plunger of which it is connected, the cylinder operating from a valve operated by the operator's foot. At the other end of the machine there is another air cylinder, connected to a crosshead in the centre. On the front face of this crosshead there is a taper pin, which is forced into the tube end by operating the lever on the front corner of the machine. This flares the end sufficiently to slip on to the scarfed end of the safe-end piece. This safe-end piece for the tube is mounted on a mandrel on the face of the stand in the right foreground, with the scarfed end out. Immediately the rear, shown in more detail in fig 5. On the front face of the machine, attached to the other end of the worm gear shaft across the machine, before referred to, there is a slotted crank, to which is attached in any position along this slot by a clamp nut, the forward end of a connecting rod. The other end of the connecting rod is attached to a horizontal bar, guided in bearings on the front of the machine, all as shown in the foreground in fig. 5. At the near end of this guided bar, there is an upward arm, attached at the upper end to a block through the centre of which the tube along the back face of the machine, driven in turn from the large gear which engages the pinion on the spindle of the machine.

The operation of the machine is as follows: With the tube in position for cutting off, the cutter rises from below, severing the tube, the tool at the same time scarfing the end. The piece as cut off drops down the inclined plate in front of the steadyrest, the cutting liquid running back into the machine through the slit in the plate. At that point, the setting of the cams on the worm gear shaft causes the release of the chuck, and simultaneously the feeding



Fig. 5.-Automatic Feeding Mechanism.

on removal from the flaring operation, the still hot end is rammed on the guiding mandrel carrying the safe-end, the impact of the operator driving it on being sufficient to hold the two parts together, although the safe-end is cold. The united pieces are placed on another truck on the right, and moved on for the next operation.

The operation of the next operation. The operation of safe-ending will be interrupted for a moment at this stage to observe the manner of making the safeend pieces. A machine for automatically producing these pieces is shown in fig. 4. In construction it closely resembles an in the machine passes. This arm operates a clamping dog on each side of the tube, which clamps the tube in this block as the tube moves forward, but slips on the return. This is the tube feed.

The chucking of the tube is also automatic, the mechanism for the operation of the chuck being located on the near side of the machine in fig. 4. On the top of the machine an air cylinder is pin connected at the rear to the frame. The plunger rod is attached to an arm which encircles the chuck, and by which the chuck is opened and closed. The valves

Fig. 6.-Automatic Chucking Mechanism.

mechanism grips the rear end of the tube and feeds it through the chuck the length of stroke to which the adjustable crank on the front of the machine is set. When fed forward that amount the other cam on the worm gear shaft causes the chuck to close, the operation from that point being repeated.

Returning to the operation of safe-ending, the truck of tubes on the ends of which the safe-end pieces have been forced is moved along a little further to the position shown in fig. 7, the ends of the tubes mounted on the truck being visible to the left in the



Fig. 7.---Swedging First Tube Ends.

automatic screw machine, the motions on it being very similar. It is, however, a much simpler machine than an automatic screw machine, from the fact that cutting off and feeding forward are the only operations required. The stock tube is held in a hollow spindle, the front end being guided in a solid steadyrest on the front end of the machine. The tool rises from below, being forced upward into the tube at the rear face of the steadyrest by a cam on the worm gear shaft across the machine. The tube is fed forward after each cut, by the attachment guided on the bars to for operating this chuck are shown in detail in fig. 6. To the right, an air pipe from below connects with twin valves attached to a projecting arm from the side of the machine. From each of these valves a flexible air connection leads, one to each end of the chuck actuating cylinder. On the end of the worm gear shaft are two small cams, in the plane of the valve plungers which they operate. One cam lets air into the cylinder for the closing, and on the release of that end of the cylinder, the air is let into the opposite end. The worm gear is operated by a worm from a shaft

Fig. S .- Cutting-off and Swedging Second End.

view. Here, the end carrying the safe-end is placed in the furnace, and heated to a welding heat, when the part to be welded together is placed in position under the vibratory air hammer, the operation the operator is performing in the illustration. The hammer dies to the right of those in use for this last operation are used for swedging down the tube end for the copper ferrule used between it and the tube plate. Between these two operations, the loose scale on the outside of the tube is scraped off by rubbing the tube back and forth a few times in the cut outs in the plate