THE MANUFACTURE OF PAPER.

I.—THE PREPARATION OF WOOD PULP BY THE SULPHITE PROCESS.

If one were asked to name the three staple articles of manufacture which are most essential to modern civilization as exemplified in the average work-a-day citizen, he would mention in their order food, clothing and paper, the first two as being essential to the physical and the last to the mental and, in a large degree, the moral well-being of the race. History shows, moreover, that as man has gradually struggled upward from his primitive and crude condition, there has been a contemporaneous and successive appreciation of these necessities of life, and the measure of demand for one of them, at least, has been a fairly good test of the degree of civilization in the later ages of the world's history.

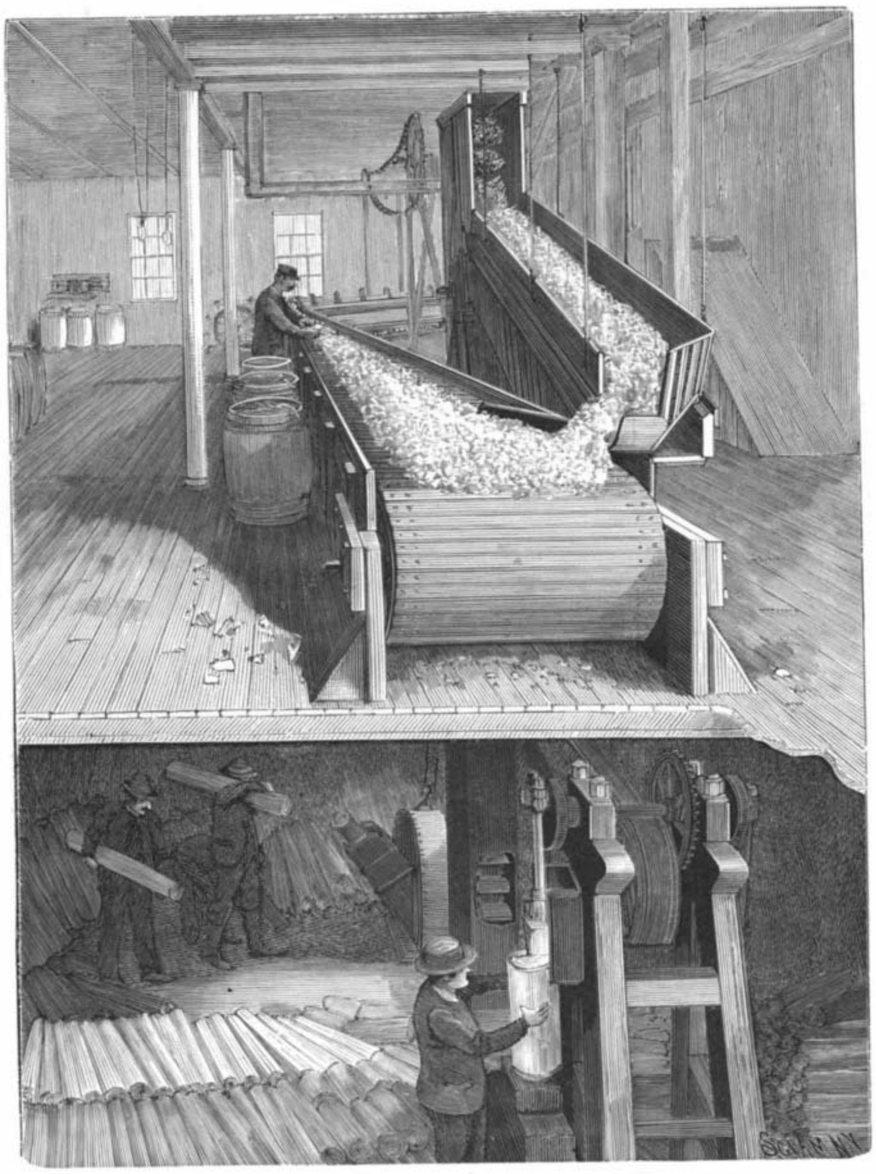
It seems like the statement of a mere truism to say that the consumption of paper by a people is the measure of their intellectual advancement; for it is a well understood fact that the countries in which education is most widely spread, where the average intelligence is highest, and the desire for knowledge and information is keenest, show the greatest consumption of paper per capita. It is a curious fact, however, that while most people have more or less knowledge of the processes by which wheat is manufactured into bread, or wool and cotton into a suit of clothes, there is probably not one in a thousand who has any conception of the ingenious processes by which the rough trunk of the forest tree is transformed into the finished sheet of paper upon which he reads the news of the day.

Outside of those who are concerned in the paper trade, either as manufacturers or wholesale purchasers and consumers, it is probable that there are few people who have any clear knowledge either of the nature of the raw materials from which the bulk of the paper is made or of the truly enormous capacity of the mills which are devoted to its manufacture.

In the whole United States there are to-day over 1,000 mills at work, whose united daily capacity amounts to over 13,000 tons of paper in twenty-four hours. Of the total amount of paper produced—which, of course, falls somewhat short of this figure—by far the larger part is manufactured from wood, and not, as was formerly the case and as is even now popularly supposed, from rags.

The paper mills of the Duncan Company, which we have selected for description, are situated on the banks of the Hudson River at Mechanicsville, about twelve miles north of the city of Troy, N. Y. Here a massive stone dam 850 feet in length with a fall of 16 feet has been constructed, and the energy of the impounded waters is developed in twenty turbines whose aggregate horse power is 3,500. This is supplemented by a steam engine plant of 750 horse power. On approaching the mills, which cover a rectangular block on the bank of the river 980 feet in length by 354 feet in width, one passes through a vast yard of spruce and poplar cord wood, in which, at certain seasons of the year, as many as 20,000 cords may be seen stored at one time. Most of this wood, which averages 9 inches in diameter by 4 feet in length, is cut in the Adirondacks and the forests of Canada and brought to the mill by rail and canal. Seventy-five cords of poplar and forty-five cords of spruce are consumed by the mills each day, which, after it has passed through the various processes and taken up the clay, starch, alum, resin, size, etc., which are used, is shipped from the mill as finished paper or chemical fiber—40 tons of the former and 34 tons of the latter per day.

All paper is made from one or more of the various vegetable fibrous substances, such as cotton, flax, straw or wood; and if a piece of paper, particularly of the finer grades, is examined beneath the microscope it will be found to consist of a mass of fibers which are roughly interlaced and present something of the appearance of fine woven textile goods. If we similarly examine a section of wood, we find that it consists of parallel fibers which are cemented together by cellular matter, and it is this fibrous material which is used in the manufacture of the wood pulp, as it is called, from which the paper is made. The preparation of the fiber by the destruction of the cellular matter is accomplished by digesting the wood in chemical solutions; the spruce being treated with sulphurous acid and the poplar with caustic soda. The pure fiber which remains is then taken to the paper mill and worked up into paper.



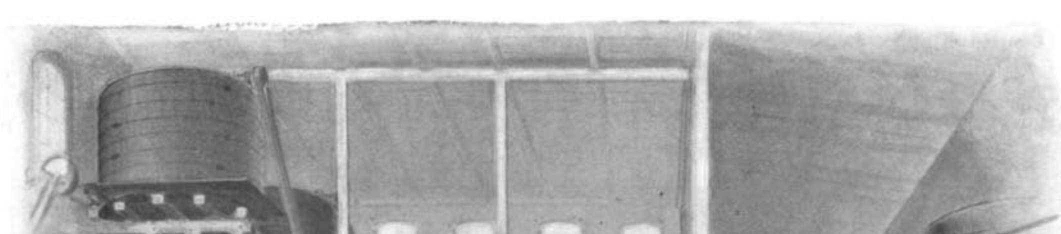
2.—CONVERSION OF LOGS INTO CHIPS.

THE SULPHITE MILL.

Our illustration, Fig. 2, shows the preparation of the "chips." The spruce logs, should they be too large, are first split to the proper size in the splitter, whose operation is explained by the cut, and they are then placed endwise in the spout of the chipper, where they bear by their own weight at an angle of thirty degrees against the face of a swiftly revolving disk, in which are four knives set in radial slots cut through the disk. Each knife cuts off a diagonal chip from the log, the thickness of the chips, or what is the same thing, the length of the fiber, being from 5/8 to 3/4 inch. The disk runs at 300 revolutions a minute and it can eat up 100 cords of wood in a day of 10 hours. The chips now fall onto a conveyor and are taken to the second story of the building, from which they are fed into an inclined oscillating screen, where the sawdust and dirt are removed, finally discharging onto a traveling sorting table, 50 feet in length, as shown in Fig. 2. Here a set of men carefully pick out all the slivers and larger knots together with the long strips which are occasionally torn off the logs by the chipper. At the end of the table the chips are discharged onto an inclined conveyor, which carries them to a large storage bin above the sulphite digester, which is capable of holding 100 cords of chips at a time.

The sulphurous acid for treating the chips in the digester is prepared by burning sulphur and drawing the fumes through a series of tanks containing a solution of milk of lime. Ohio white lime containing about 45 per cent of magnesia is used in preparing the solution, for the reason that salts of magnesia are soluble in hot water, whereas calcium salts are not and would form a troublesome scale in the digester. The acid plant, which is in duplicate, is shown in Fig. 3. The sulphur is burned in the retorts shown in the room adjoining the tank room, and the fumes are led through a coil of cooling pipes and then passed in succession through a series of large tanks filled with a solution of lime water. After passing the coil the gas enters the bottom of the lowest tank of the series and rises through the solution, where much of it is absorbed. What is not absorbed collects above the liquid and is led to the bottom of the second tank, the process being again repeated in the third tank of the series. The operation is assisted by a vacuum pump, which maintains a partial vacuum above the liquid in the last tank. The pure milk of lime solution is fed from the top tank of all, and the acid solution at the proper strength is drawn off from the lowest tank and stored in large receivers ready for use in the digesters.

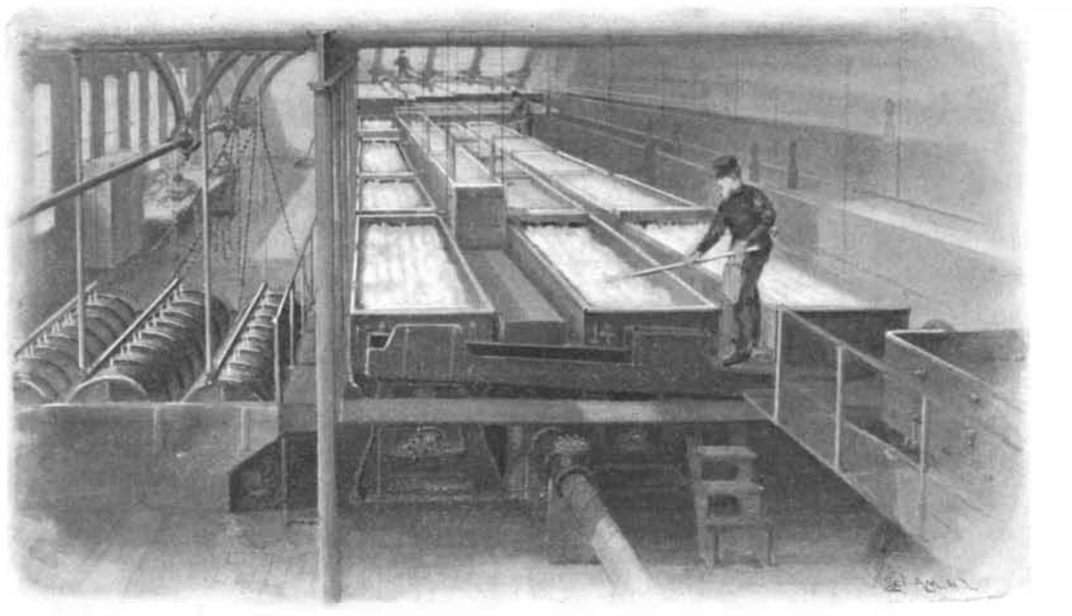
The digester, Fig. 1, is a huge cylindrical steel plate structure, 38 feet long and 15 feet in diameter. The shell is one inch in thickness and it is built with butt joints, the rivets being countersunk on the inside, so as to secure a smooth surface for the lead lining. The latter, 1/8 inch thickness, is laid close against the shell and is seamless throughout. The digester is closed at both ends with covers of cast steel protected with linings of 1/2 inch of lead. The shell is further protected from the acid by a thick lining of a special grade of brick. For convenience of erection and repairs the digester, which weighs 125 tons, is hung on trunnions, whose journals may be carried on two pairs of massive lattice girders, by means of long six-inch rods with screwed ends depending from the top of the columns. While it is in operation, the digester rests upon six ten-inch cast iron columns; but when it is desired to make repairs, it can be raised by means of the screws from the columns, swung into the horizontal position (the slight brick filling of the arches in the side walls of the building being taken out), and lowered onto rollers on the floor.



3.—PREPARATION OF SULPHITE PULP—THE SULPHUROUS ACID PLANT.

The digester is filled to the top with chips from the bin overhead, and the acid is then piped in by an overhead pipe which leads from the large storage tanks, whose capacity is 60,000 gallons. The cover is then bolted on and steam at 80 pounds pressure is introduced at the bottom. The heating of the lower layers of liquid causes a continual circulation throughout the mass during the whole period of cooking, which varies from nine to twelve hours. During the cooking, the acid solution attacks and renders soluble the incrustating matter of the wood—resin, lignose, cellular matter—and dissolves it out, leaving only the pure fiber of the wood. The acid solution has a weak chemical affinity, and gas is liberated on a slight rise of temperature. The sulphur gas rises and escapes by the pipe which (Fig. 1) will be noticed leading from the throat of the digester to a trap in the corner of the upper room. From the trap it is led through the acid storage tank and condensed, adding its strength to the liquor.

When the cooking is completed, a ten-inch blow-off valve is opened and the contents are driven out into the "blow pit," a large wooden tank furnished with a perforated false bottom. The steam escapes through a four-foot vertical stack and the spent liquor, containing the dissolved resinous and cellular matter of the wood, drains off and goes to waste. The pulp at this stage has a beautifully transparent appearance, due to the bleaching effect of the sulphurous gas. When the spent liquor has strained off, the "pulp," as it is now called, is taken to the wash pits, where it is thoroughly washed with pure water. From the wash pits it is pumped up to a mixing box in which it is mixed with a sufficient amount of water to give it the proper fluidity, and is then run into the screen room shown in Fig. 4. Here it passes through a threefold system of screens for the removal of foreign bodies or such particles as would produce blemishes in the paper. It first passes through the coarse screens, located at the far end of the room, which have a one-eighth inch mesh and serve to take out the coarse knots and any uncooked fiber. It then flows into a settling box, where any particles of lime or dirt are removed by gravity, and finally passes onto and flows through the "fine screens."


4.—THE FINE SCREENS FOR REMOVING TOO COARSE MATERIAL FROM THE PULP.

The general arrangement of the latter is shown in the figure referred to, and a cross section of these screens and copper straining cylinders is given in Fig. 5. The fluid pulp flows from the settling tanks into troughs which open by means of side gates onto the screens, of which there are four in each row. Each screen consists of a shallow box open at the top and provided midway of its depth with a horizontal screen consisting of a brass plate perforated with innumerable fine slits $\frac{18}{1000}$ in width. The bottom of the box is attached to the sides by flexible rubber gaskets, and it is kept in continual and rapid vertical oscillation by means of cams mounted on a revolving shaft beneath the screen, which acts on a shaft projecting from the bottom of the screen box. This vibration produces a bellows-like effect and draws the fine pulp down through the screen, leaving the coarser material behind.

The pulp now flows into the copper cylinders. These are about 3 feet in diameter and 15 feet long. The outer shell is freely perforated and the interior is traversed by a sheet copper worm whose outer edge is riveted to the outer shell and its inner edge is in contact with the hollow axial shaft upon which the cylinder rotates. The pulp flows into the cylinder at one end, and as it is guided through by the worm the water drains away, leaving the moist pulp, which now looks something like half melted snow, to fall out at the other end of the cylinder. Jets of water are playing continually upon the outside of the cylinder for the double purpose of keeping the perforation from being choked up by the pulp and washing the fiber. From the copper cylinders the pulp falls onto a conveyor which takes it through the "bleaching engine."

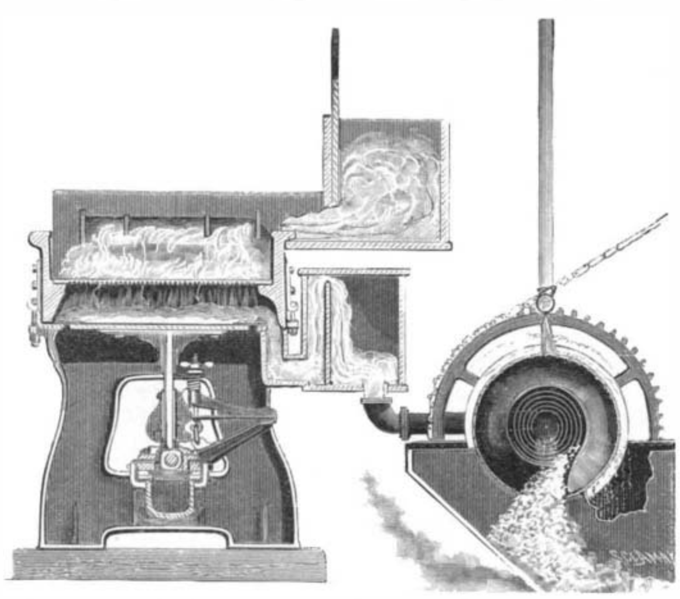
Paper made from sulphite pulp at this stage of the process would be apt to fade and turn yellow. To prevent this it is bleached by subjecting it to the action of chlorine for a period of three hours, in what is known as the bleaching engine. This is a large iron tank, open at the top and provided with semicircular ends, half way across which is placed a revolving drum provided with transverse bars. The pulp is placed in this tank together with a solution of chlorine and a little oil of vitriol to hasten the bleaching. Steam is introduced and the drum or agitator is set in motion. The latter works in the fluid contents of the tank much as a deeply immersed paddle wheel would in water, loosening up the pulp and causing a thorough contact with the bleaching liquor. The pulp is emptied into "drainers" in the cellar of the building, where the liquor is allowed to drain away. The pulp is then thoroughly washed with fresh water and again drained. When it is nearly dry, it is dug and sent in cars to the paper mill.

The process as described, from the time the pulp leaves the fine screens, is applicable only to such sulphite pulp as the Duncan Company manufacture directly into paper themselves. In our next article we shall describe the manufacture of soda pulp and show how that portion of the pulp, both sulphite and soda, which is supplied to the open market is prepared for shipment to other paper mills.

Simonides, the Forger of Manuscripts.

Prof. Max Müller says that Simonides, the celebrated forger of Greek manuscripts, was certainly a most extraordinary man—a scholar who, if he had applied his ingenuity to editing instead of forging, might have held a very high position. His greatest achievement was, of course, the newly discovered Greek text of the history of ancient Egypt by Uranios. The man possessed a large quantity of later Greek MSS. It seems that in the eastern monasteries, where he sold, he also acquired some Greek MSS., by what means we must not ask. He tried several of these MSS. with chemicals, to see whether, as was the fashion during the middle ages, the parchment on which they were written had been used before, and the old writing scraped off in order to get writing material for some legends of Christian saints or rather modern compositions. When that has been the case, chemical appliances bring out the old writing very clearly, and he knew that in this way some very old and valuable Greek texts had been recovered. In that case the old uncial writing comes out generally in a dark blue, and becomes legible, as underlying the modern Greek text.

As Simonides was not lucky enough to discover or recover an ancient Greek text, or what is called a palimpsest MS., the thought struck him that he might manufacture such a treasure, which would have sold at a very high price. But even this did not satisfy his ambition. He might have taken the text of the Gospels and written it between the lines of one of his modern Greek MSS., adding some startling various readings. In that case detection would have seemed much more difficult. But he soared higher. He knew that a man of the name of Uranios had written a history of Egypt, which was lost. Simonides made up his mind to write himself in ancient Greek a history of Egypt such as he thought Uranios might have written. And, deep and clever as he was, he chose Bunsen's "Egypt" and Lepsius' "Chronology" as his authorities. After he had finished his Greek text, he wrote it in dark blue ink and in ancient uncial Greek letters between the letters of a Greek MS. of about 1200 A.D.


5.—SECTION THROUGH THE FINE SCREENS AND COPPER CYLINDERS.

Anybody who knows the smallness of the letters in such a MS. can appreciate the enormous labor it must have been to insert, as it were, beneath and between these minute lines of each letter the supposed earlier writings of Uranios, so that the blue ink should never encroach on the small but true Greek letters. One single mistake would have been fatal, and such is the knowledge which antiquaries now possess of the exact changes of Greek letters in every century that here, too, one single mistake in the outline of the old uncial letters would have betrayed the forger.

When Simonides had finished his masterpiece, he boldly offered it to the highest tribunal, the Royal Berlin Academy. The best chemists of the time examined it microscopically, and could find no flaw. Lepsius, the great Egyptologist, went through the whole text, and declared that the book could not be a forgery, because no one except Uranios could have known the names of the ancient Egyptian kings and the right dates of the various dynasties, which were exactly such as he had settled them in his books. The thought that Simonides might have consulted these very books never entered anybody's mind. Great was the excitement in the camp of the Egyptologists, and, though the price demanded by Simonides was shamefully extravagant, Bunsen persuaded the then King of Prussia, Frederick William IV., to pay it and to secure the treasure for Berlin. Dindorf, the famous Greek scholar, had been intrusted by Simonides with the editing of the text, and he had chosen the Clarendon Press at Oxford to publish the first specimen of it. In the mean time, unfavorable reports of Simonides reached the German newspapers, and during a new examination of the MS. some irregularities were detected in the shape of the uncial M, and at last one passage was discovered by a very strong microscope where the blue ink had run across the letters of the modern Greek text. No doubt could then remain that the whole MS. was a forgery.

Simonides was forced to refund the money and was sent to prison, never to reappear again in the libraries of Europe. But Prof. Müller tells us, he succeeded in palming off a number of his forgeries upon public and private collections in England, among them portraits of the Virgin Mary, some of the Apostles painted by Luke (!), and a copy of Homer, with a dedication from Pericles to the Tyrant of Syracuse. Even after his forgery of Uranios was exposed, he received an offer of £100 for it as a curiosity, but refused the offer.—We are indebted to The Home Journal for the above particulars.

International Congress of Applied Chemistry.

We are informed by Dr. W. H. Wiley, of the Department of Agriculture, that the Second International Congress of Applied Chemistry will be held in Vienna in July, 1898. Nearly 2,000 members were present at the last meeting, and it required five large volumes to contain the report of its proceedings. A committee has been appointed to promote the interests of the Congress in this country, and it is hoped many chemists will be induced to attend. It is expected that arrangements can be made by which substantial reductions can be obtained in the transportation to Vienna. The opportunity of meeting distinguished chemists from all parts of the world will doubtless be appreciated by the American members. The scientific work of the Congress will be conducted in twelve sections. Excursions to localities of interest will be arranged for and will be announced at a later period. Papers in German, French and English will be accepted, and authors are requested to communicate with the chairmen of the various sections and send them titles of the papers and subjects which they would like to have discussed. Further information may be obtained by addressing Dr. W. H. Wiley at Washington, D. C.

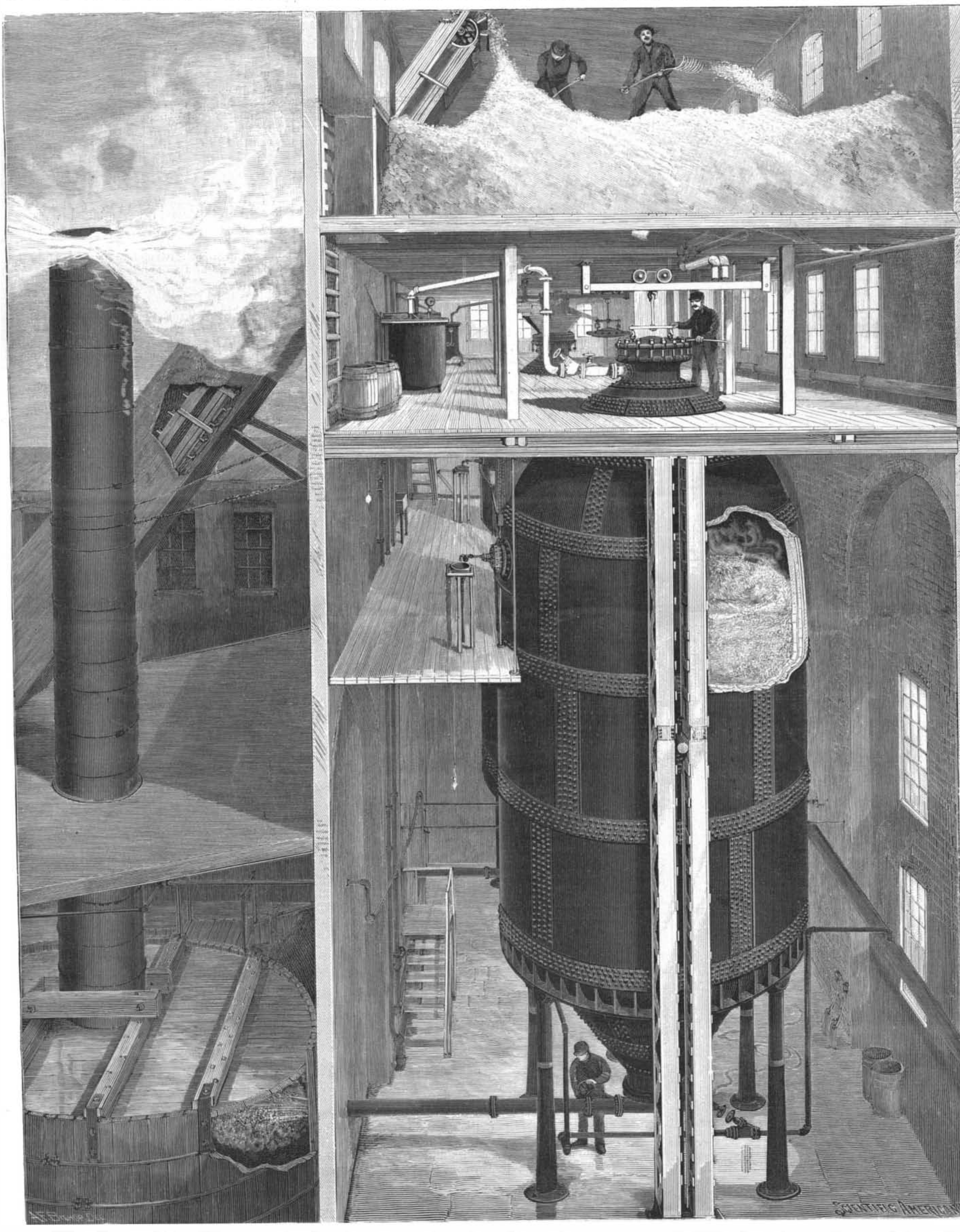
WORK on the Jungfrau railway is progressing satisfactorily. The Lauterbrunnen River furnishes 2,400 horse power used for the electric rock drills. The bed of the river has been changed for a distance of about six miles. The line is practically complete to the Eiger glacier, and this section will be opened for traffic in June. Work has also been begun on the main tunnel and more than 150 yards have been completed; the solid rock has been found at 30 yards under the snow, instead of 70 yards, as first expected.—Cosmos.

SCIENTIFIC AMERICAN

[Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1898, by Munn & Co.]

A WEEKLY JOURNAL OF PRACTICAL INFORMATION, ART, SCIENCE, MECHANICS, CHEMISTRY, AND MANUFACTURES.

Vol. LXXVIII.—No. 12. ESTABLISHED 1845.] NEW YORK, MARCH 19, 1898. [$3.00 A YEAR. WEEKLY.



THE MANUFACTURE OF PAPER—I. PREPARATION OF WOOD PULP BY THE SULPHITE PROCESS.—SECTIONAL VIEW SHOWING BIN FOR WOOD CHIPS AND THE MAMMOTH SULPHITE DIGESTERS.—[See page 185.]