the severe winter climate of Chicago might operate against them. The more important consideration, however, was that air could be used for calking and chipping hammers and drills or reamers, so that a compressor plant for the yard was a necessity in any event, and we did not want to go to the expense of an hydraulic plant in addition if it could be avoided.

As naturally, also, seeking for portable riveters, we first applied to the manufacturers of the compression bow machines so extensively used in bridge shops, and finally found one maker who guaranteed the performance of a machine with a horse-shoe frame having a gap of 72 inches, which we needed to drive the bottom rivets in a 6-foot center keelson. This was a matter of some difficulty, as the gap usually used was not more than 42 inches, and, in fact, the first machine furnished us in February, 1896, proved too light for the work and had to be replaced by a heavier one, the weight finally reaching over 2,500 pounds. A similar tool, with the gap cut down to 45 inches, weighed over 1,700 pounds, and a very little experience showed that even with this lighter weight the difficulty of handling was too great to permit of the economical use of this kind of a machine for more than a very small portion of the ship.

In the spring of 1896 we heard that at the works of the Lassig Bridge and Iron Co., in Chicago, some experimental rivets had been driven with an ordinary pneumatic calking hammer. Trying this at once in our yard we found the method perfectly feasible, though severe on the man using the hammer. It was also almost impossible to hold on to the rivets by the ordinary heavy hammer, the blows of the pneumatic hammer on the point being so heavy and continuous that the holder-on was unable to keep his hammer from being fairly "jarred" off the head of the rivet. This difficulty, however, was quickly obviated by the use of a pneumatic holder-on which we devised, of the simplest construction, being only a cylinder into which air is admitted forcing out a piston, the rod of which is cupped out to go over the rivet head. The parallel arrangement of the longitudinals in the double bottom of our lake ships made it easy to obtain a bearing or resistance for the cylinder itself, a piece of pipe of the proper length being screwed to it. This made a perfectly practicable method, and many rivets were driven by it, as shown in Fig. 1, Plate 44. We still use it to some extent for odd rivets or in certain contracted spaces.

The next step was naturally the connection of the hammer and holder-on by a horse-shoe frame or bow, forming a single machine. As the bow has only to resist the pressure of the holder-on and the blows of the hammer, it can be made of very light construction and is very easily handled and moved to various parts of the ship. Nearly all of the inside rivets in our ships are now driven by these machines, Fig. 2, A and B, Plate 45.

A variation in the device is to mount the hammer itself as a piston in a cylinder, to which air is admitted to force out the hammer as the point of the rivet is beaten down, using a plain die on the other side, which die can, therefore, be made small to get into contracted places, Fig. 2, C, Plate 45.

The weights of the whole arrangement for various depths of gap, taken from actual machines in use in our yard, are as follows:—9 inches, 83 pounds; 51½ inches, 160 pounds; 70 inches, 220 pounds.

In the larger ones the bow is made of a plain piece of wrought-iron pipe.

In some cases the riveter is suspended by a chain hoist from a trolley carried on a beam supported by a pair of A frames, Plate 46. As a general rule, however, the whole machine is so light that it is easily moved around by hand, Plates 47, 48 and 49. A wooden roller may be fitted on the cross brace to facilitate moving the riveter along a center keelson or girder.

That these machines can and do make better work than hand riveting is evident from several considerations. It is well known that in hand work constant watchfulness is required to make the men properly "plug" the rivet before heading over the point; that is, to strike the first blows exactly in line with the axis of the rivet so as to upset it clear to the head and make it properly fill the holes; it is much easier and quicker for the men to knock the head over at once, and when that is done, as the head and point look all right, there is no way of determining in what condition the body of the rivet is, unless it is loose under test, or loosens up in service afterward with the constant vibration and jar of the ship, as often happens. With the machine, however, it is almost impossible not to plug the rivet, the hammer being very easily and naturally brought in line with its axis, and, in fact, will not drive the rivet properly unless it is so in line, and the blows of the hammer being so rapid that the plugging is accomplished before the point is formed. The whole operation of driving the rivet is completed much more quickly than by hand, and before the rivet has lost its heat, the resulting contraction afterwards drawing everything firmly together as the rivet gets cold, and strengthening the joint by the well-known effect of the friction between its parts.

Again, there are very many places in the framework of a ship where there is not sufficient space for swinging a hand hammer in driving a rivet, or where the rivet can be gotten at from only one side. Such rivets as those through beam knees and frames, in the connections of floors to center keelsons, wash plates between floors, frame brackets at tank tops and decks, in cellular tanks, and generally wherever the available space is only that of the frame spacing, or less, or where a rivet comes in the bosom of an angle or channel, are of this type, and are among those most important to be well driven, the integrity of the framework depending largely upon them. From the nature of the case, hand-driven rivets in such situations are not what they should be, but it is evident that such considerations do not affect the machine in the slightest degree, and that if the hammer can get on to the rivet at all it will drive it as well in such locations as in the most open parts of the work.

Passing now to the case of a rivet so located in the ship that it is not possible to get at both sides of it by a bow frame, we must distinguish at once between those that are finished with a full or button-head point, as in bulkheads, and those with a countersunk flush point, as in decks, tank tops, and the outside shell. For decks and tank tops, where the rivets are put up from below and the action of the hammer is always vertically downward, a simple arrangement of the hammer mounted on a bent pipe as if on a wheelbarrow with one or two wheels, as in Plate 50, is all that is necessary. The operator raises the handle end sufficiently to get the die over the point of the rivet and then bears down as the air is turned on, the bend of the pipe being loaded with lead. A second man with a chipping hammer cuts off the surplus metal, and a few seconds' work of the riveter again suffices to complete a very satisfactory operation. A pneumatic holder-on is used below, and three men and a heater boy will drive from 800 to 1,000 rivets in a day.

In the case of bulkhead rivets, it is evident that the combined hammer and holder-on can be fastened to the end of a beam which slides loosely on a central supporting stud bolted to the bulkhead, with an adjustable stud bolt on the other end of the beam governing the distance of the hammer die from the rivet point, and reaching a good many rivets at one setting. The pneumatic holder-on may be similarly mounted on the other side of the bulkhead.

The die is cupped out, and it is evident that after the first stroke of the hammer the die will be firmly held in position by the metal, which is forced into the hollow of the die. The holder-on is similarly kept central with the rivet by its hollow-ended die going over the head. The resulting finished rivet is all that can be desired.

In the case of flush-pointed rivets, however, a very different arrangement is required. It is evident that, as in handwork, the varying thicknesses of plating, liners, butt straps, frame flanges, etc., and amount of countersink in the plate, make it impossible to so gauge the length of the rivet under the head that, when beaten down, it will exactly fill the countersink and finish flush with the surface of the plate. The only practicable method of driving is to follow as closely as possible the hand method, beating the rivet down with the surplus metal crowded off to one side, chipping this surplus metal off by a cold chisel, either by hand or by an ordinary pneumatic chipping hammer, and then finishing properly the point.

To do this it is necessary that some freedom of movement be given to the hammer—that is, it must be possible to incline the axis of the hammer to a slight angle with the axis of the rivet in any direction, in order that the surplus metal in the point may be properly crowded off to one side to make easy chipping, and also that the point may be properly finished, and, if necessary, slightly rounded, and any seams around the point between the rivet and the plate properly driven together and made water-tight.

To do this, three methods may be used, as shown in the cuts, for fastening the hammer to the beam:—

First. The hammer may be mounted in gimbals. Plate 51.

Second. The hammer may be so mounted in a frame that while the die is held in position against the rivet, the lower end may be given a rotary movement. This is not as good as the gimbals.

Third. The hammer may be mounted on trunnions, and the beam carrying it turned on its own axis and moved forward and back longitudinally. The third method does not seem very practicable, and we have never tried it.

There is still another method by which countersunk flush rivets may be driven by hammers. In this, the hammer is fastened immovably to the end of the beam, as in the bulkhead riveter, and the flat-faced die has a central hole about $^3/_{16}$ inch diameter drilled in it. When the rivet is beaten down some of the hot metal enters the hole and the result is a projecting teat on the rivet point, the remainder of the surplus metal flattening out equally on all sides.

This surplus metal is removed by a face milling tool, also made with a central hole, which fits over the teat and holds the tool in position. The milling tool is driven by a pneumatic drill, and after the point of the rivet is milled down flush with the plate the teat is easily cut off by a blow of a hand hammer on a cold chisel. The rivet, however, is not finished in quite as "ship-shape" a manner as by the other method, and we have had so much difficulty in getting a milling tool of the right shape to cut properly that we have abandoned it.

In the Chicago yard, therefore, the only method now used is the first one cited above, which has proved most satisfactory in every way, both on new construction and in the dry-dock on repair work. Plate 51 shows the construction and mounting of the hammer in the gimbals on the end of the pipe beam, giving it the necessary swinging motion, as well as a certain amount of motion bodily sideways in any direction without moving the beam. For bottom rivets, Plates 51 and 52, the beam is hung by a bolt through its center, on which it rotates, to a trolley running inside of a slotted pipe which is bolted to the bottom of the ship, enabling the operator to reach many rivets at one setting. Plate 51 shows a variation of the same arrangement, where, instead of bolting the slotted pipe to the ship, it is held firmly up against the bottom by the simple pneumatic jacks at each end. This avoids missing any bolt holes and is well suited to work in the dry-dock. It will, of course, be understood that in Plate 51 the arrangement is brought out into open ground to get a clear photograph.

For the side of the ship Plate 53 shows the mounting we have so far found most satisfactory. There the short vertical beam carrying the hammer and provided at its lower end with an adjustable bolt to govern the distance of the hammer from the rivet, is fastened to a bored-out tee which slides freely on the horizontal pipe. This pipe is counterweighted and hung from pulleys above inside of flat iron guides bolted to the ship's side. The resulting free vertical and horizontal movement of the hammer enables a large portion of the side to be covered without shifting the rig.

For the bilges, which for a large portion of the length of our lake ships are circular, the hammer beam is again a horizontal pipe fastened to a double frame which fits the bilge and travels fore and aft on trolleys above and below. Plate 54 shows the arrangement.

It will be understood that for all these shell rivets the method is to beat down the head to fill the countersink, chip off the surplus metal, as in hand riveting, by a chipping hammer, and then finish by the machine. In all these methods of mounting, after the rivet is plugged and the head is beaten down, the hammer is easily swung out of the way to enable the chipping to be done, Plate 55.

In all cases the pneumatic holder-on is used against the head of the rivet inside. For the bottom and bilges, the tank top lends itself with facility as a support against which the holder-on can be braced by means of the pipe extension referred to above. In a single ship-bottom little difficulty is experienced in adjusting a short piece of plank as a brace by means of hook bolts taking hold of the reverse bars. For the side rivets we have found a simple method to be the use of two pieces of 6 inches by 6 inches scantling extending from the tank to the deck above or from deck to deck, easily bolted in position about eight feet apart, with a horizontal piece of two-inch plank sliding freely on their outboard sides. The plank forms the brace for the holder-on, and is counterweighted and easily moved up and down in unison with the horizontal pipe carrying the hammer outside.

As for the quality of the work done by these various methods of power riveting, I can say that the unanimous opinion of the hull inspectors who have been on duty in our yard for two years and more is that the rivets are first-class in every respect, and make far better and tighter work than those driven by hand.

As for the cost, I will say that, adding cost of air, repairs, etc., the saving is from one to two cents per rivet over piece-work prices for hand riveting, depending upon the location in the ship and averaging about 1¼ cents. In an ordinary lake steamer of 4,000 tons the saving is from four to five thousand dollars over hand work.

A further and very important advantage, however, is in the fact that skilled labor in one of the principal departments in a shipyard, which has hitherto been indispensable and correspondingly arrogant and high handed, can be replaced by unskilled labor.

In conclusion, I want to say that the quality of the work done by portable pneumatic riveters in shipbuilding is such that the various classification societies cannot ignore it, and before very long will doubtless recommend, if not require, that all rivets in at least the principal portions of the ship be driven by power.

DISCUSSION.

THE PRESIDENT:—Gentlemen, this valuable and instructive paper is now open for discussion.

MR. R. L. NEWMAN:—Mr. Chairman and gentlemen, I may remark, in regard to Mr. Babcock's paper, that during almost the same period of his experiments we have been going on with experiments of the same kind and with equal success. About two years and six months ago I purchased six pneumatic riveters and worked them in the Globe Iron Works. On the revenue cutters Algonquin and Onondaga we riveted up the bulkheads with the small pneumatic chippers, merely by hand, and with every success. The revenue cutter officials were thoroughly satisfied with the quality of the work, and my experience is that they are, if possible, even more particular than our naval brethren.

In regard to Mr. Babcock's steam riveter, I had the pleasure of seeing that work

To illustrate paper on "Portable Pneumatic Riveters in Shipbuilding,"
by W. I. Babcock, Esq., Member.

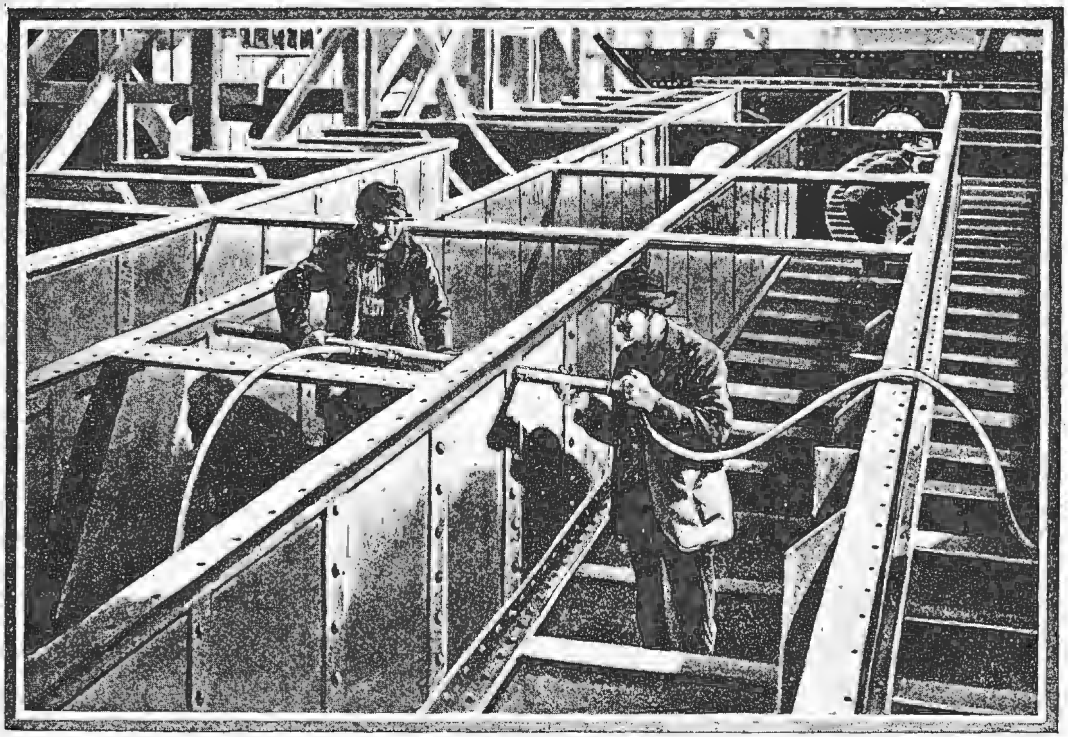
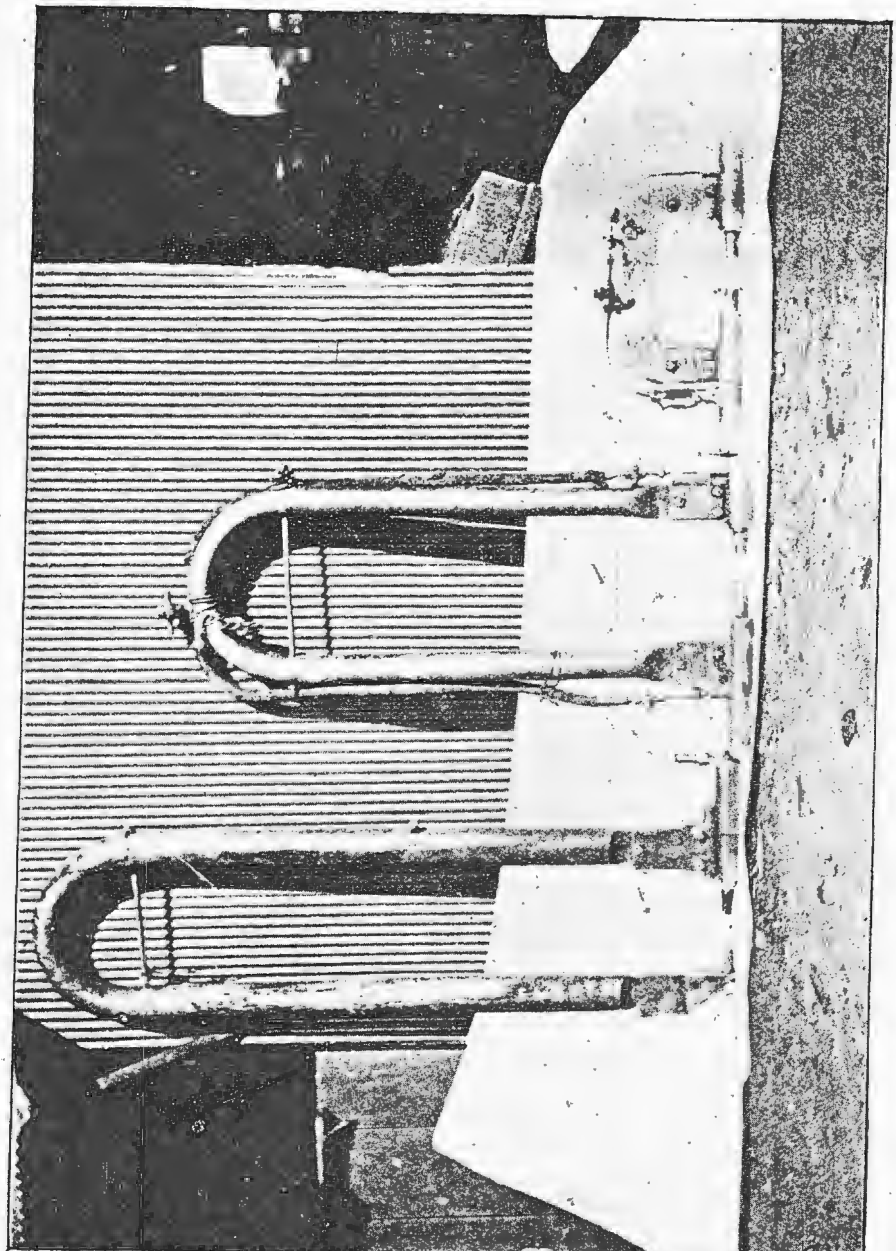


FIG. 1.

To illustrate paper on "Portable Pneumatic Riveters in Shipbuilding,"
by W. I. Babcock, Esq., Member.



C A B

Fig. 2.

Transactions Society Naval Architects and Marine Engineers, Vol. 6, 1898.

Plate 46.

To illustrate paper on "Portable Pneumatic Riveters in Shipbuilding,"
by W. I. Babcock, Esq., Member.

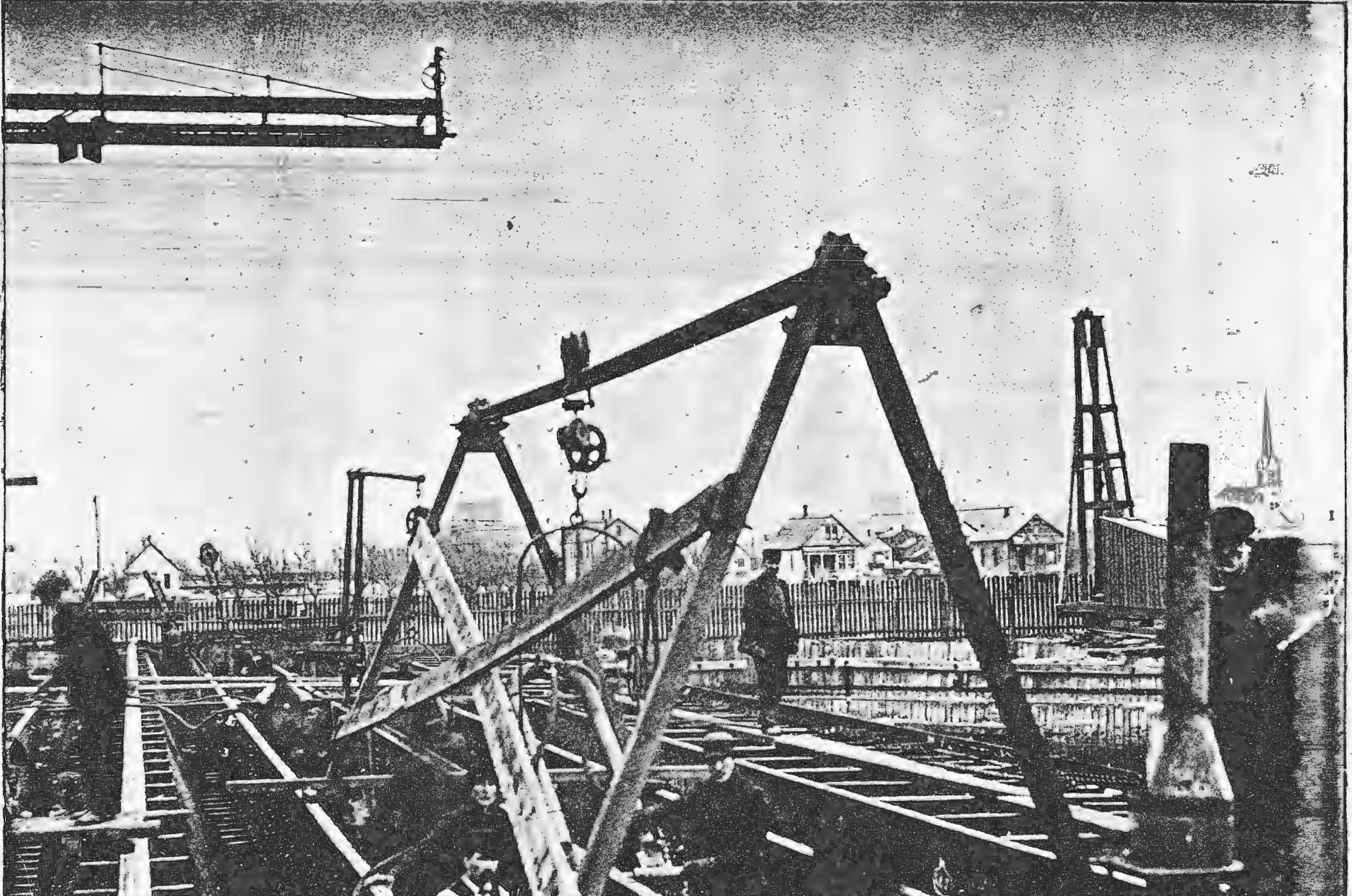


FIG. 3.

*To illustrate paper on "Portable Pneumatic Riveters in Shipbuilding,"
by W. I. Babcock, Esq., Member.*

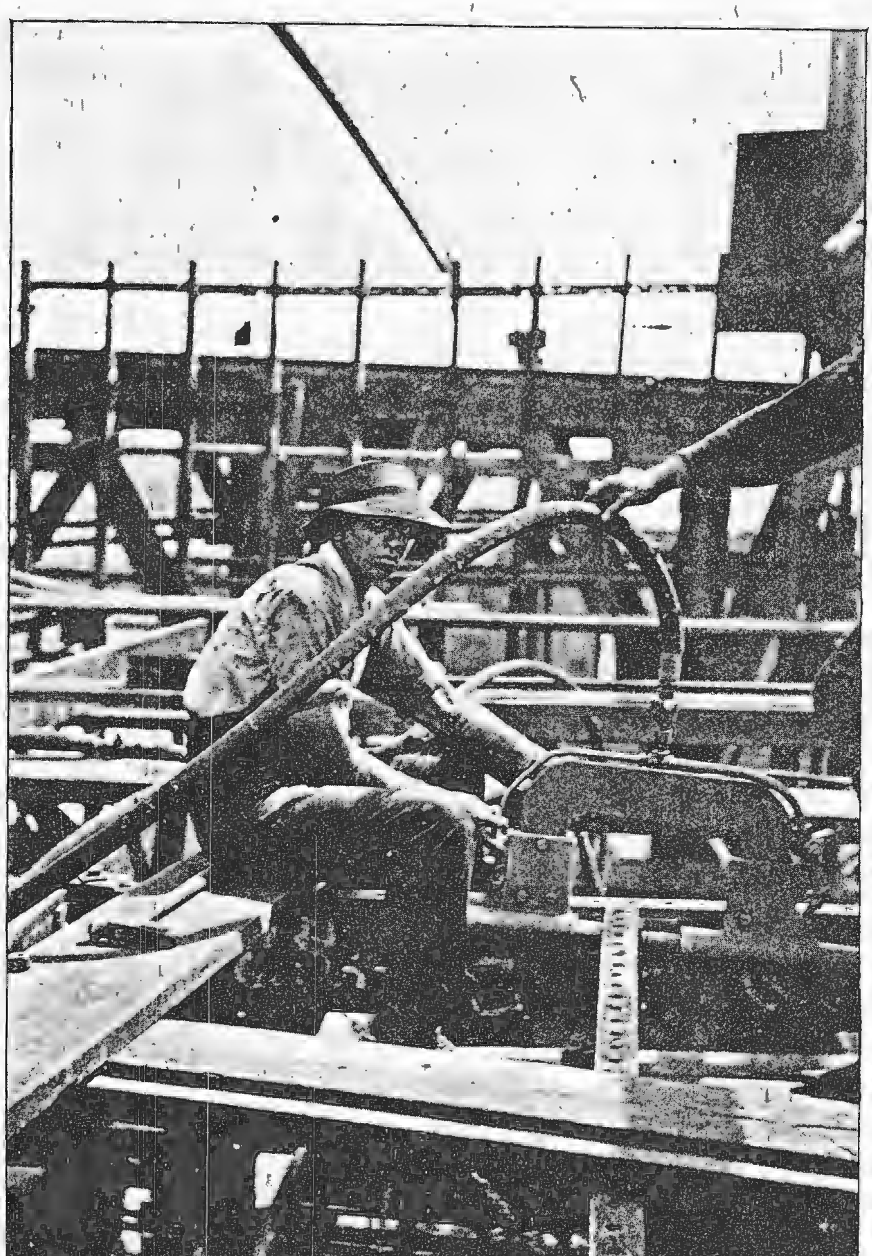


FIG. 4.

To illustrate paper on "Portable Pneumatic Riveters in Shipbuilding,"
by W. I. Babcock, Esq., Member.

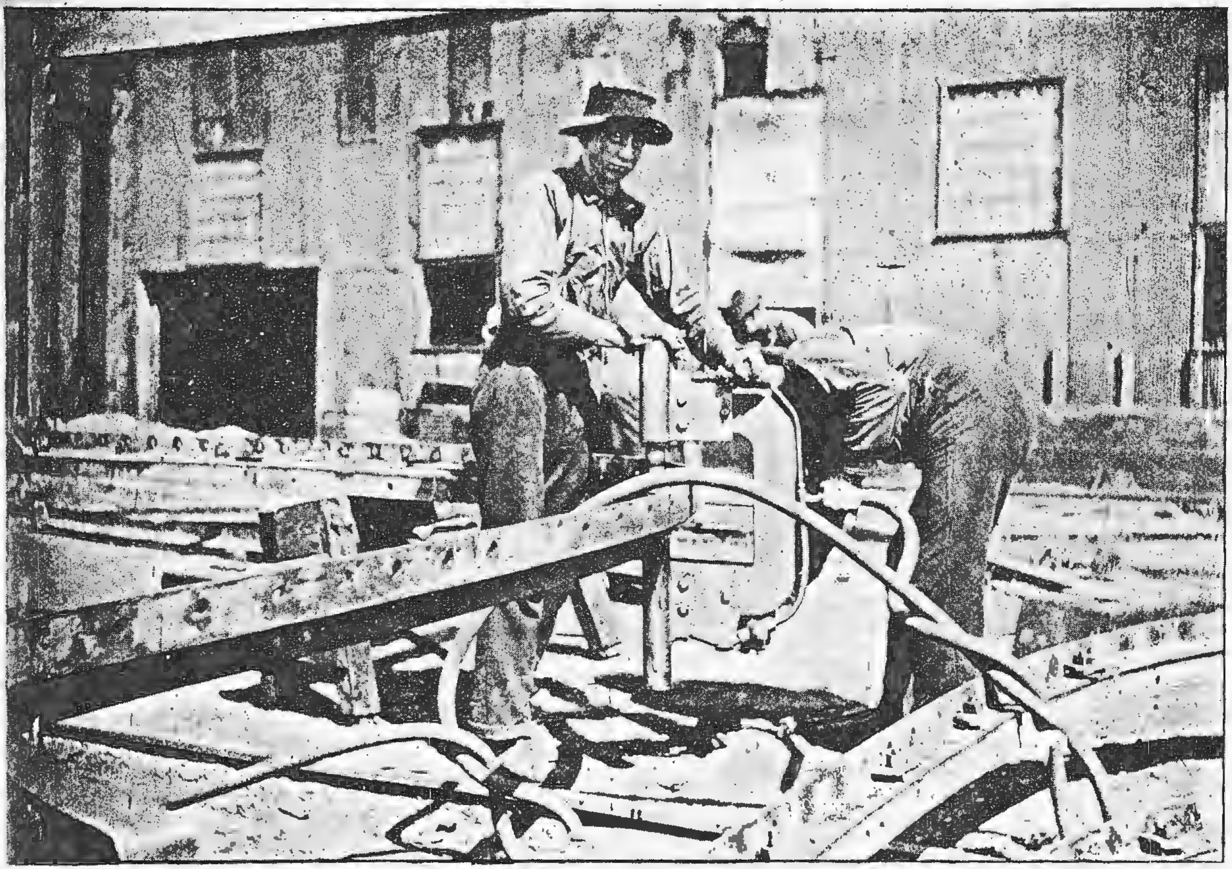


FIG. 5.

To illustrate paper on "Portable Pneumatic Riveters in Shipbuilding," by W. I. Babcock, Esq., Member.

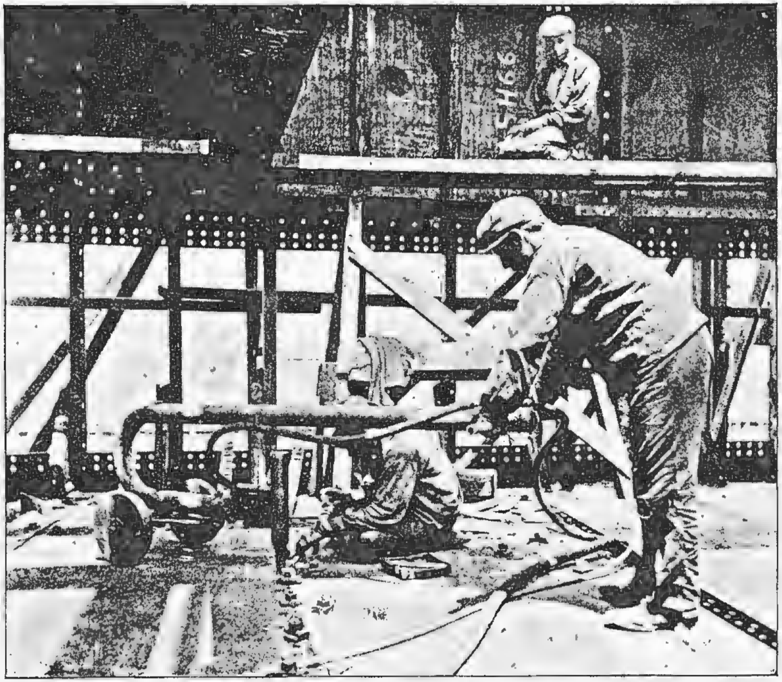


FIG. 7.

To illustrate paper on "Portable Pneumatic Riveters in Shipbuilding," by W. I. Babcock, Esq., Member.

Fig. 9.

To illustrate paper on "Portable Pneumatic Riveters in Shipbuilding," by W. I. Babcock, Esq., Member.

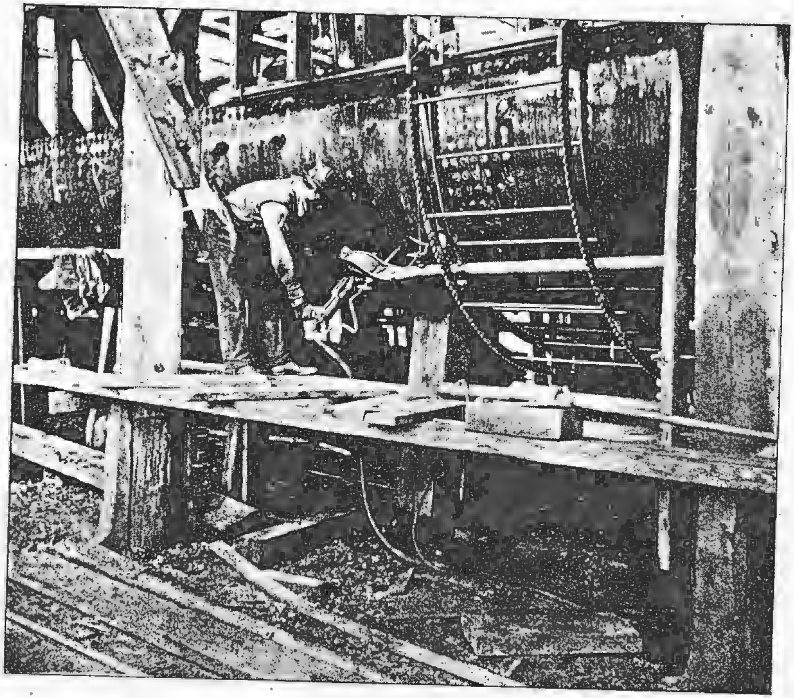
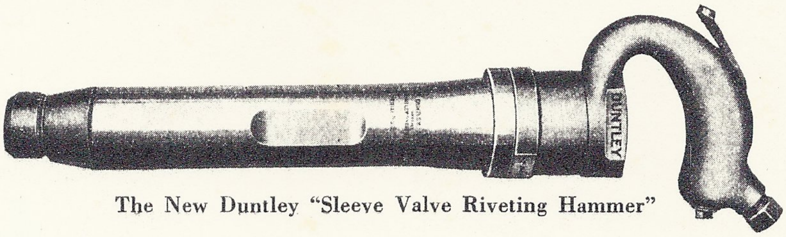


FIG. 11.

Duntley Pneumatic Tools



The New Duntley "Sleeve Valve Riveting Hammer"

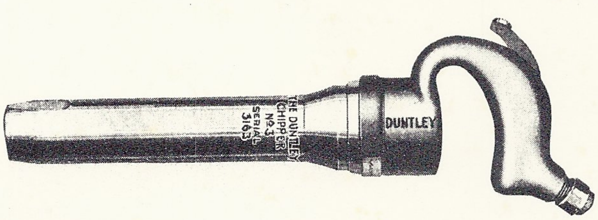
New Features

The New Duntley Riveting Hammer is the result of efforts to correct a weakness which has existed in pneumatic hammers since the present type of standard hammer secured universal adoption in 1905. This weakness has been the item of excessive upkeep cost due to exposure of frail valve construction to piston contact. The Duntley hammer protects the valve by operating the same on a sleeve giving a continuous smooth bore by which the piston has no contact whatever with the valve.

Interchangeability

The new Duntley Riveter is interchangeable in parts to standard riveters now in use and all parts are made subject to standard jigs and gauges insuring absolute accuracy and interchangeability. Stocks of spare and replacement parts are maintained at all branch offices for prompt delivery. The use of specially processed steel and an improved hardening treatment insures durability which together with the new features preventing breakage of parts, provides a hammer of long life and low up-keep cost.

Another important feature of the new Duntley Sleeve Valve lies in the fact that old, worn or broken valves of standard hammers can be reclaimed and equipped with this new improved valve construction.



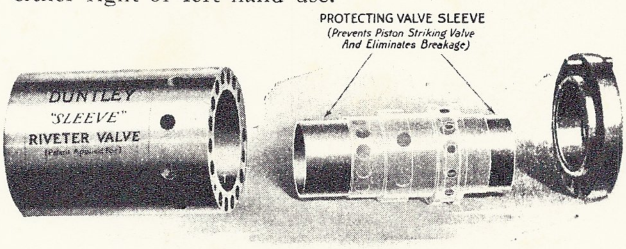
The Duntley Chipping Hammer

Cost-Saving Methods of Rivet Cutting

The Duntley Rivet Cutter is popular in ship yards. It avoids the slow, expensive work of sledge and hammer. It cuts rivets cold, avoiding damage to plates by excessive heat. It reduces cost. In punching out countersunk rivets from ship bottoms, three men with a Duntley will do the work of a dozen. In removing rivets in ship interiors, twelve to twenty rivets can be cut per minute. It is also extremely valuable in digging concrete in ships, straightening or loosening jammed or warped plates. In this general use it will save ninety per cent in labor and time.

Valve and Cylinder Breakage Up-Keep Reduced

In hammers commonly used in shipyard and structural iron work, a short piston is generally used by the workman which, by being shorter than originally intended, has a tendency to flutter or vibrate, thereby hitting the valve, causing breakage and high cost of up-keep. In the Duntley hammer either a short or standard piston can be used without danger to the valve because of the valve operating on a sleeve providing a double wearing surface and a continuous bore giving a full stroke of the piston, thereby developing greater power, prolonging the life of the valve and securing greater service from the hammer. In the Duntley hammer the cylinder has also been strengthened by eliminating the exhaust ports from the usual location which tended to weaken the cylinder at its vulnerable point. The exhaust is made direct from the valve and can be instantly adjusted to throw the exhaust in any direction, making its use convenient for either right or left hand use.



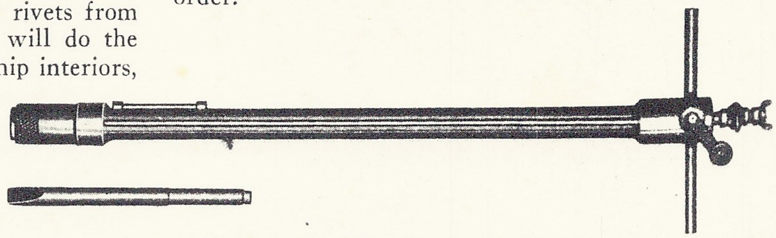
The Duntley "Sleeve Valve" for Riveting Hammer Equipment

Chipping and Caulking Efficiency

The Duntley Chipping Hammer represents both the highest achievement in hard-hitting effectiveness and an extraordinary durability under the severe conditions of usage to which tools of this character are subjected.

The simplicity of construction of this tool and its easy accessibility for inspection, cleaning and repair are added factors of efficiency, economy and durability.

Duntley Chipping Hammers manufactured in one, two, three and four inch strokes, can be furnished with closed or open handle, with the piston type of throttle valve and round or hexagon bushing as specified in the order.



The Duntley High Power Rivet Cutter

DUNTLEY PNEUMATIC TOOL COMPANY

FISHER BUILDING, CHICAGO, ILL.

"Thor" Pneumatic Riveting Hammer

The main feature and the great advantage of this long-stroke riveting hammer is in its one-piece construction, the handle, barrel and valve chamber being a one piece steel forging. This obviates the necessity of using couplings, clamps, keys, lock-nuts, and other complicated mechanism, which frequently break, become loose and cause considerable delay, annoyance and expense by the necessity of their having to be renewed or tightened.

The main valve lies parallel with the main bore, but

One-Piece Long Stroke Riveting Hammer

is not directly operated with the air on the downward stroke. When the piston returns, it opens an auxiliary valve which admits a slight amount of air. After the

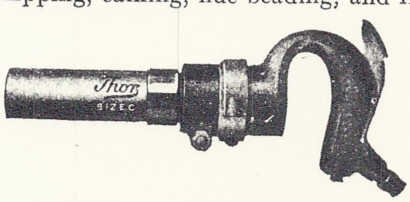
ONE-PIECE LONG-STROKE RIVETER FOR DRIVING 1⅛" RIVETS

Size	Stroke	Piston Diam.	Blows per min.	Weight Lbs.	Air Used	Length	Use Hose I. D.
90	9"	1 1/16"	700	22	23	20½"	¾"

piston has started downward, the main valve opens. Therefore, the piston from a gentle start gets an extremely forceful and quick acting blow and a quick return.

"Thor" Chipping and Calking Hammer

The A, B, C, and D Chipping, Calking and Flue Beading Hammers are made with a single valve and have been designed for every purpose for which this class of tools is used such as chipping, calking, flue beading, and light rivet-



Chipping, Calking and Flue Beading Hammer

ing. Special attention has been given to making a hammer that would stand up under all conditions, and at the same time be simple in construction and develop the maximum power.

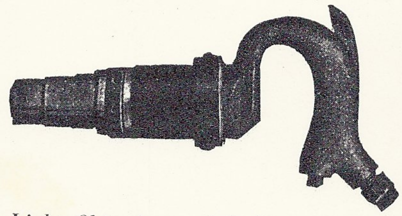
CHIPPING, CALKING AND FLUE BEADING HAMMER FOR GENERAL CHIPPING AND CALKING

Size	Stroke	Piston Diam.	Blows per min.	Weight Lbs.	Air Used	Length	Use Hose I. D.
C	3"	1 1/16"	1600	12½	15	14¾"	½"

"Thor" Light Scaling Hammer

The size M. Light Chippi and Scaling Hammer is ma with a ¾ inch stroke and a inch piston diameter. It weig 5½ pounds. Size N has 1¼ inch stroke and a 15/ inch piston diameter, and weighs 7 pounds. The types are adapted for very light chipping and scalin and for cleaning paint or rust.

The principal feature of Thor Chipping Hamme consists of an entirely new valve mechanism, the val block consisting of two solid cylindrical parts, harden and ground. The valve is a cylindrical shell (harden

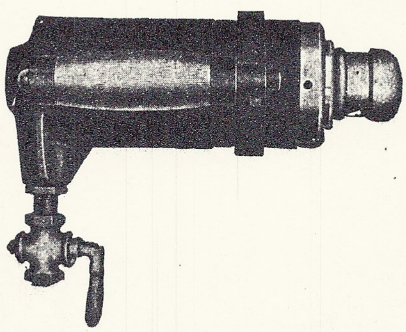


Light Chipping and Scaling Hammer

and ground) on the outside of the valve block, wit wearing surface covering practically the entire block When the handle is on, the valve is entirely protected The wearing surface is many times larger in propor tion to its weight than any other hammer made, an all the wearing surfaces are hardened.

"Thor" Pneumatic Holder-On

Thor Pneumatic Holders-On are of the single piston typ made with a heavy case—hardened steel plunger, with ample area to hold a rivet against the work and provided with a spring pressed plunger to hold the rivet set. The air inlet between throttle and holder-on plunger is provided



Pneumatic Holder-On

with check valve to admit air under the plunger slowly and prevent the plunger from shooting out too fast and, at the same time, relieve the air quickly. The cylinder is cast steel in one piece, which absolutely prevents leakage of air or the center shifting.

PNEUMATIC HOLDER-ON—LONG

Size No.	Length Over-all: With Set and Center	Length Over-all: Without Set or Center	Diam. of Piston	Length of Stroke	Outside Diam.	Distance from Center to Outside	Weight Pounds
1	11⅜"	8¾"	3⅛"	4"	3½"	1¾"	19