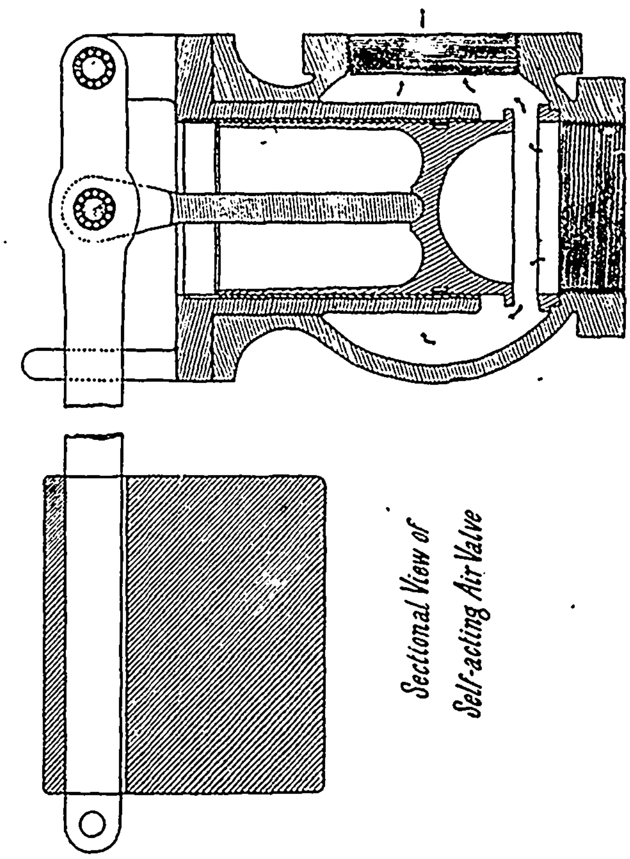
the tail race. Opening out of the top of the separating tank is a 7-inch pipe to conduct away compressed air. This main extends up the shaft, and is carried into the mill. After it enters the mill a self-acting regulating valve (of which a sketch is shown) is placed for the purpose of preventing the water from entering the air pipe, should the supply in the separating tank fall short at any time of the demand. As the air fills the separating tank, the pressure increases by a few pounds. When the pressure lessens to a certain degree by the rise of the water, the valve closes automatically before the water can reach to within 15 inches of the top of the separating tank, and thus adjusts itself to the supply of air from the compressor. From this valve a 6-inch pipe is carried to seven pairs of 8 x 12 inch engines, also to two singeing machines, a 9 x 12 inch single engine, and two Worthington pumps. A 1-inch steam radiating pipe passes through a portion of the air pipe and raises the temperature of the air to about 150° Fah.

In the working of the compressor the water is carried through the penstock to the upper tank, which it fills to about the same level as the forebay. From thence it enters the opening between the two castings of the head piece, passing among and in the same direction as the small air pipes. The water creates a partial vacuum at the ends of these small pipes, so that the atmospheric pressure drives the air into the water in innumerable small bubbles, which are carried with the water down the compressing pipe. In their downward course the bubbles are compressed according to the depth and weight of return water sustained. When they reach the disperser their direction of motion is changed from the vertical to the horizontal. The disperser directs the mixed water and air to the circumference of the tank. Its direction is again changed towards the centre by the apron, from whence it is again returned towards the circumference of the tank. During this process of travel the air has been separating by rising in the tank and also under the disperser and apron. The water (almost free of air in this plant) escapes under the lower edge of the separating tank, and returning up the shaft surrounding the compressing pipe, is carried off in the tail race. The air rising through the water to the top of the separating tank, displaces the water, and is kept under nearly uniform pressure by the weight of the return water. The variation in pressure does not exceed three pounds per square inch.

The air bubbles are comparatively small; they are surrounded by a cold body of water, and compression takes place through the whole length of the compressing pipe. From this it will be readily inferred that this mode of compression is isothermal, a process which is not accomplished by any other compressor. More energy is consumed in compressing a body of air adiabatically than in compressing it isothermally. The rise in temperature acquired by air compressed adiabatically is generally lost in transmission. Hence by this system of compression a considerable saving of energy is effected. It is a well known fact that a given space will hold a weight of water vapor greater or less according as the temperature is high or low. If at any given temperature a space is saturated with vapor, when the vapor is compressed isothermally into smaller space a portion of it will be condensed. Where air is compressed mechanically it is heated, and the water vapor contained is not condensed because of the rise in temperature. When, however, the air passes through the cool transmission pipe, condensation takes place. Should condensation not occur in the transmission pipe on account of insufficient cooling, it takes place at the exhaust of the motor because of the great fall in temperature due to the work done by the expanding air, thereby filling the exhaust with ice. Where compression of air is effected by water as in the system considered in this paper, condensation takes place on the walls of the bubble, and so can neither take place in the transmission pipe, nor at the exhaust, even when the temperature is very low. The compressed air delivered is of the same temperature as the water compressing it, and in the Magog plant its volume is about two-ninths of that at atmospheric pressure. Hence the air after its expansion in the motor will not contain sufficient vapor to saturate it at even the greatly reduced temperature. By a test made on 50 cubic feet of air delivered by the compressor while in full operation, it was ascertained that the air when expanded to atmospheric pressure contained one-fifth of the amount of



Sectional View of Self-acting Air Valve

vapor usually found in the atmosphere during fine weather, or about 14 per cent. of saturation.

On the proposal of this method many engineers and others raised the objection that the air bubbles after being carried down 34 feet (the height giving a pressure equal to that of the atmosphere), would separate out by their buoyancy and fall no further. They thus predicted as a limit of pressure attainable about 30 pounds absolute. Others predicted that the cold air entering and being diffused throughout the water, would congeal the same. Others again promised us an efficiency of not more than ten per cent. from experience obtained about 200 years ago with the trompe used in the south of Spain. I am pleased to say, however, that none of these predictions have been fulfilled. In the maiden plant at Magog, we have actually obtained an efficiency of over 62 per cent., and this was obtained in spite of the fact that we are wasting, owing to the insufficient size of the air chamber, about 20 per cent. of the air compressed. This defect, which can be easily remedied in future plants, is accountable for a loss of about 15 per