near the close of the eighteenth century, and with all their subsequent improvements are to-day used, as heretofore inferred, in both the woolen and worsted industries. These machines in the main consist of large cylinders belted with leather, the leather in turn being fitted with fine wire teeth. The teeth on one cylinder are all curved in one direction, and those on another in the opposite direction. When in operation, these cylinders revolve in opposite directions within a fraction of an inch of each other. As the carding machines operate upon the wool, it is pulled into a fine film and wound around the cylinders. Finally this film is automatically gathered from the cylinders and guided until it comes from the machine in a delicate rope of loose fibers. A long antiquated method of carding consisted in drawing the fibers over two oblong boards covered with leather fitted with fine wires. The first carding mill in this country was established at Pittsfield, Mass., in 1790. At first the carding was an industry in itself, and the other departments of woolen manufacture were carried on at other places.

It is at this point in the manufacture that the combing away of the short fiber and the collecting together of the long fibers for modern worsted cloth is introduced. The long fibers are all laid parallel to each other. The machinery for this operation is equipped with thousands of closely-set teeth no larger than pins. An idea of the general appearance of the machines can be gained from the photograph of a combing room. The combed and collected wool is delivered into metal cans in the form of loosely-twisted ropes. In the drawing room these loose ropes are "drawn" out, which means just what the name implies. It goes into one drawing machine as one yard and comes out eight yards, and so on.

The next operation, that of spinning, is one of the oldest industries in the world's history. Fifteen hundred to two thousand years before Christ the spindle and the distaff were known to the people of Egypt. The distaff was a simple stick around which the fiber was coiled, and held in the left hand. The spindle resembled a top set in motion by a twirl of the hand. Two or three thousand years later came the placing of the revolving spindle in a frame where it could be operated by foot power, and in 1763 the spinning jenny—a most important invention, comprising eight spindles—made its appearance. A modern factory to-day operates several thousand spindles in the aggregate.

Spinning is the final operation in the converting of raw fiber into thread. It is a continuation of the drawing process to attain the desired thickness of thread and at the same time twisting the fibers into the firm continuous threads of the strength necessary for the subsequent operations of weaving. In worsted manufacture the threads are then either twisted together with more threads of wool or with threads of silk, this depending upon the quality of the cloth to be made. The thread, before going to the looms, is wound first onto a six-inch spool and then unwound onto larger spools.

Weaving is the passing of one set of threads transversely through another and interlocking them in such manner as to form a united surface. The threads which run lengthwise are known as the warp, and the transverse threads the weft. Part of the threads forming the warp are raised and part depressed, thus leaving a space between. Through this space between the raised and depressed threads of the warp the shuttle carrying the weft is passed. Then by raising the threads which are depressed and lowering those which are raised, the interlocking results. All this was accomplished by hand looms for centuries. What is known as the "power loom" did not make its appearance until the nineteenth century. The power loom to-day automatically raises and lowers the series of threads, and passes the shuttle through the intervening space and likewise the subsequent operation, with all the skill of the human hand. A master mechanic sets the looms for the performance of a certain piece of work, and girls keep the shuttles filled. If in the operation a thread breaks at any point, the loom stops automatically.

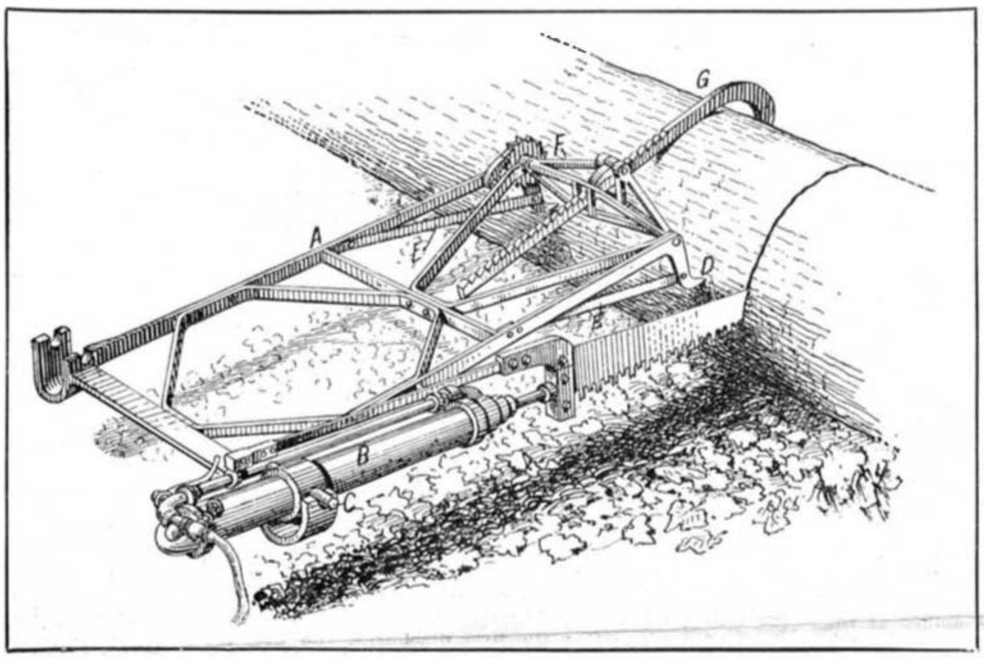
The cloth, after coming from the looms, is still further cleansed, examined, and dyed. The water is then extracted, and the cloth travels over a system of steam pipes. Unevenness is removed by an operation known as "shearing," after which comes the pressing between large rollers. Next it is measured, and wound into rolls.

THE USE OF COMPRESSED AIR IN LOGGING.

BY E. A. STERLING.

Machinery of special design has found extensive use in logging operations, particularly in the forests of the South and West. Logging railroads, donkey engines, steam skidders, and wire rope systems of various kinds contribute to the ease and economy of getting logs to the mills. The primary steps of felling the trees and sawing them into log lengths have, however, been done mainly by hand labor up to the present.

Machine saws of practical value for cutting standing timber have never been perfected, largely because the necessary power has not been available, and also on account of the danger and difficulty of handling a machine of any kind in rough forest land. The same is true in the main of sawing the felled timber into standard logs. An exception to the latter is found on the lands of the McCloud River Lumber Company in Siskiyou County, California, where a compressed-air "bucking-up" saw has been successfully used for some years. The trees are felled by hand, and cut into log lengths by the machine saw. The company operates on comparatively level land near the base of Mount Shasta, where the forest of yellow pine, sugar pine, and white fir is composed of unusually large individual trees in open stands. The ground cover is a rather dense chaparral.



The Compressed-Air Saw, Showing the Adjustable Frame and Pivoted Cylinder.

The Compressed-Air Logging Saw in Operation.

THE USE OF COMPRESSED AIR IN LOGGING.

The machine consists of a traction engine equipped with an air compressor and a storage tank. To the air tank are attached rubber hose which give a working radius of 300 feet. The saws, which are similar to a heavy cross-cut saw, are actuated by a piston working in a small cylinder set in a movable frame, which can readily be attached to logs of any diameter.

The cylinder, which has pivot trunnions removably hung in bearings, is connected with the compressed-air tank by a line of hose. The usual outfit consists of three frames and one saw. The saw when started is left to work automatically, while the two empty frames are being moved to new cuts and attached to receive the saw. A "swamping" crew precedes the compressed-air saw and trims the felled trees, throwing the brush to one side to give room for the machines. The traction engine is moved under its own power to convenient points, where several trees are within reach of the transmission hose. There is a decided economy both in time and labor in the use of the compressed-air machine. To operate it requires nine men, and the average daily expense, exclusive of repairs, is $25. Its daily capacity is from 125,000 to 140,000 feet board measure, though under exceptionally favorable conditions a cut of 160,000 feet is possible. To secure the same output with hand labor would require from fifteen to seventeen men at a daily wage of $2.50, the average cut per man being from 8,000 to 10,000 feet. This gives a daily saving of $12.50 to $17.50 in favor of the compressed-air saw, on an output of from 125,000 to 140,000 feet board measure of logs. This is ample to cover repairs and give a sustained balance above the interest on the initial investment. There is no apparent reason why a similar machine should not be used in other regions where conditions are favorable.

Making Quartz Glass.

It is announced from the Carnegie Geophysical Laboratory in Washington city that quartz glass can be successfully manufactured, but the authorities of that institution decline to commit themselves as to its feasibility from a commercial viewpoint. The chief value of quartz glass over ordinary glass is found in the fact that it can be heated to a temperature of about 1,000 deg. C. without softening, and its expansion under ordinary heat is so small as to be almost a negligible quality. It also can be heated red hot and plunged into cold water without in the least cracking. It has the distinct property of permitting the passage of ultra-violet light rays, making it remarkably valuable in photographic uses.

Quartz glass has been made in Germany for laboratory uses in the form of tubes, by heating small, clear quartz crystals and sticking them together. The tubes and other vessels made after this manner were rough, patchwork-looking affairs, but served many useful purposes. No way was known by which the substance could be manufactured into glass sheets of any size, by reason of the fact that masses of broken quartz could not be fused together without having the resultant glass full of bubbles. Quartz will liquefy under intense heat, but it will never become soft enough for the air bubbles to escape, the result being that melted quartz is a dirty, porous mass more or less like pumice stone.

At the Carnegie Laboratory many methods were tried before definite, satisfactory results were obtained. If the quartz was intensely heated, free silicon was deposited on the inside of the air bubbles, and the glass was spoiled. The final solution of the problem was found in heating the quartz to the melting point, about 4,000 deg. F., and then subjecting it to an air pressure of between 400 and 500 pounds. After this it was allowed to gradually cool. The air pressure squeezed out the air bubbles, and the result was a solid and clear mass of quartz glass. The plates so far made at the laboratory are only about three by five by half an inch in size. The bubbles are few, not over one-half a millimeter in diameter, and are not frequent enough to interfere with the use of the glass for lenses, mirrors, and other optical work. With more skill and experience the glass can be made without the flaws which confronted the workers.

A novel feature in tunnel design devised by Mr. Charles M. Jacobs, the chief engineer to the Pennsylvania tunnels under the Hudson River, is found in the screw piles, which will be placed at intervals of 15 feet throughout the length of the tunnels. While the silt forming the bed of the river is sufficiently tenacious to hold the tunnels in perfect alignment during construction, it was not considered firm enough to do so when the tunnels are in use. To forestall this possible danger screw piles will be sunk to a solid foundation, and upon them the tunnel proper will rest. The piles will be 27 inches outside diameter, and the shell will be 1¼ inches thick. The sections will be 7 feet in length, and will be bolted together through internal flanges. The lowest section will be cast with one turn of a screw 4 feet 8 inches in diameter.