TECHNICAL REPORT

TE87-05

Toggle Action Clamps and Their Applications

author

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abstract

A toggle action clamp is a mechanical leverage device that increases a force exerted by human effort, through the effort of oil or air pressure. The leverage ratio can be increased, theoretically to infinity and practically to one hundred times.

index terms

Clamps
Assembly
Die Design
Fabrication
Tool Design

SME

1987

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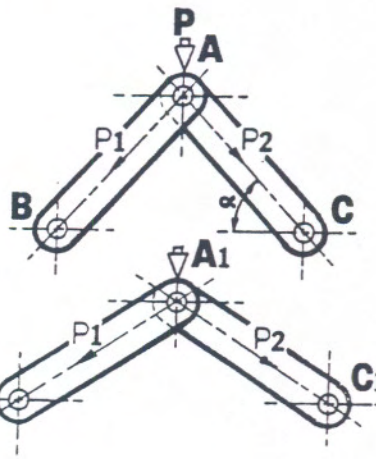
What Is A Toggle Action Clamp

It is a mechanical leverage device that increases a force exerted by human effort or through the effort of oil or air pressure.

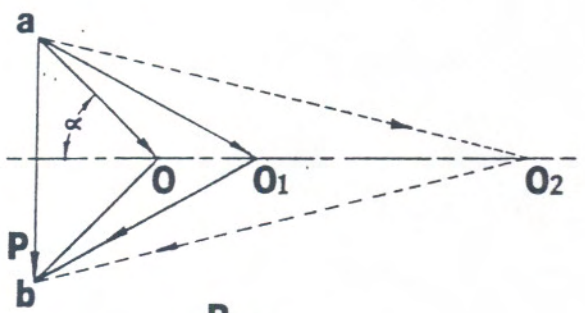
The leverage ratio could go up theoretically to infinity and practically to a hundred times.



HOW TOGGLE ACTION MECHANISM WORKS:

A toggle action mechanism is a two link mechanism that hinges as shown.

When a force (P) is acting at the hinge (A), this force could be analyzed on the two axis (AB & AC) and we get the force (P1 & P2) acting along the two center lines of the two links.



The triangle of force for that link is as shown.

If (C1) becomes a fixed hinge and (B1) a horizontally guided roller, and if we assume that the roller is moving against a horizontal resistance (– P1x).

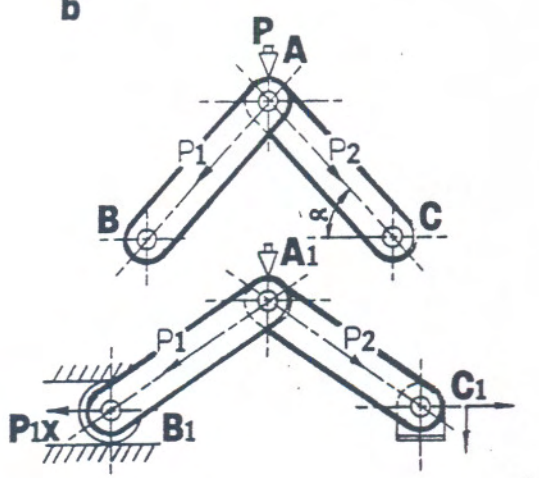
It is clear from the 2nd force triangle that (P1x) is increasing as long as the force (P) is constant and moving down to the flat positions (B2 A2 C2).

At that position, if we remove (P), we get an unstable equilibrium and point (A) tends to regain its upper position or goes to a lower position.

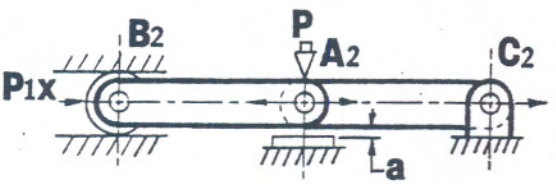
To provide a permanent lock at that position, (A) has to travel down an additional distance (a) and to stop against the locking stop (usually a few thousandths of an inch).

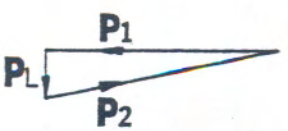
This will create a locking force (PL) and the whole joint is now in a stable equilibrium.

If the clamp should now be de-clamped, another force (PL) acting in opposite directions is able to unlock the clamp.



Plotting the triangle of force of force of Oab, O_1ab and O_2ab, it is clear that with the same force P, the forces P_1 and P_2 increase. And when O is infinity, P and P equal infinity. In practice, the buckling, bending, friction, and deviation of the link provide a determined value of P_1 and P_2.



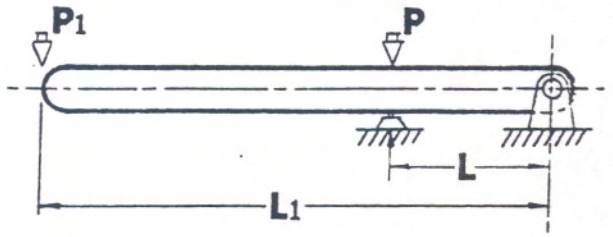


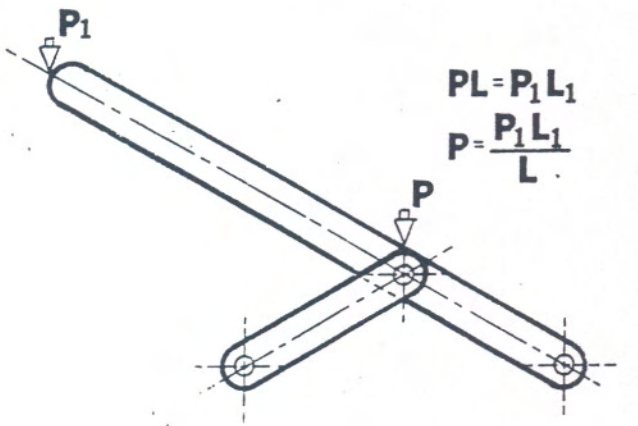
HOW THE CLAMP HANDLE ACTS:

In the illustrated drawing (P1) acting at the edge of the hinged lever at (a) the reaction (P) at (b) is equal.

$$P = P1 \times \frac{L1}{L}$$

That means, besides the toggle action multiplication of force, we are still able to increase the mechanical effort applied by means of the clamp handle.





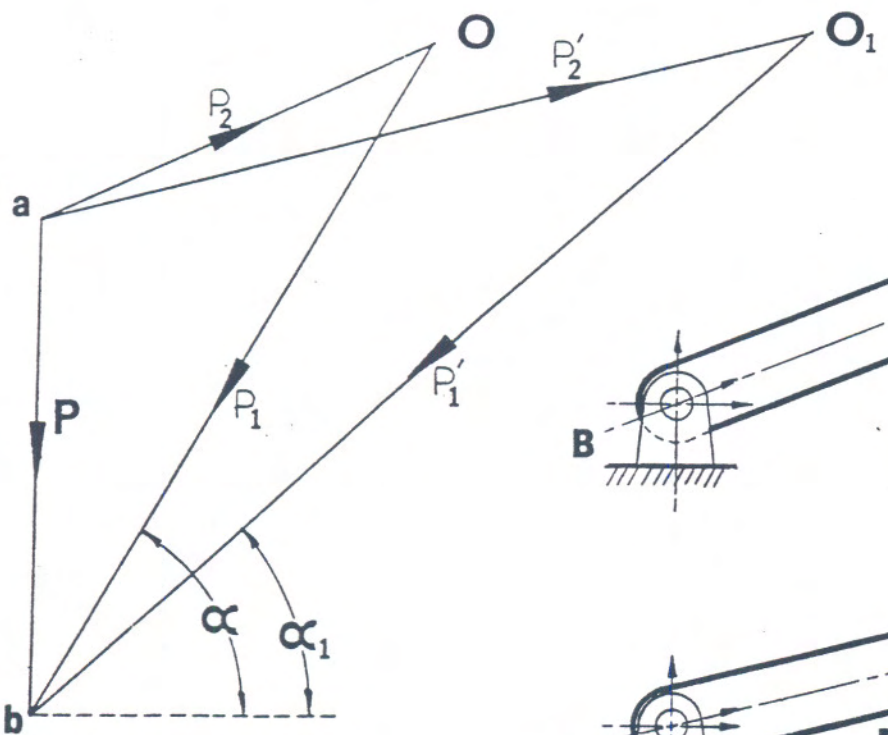
REVERSED TOGGLE ACTION:

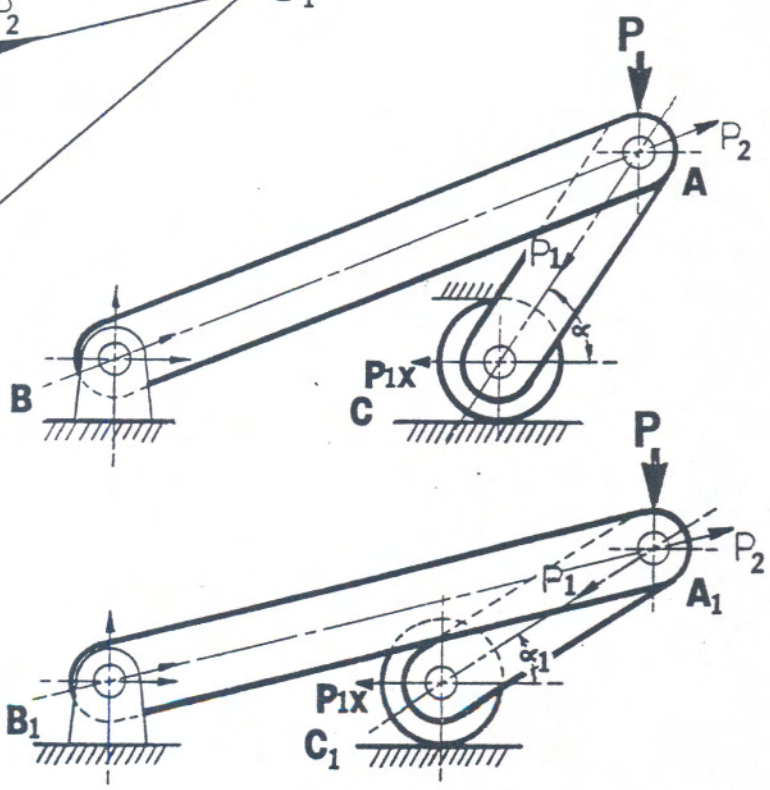
In this case the two links are not equal and the distance between (B) and (C) is smaller as shown.

The triangle of force becomes (abo).

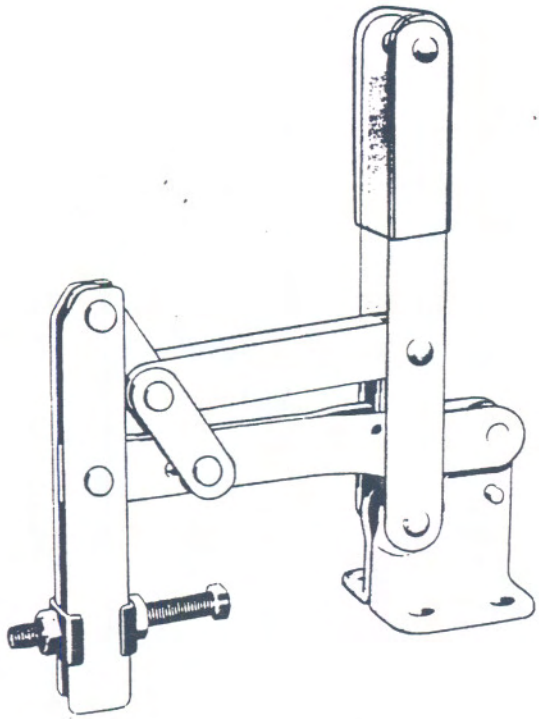
If the angle (CC) becomes smaller and keeping the action and the magnitude of force (P), the same, the triangle becomes (abo_1) with the result of increasing ($P1x_1$) as shown.

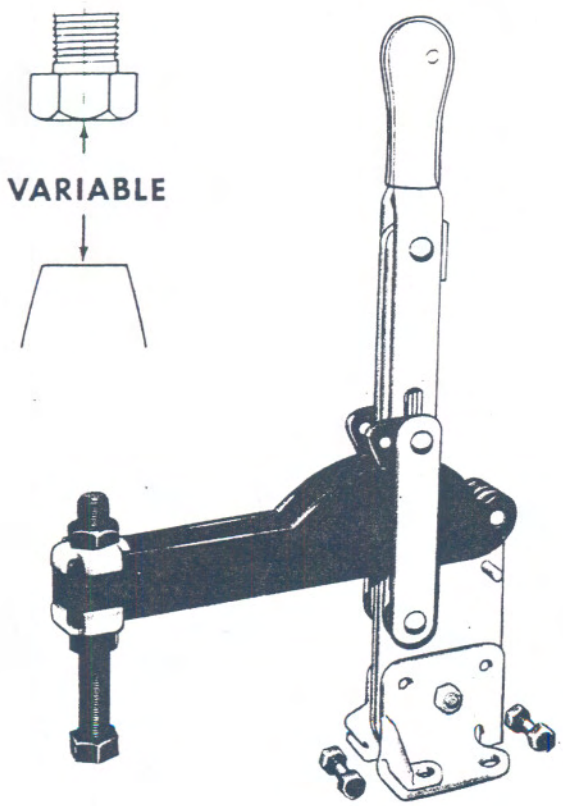
When (CC ⟶) zero "0" goes to infinity and this increases the force P1x theoretically to infinity.





The most important feature of the Toggle Action Clamps





We can summarize the most important features of toggle action clamps as follows:

(1) Very high ratio of leverage not existing in cam, lever, screws, wrench, etc.

(2) It is very fast.

(3) It has a very good and secure method of locking which may hold as long as it is needed without additional human effort or pressure.

(4) It is simple, easy to get, and to maintain.

(5) As it is made in volume, therefore it is inexpensive.

(6) It has its handle, mounting base and holes incorporated into it.

(7) It has an adjustable spindle to take care of wear and can be adjusted accordingly.

(8) The designer has a very wide selection to fit any profile, any capacity or to fit any application.

(9) Air Clamps are essential for automation and for mass production.

(10) Toggle Action Clamps could be used as:
- a) Locators (Page 17)
- b) Ejectors (Page 18)
- c) Centralizers (Page 19)
- d) Balancers (Page 20)
- e) Equalizer (Page 19)

(11) Toggle Action Clamps' mechanism has a wide range of applications and configurations.

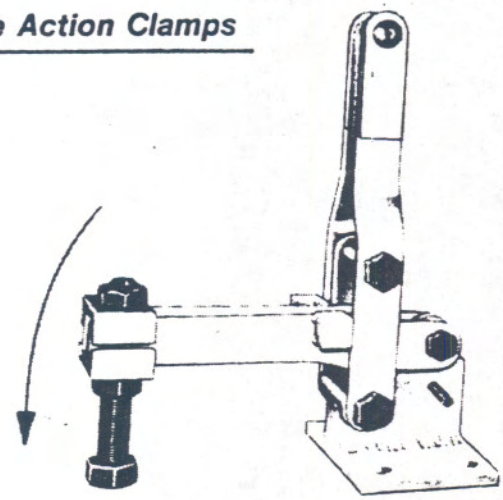
(12) Toggle Action Clamps replace various clamping methods such as screw and cams effectively and economically.

(13) No limits of application and use (see applications pages 18 to 35).

The Various Shapes & Forms of Toggle Action Clamps

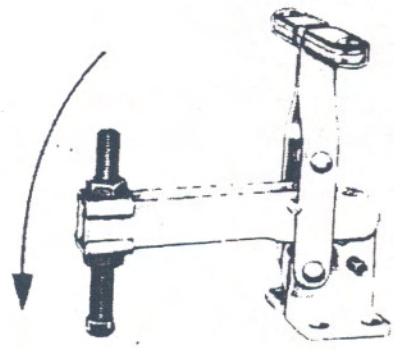
1 VERTICAL HANDLE

The Vertical Hand Clamp is the most common clamp for easy grip and hold down workpieces.



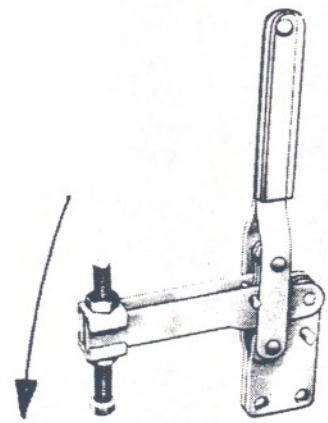
2 T-HANDLE

The T-Handle Toggle Action Clamp is used for low overall height in order to give a low profile.



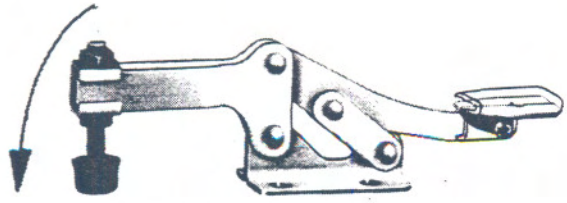
3 SIDE MOUNT

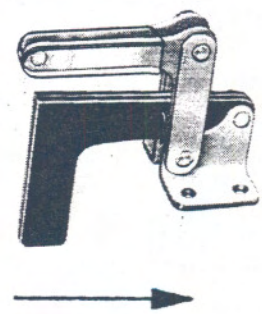
The Side Mount Clamp is a Vertical or Horizontal Clamp to be fitted on the sides, when there is no room for the ordinary flanged base.



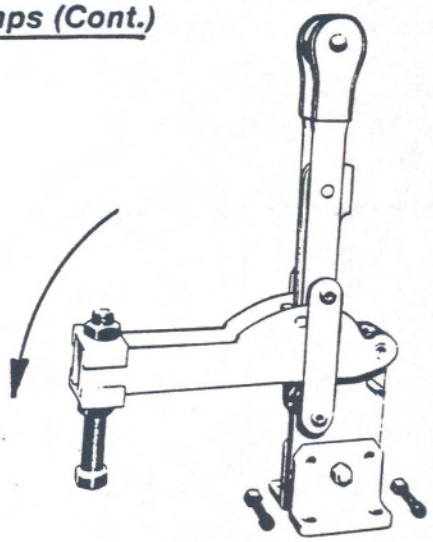
4 HORIZONTAL HANDLE

Horizontal Handle Clamps are Low Profile Clamps.





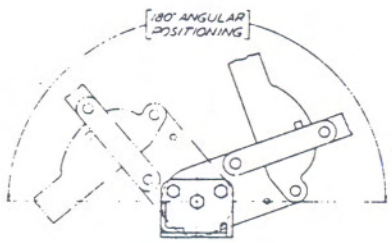
The Various Shapes & Forms of Toggle Action Clamps (Cont.)

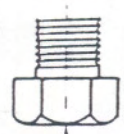


5 SIDE MOUNT & SWIVEL BASE

Use:I:As side mount clamps, when base is removed.

Use:II:With the base positioned, the swivel plate permits ANGULAR location of the toggle bar within 180 DEGREES, the swivel plate is then permanently held by installation of two bolts.





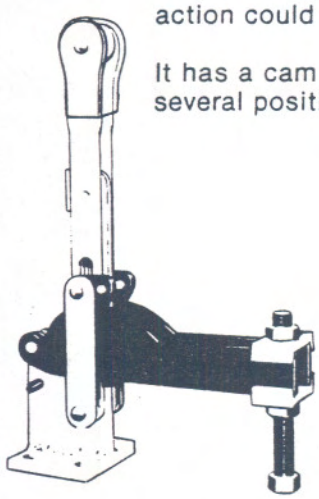
This series has been designed to COMPENSATE FOR VARIATION IN THICKNESS in parts to be held.

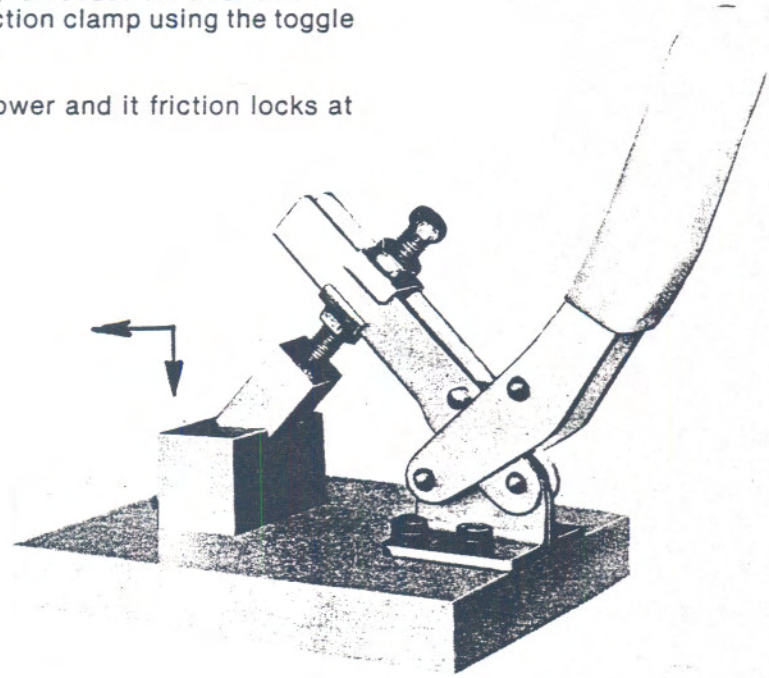
6 *THE CAM ACTION CLAMP:*

The ordinary toggle action clamp does not permit much variation at its locking position.

Therefore, if clamping is needed for a variation of thicknesses, a cam action clamp using the toggle action could be used.

It has a cam and follower and it friction locks at several positions.





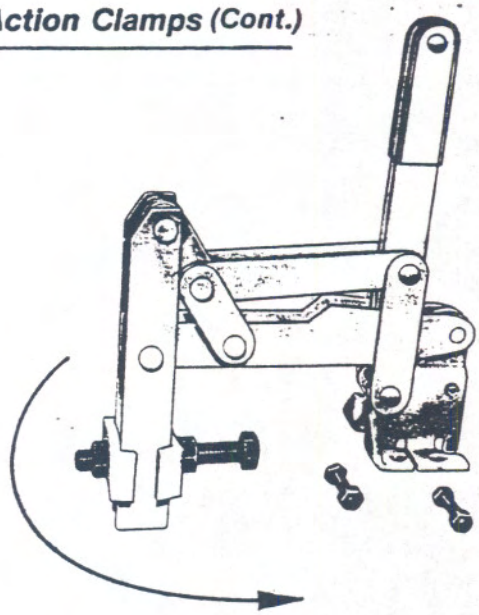
7 J-TYPE

It is 2 Clamps in one to exert 2 perpendicular forces for a fast and easy clamping.

The Various Shapes & Forms of Toggle Action Clamps (Cont.)

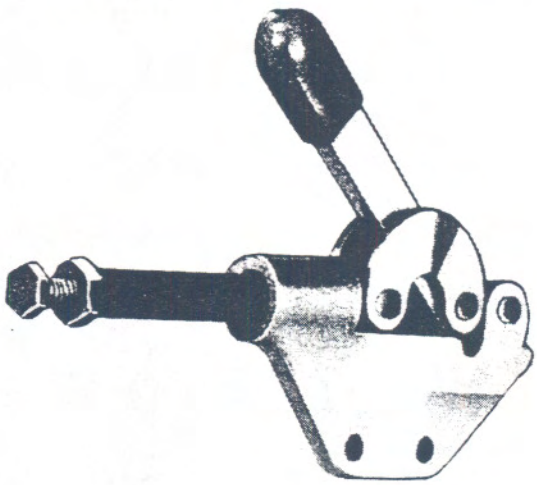
8 DOUBLE TOGGLE ACTION CLAMP:

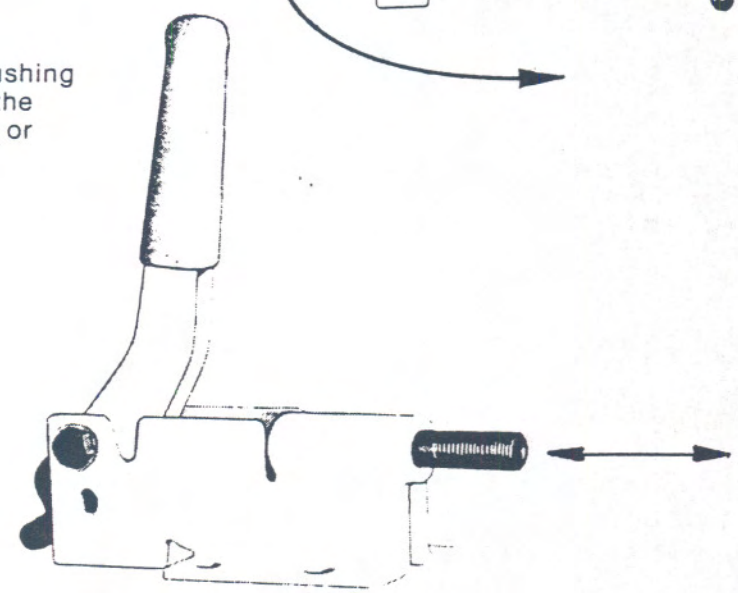
It is a clamp actuated by two sets of toggle action mechanisms to get an inner horizontal force when the handle of the clamp is in the regular vertical position, and' at the same time, a higher mechanical advantage.

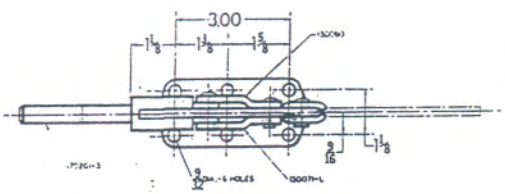


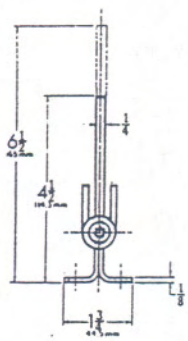
9 PUSH-PULL CLAMPS

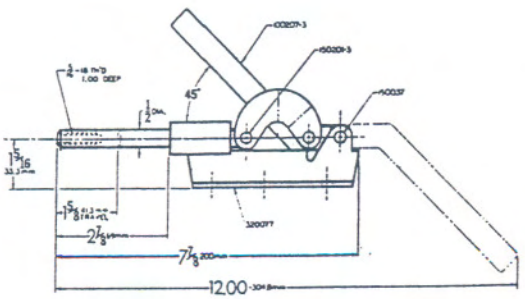
They are designed to exert a continuous pushing or pulling force, during the entire travel of the plunger and holding workpieces in pushing or pulling position during a process.

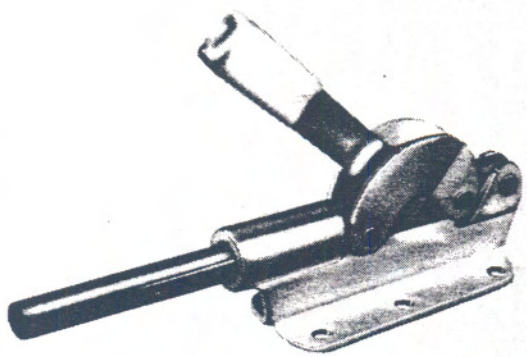


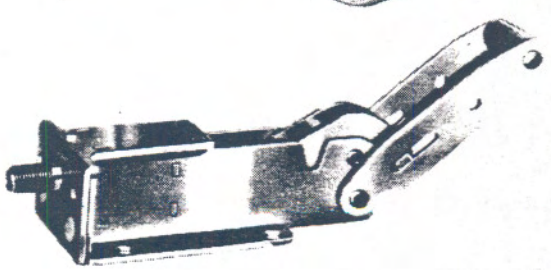






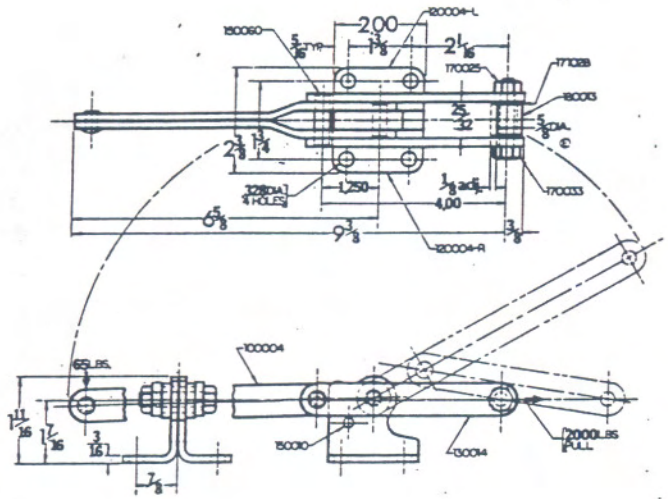


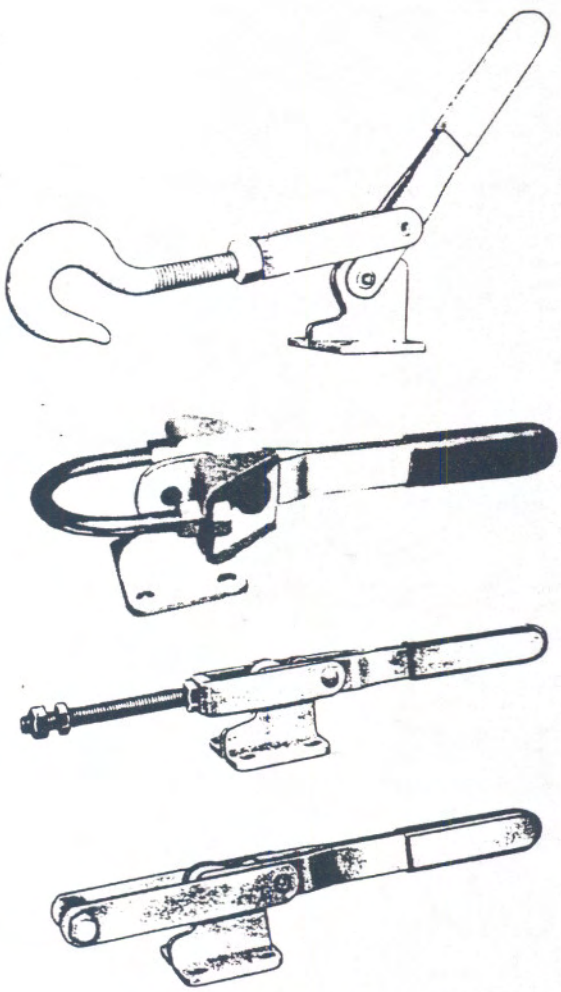




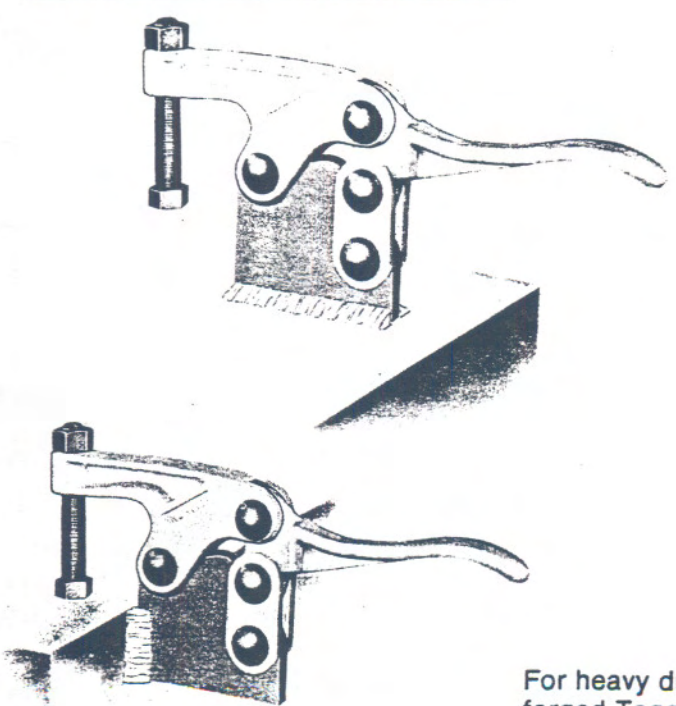
10 *Pull Clamps*

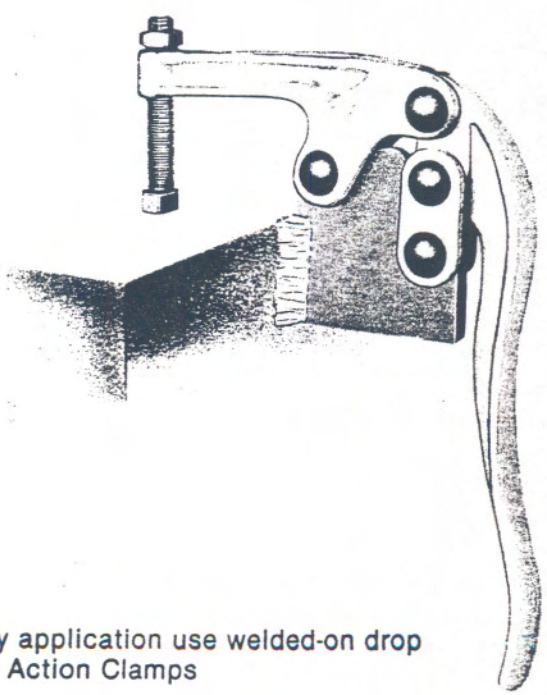
They are designed to exert a continuous pulling force during the entire pull travel of the hook, U-Bolts, threaded bar or eccentric roller - they lock only in Pull.





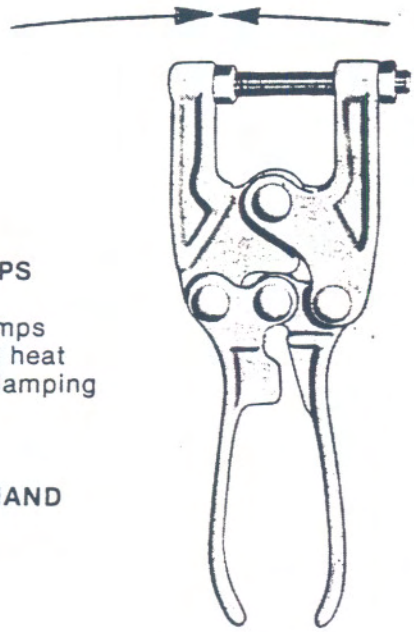
11 WELDED-ON DROP FORGED CLAMPS

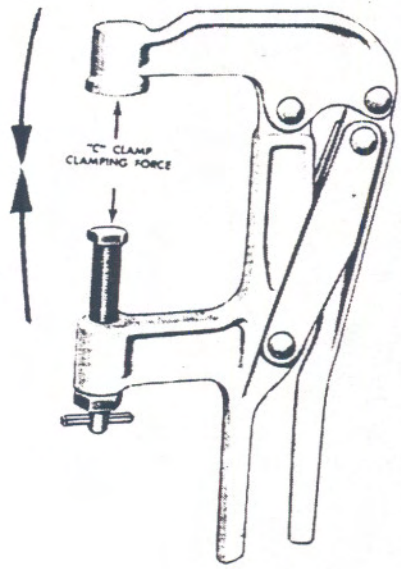




For heavy duty application use welded-on drop forged Toggle Action Clamps

The Various Shapes & Forms of Toggle Action Clamps (Cont.)





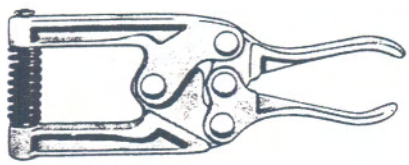
PORTABLE CLAMPS
TOGGLE ACTION CLAMPS

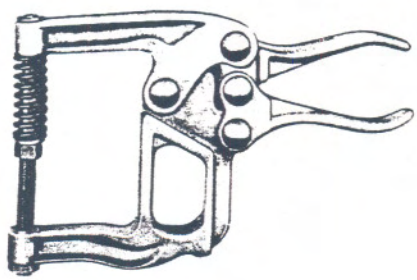
Hand Toggle Action Clamps made of drop forged and heat treated steel for heavy clamping forces up to 2400 lbs.

USED UNIVERSALY BY HAND

FLEXI-GRIP TOGGLE PLIER

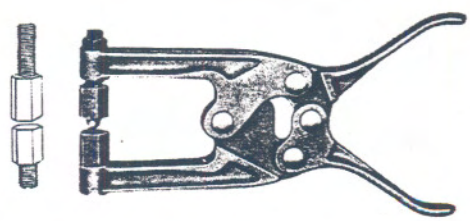
Spring loaded Toggle Action Plier for clamping various thicknesses





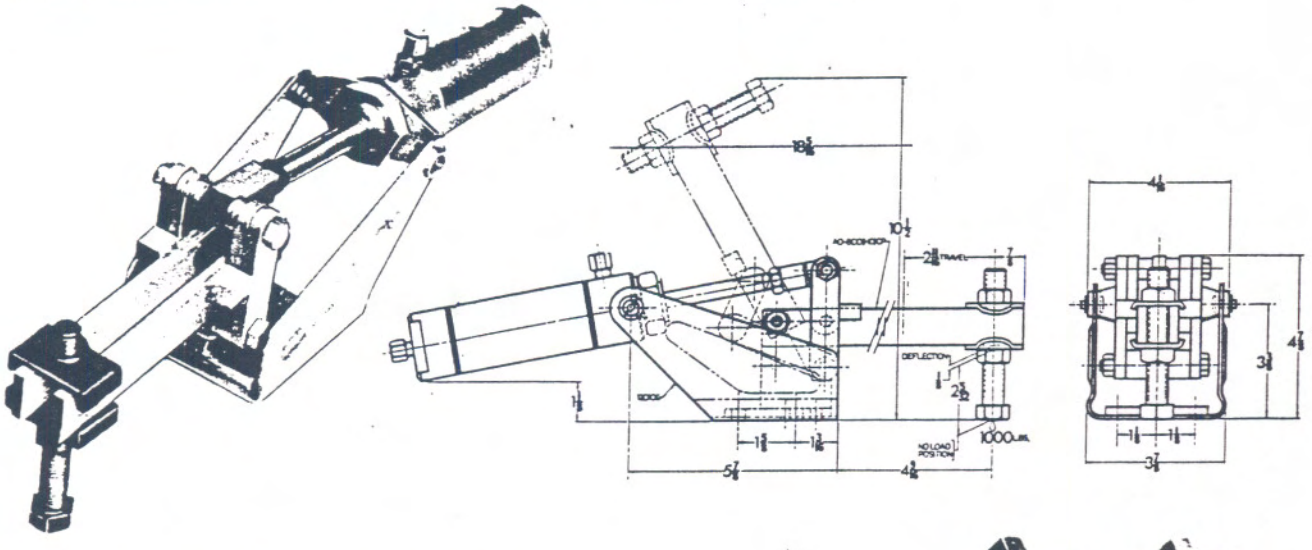
HOLE LOCATING TOGGLE PLIER

Two or more pieces can be joined and located through their common holes in order to perform a manufacturing process.

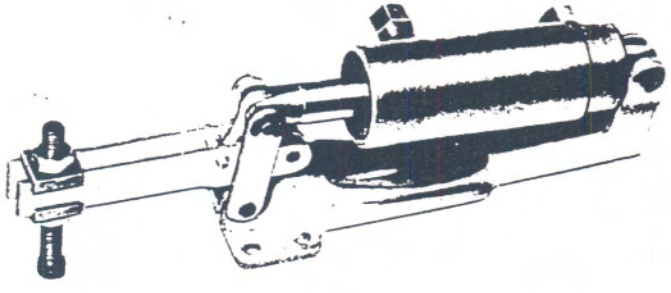


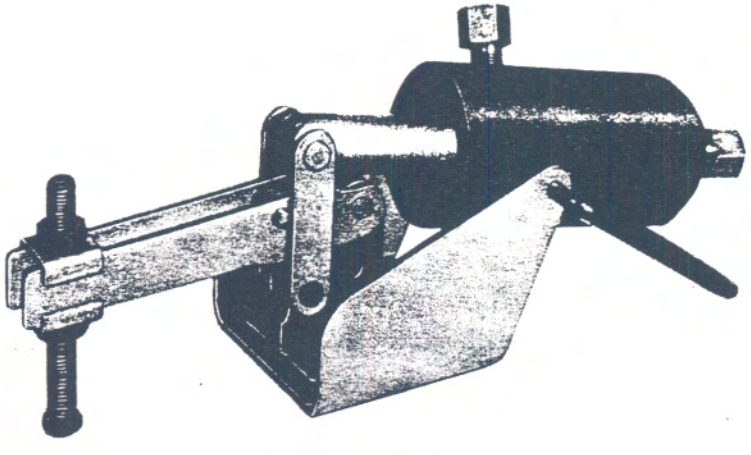
The Various Shapes & Forms of Toggle Action Clamps (Cont.)

12 *Horizontal Cylinder Air Operated Toggle Action Clamps*



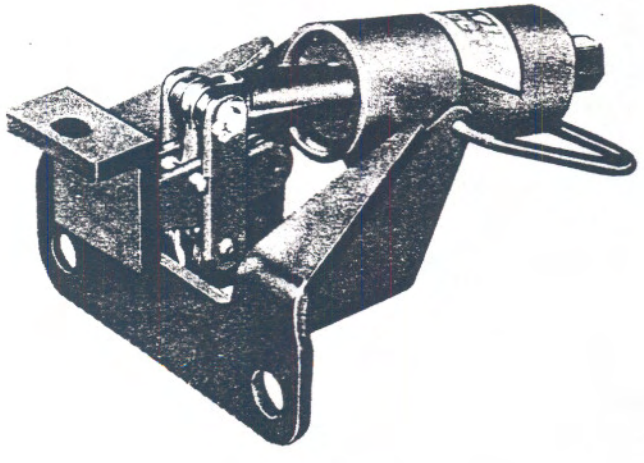
When basic Toggle Action mechanisms of hand clamps is used, air or oil operated pressure activates the cylinder and replaces the human effort with larger mechanical force.





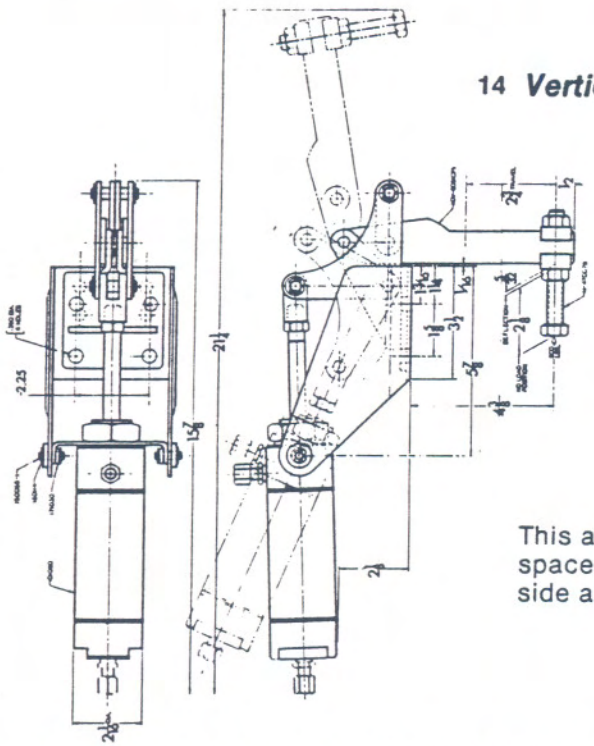
13 *With Special Toggle Bar and Front Mount*

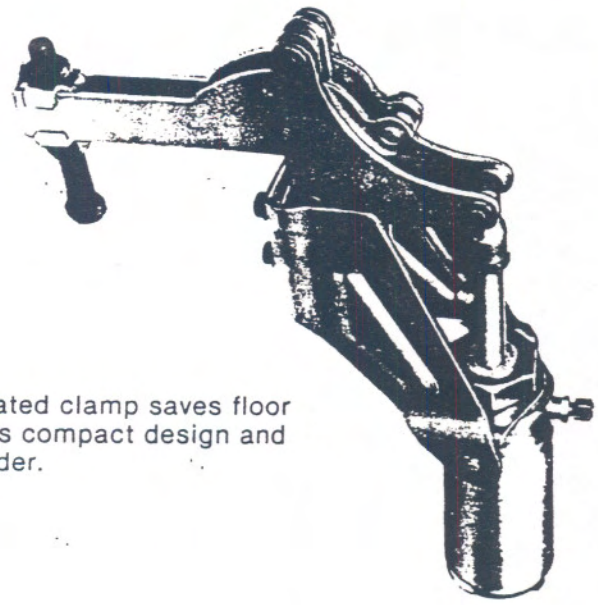
Air operated clamps come in different mountings, shapes, configurations and capacities in order to fit the various applications.



The Various Shapes & Forms of Toggle Action Clamps (Cont.)

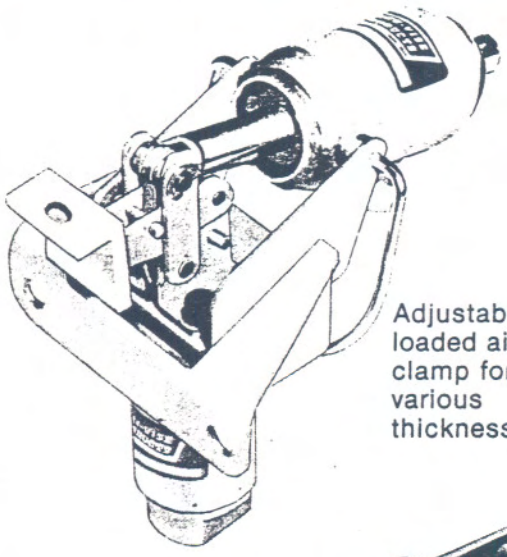
14 *Vertical Cylinder Air Operated Toggle Action Clamps*





This air operated clamp saves floor space with its compact design and side air cylinder.

15 With Special Adjustable Height Mechanism

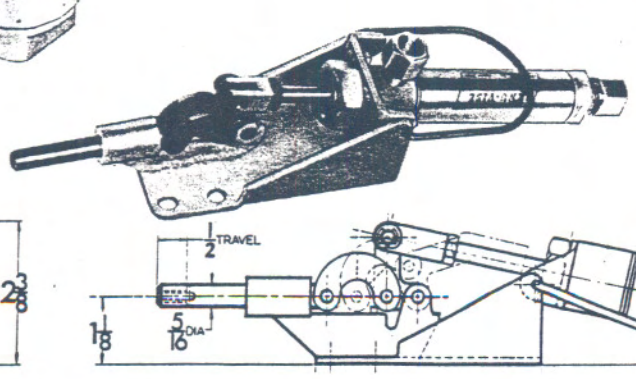


Adjustable spring loaded air operated clamp for clamping various thicknesses

Adjustable height

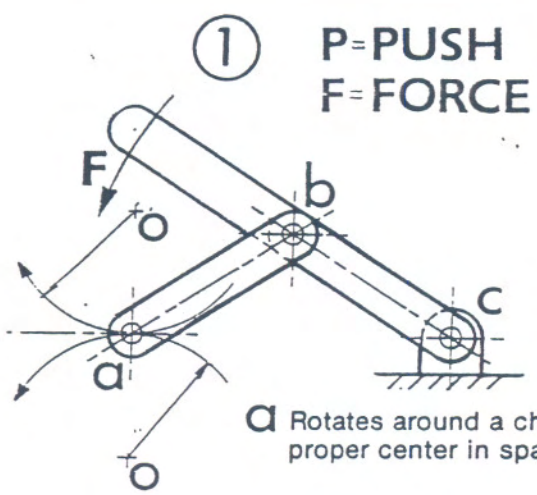
Special End Toggle Bar

16 *Air Operated Push Clamp*

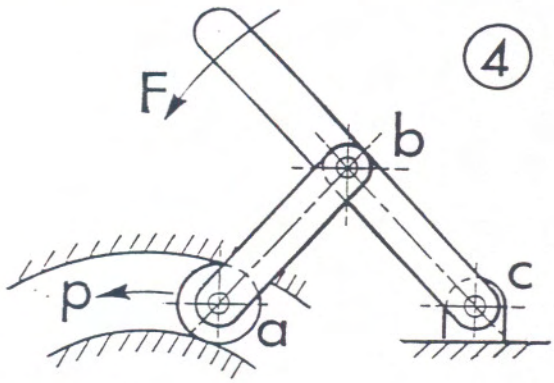


An air operated push clamps can continue functioning in the event of air pressure loss.

EVOLUTION OF A TOGGLE ACTION MECHANISM

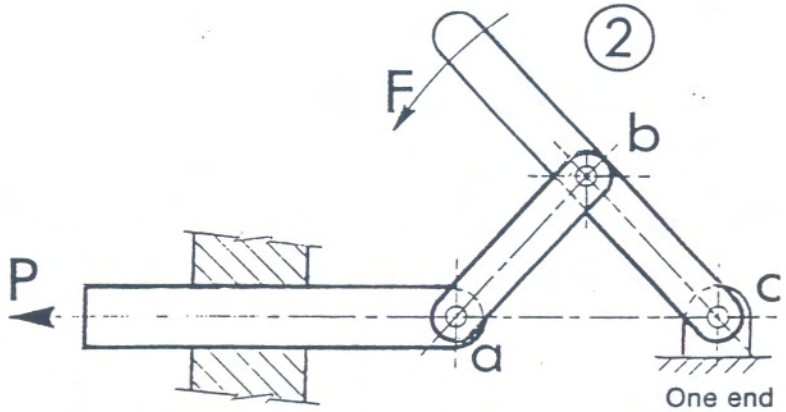


a Rotates around a chosen proper center in space. O.



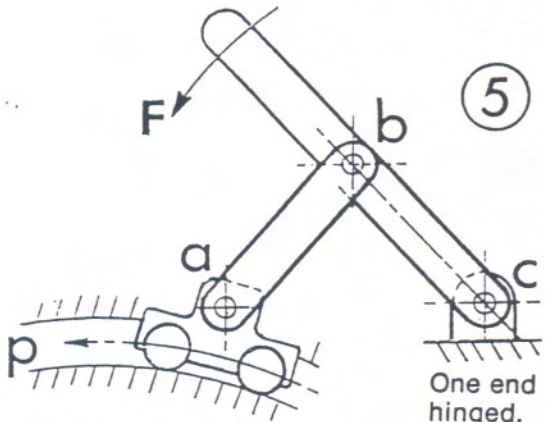
Roller moves in a curved guide or slot.

One end hinged.



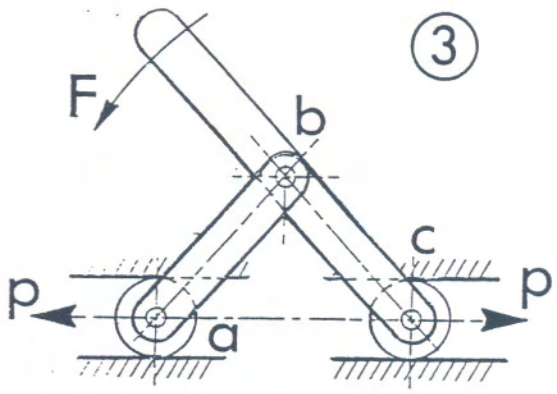
One end hinged.

STRAIGHT LINE PUSH

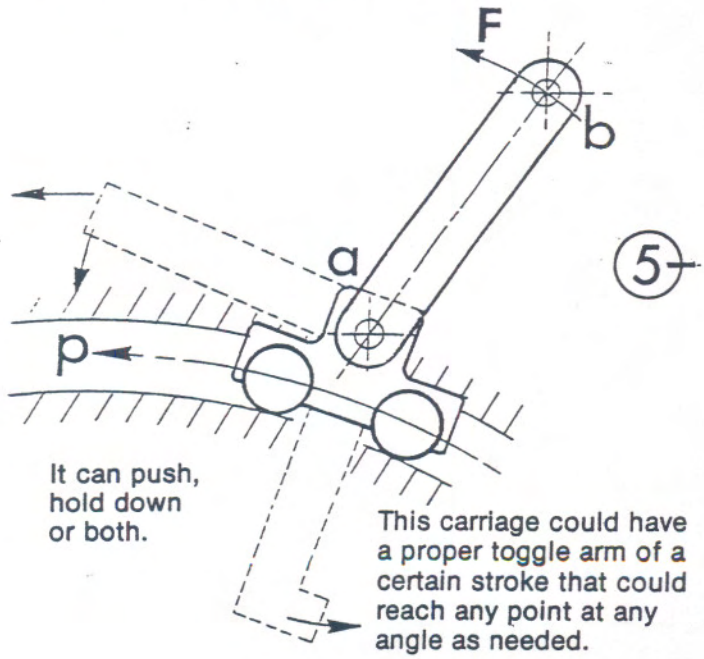


One end hinged.

The hinged end drive a roller Guided Body that is toggly locked at the **end** of the stroke.

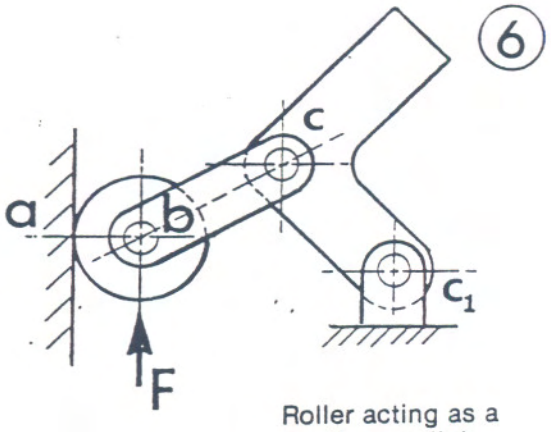


The two ends have rollers and move in straight guided path.

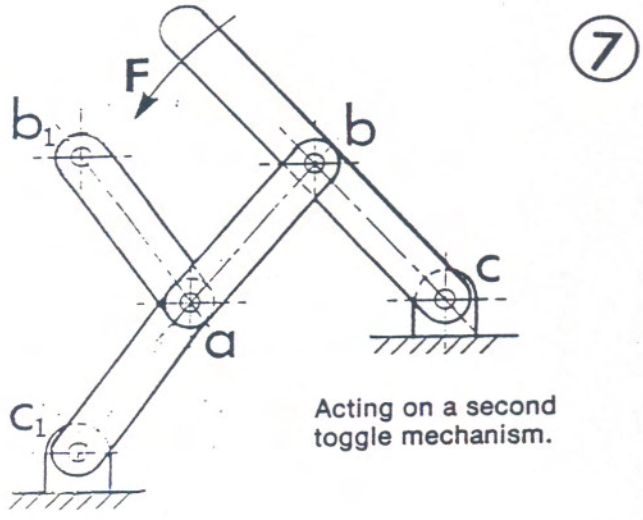


It can push, hold down or both.

This carriage could have a proper toggle arm of a certain stroke that could reach any point at any angle as needed.

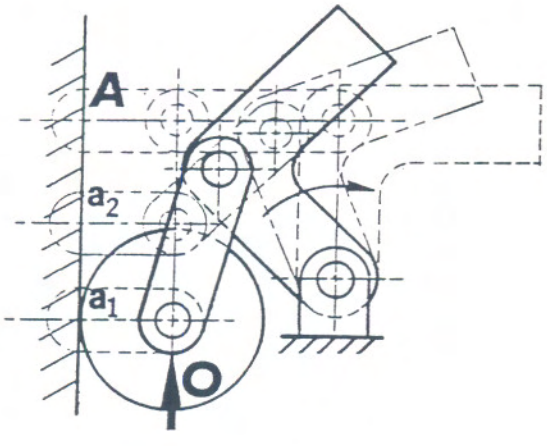


Roller acting as a continuous link.



Acting on a second toggle mechanism.

ROLLER ACTING AS A CONTINUOUS LINK IN A TOGGLE ACTION MECHANISM.

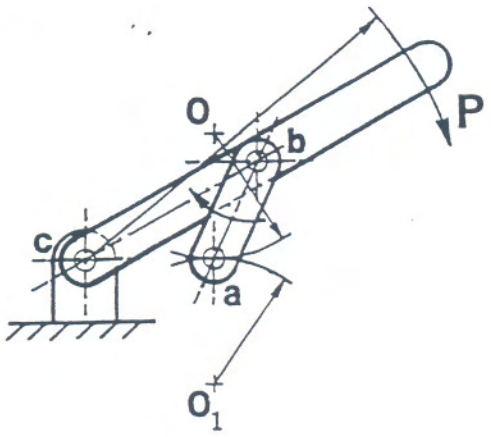


a_1o = *a link with center* o&a_1
a_2o = *a link with center* o&a_2
AO = *a link with locking center* O

TE87-05-13

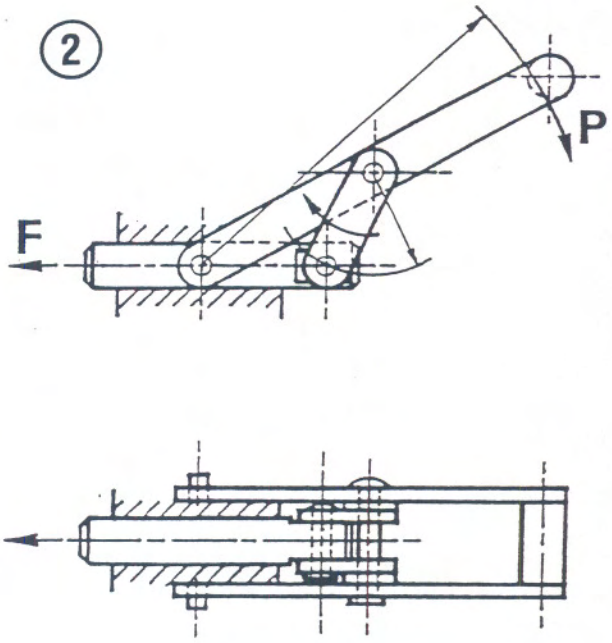
EVOLUTION OF THE INWARD TOGGLE ACTION MECHANISM

①



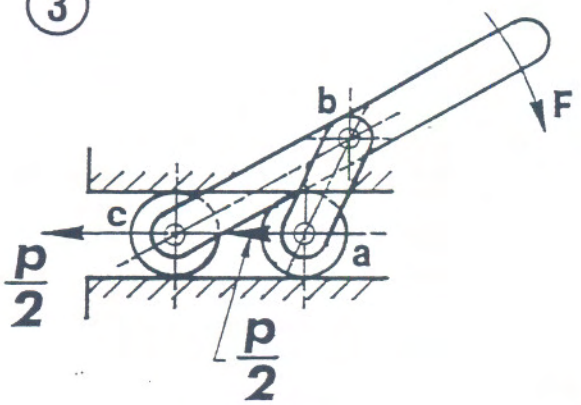
Inward Toggle

②



Inward Push Toggle

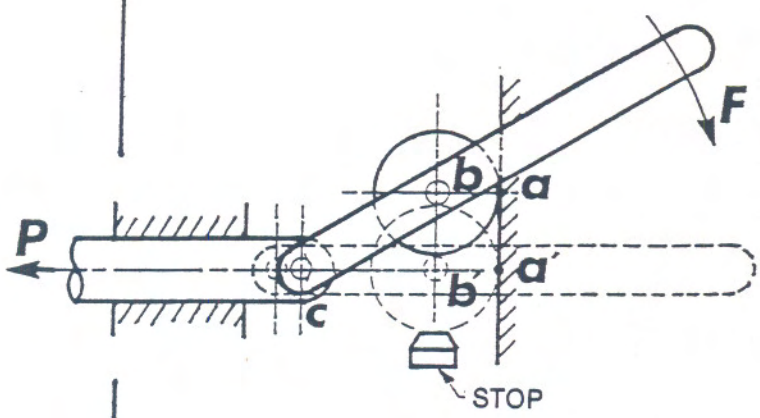
③



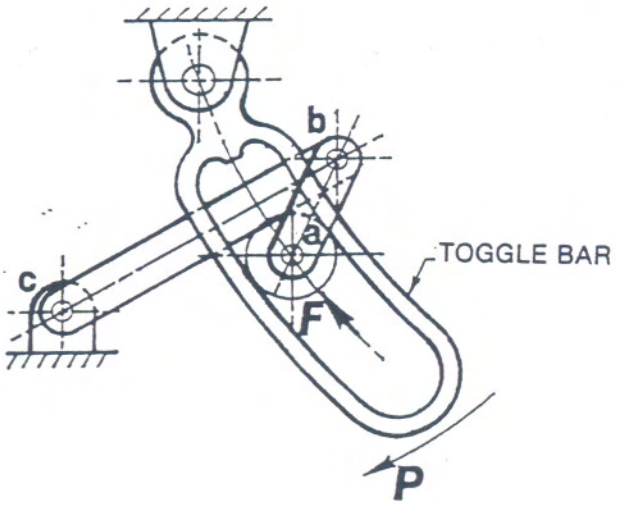
Inward Double Roller Toggle

④

Toggle Push Clamp Using Roller Link

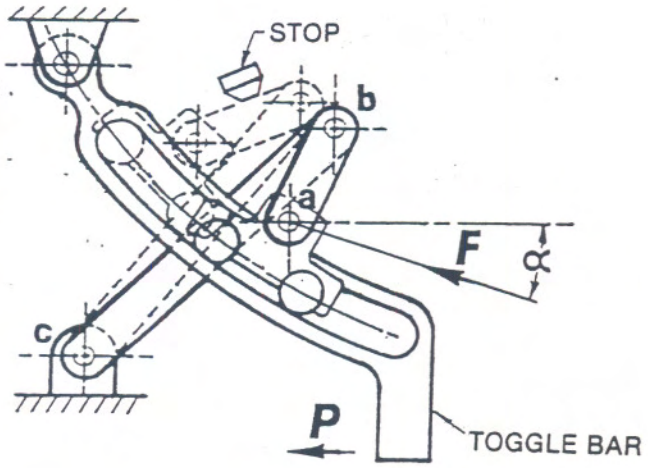


(5)



Roller Carriage in Curved, Slotted Toggle Bar

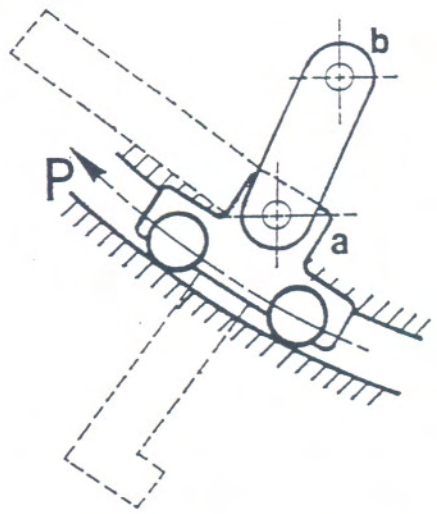
(6)



CONTOUR COULD BE VARIED TO FIT A REQUIRED APPLICATION

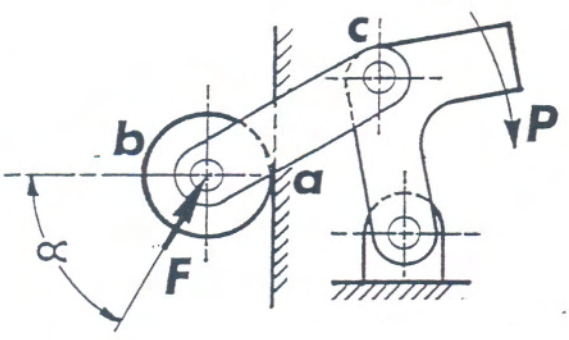
Roller Toggle in Guided Curved Path

(7)



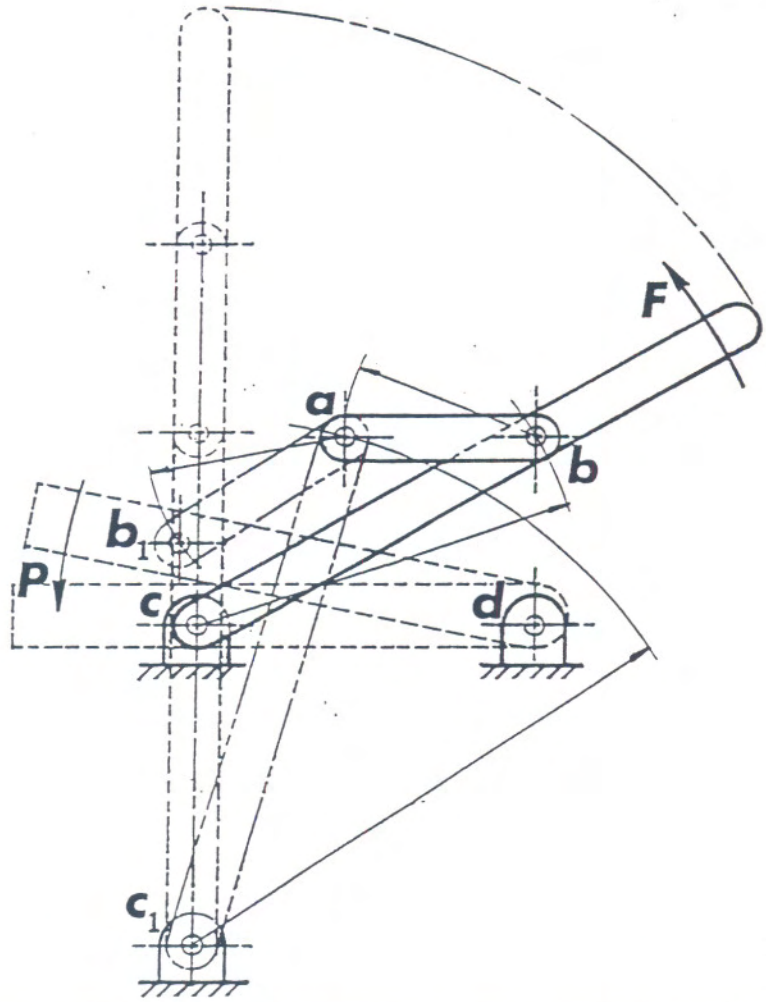
UNLIMITED CONFIGURATIONS OF CARRIAGE TOGGLE BAR

(8)



Inverted Toggle Roller Arm Clamp

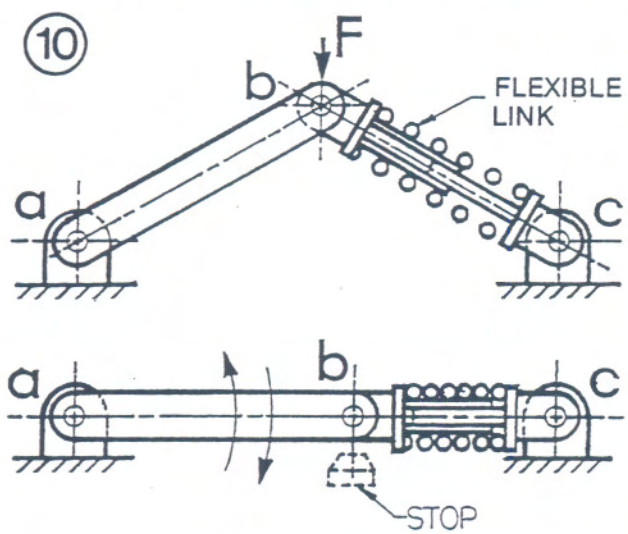
(9)



Double Inward Toggle
abc = 1st Toggle
b_1ac_1 = 2nd Toggle
b_1d = Toggle Bar

Toggle Action with Flexible Link

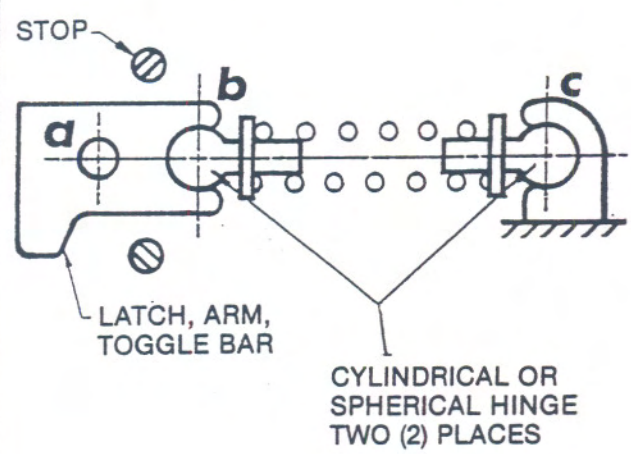
(10)



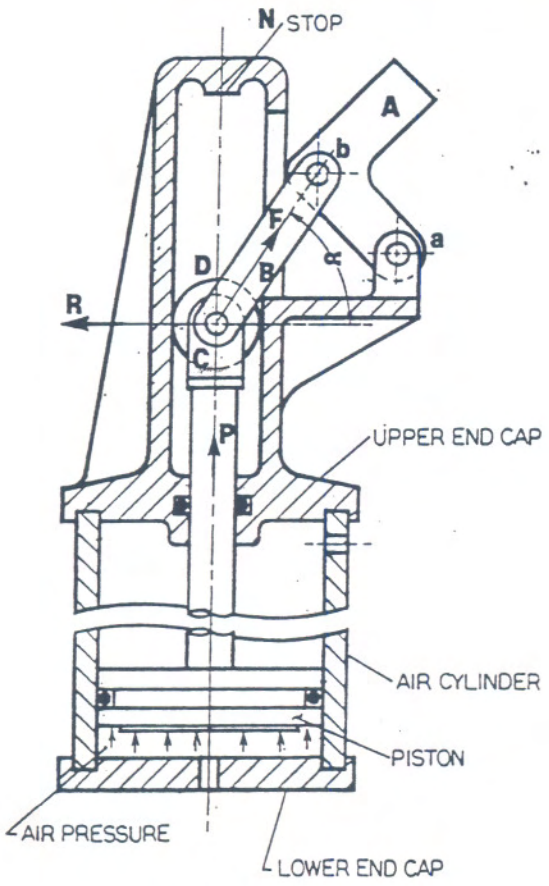
Unstable Equilibrium

(11)

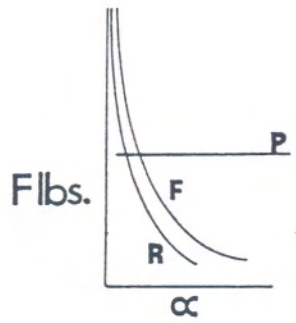
ARTICULATED TOGGLE

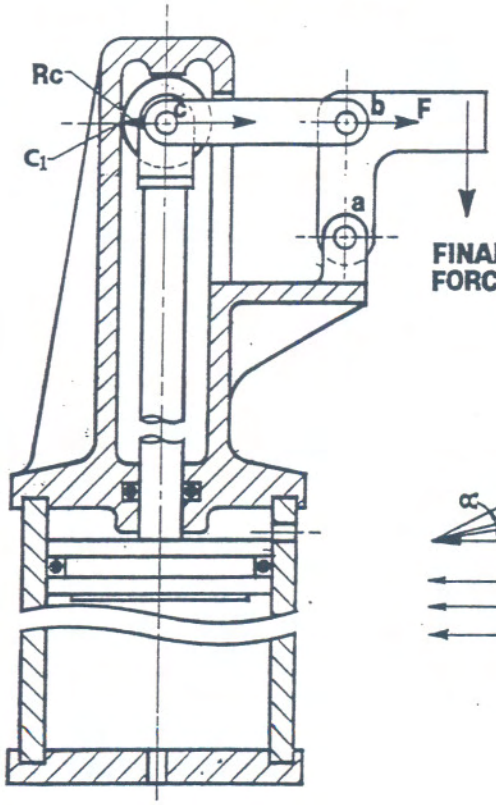


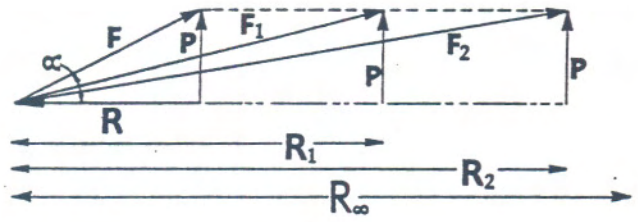
FINGER TOGGLE ACTION AIR OPERATED CLAMP



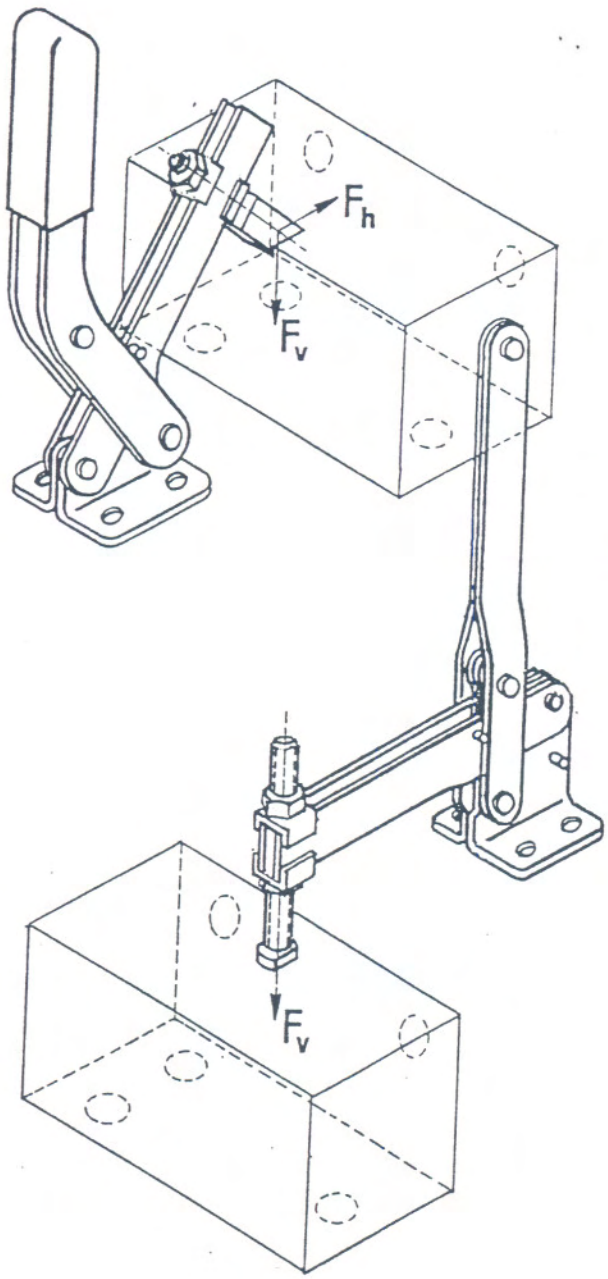
A: ROTATING ARM.
B : LINK.
C: PISTON ROD & YOKE.
D: ROLLER.
N: STOP POINT.
CC_1: ACTS AS A LINK.
C_1Cb: THE THREE CENTERS IN LINE.

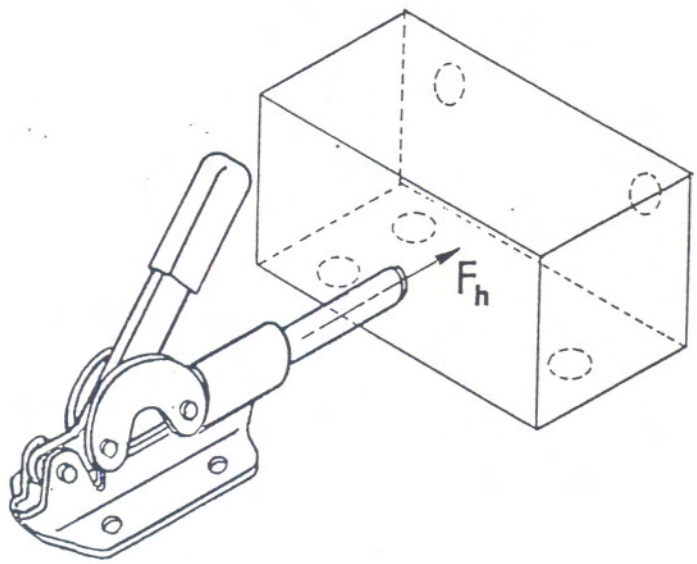






LOCATING BY TOGGLE ACTION CLAMPS





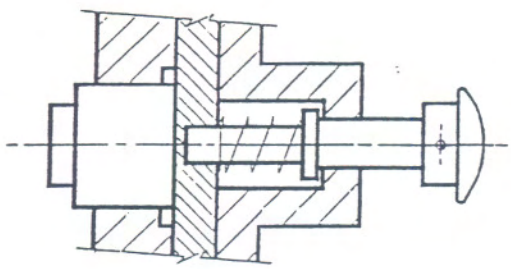
Locating by Toggle Action Clamps

Centralizing With The Use Of Toggle Action Clamps

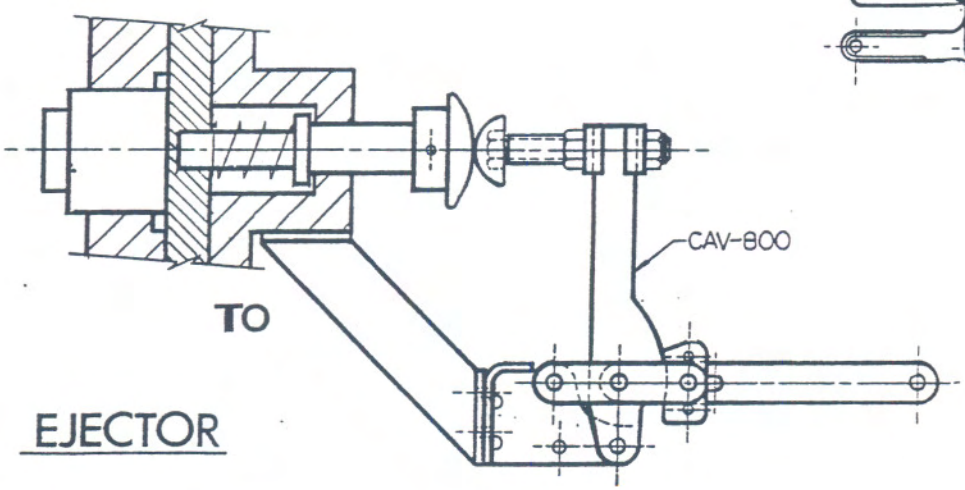
To centralize a work piece in any of the X-X, Y-Y or Z-Z axis, a second clamp is used on the opposite side and the two threaded clamp spindles are adjusted accordingly.

Toggle Action Clamps Used as Ejectors

Ejectors are mechanisms that eject a work piece from a fixture or jig after drilling, milling, welding, etc. Toggle Action Clamps are very effective for such applications.

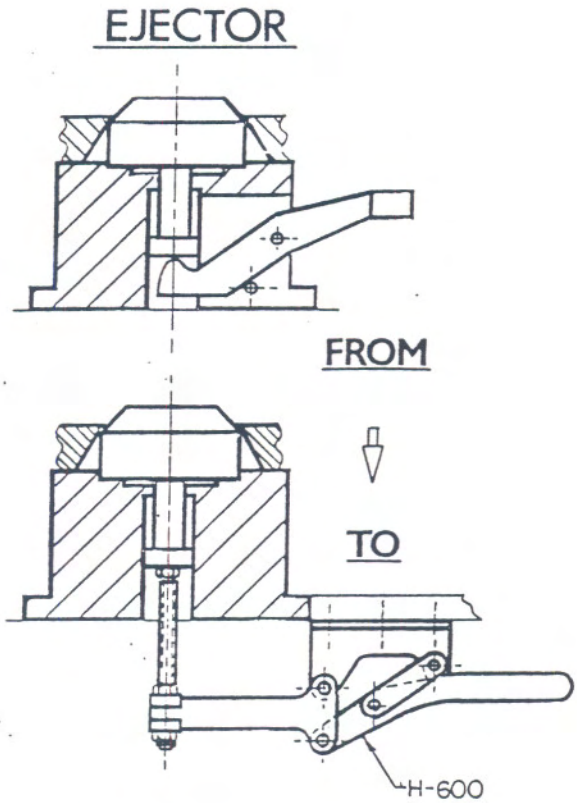


FROM

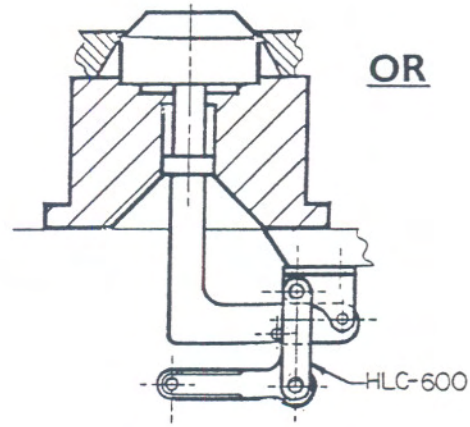


TO

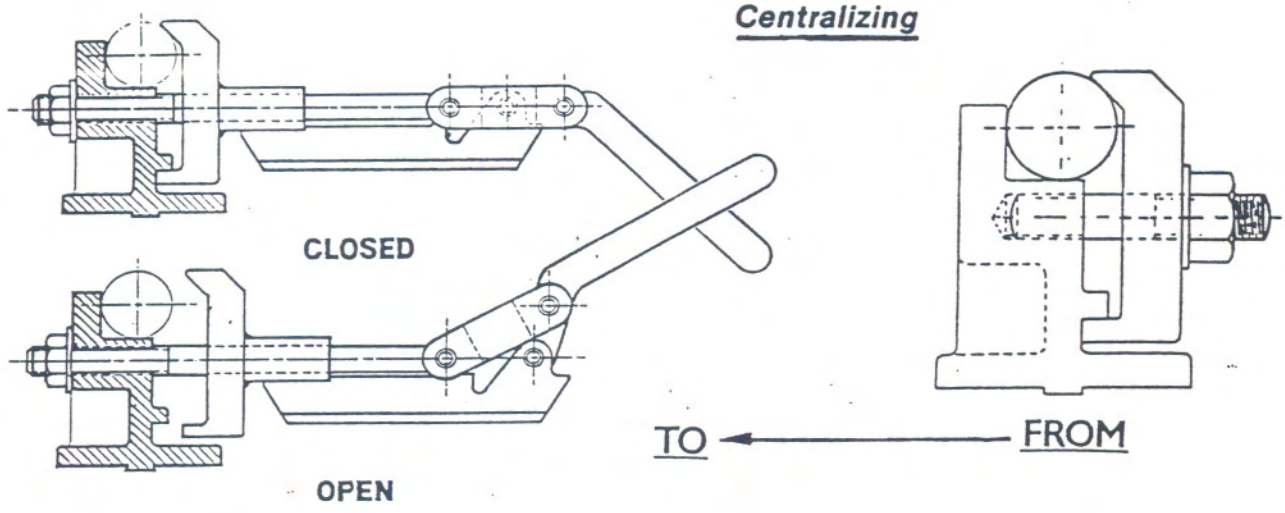
EJECTOR



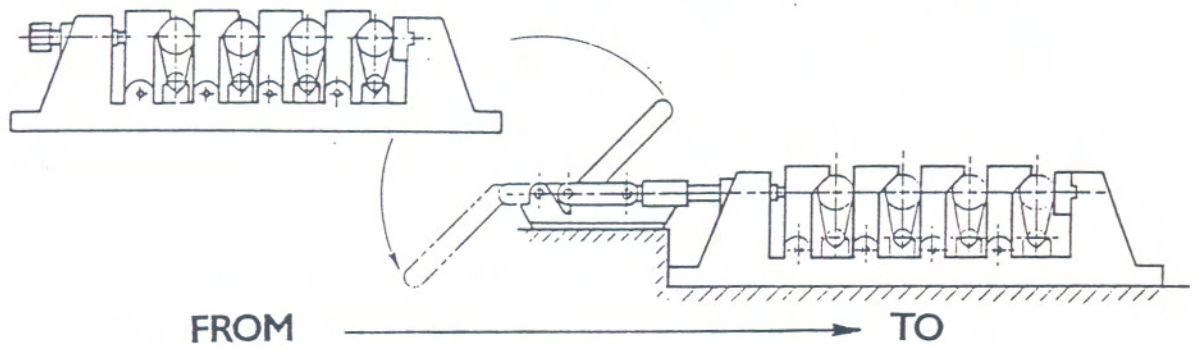
OR

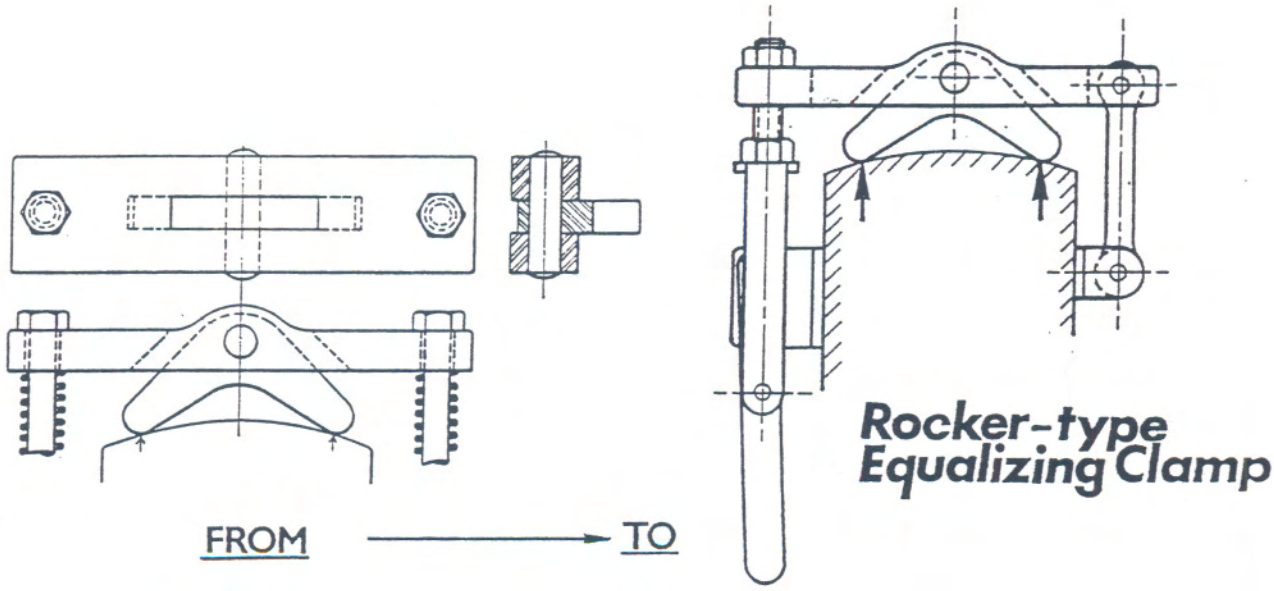


Centralizing

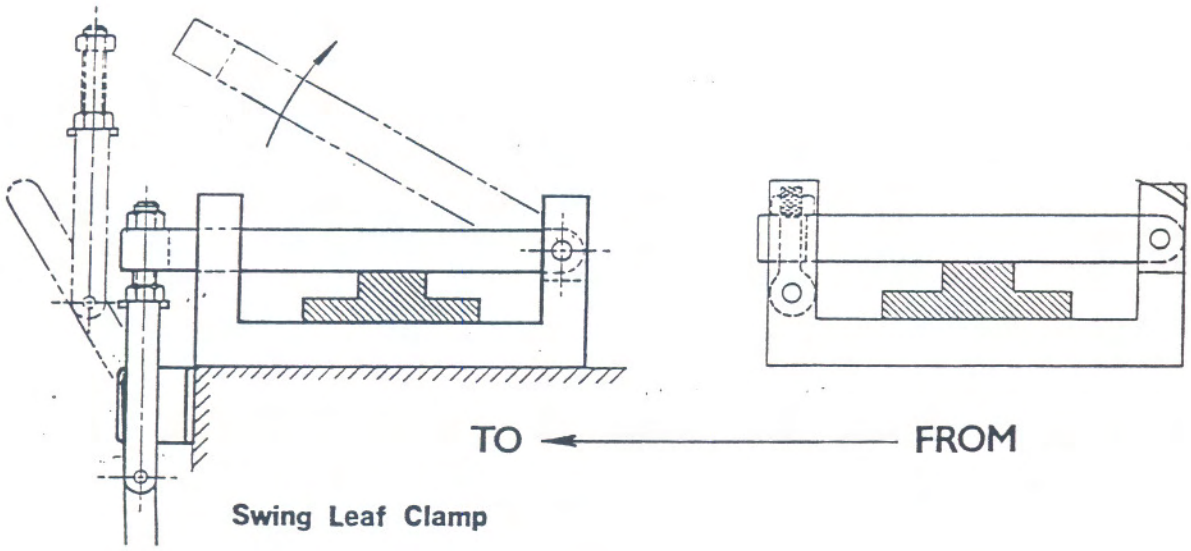


Multiple Clamping with Shaped Spacers

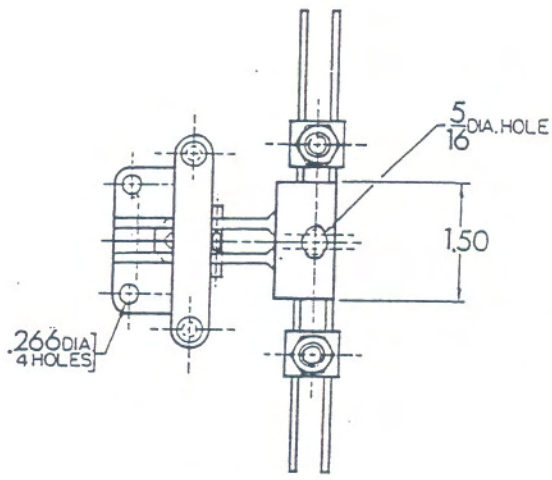


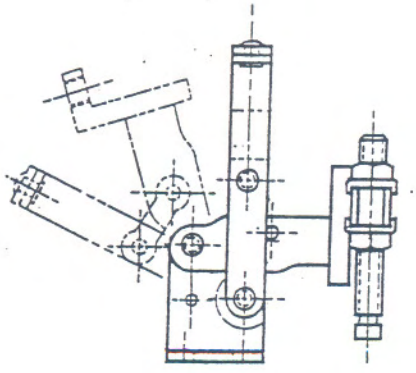


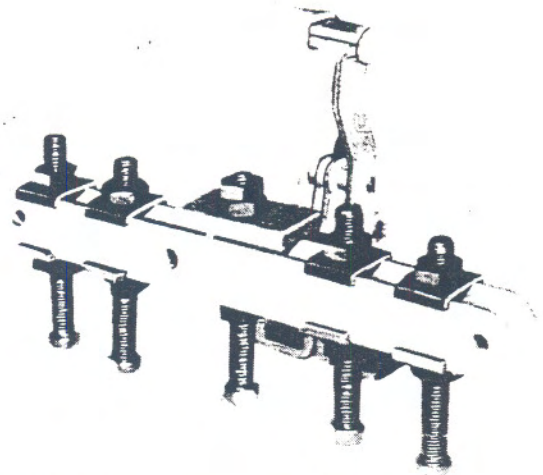
Rocker-type Equalizing Clamp



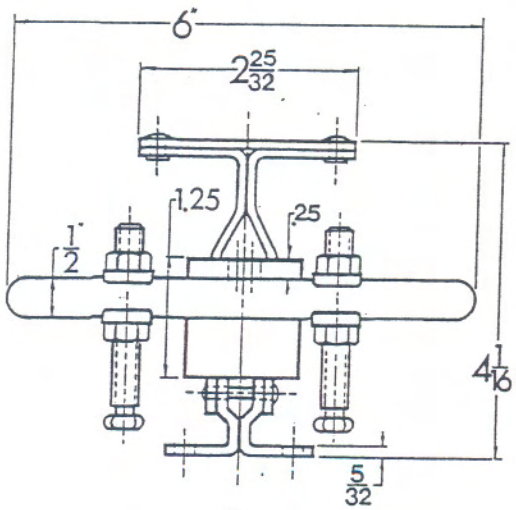
Swing Leaf Clamp





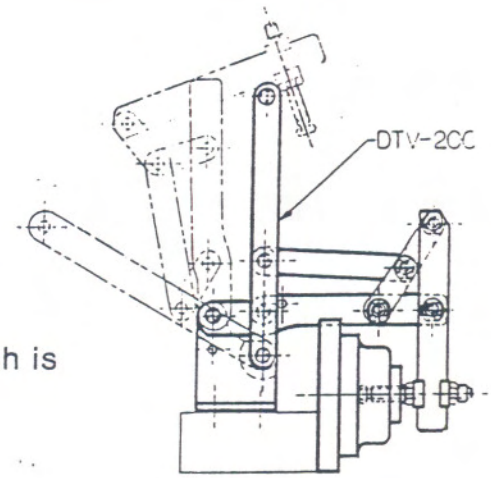


TOGGLE CLAMP WITH BALANCER BAR AND SPINDLES.

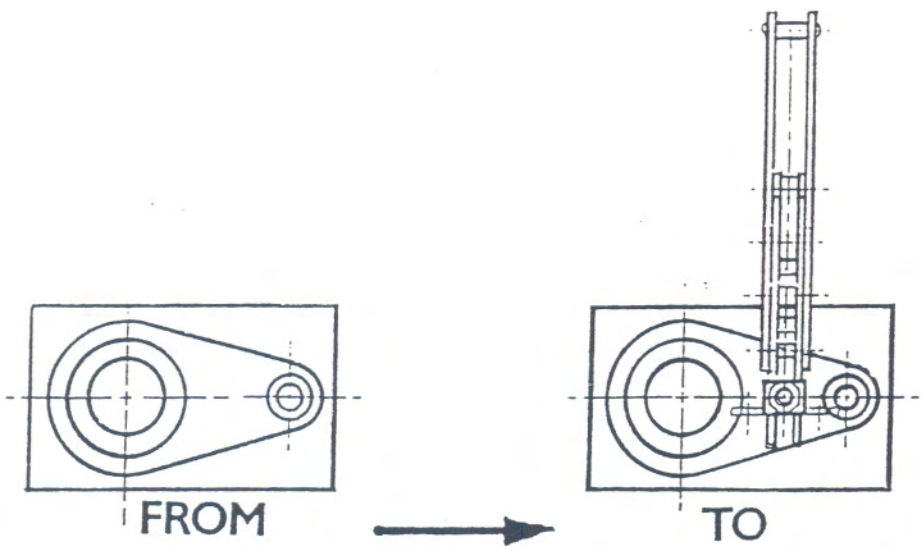


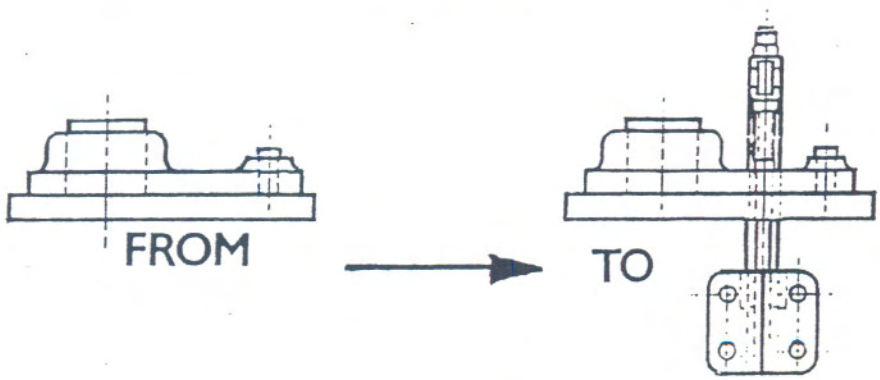
FROM..... TO.....

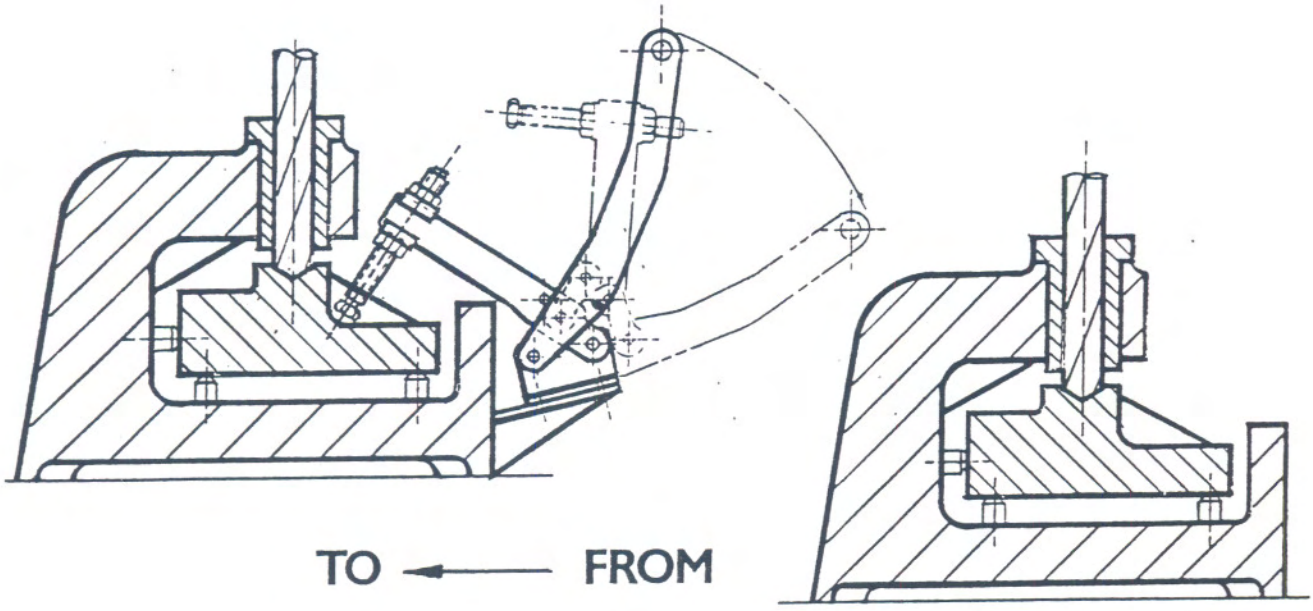
Graphic Samples of Applications Replaced by Toggle Action Clamping

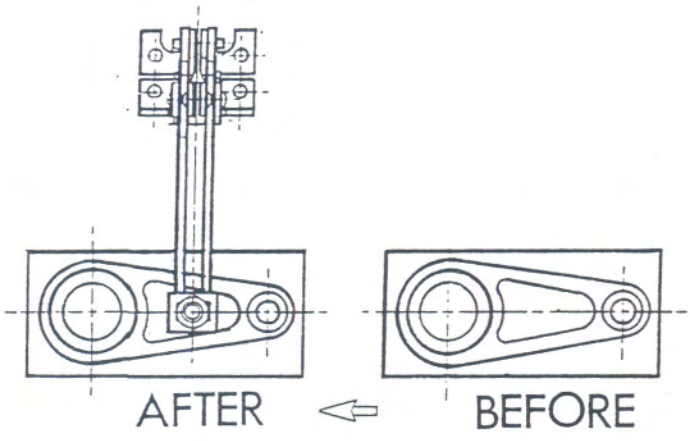


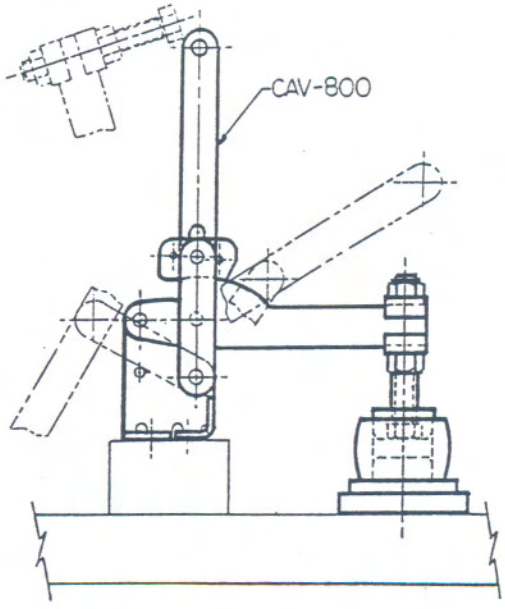
The sample below demonstrates an alternate method to repeated clamping and holding which is simpler to perform and more economical.

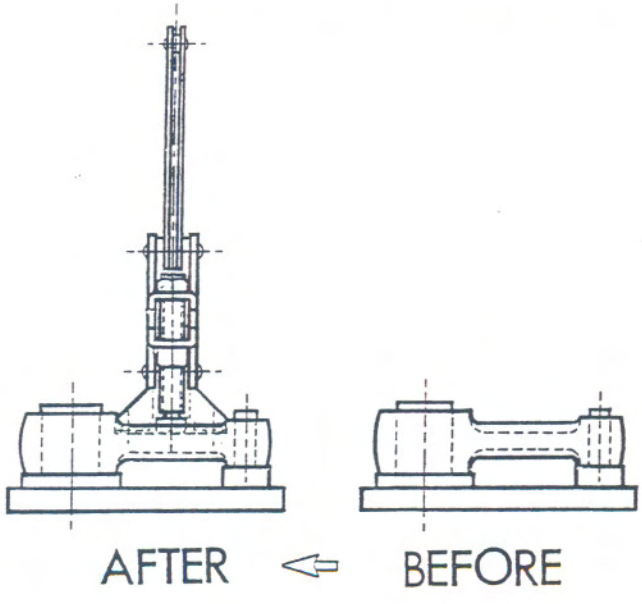





TO
FROM

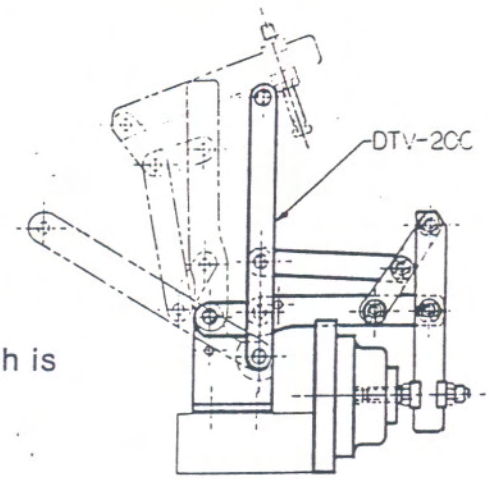

AFTER
BEFORE


CAV-800

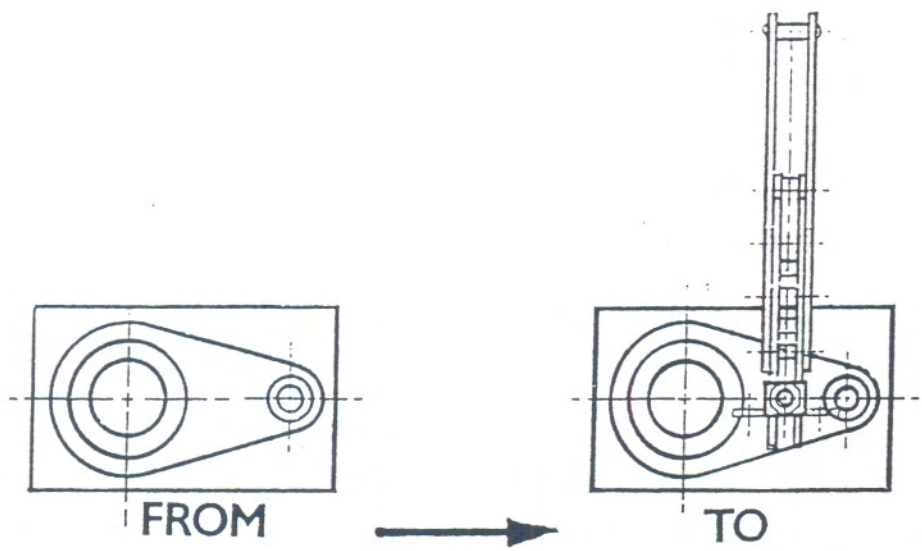

AFTER
BEFORE

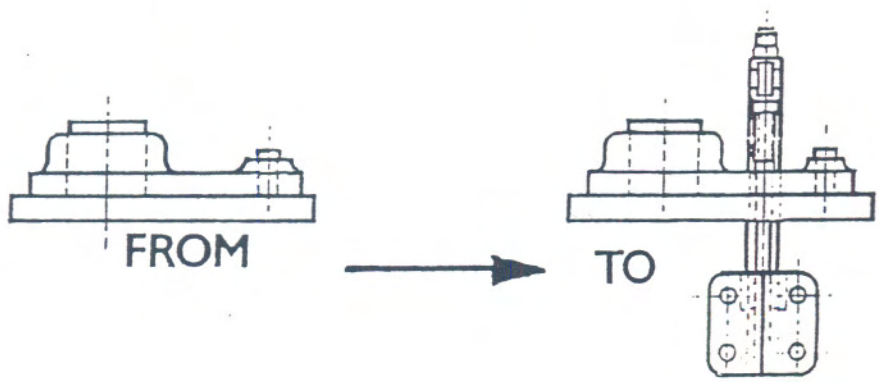
FROM..... TO.....

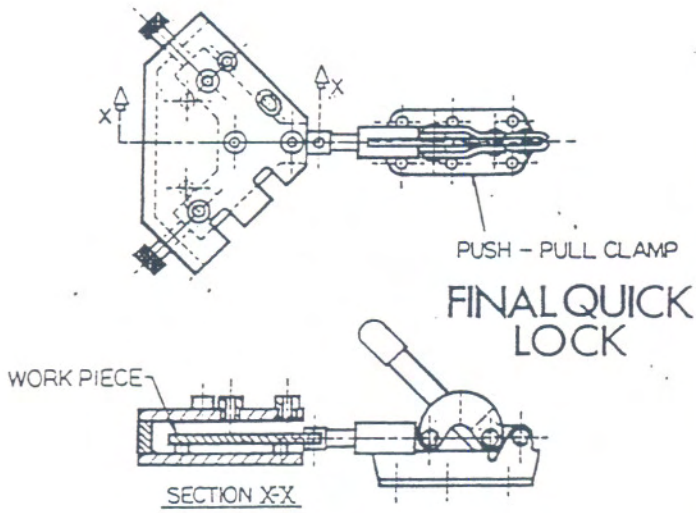
Graphic Samples of Applications Replaced by Toggle Action Clamping

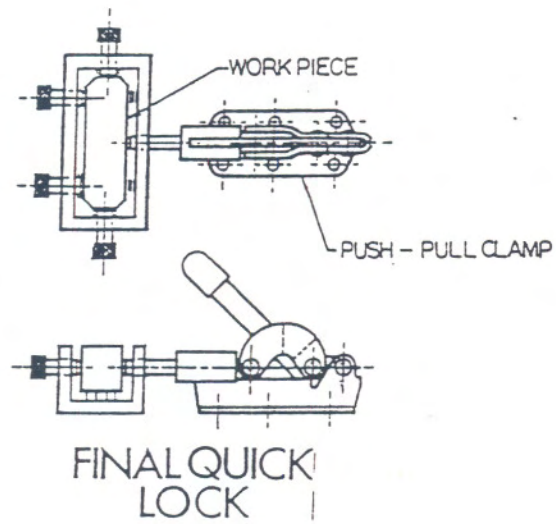


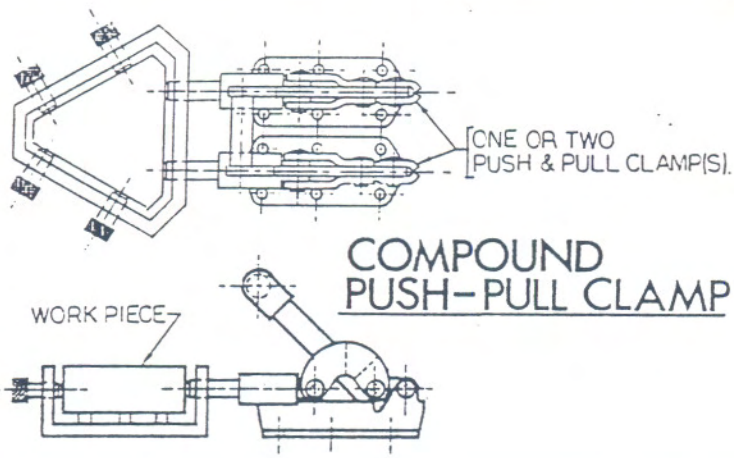
The sample below demonstrates an alternate method to repeated clamping and holding which is simpler to perform and more economical.

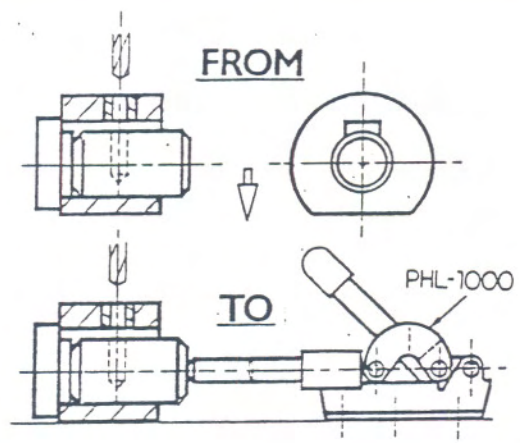


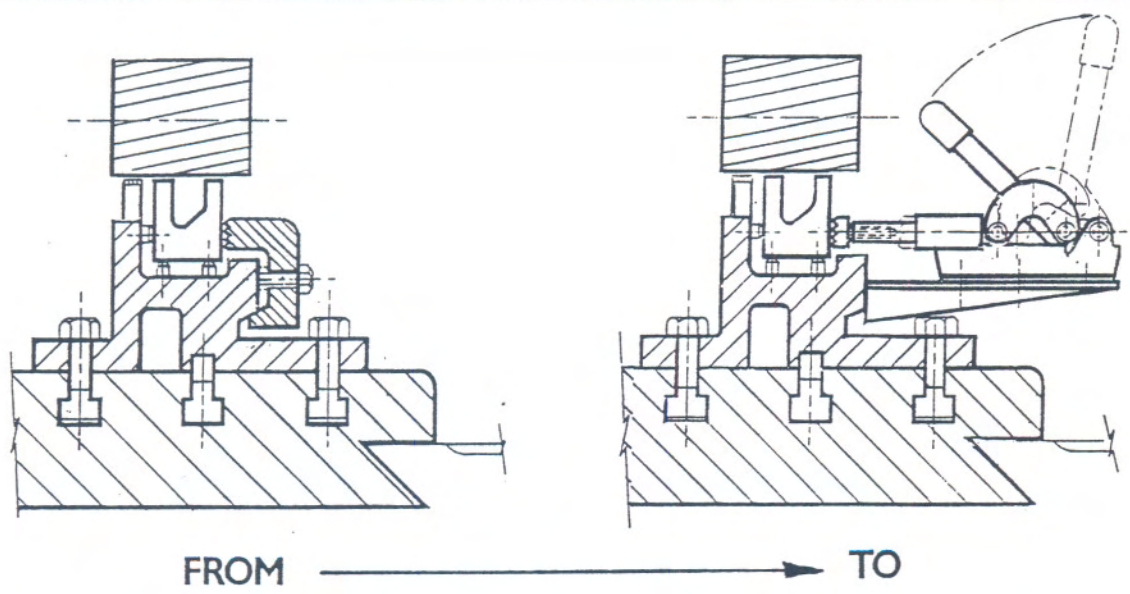



X
X
PUSH – PULL CLAMP
FINAL QUICK LOCK
WORK PIECE
SECTION X-X


WORK PIECE
PUSH – PULL CLAMP
FINAL QUICK LOCK


ONE OR TWO
PUSH & PULL CLAMP(S).
COMPOUND
PUSH–PULL CLAMP
WORK PIECE


FROM
TO
PHL-1000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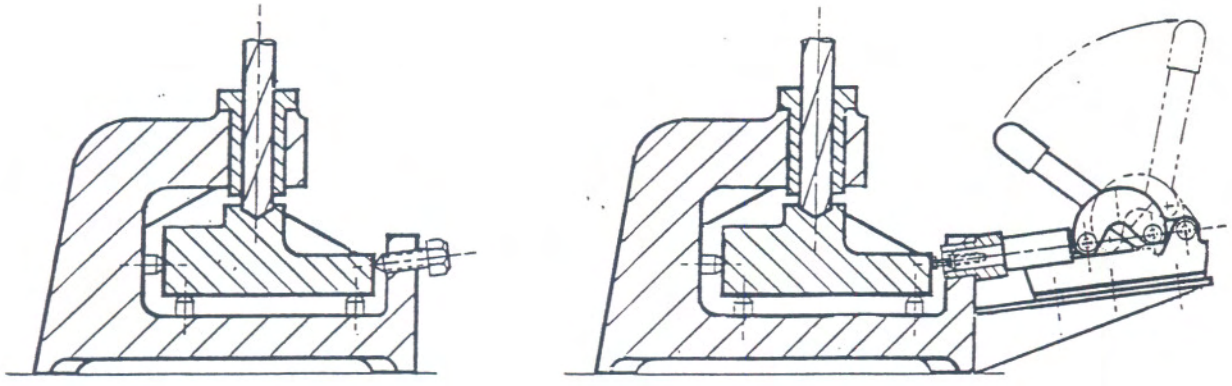
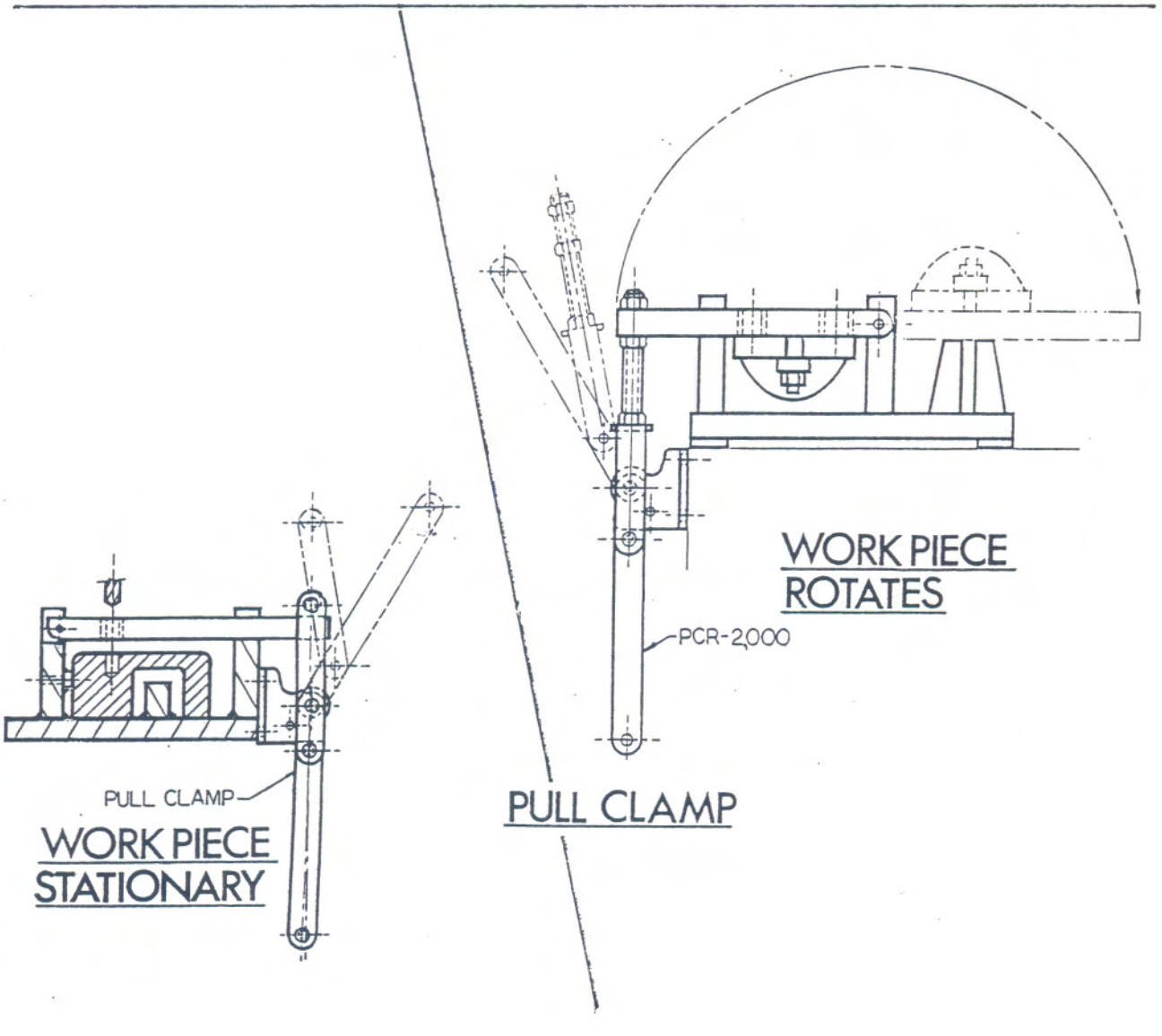
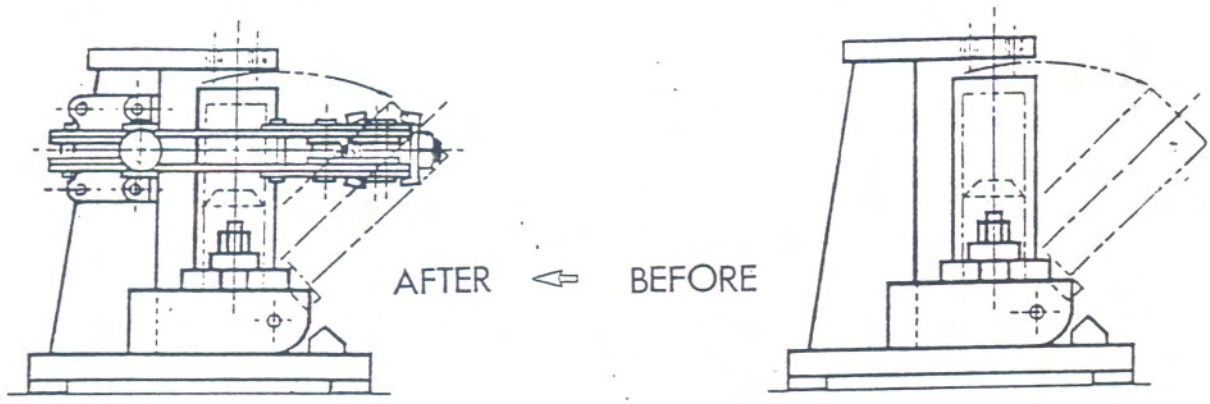
TO

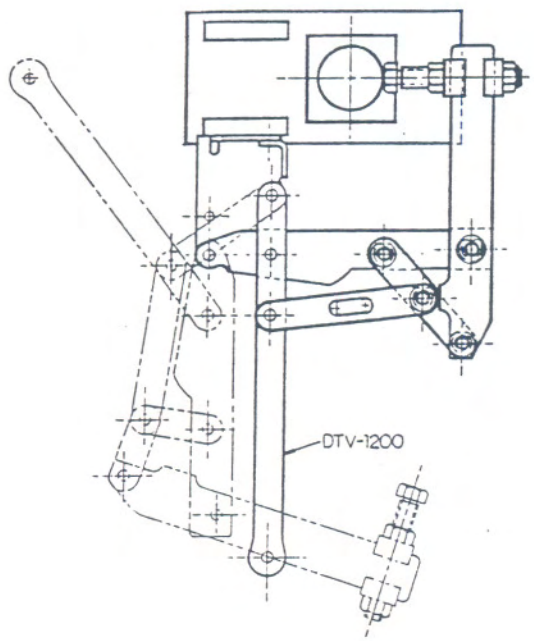


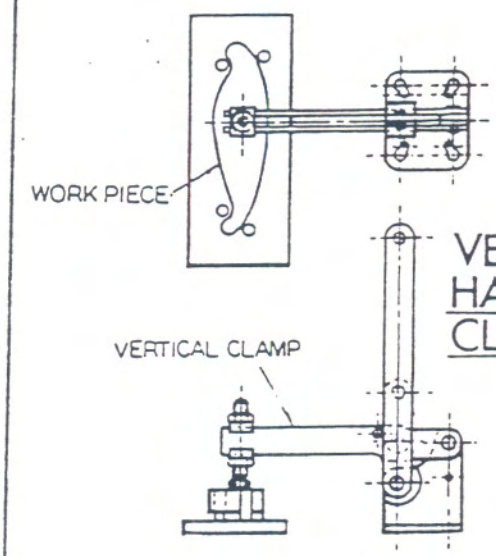
FROM ⟶ TO


WORK PIECE
ROTATES
PCR-2000
PULL CLAMP
PULL CLAMP
WORK PIECE
STATIONARY



DOUBLE TOGGLE ACTION CLAMP

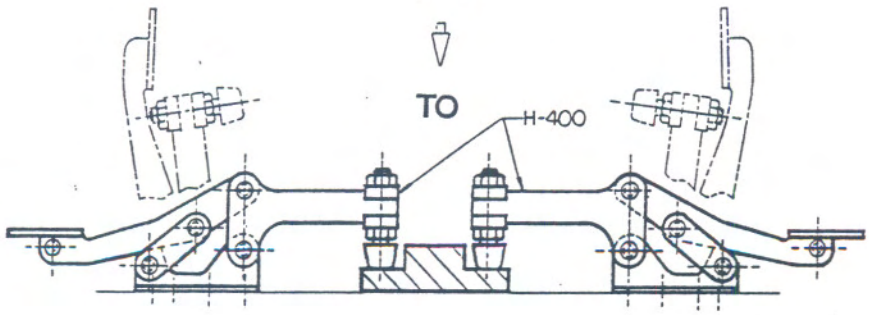




VERTICAL HANDLE CLAMP

FROM

TO



Toggle Action Clamps in the Welding Fields

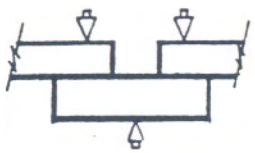
WELDING FIXTURES

A welding jig or fixture is a piece of equipment containing several parts that form a weldment in such a way, that it keeps a fixed dimensional relationship among the different parts.

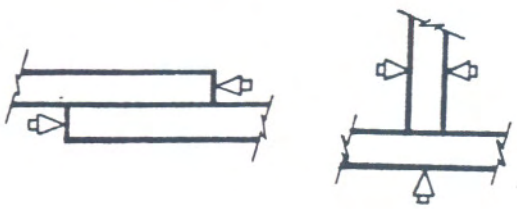
It has to fulfill the following requirements:

1. To *accommodate* each part in its proper place.

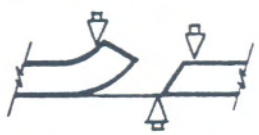
2. It has to *hold* it in its place with minimum deviation, allowing for reasonable expansion without warping or twisting.



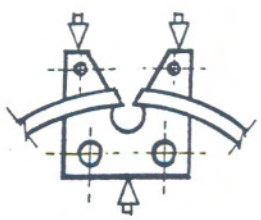
3. It has to *locate* the part in its place so that it keeps its accurate relationship with the other components as required.



4. It has to be capable of performing some straining effort to bring the different components together, specifically when welding more than one sub-assembly.



5. It has to give effective support and backing to all parts in order to prevent any deviation.



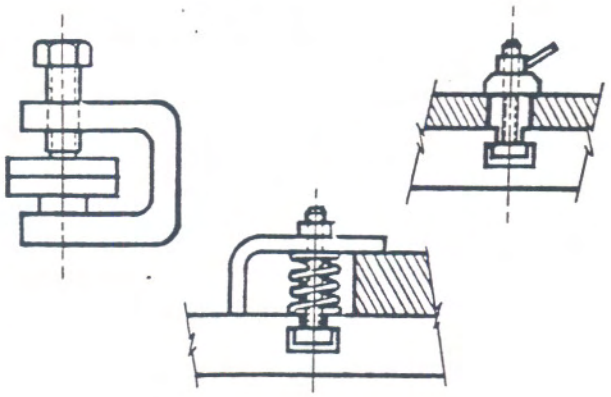
6. It has to be simple in shape and light in weight without any overdesign.

7. It has to permit easy access to welding with minimum parts exposed to sputters and heat, especially screws, pins, hinges, etc.

8. It has to provide the maximum flat or horizontal welding position and has to avoid overhead and vertical welding positions.

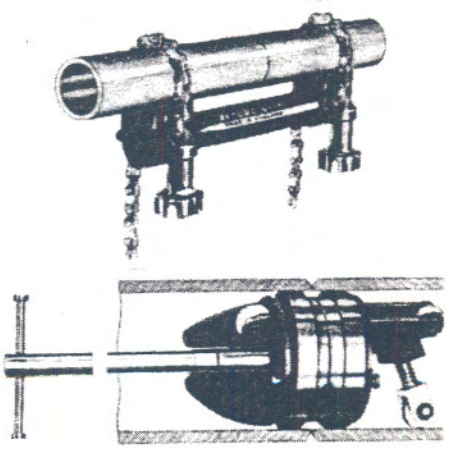
9. The welded part must be easy to remove from the jig or fixture with the least effort. And, in cases where effort is needed, some push clamps or cam-levers can do the work of the ejections.

10. The fixture has to be accurate to minimize any need for additional machining, grinding or any other operation.



11. It must be rigid enough to compensate for any strain exerted by the expansion of welded parts.

12. It has to be robust enough not to deflect under its weight due to improper support.



13. Each part must fit into its own proper place without the possibility of having to use any other part.

14. A welding jig or fixture has to be designed in light of its accuracy, durability, number of weldments to be made, etc.

15. Parts in a jig which are subjected to excessive wear and abrasion must have hard shoes or a hard face welded layer.

16. A fixture has to be a good conductor of electricity and provide good grounding.

17. An important welding fixture has to be easy to maintain, stored in a proper place and kept in good condition.

18. A fixture must have enough tolerance to take care of different deviations and dimensions of rolled steel parts or steel castings which usually do not come with the same tolerance.

19. A fixture has to be a unit with all the parts, such as clamps, pins, levers, an integral part of it.

20. Where components are jig drilled or machined for other purposes, advantages should be taken of the holes and faces for positioning in the welding jig. Fitted pegs and machined stops can often take the place of more complex fitting.

21. Fixtures which need to be turned or tilted during welding must have an easy means of support as legs or curved surfaces; we have to reduce this turning to a minimum to prevent "welder fatigue" from taking place.

22. Proper bed-plates are helpful when used. They may be heavy iron with T-slots or may be made of rolled steel of I-beams and channels as grillage with or without a sheet steel top of a proper thickness.

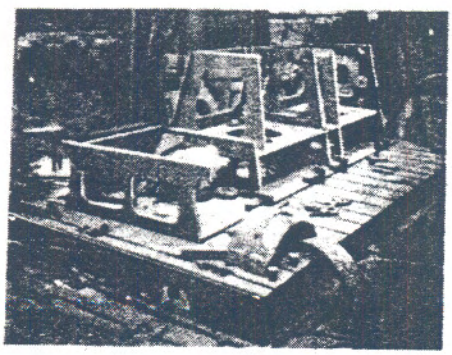
    An important feature of bed-plates is the drilling, cutting or welding of parts to it. Those parts could be restored by grinding. Consequently, the bed-plate will then be ready for re-use.

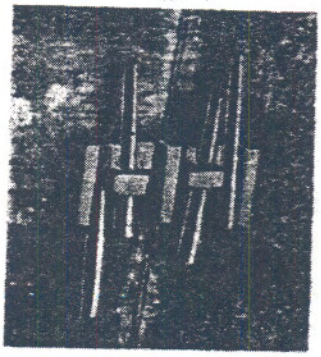
23. All locking means as clamps, wedges, pins, etc. must give a firm and definite locking capability.

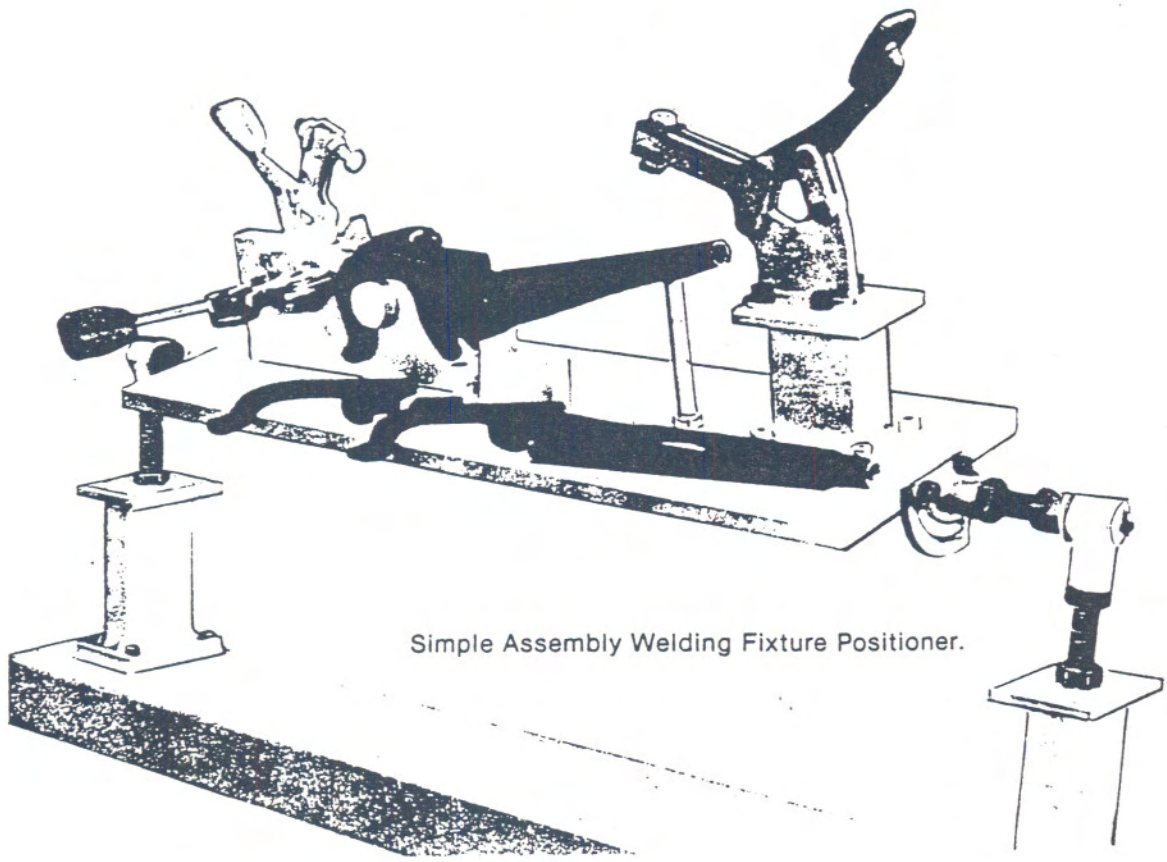
24. A welding fixture has to be designed so that it could be used again for other similar purposes, sizes, shapes, etc. (standardization through families).

25. Machining and tool room work are highly expensive and time consuming. Therefore, they should be avoided as much as possible and replaced by other means of adjusting, such as ready made components of jigs and fixtures.

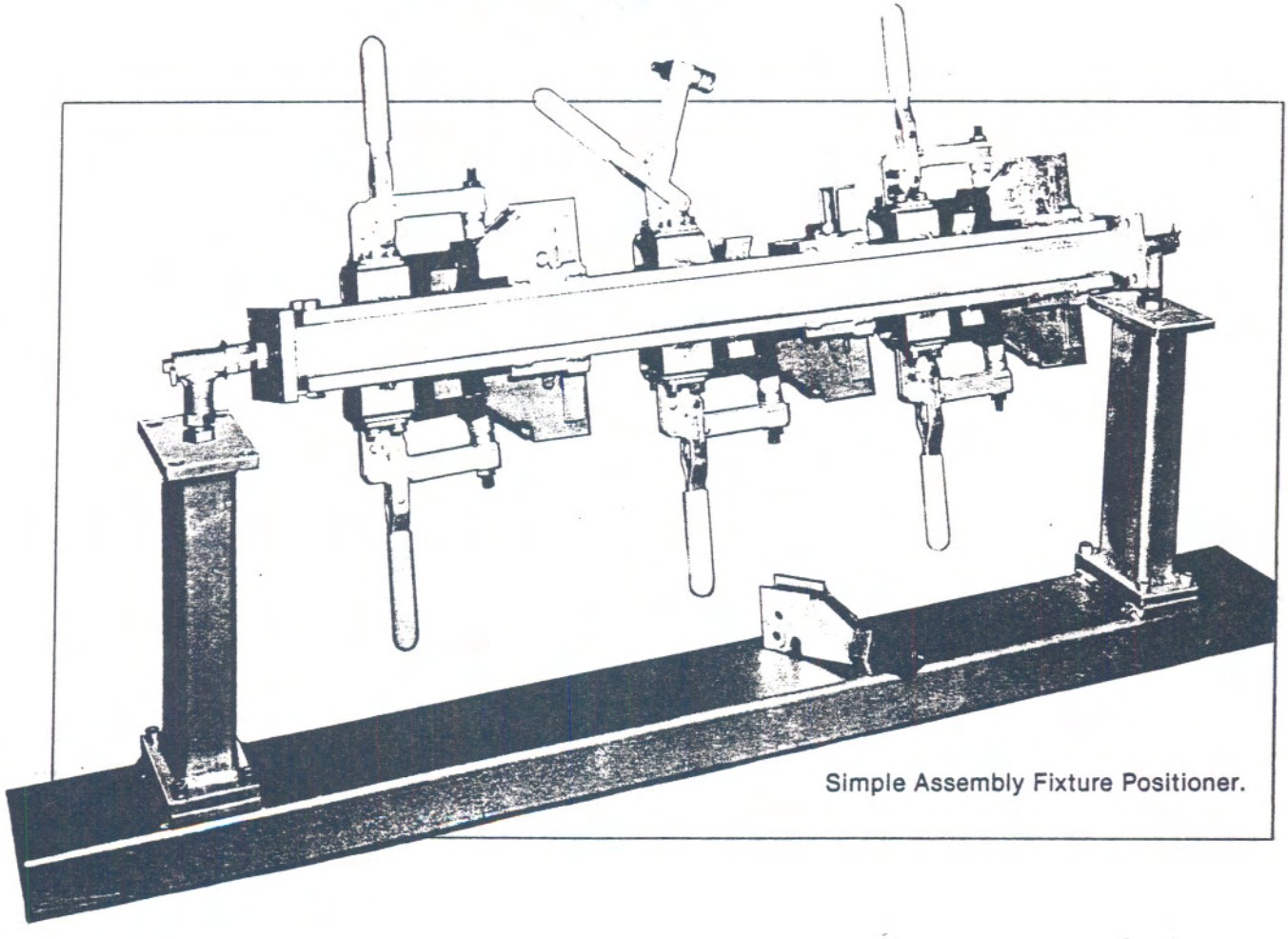
26. Accuracy means cost. The greater the accuracy, the more we pay. Accuracy should correspond to the type of work required. Therefore, accuracy should be practiced, bearing in mind the function and purpose of the welded part and where it is going to fit.







Simple Assembly Welding Fixture Positioner.

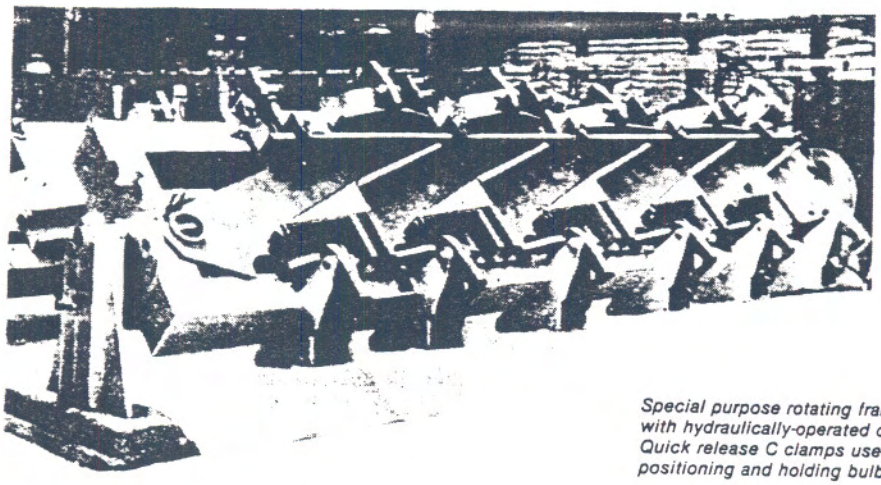


Simple Assembly Fixture Positioner.

POSITIONERS

A positioner is a handling device or machine that enables a workpiece to be put into a variety of positions.

Positioners may vary in complexity from a simple turntable, axle, to a highly mechanized and controlled machine.



Special purpose rotating frame jig with hydraulically-operated clamps. Quick release C clamps used for positioning and holding bulb angle.

The main purpose of a welding positioner is to allow welding to be done in a flat position. A properly designed positioner has many advantages:

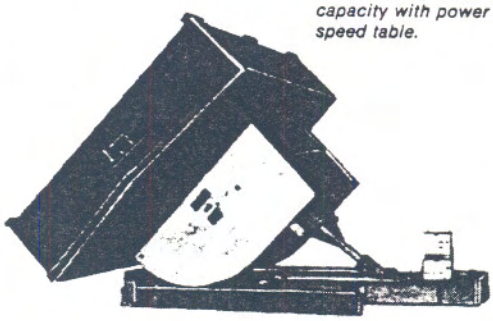
1. *Increased production* by using larger guage wires or electrodes, higher current welding machines and, therefore, higher deposit rates, fewer runs and less descaling.

2. *Improved quality*, because there is less possibility of slag inclusions, undercut and operator fatigue.

3. *Less skilled operators*, because welding is easier and there is greater control over welding procedure, less skilled welders give good results.

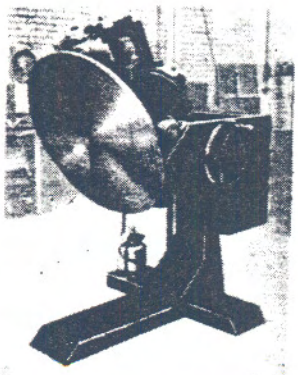
4. *Reduced handling time* for cranes and other shop equipment while welding is being done.

Rocker-type positioner of 8 ton capacity with power driven variable speed table.



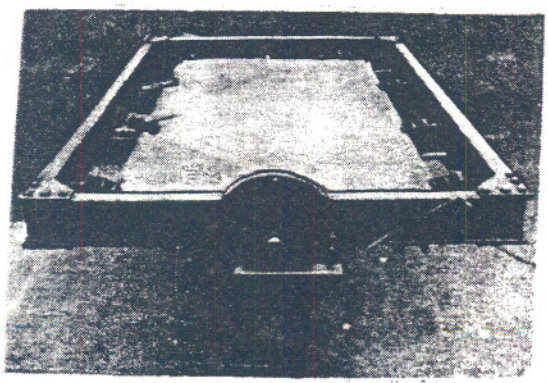
5. *Require less floor space* than cranes and are removed entirely when they are not in use.

6. *Greater safety* because the assembly is firmly clamped down and there is no chance for turning over or slipping accidentally.



Variable speed range positioner with vertical adjustment of table.

Special-purpose rotating frame jig for welding of mineral waggons.



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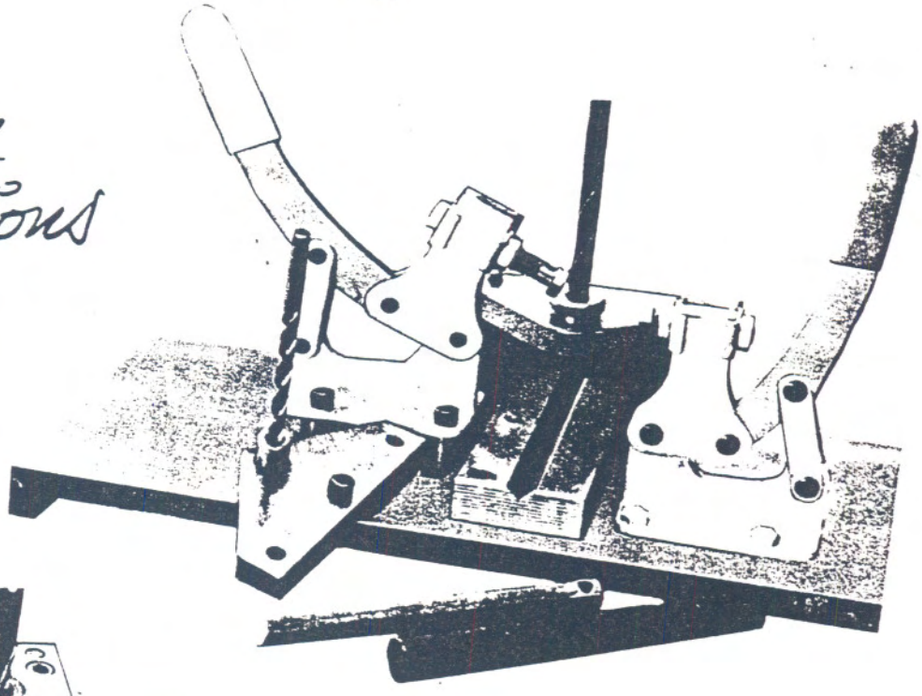
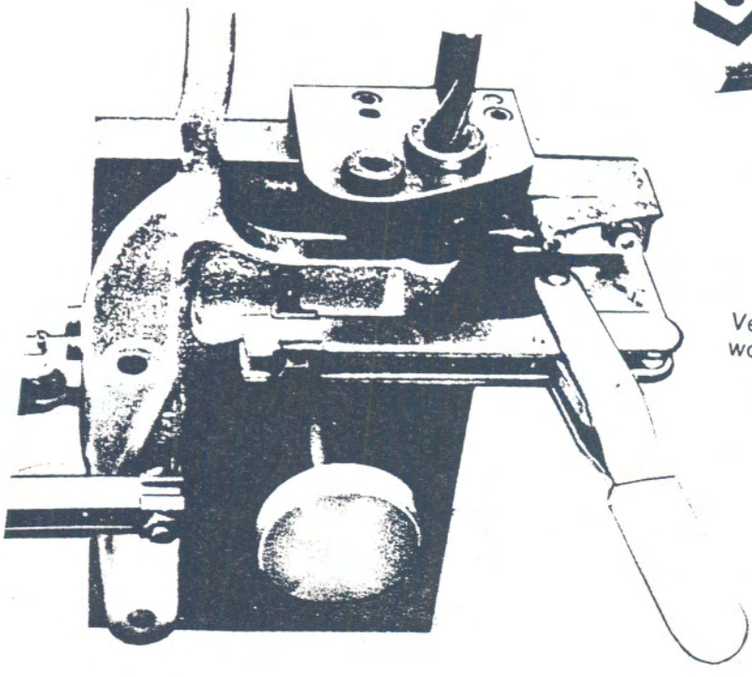
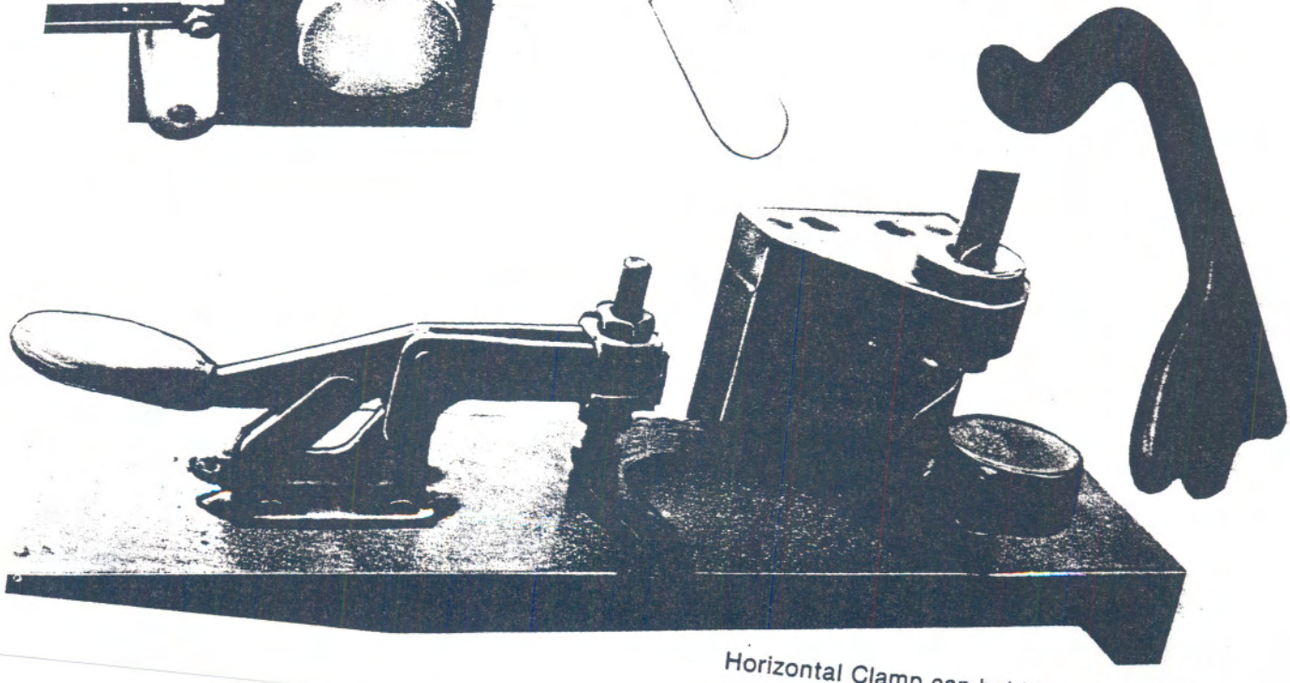
Sample Applications



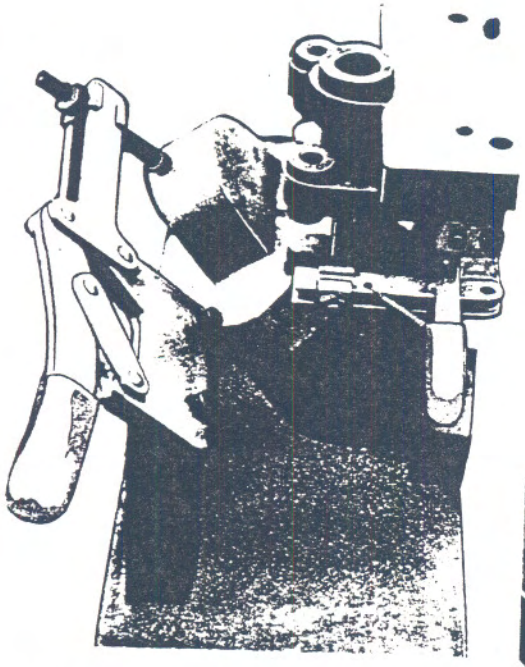
A bar drilling fixture with a V-Block for side drilling.



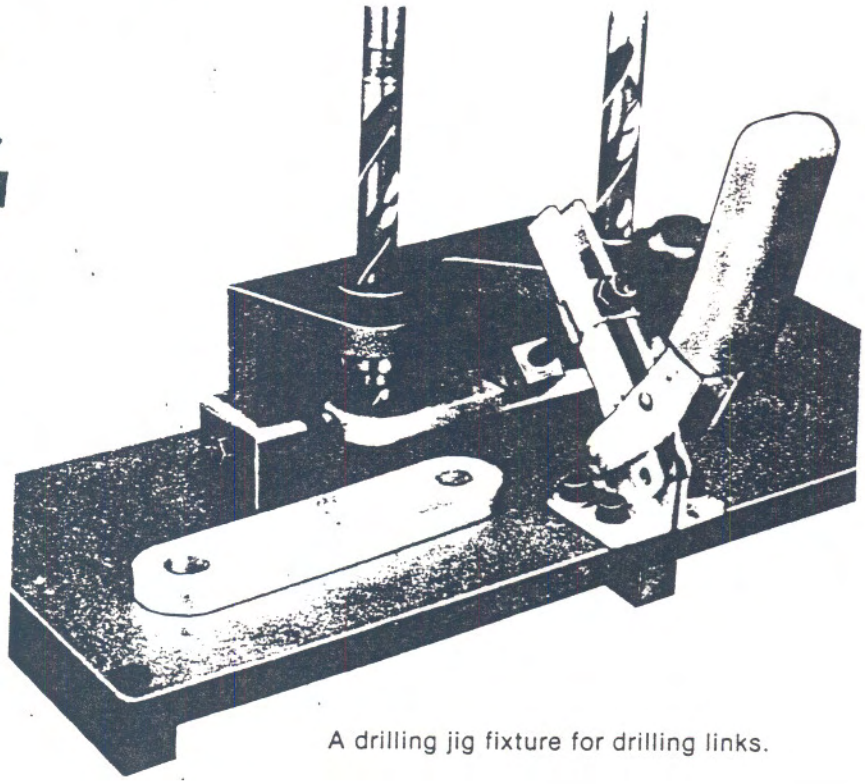
Vertical Handle Clamp holding a forged work piece in a drilling jig.



Horizontal Clamp can hold that jaw for you.

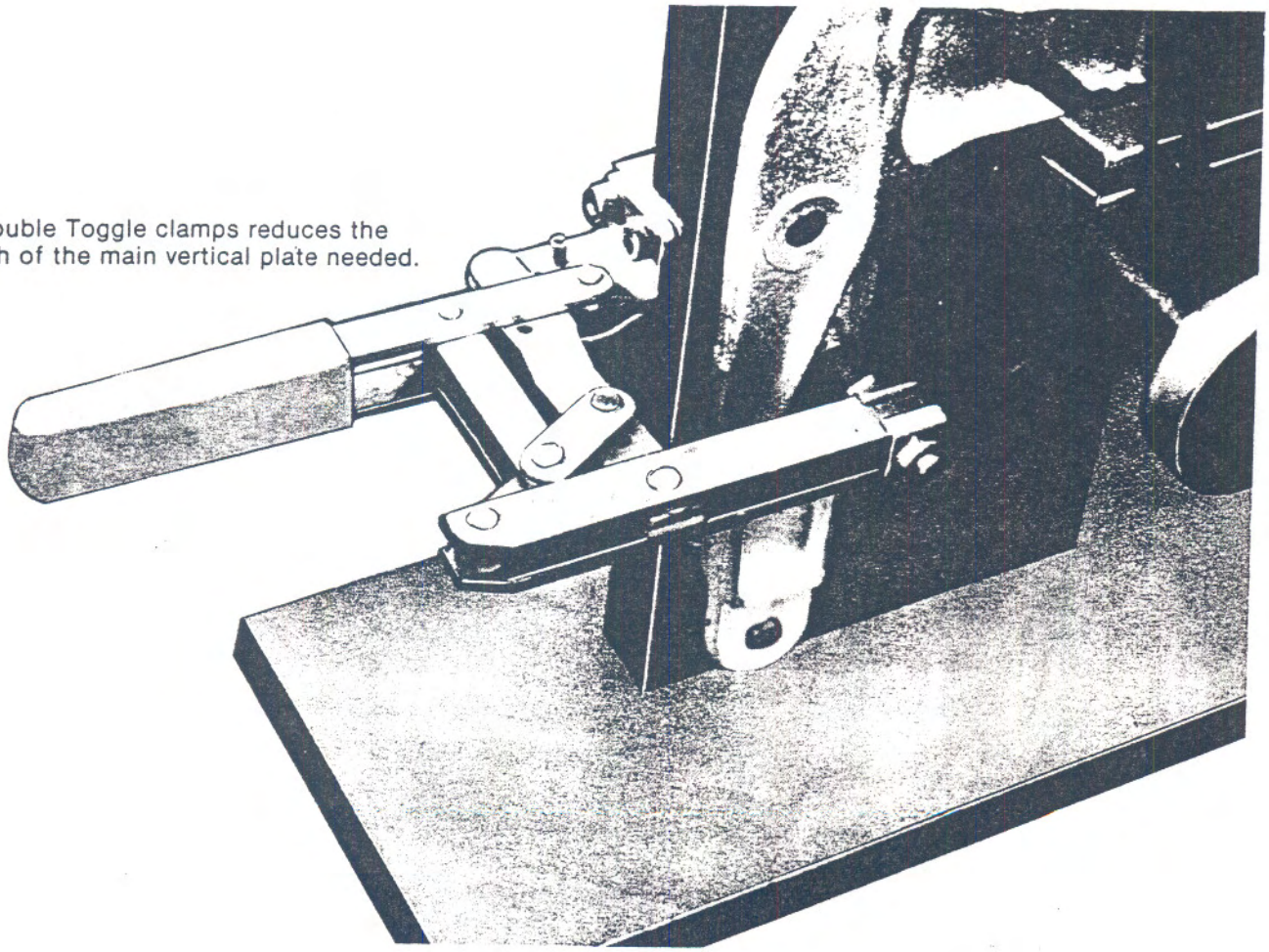


Jig for drilling a hydraulic cylinder head held by Horizontal Clamp.

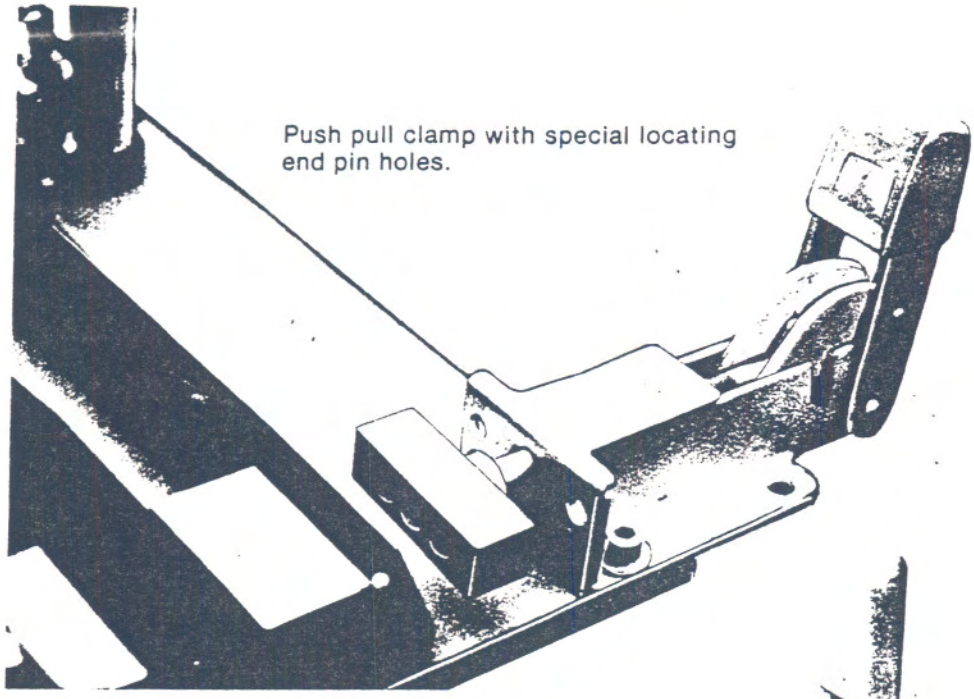


A drilling jig fixture for drilling links.

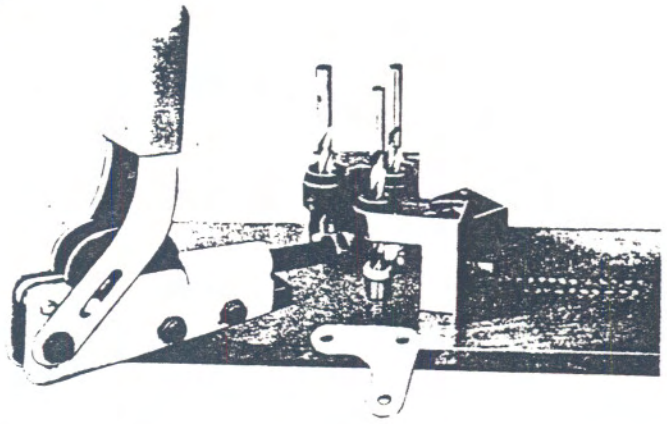
A Double Toggle clamps reduces the width of the main vertical plate needed.



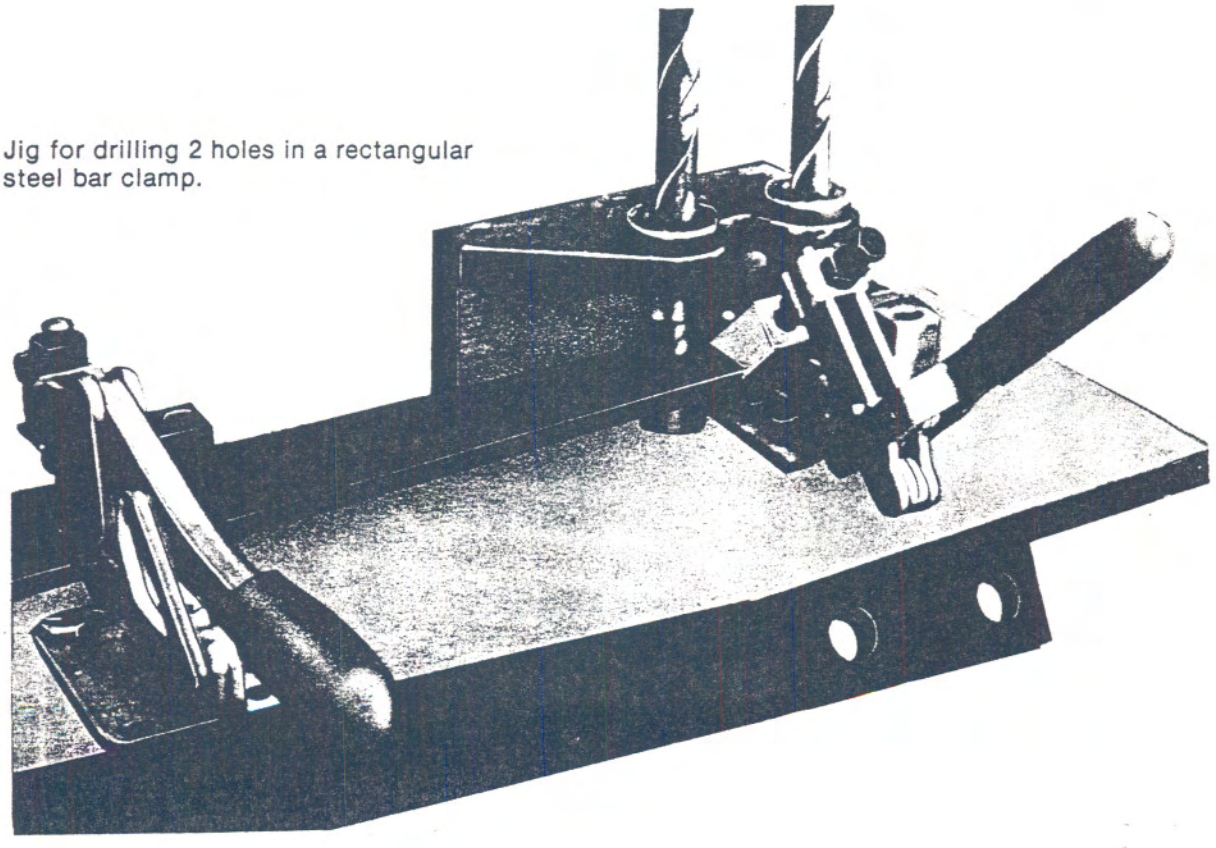
Push pull clamp with special locating end pin holes.

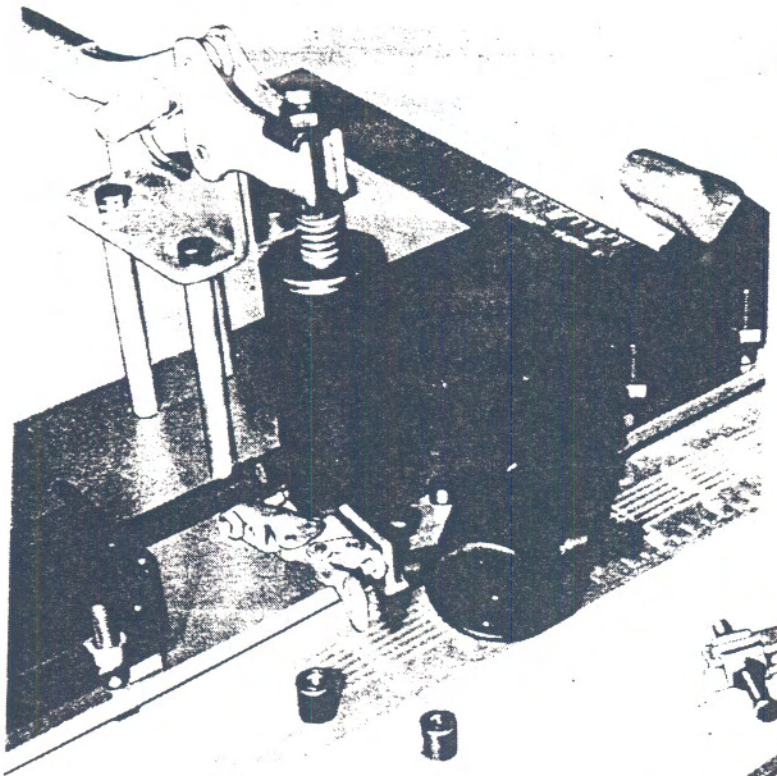


Another push pull clamp securely locks that tri-link for drilling.

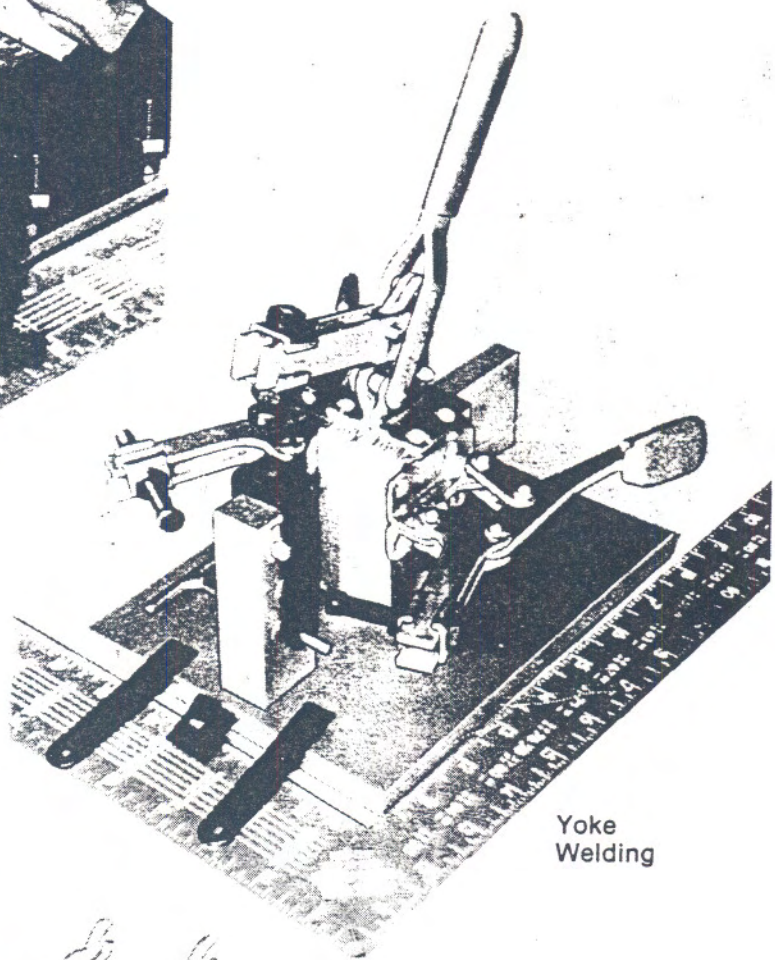


Jig for drilling 2 holes in a rectangular steel bar clamp.

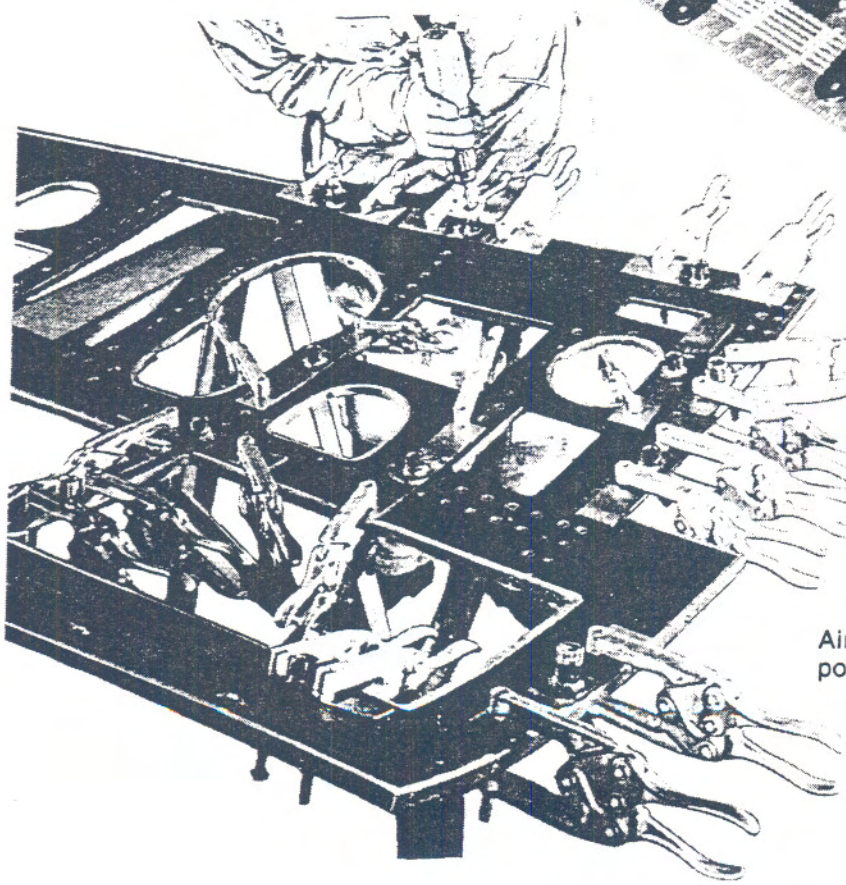




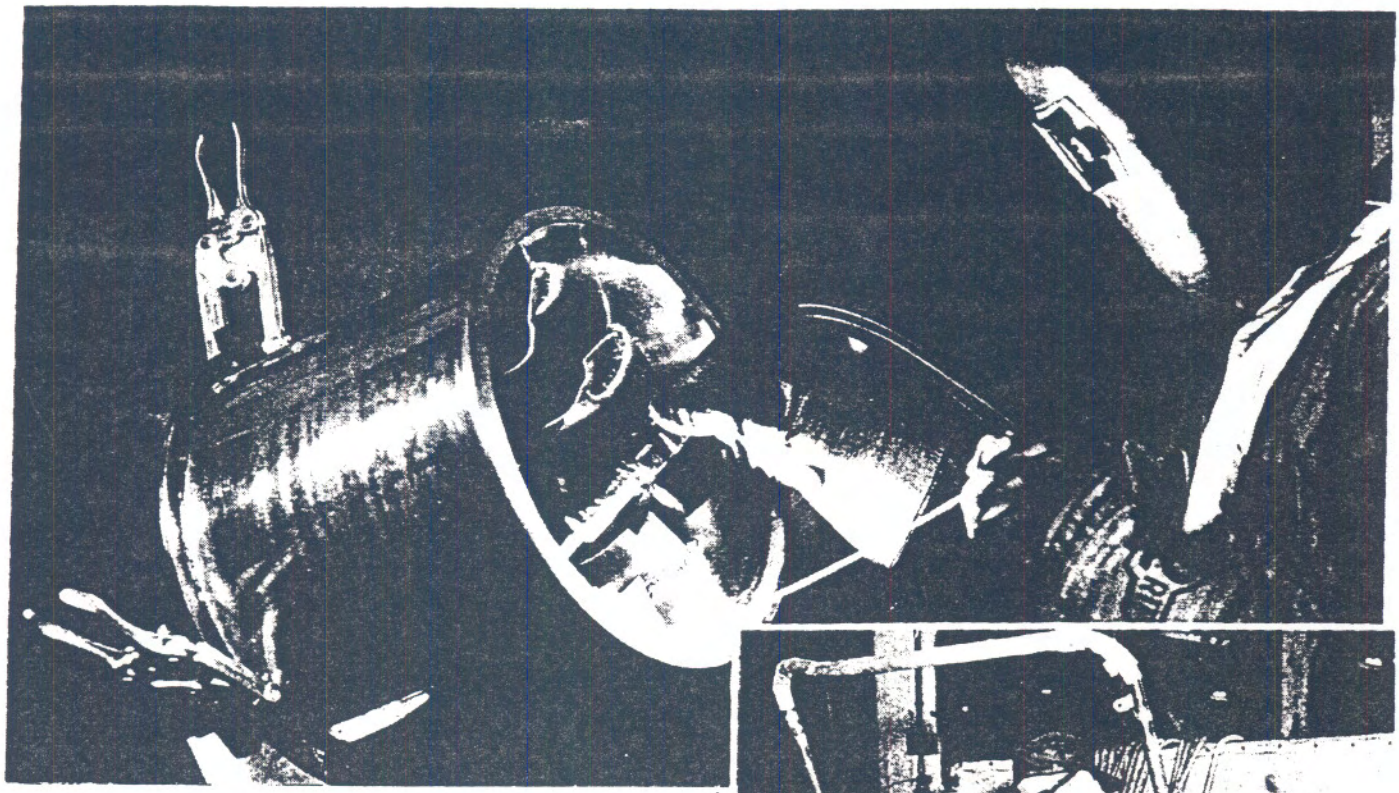
Cylinder end cap welding with side bushing.



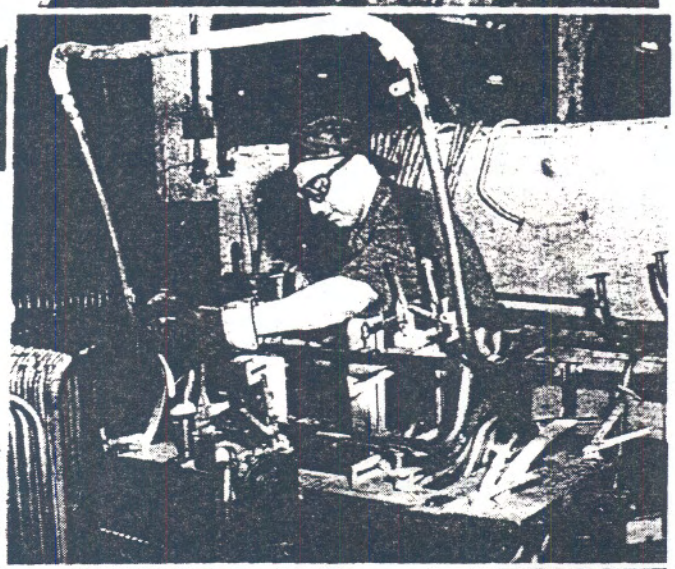
Yoke
Welding



Airplane Wing Plate drilling using
portable hand pliers.

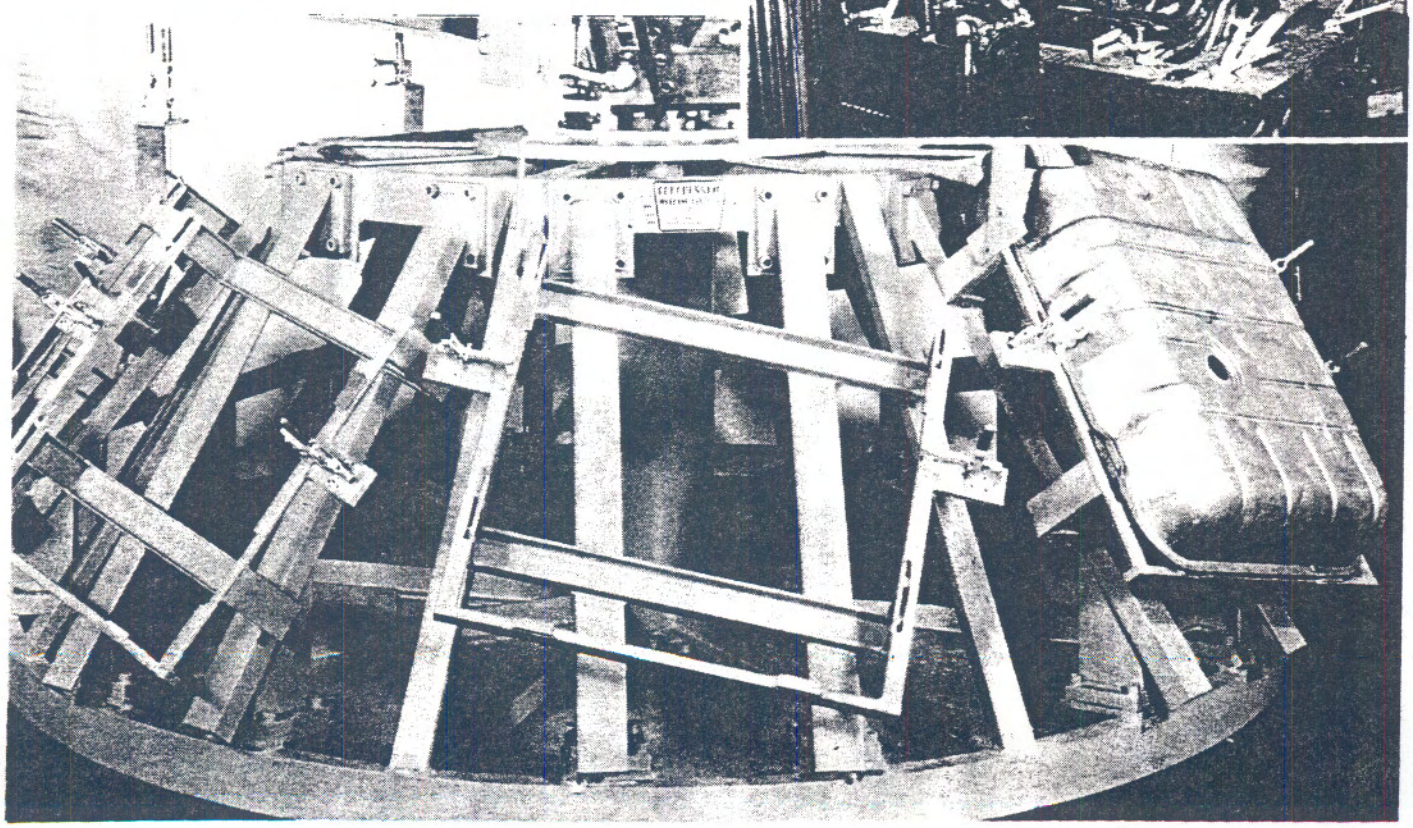


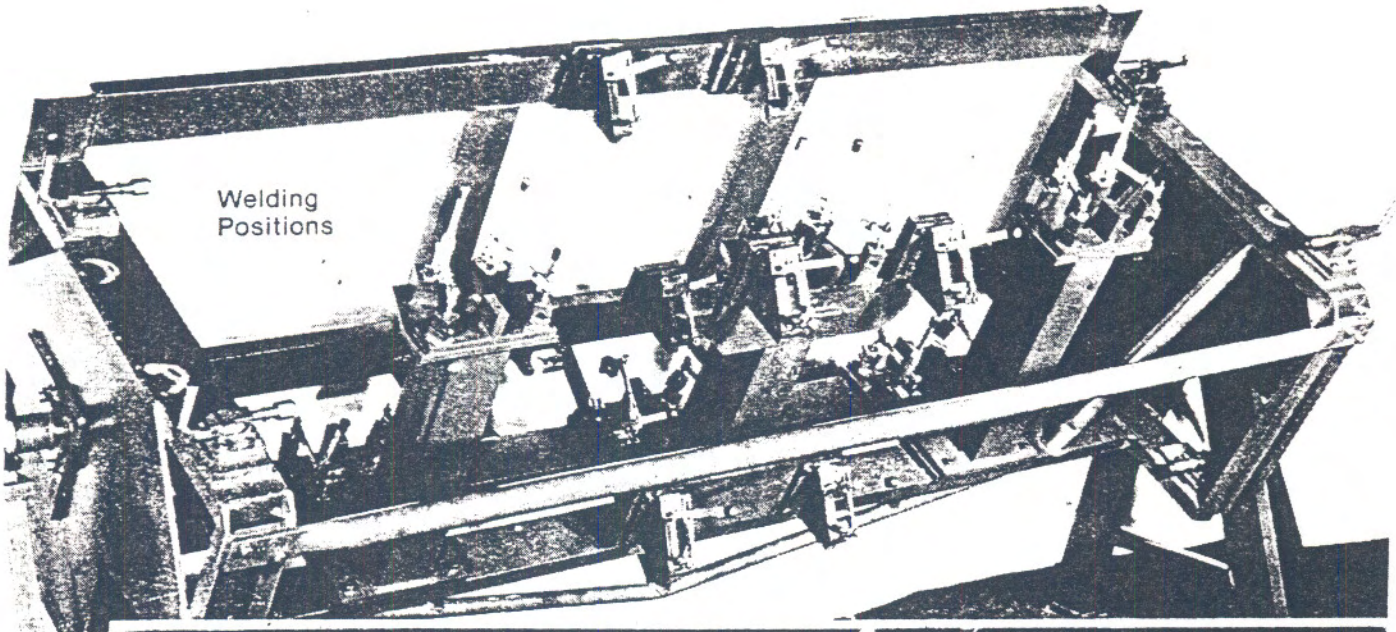
Quick Clamping by Hand Pliers.

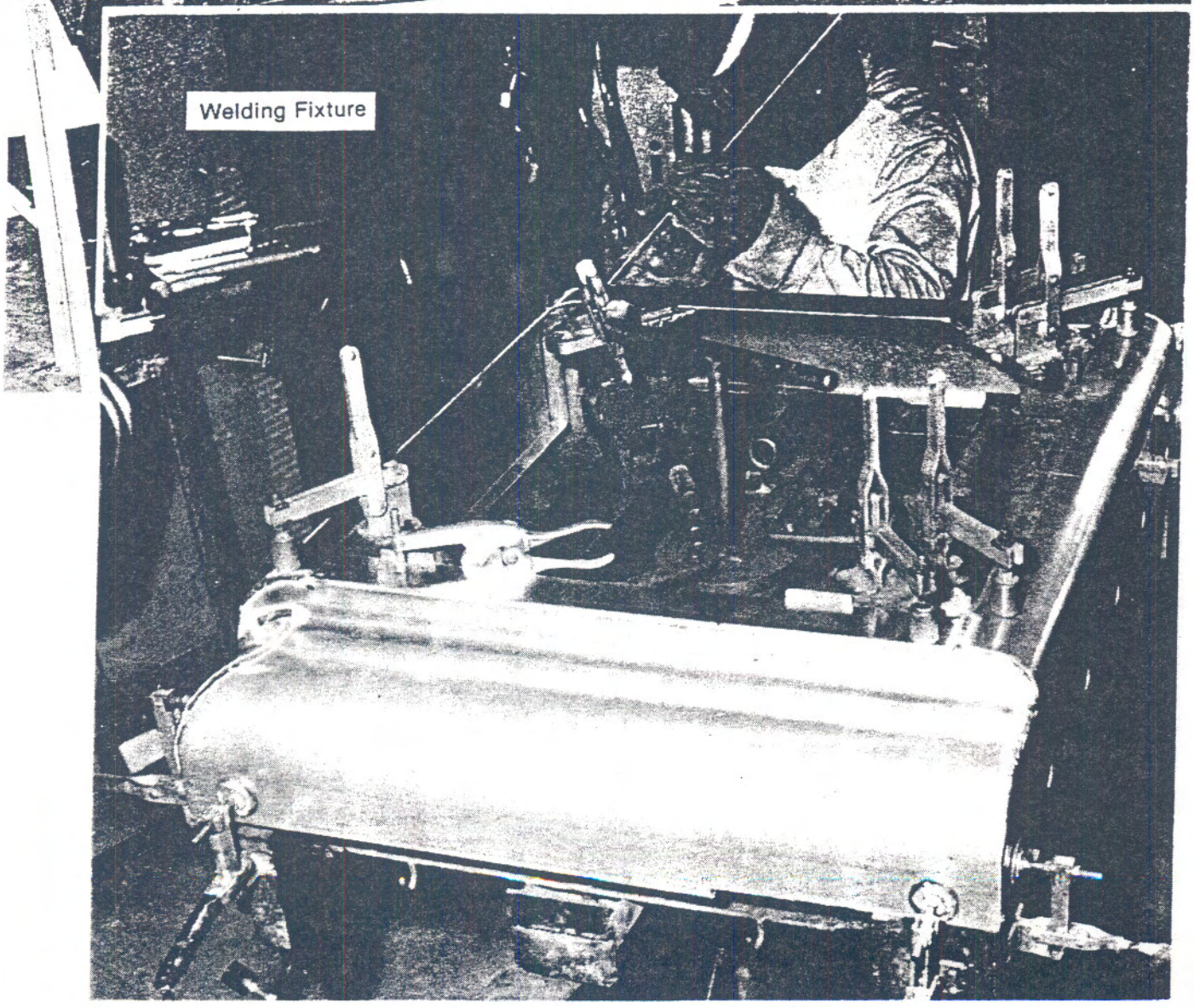


Clamping and Welding Tubular Components.

Gas Tank Welding Turn Table.




Welding
Positions


Welding Fixture