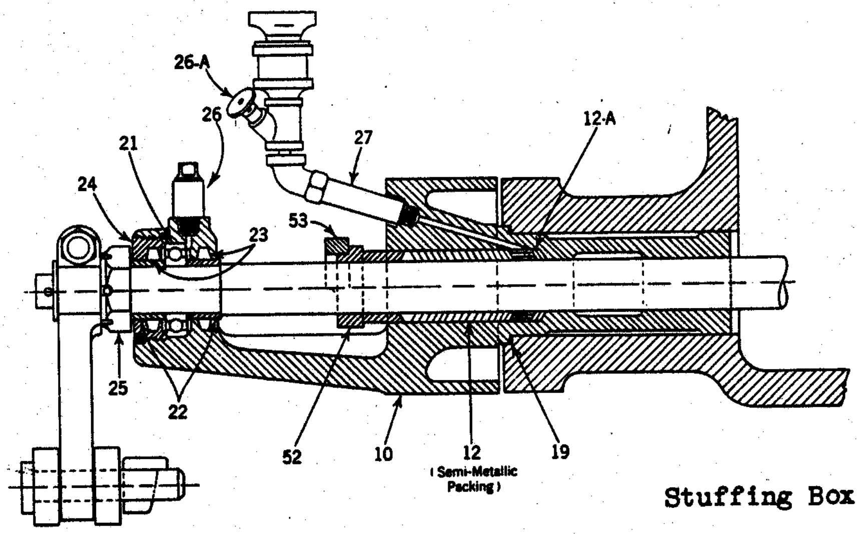
H. T. COVER,
Chief of Motive Power.



Throttle Header Assembly



Camshaft



Stuffing Box

Fig. 1 Throttle Header Assembly, Camshaft and Stuffing Box

REF. NO.	NAME OF PARTS	REF. NO.	NAME OF PARTS
EHMV AHMV	American multiple-valve throttle as an integral part of an Elesco type "A" or type "E" superheater header	12-A 13 14 15 16 17	Lantern Gland Stuffing Box (Gas Joint) Stuffing Box Gland (Gas Joint) Main Valve Cover Gasket Pilot Valve Cover Gasket Camshaft Bearing Plug Gasket
1	Main Valve		
1-A	"A" Valve	18	Camshaft Bushing Gasket
2	Pilot Valve	19	Camshaft Bearing Gasket
3	Camshaft	21	Camshaft Ball Bearing
4	Pilot Valve Seat	22	Camshaft Sleeves
5	Main Valve Seat	23	Camshaft Oil Rings
5-A	"A" Valve Seat	24	Camshaft Ball Bearing Retaining Plug
6	Main Valve Cover		
7	Pilot Valve Cover	25	Camshaft Nut
8	Camshaft Bushing	26	Oil Cup
9-A	Camshaft Plug Bearing	26-A	Lubricator
9-B	Camshaft Bearing Plug	27	Lubricator Extension
10	Camshaft Bearing	52	Stuffing Box Gland (Steam Joint)
12	Stuffing Box Packing (Steam Joint)	53	Stuffing Box Gland Flange

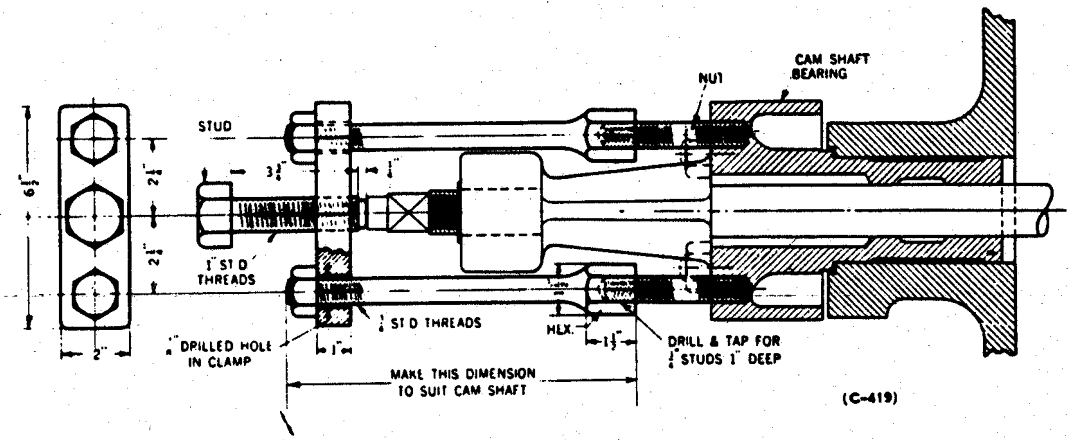


Fig. 2 Jack for Pulling the Camshaft Bearing.

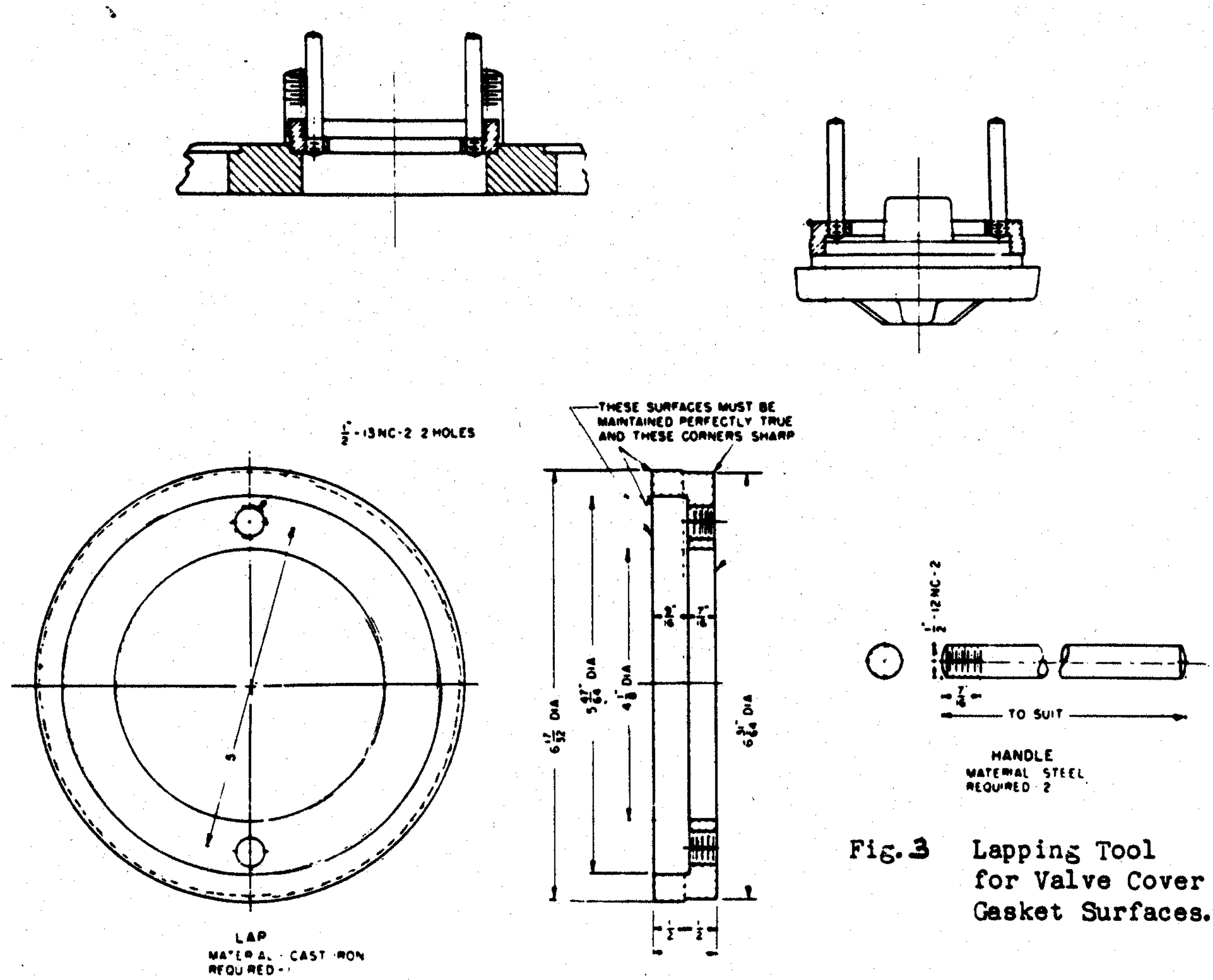
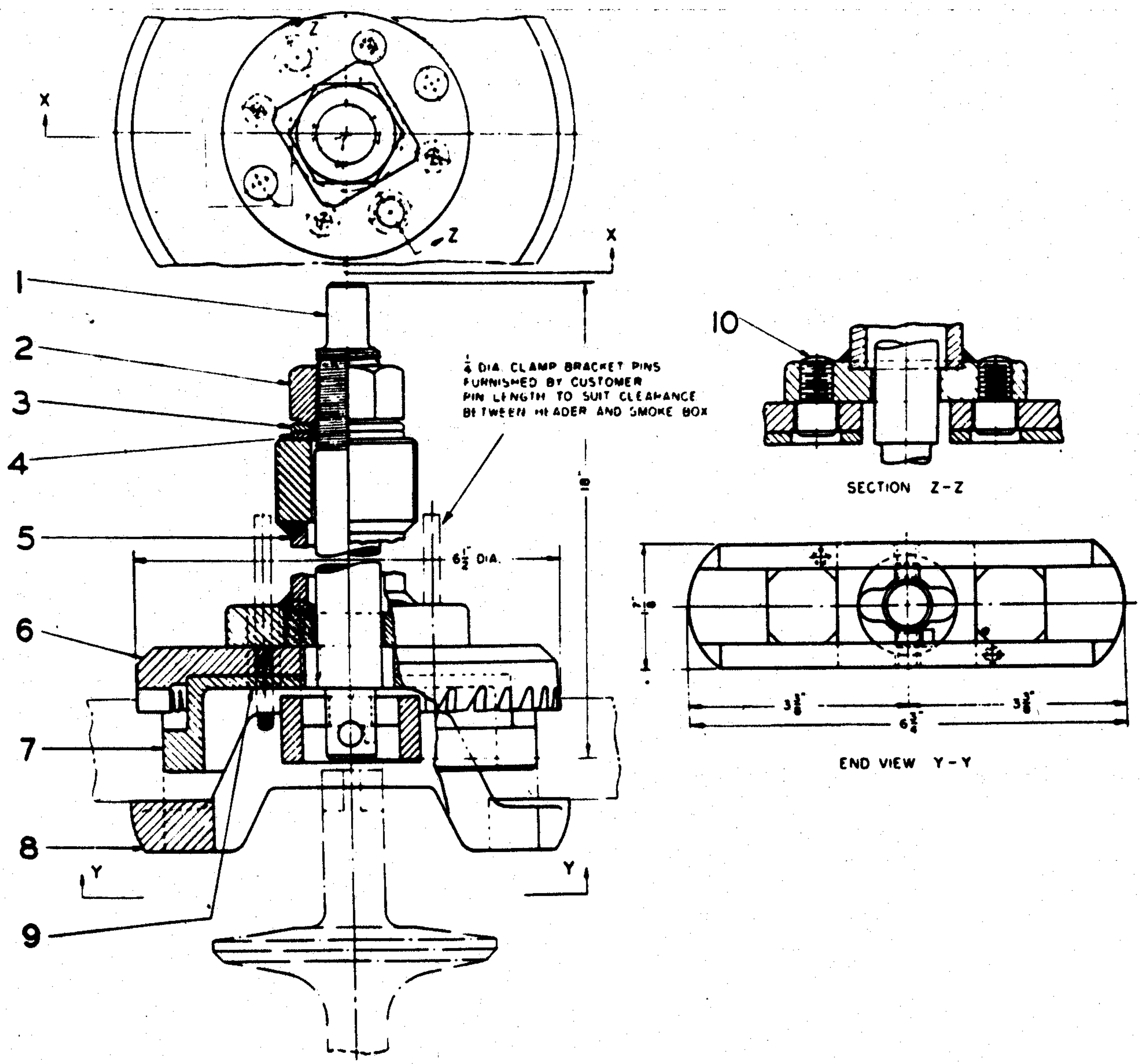


Fig. 3 Lapping Tool for Valve Cover Gasket Surfaces.



SECTION X-X

Fig. 4 Reamer Assembly

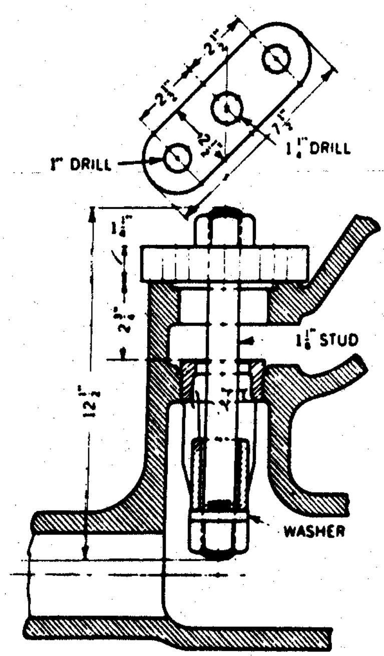


Fig. 5 Pilot Valve Seat Puller

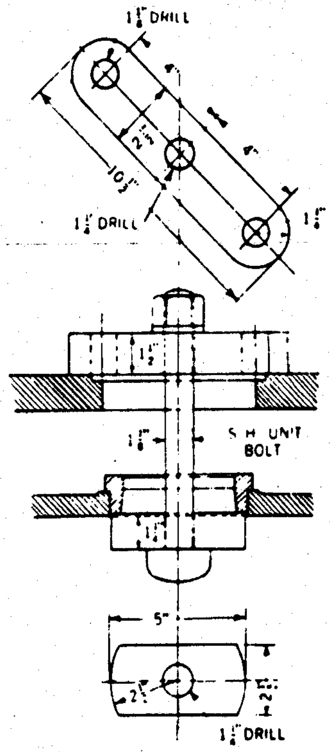


Fig. 6 Main Valve Seat Puller

VALVE SEAT P.C. NO.	A	B	C	D	E	F
7194	3 9/16"	5 1/2"	1/16"	9/16	3 29/32" 5 29/32"	4 13/32" 6 13/32"
7184	4 1/8"	5 1/2"	3/32"	9/16"	3 15/16"	4 13/32"
7911	4 1/2"	5 11/16"	3/32"	9/16"	3 15/16" 5 15/16"	4 13/32" 6 13/32"

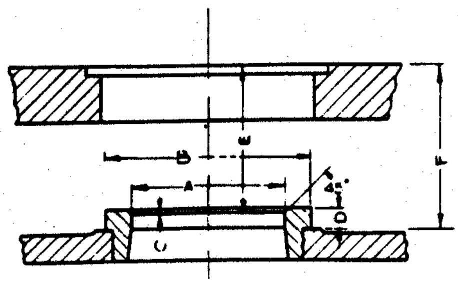
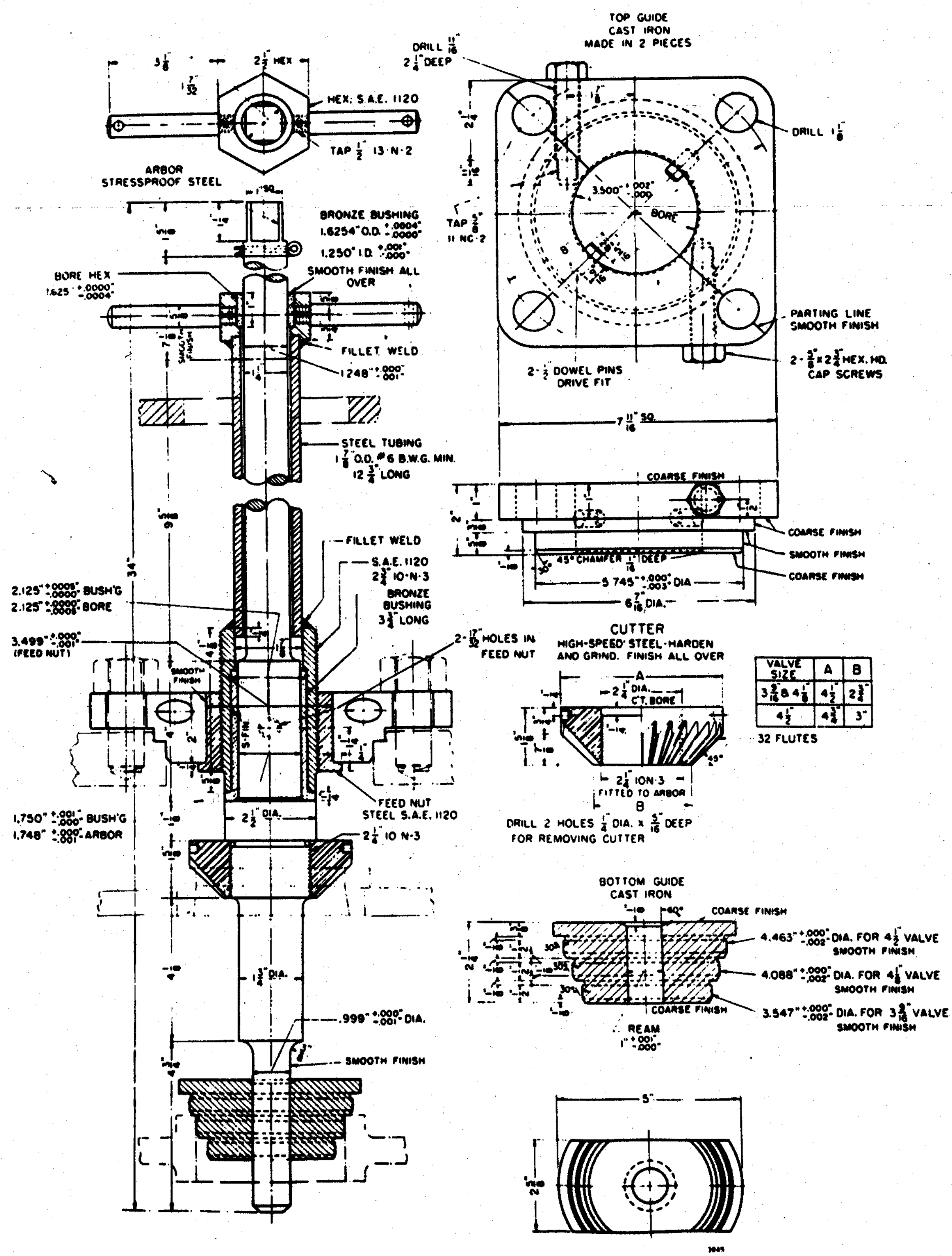


Fig. 7 Main Valve Seat



VALVE SIZE	A	B
3 3/16 & 4 1/8	4 1/2	2 3/4
4 1/2	4 3/4	3"

Fig. 8 Main Valve Reseating Tool

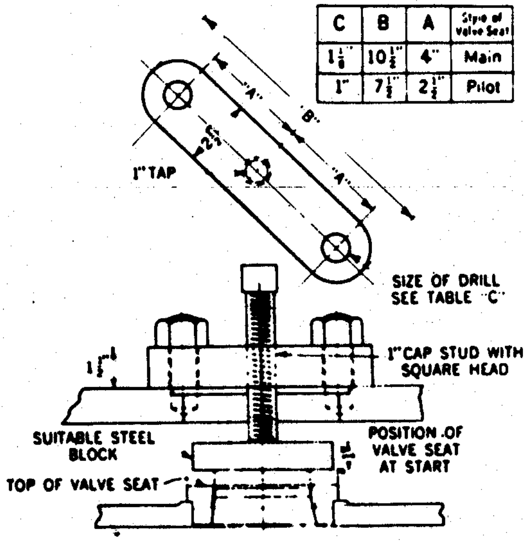


Fig. 9 Tool for Applying Valve Seats

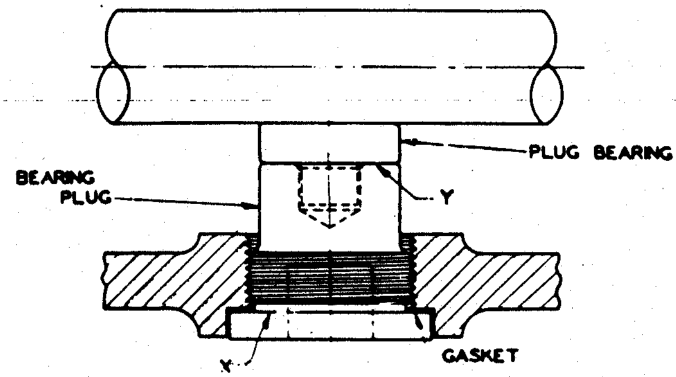


Fig. 10 Camshaft Bearing Plug

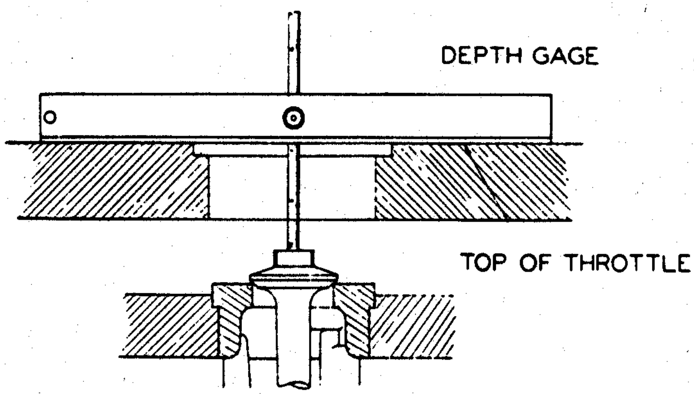


Fig. 11 Gage for Valve Intervals

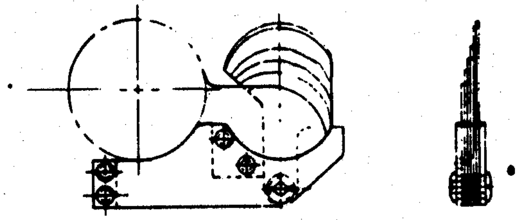


Fig. 12 . Checking Cam Contours with Gage

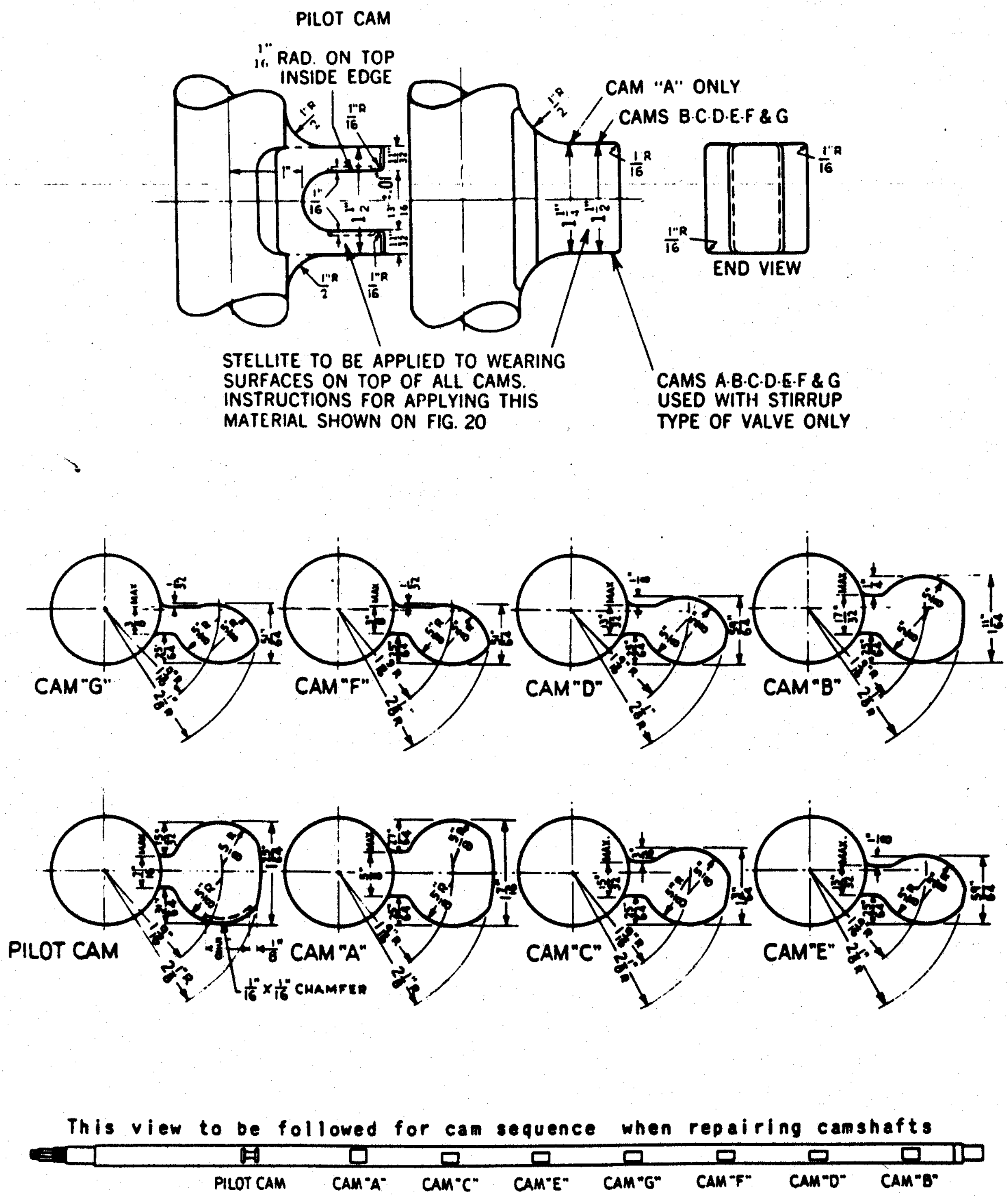


Fig. 13 Throttle Valve Cam Contours

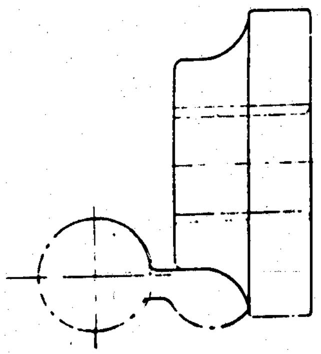


Fig. 14 Grinding Cam Contours with Stone

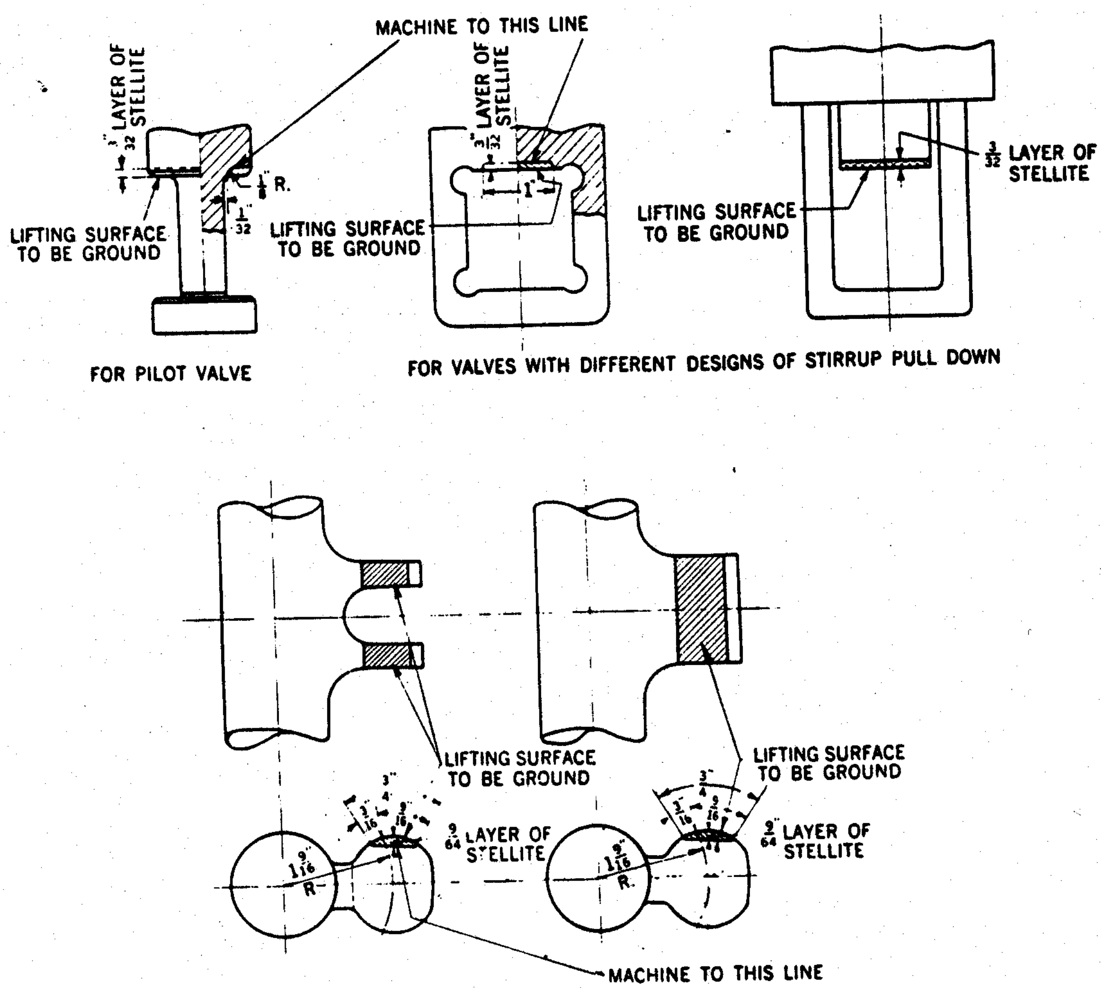


Fig. 15 Method of Applying Stellite to Throttle Valves and Cams

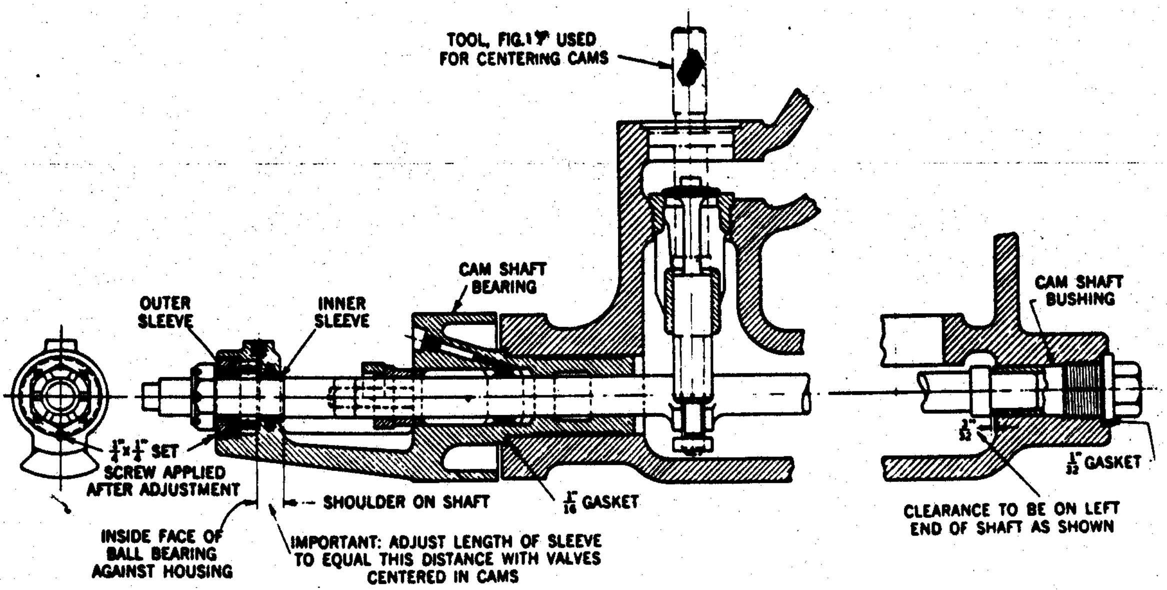


Fig. 16. Lateral Adjustment for Camshaft

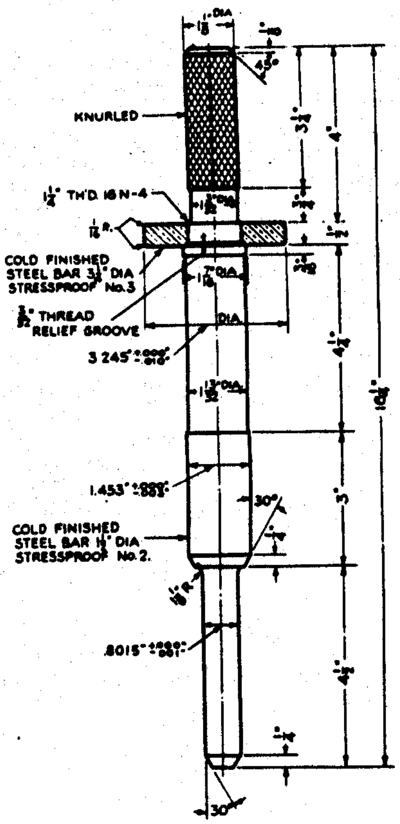
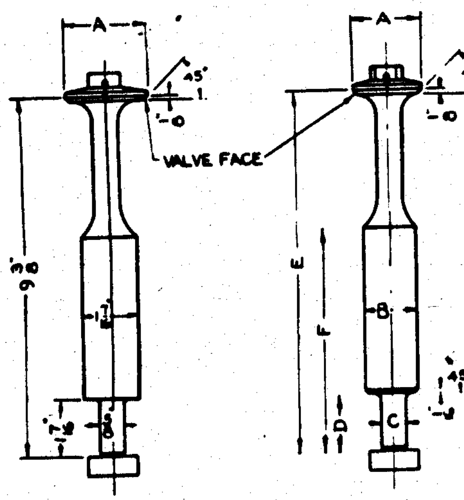


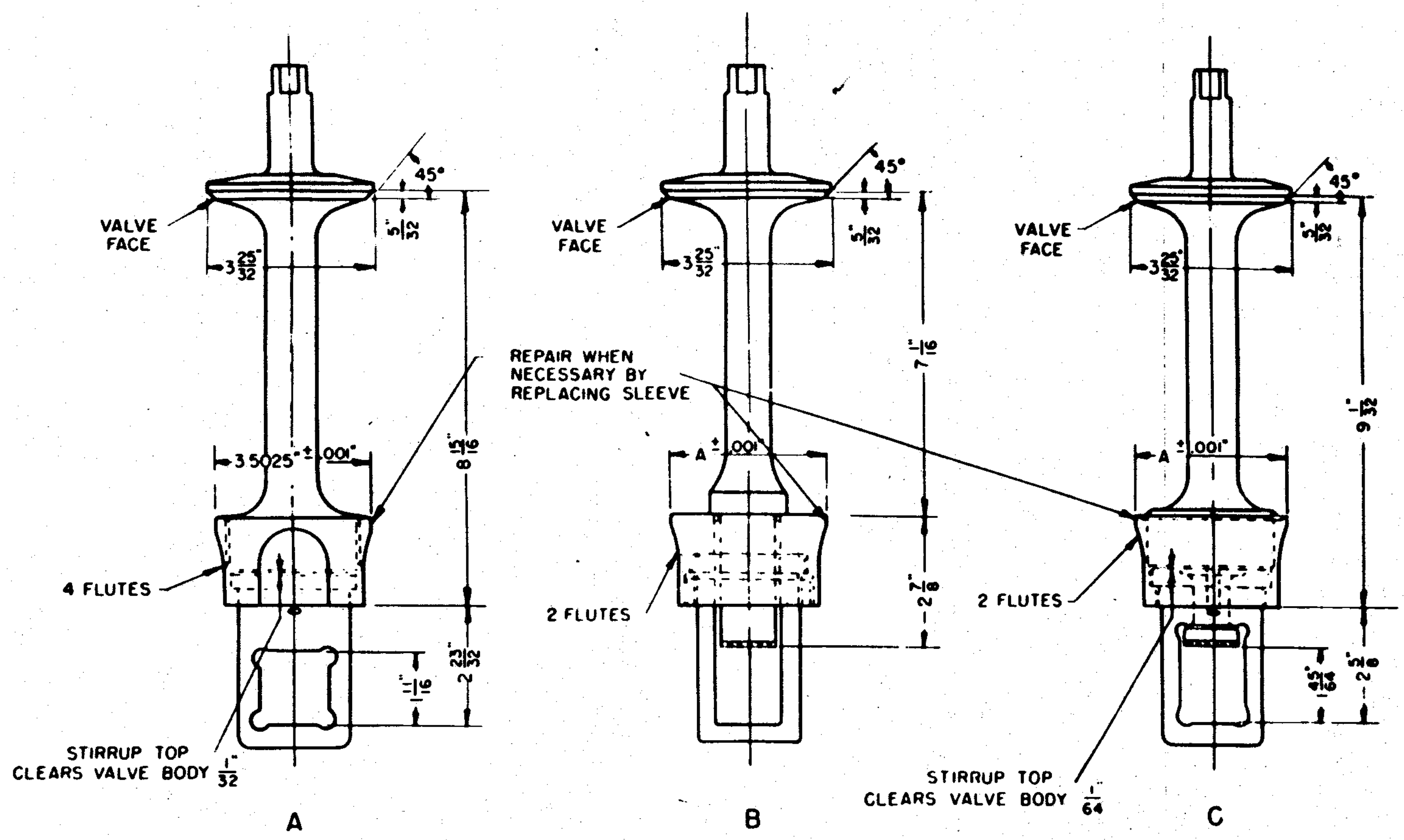
Fig. 17 Camshaft Adjusting Tool



VALVE SIZE	PIECE NO	A
1 5/8"	7907	1 13/16"
2"	7981	2 3/16"

VALVE SIZE	PIECE NO.	A	B	C	D	E	F
1 5/8"	7094	1 13/16"	1 7/16"	5/8"	1 7/16"	9 5/8"	5 3/4"
2"	7095	2 3/16"	1 7/16"	5/8"	1 7/16"	9 5/8"	5 3/4"

Fig. 18 Pilot Valves



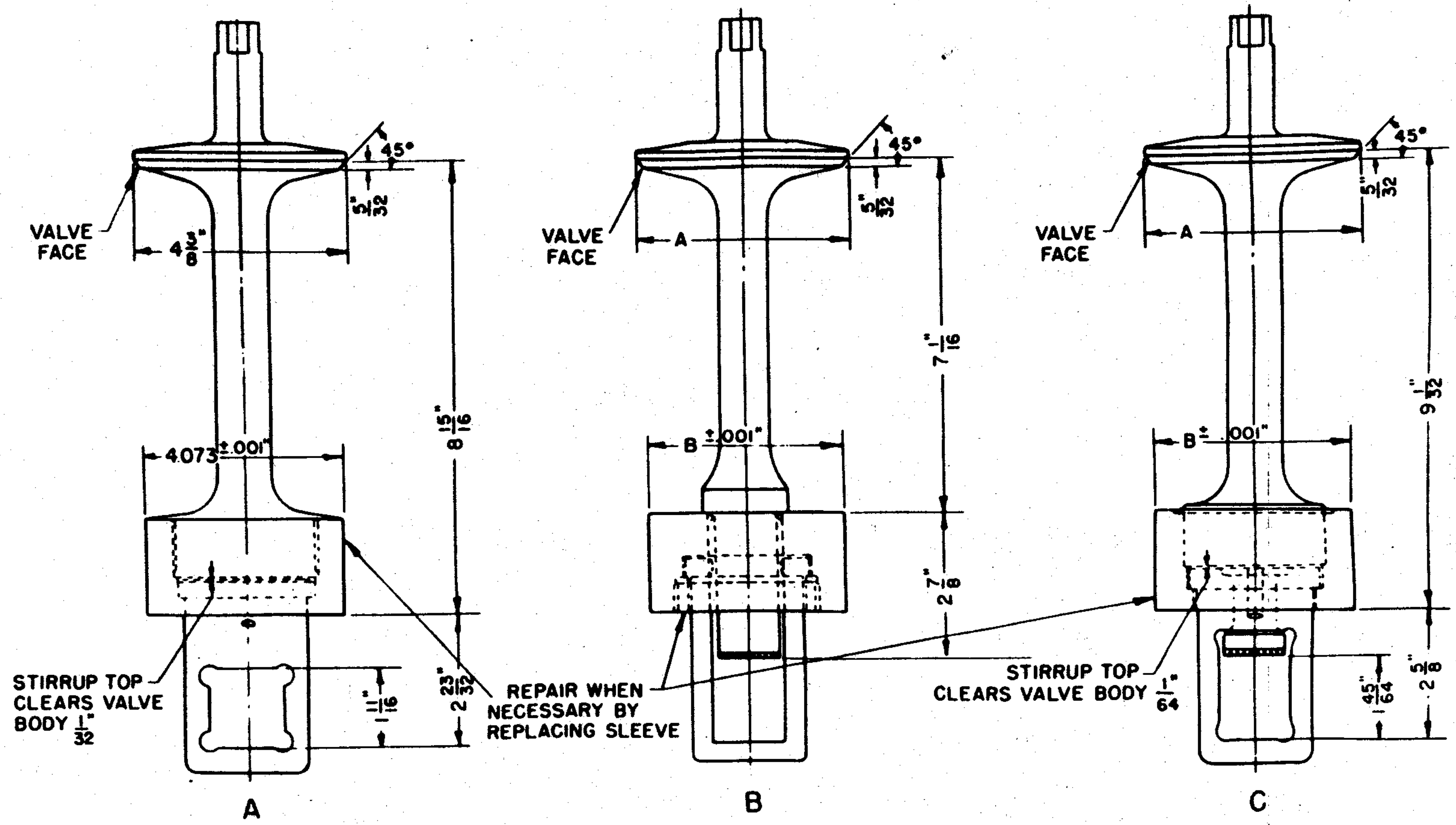
PIECE NUMBER 7061

PIECE NUMBER	A
12157	3.5025"
* 12154	3.5025"
12158	3.5425"

* FURNISHED WITH 4 FLUTES

PIECE NUMBER	A
13597	3.5025"
13598	3.5425"

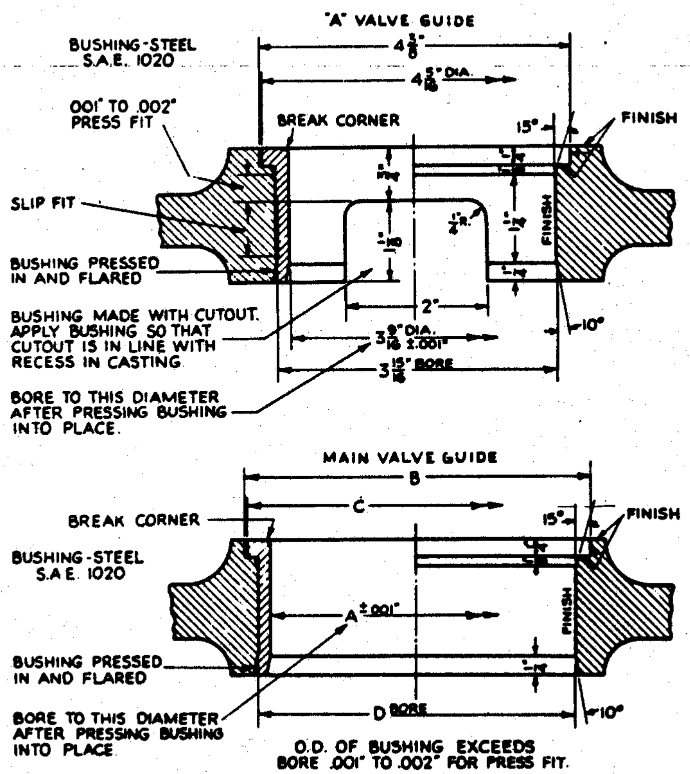
Fig. 19 "A" Valves



VALVE SIZE	PIECE NUMBER	A	B
$4\frac{1}{8}$"	12155	$4\frac{3}{8}$"	4.073"
$4\frac{1}{2}$"	12156	$4\frac{3}{4}$"	4.448"

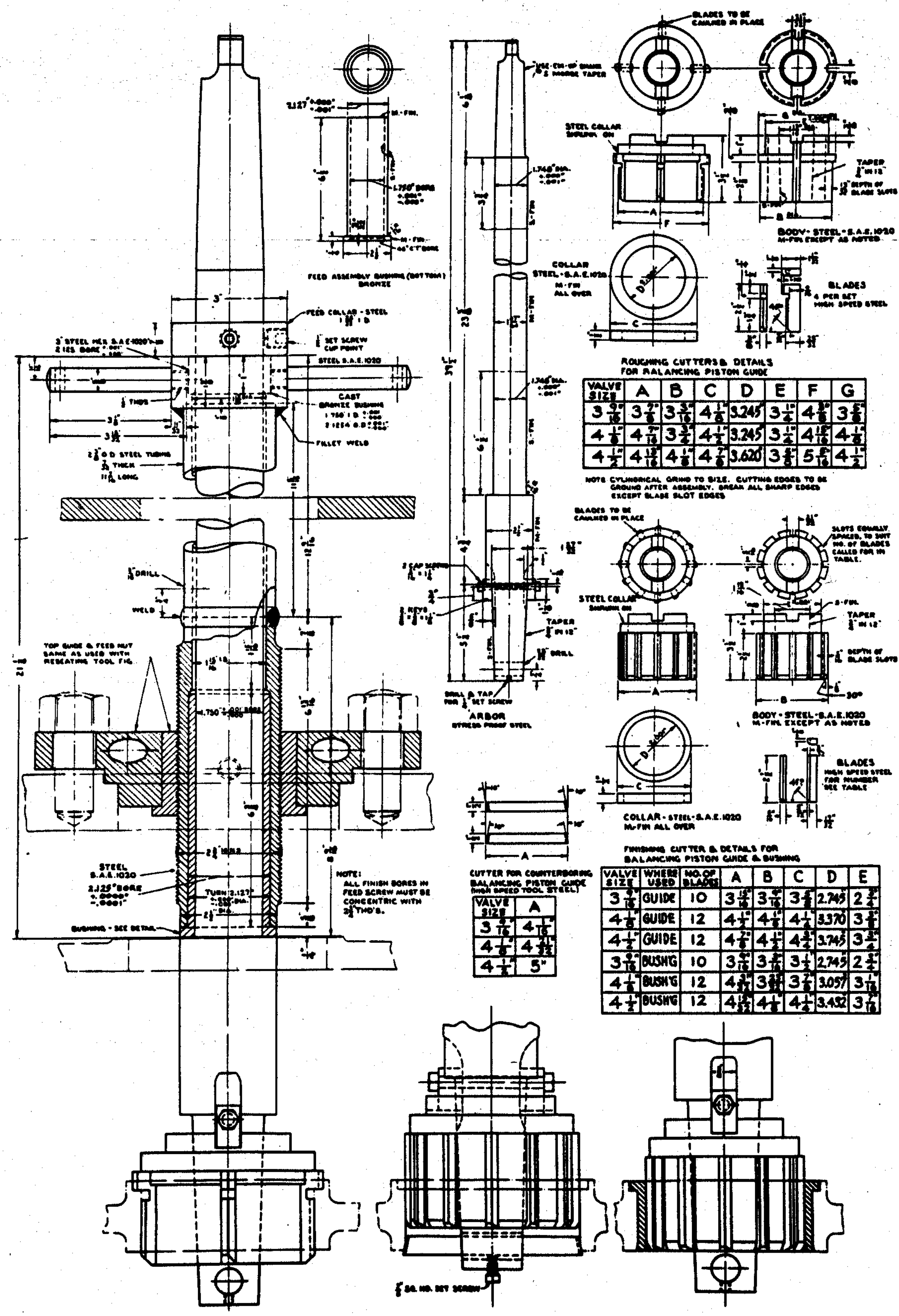
VALVE SIZE	PIECE NUMBER	A	B
$4\frac{1}{8}$"	13594	$4\frac{3}{8}$"	4.073"
$4\frac{1}{2}$"	13596	$4\frac{3}{4}$"	4.448"

Fig. 20 Large Main Valves



A	B	C	D
$4\frac{3}{32}$"	$4\frac{13}{16}$"	$4\frac{7}{8}$"	$4\frac{1}{2}$"
$4\frac{15}{32}$"	$5\frac{5}{16}$"	$5\frac{1}{4}$"	$4\frac{7}{8}$"

Fig.21 Repair of Balancing Piston Guide



ROUGHING CUTTERS & DETAILS FOR BALANCING PISTON GUIDE

VALVE SIZE	A	B	C	D	E	F	G
3 9/16"	3 7/8"	3 3/16"	4 1/8"	3.245"	3 1/4"	4 3/8"	3 5/8"
4 1/8"	4 7/16"	3 3/4"	4 1/2"	3.245"	3 1/4"	4 13/16"	4 1/8"
4 1/2"	4 13/16"	4 1/8"	4 7/8"	3.620"	3 5/8"	5 5/16"	4 1/2"

NOTE CYLINDRICAL GRIND TO SIZE. CUTTING EDGES TO BE GROUND AFTER ASSEMBLY. BREAK ALL SHARP EDGES EXCEPT BLADE SLOT EDGES

CUTTER FOR COUNTERBORING BALANCING PISTON GUIDE (HIGH SPEED TOOL STEEL)

VALVE SIZE	A
3 9/16"	4 1/16"
4 1/8"	4 11/32"
4 1/2"	5"

FINISHING CUTTER & DETAILS FOR BALANCING PISTON GUIDE & BUSHING

VALVE SIZE	WHERE USED	NO. OF BLADES	A	B	C	D	E
3 9/16"	GUIDE	10	3 13/16"	3 9/16"	3 5/8"	2.745"	2 3/4"
4 1/8"	GUIDE	12	4 1/2"	4 1/8"	4 1/4"	3.370"	3 3/8"
4 1/2"	GUIDE	12	4 7/8"	4 1/2"	4 3/4"	3.745"	3 3/4"
3 9/16"	BUSH'G	10	3 9/16"	3 7/16"	3 1/2"	2.745"	2 3/4"
4 1/8"	BUSH'G	12	4 3/32"	[illegible]	3 7/8"	3.057"	3 1/16"
4 1/2"	BUSH'G	12	4 15/32"	4 1/8"	4 1/4"	3.432"	3 7/16"

Fig. 22 Tool for Boring Balancing Piston Guide

K	J	H	G	F	E	D	C	B	A
2 1/2"	3 19/64"	3 19/64"	3 5/8"	3 11/32"	3 7/8"	12 1/2"	22"	10 5/8"	3 15/32"
2 1/2"	3 19/64"	3 19/64"	3 5/8"	3 7/16"	4"	12 1/2"	22"	10 5/8"	3 9/16"
2 1/2"	3 19/64"	3 19/64"	3 5/8"	3 7/16"	4"	14 1/2"	24"	12 11/16"	3 9/16"
2 7/8"	3 3/4"	3 3/4"	3 31/32"	3 13/16"	4 3/8"	12 1/2"	22"	10 5/8"	4"
2 7/8"	3 31/32"	3 31/32"	4 3/16"	3 7/8"	4 1/2"	12 1/2"	22"	10 5/8"	4 3/32"
3 1/2"	4 15/64"	4 15/64"	4 9/16"	4 11/32"	4 7/8"	12 1/2"	22"	10 5/8"	4 15/32"
3 1/2"	4 15/64"	4 15/64"	4 9/16"	4 11/32"	4 7/8"	14 1/2"	24"	12 11/16"	4 15/32"

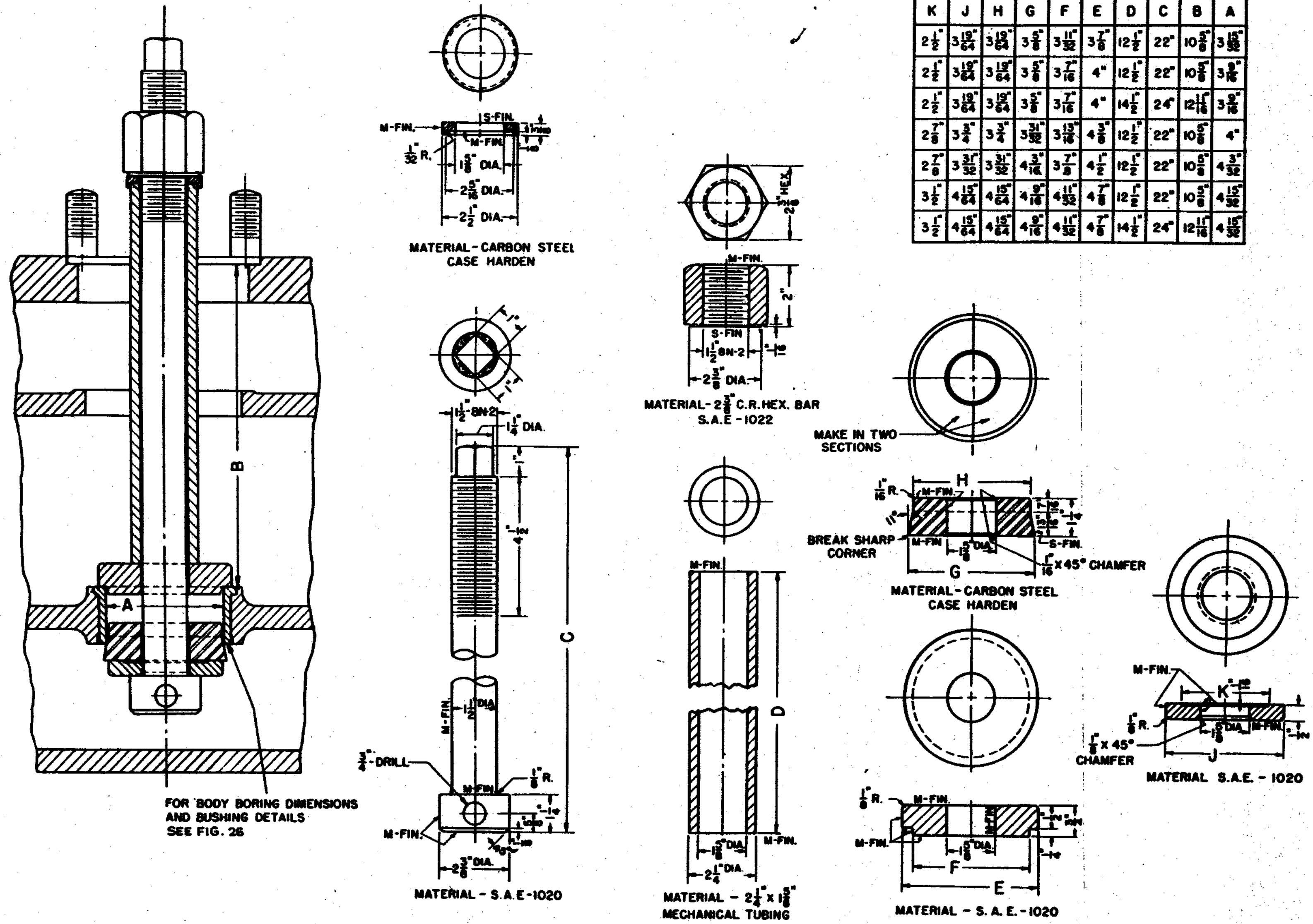


Fig. 23 Flaring Tool for Balancing Chamber Bushing

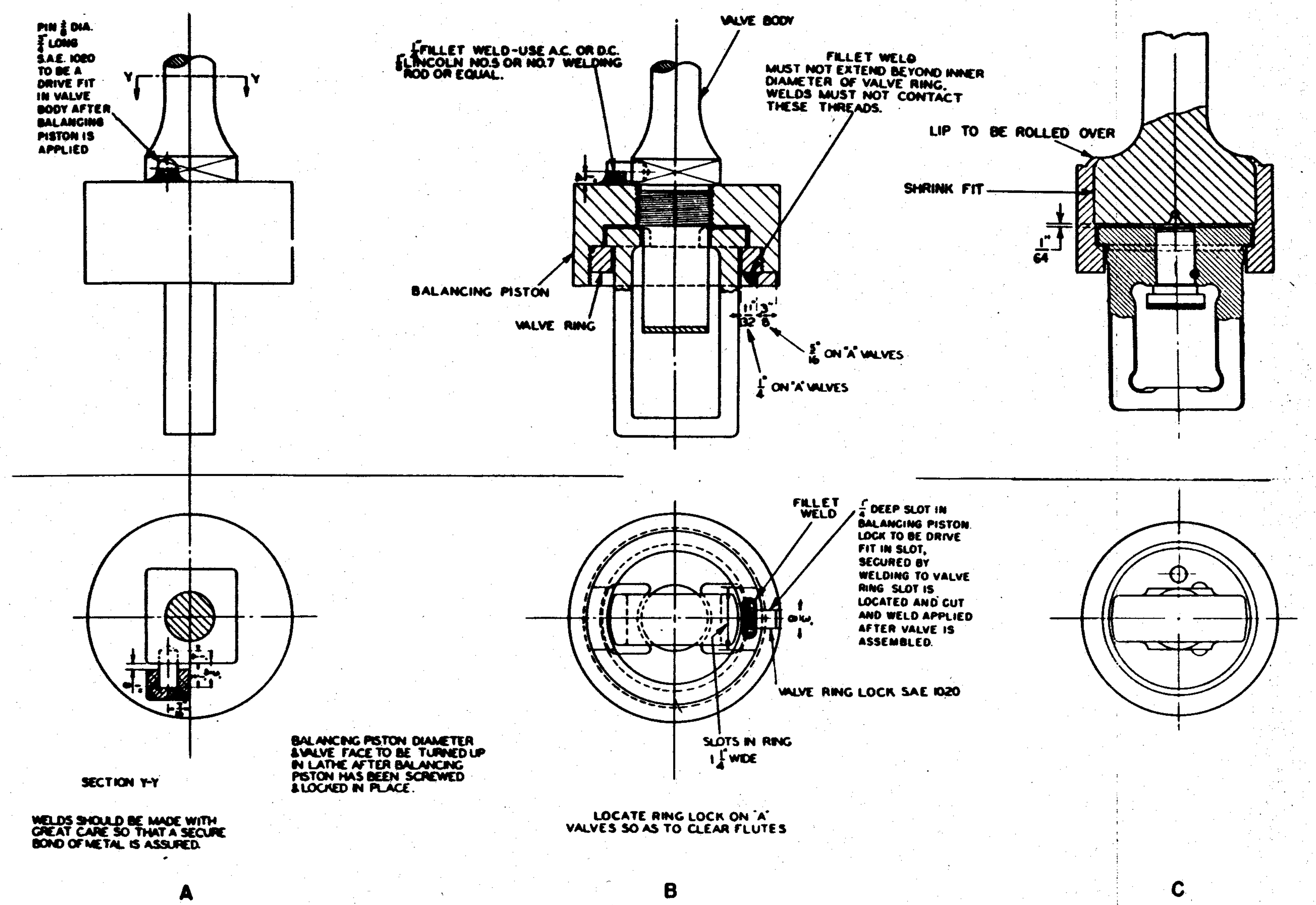


Fig. 24 Stirrup Assembly for Valves

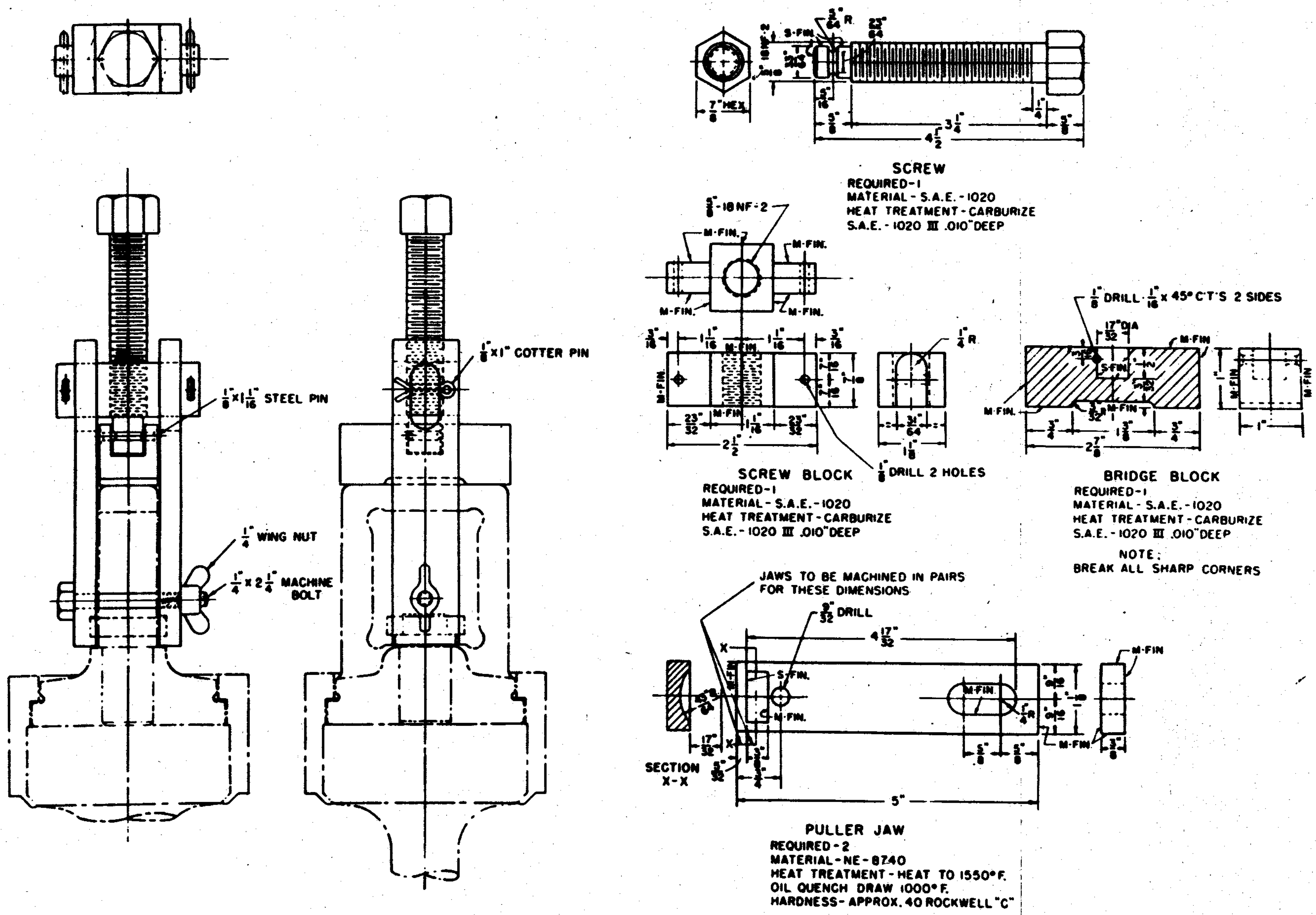


Fig. 25 Throttle Valve Stirrup Pin Puller