“The Cements of the Gate of France”

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"The city of Grenoble is situated at the foot of Mount Rachais, from the base of which rise the abrupt rocks that are crowned by forts Rabot and Bastille. Above Fort Bastille rises Mount Jalla, which overlooks Grenoble, and is about 1,400 feet in height, and from which may be enjoyed a magnificent view of the Graisivandan plain. This mountain contains the celebrated deposits of the Gate of France, which were discovered in 1842 by Col. Breton of the engineers, now on the retired list.

"The Society of Cements of the Gate of France takes its name from one of the ancient gates of Grenoble, which was built under Lesdiguieres, and is situated upon the right bank of the Isere, to the northwest of the city. It includes three houses which are engaged in the manufacture and sale of cements: those of Dumolard & Viallet and of Arnaud, Vendre & Carriere, whose quarries are located on Mount Jalla, and of Dupuy de Bordes & Co., whose works are at Seyssins, four miles south of Grenoble. We shall occupy ourselves here with the first of these establishments, as this is the most important and the most interesting as regards exploitation.

"***Limestone of the Gate of France***. – The cement stone of the Gate of France is extracted from a thick stratum of argillaceous and bituminous limestones, which are black in color and very finely grained, and which have a conchoidal cleavage. According to Mr. Lory, a noted geologist, this stratum is intimately connected with the base of cretaceous earth, and is remarkable for the homogeneousness and fineness of the clayey mixture which it contains in the proportion of about 24 per cent.

"The principal deposit of the Gate of France makes an angle of about 15º with the vertical, and its thickness is 14 ¾ feet. To the right of this first deposit there are two others that have the same composition, but whose thickness is but from one to one and a half yards thick.

"Further along we give the results yielded by an analysis of this limestone.

"***The Quarries***. – Messrs. Dumolard and Viallet's quarries, which are located at the top of Mt. Jalla, comprise twenty superposed galleries, 11 ½ feet in height, separated by partitions of the same thickness (Figs. 1 and 2). The principal one of these is 1,300 feet above the furnace tops. The stones taken from the fourteen upper galleries are let down into the principal gallery through shafts in the secondary strata. Those from the five lower galleries are lifted to the same level by an elevator actuated by water in ordinary weather and by a steam engine in times of drought. The stones are carried in cars of 70 cubic feet capacity.

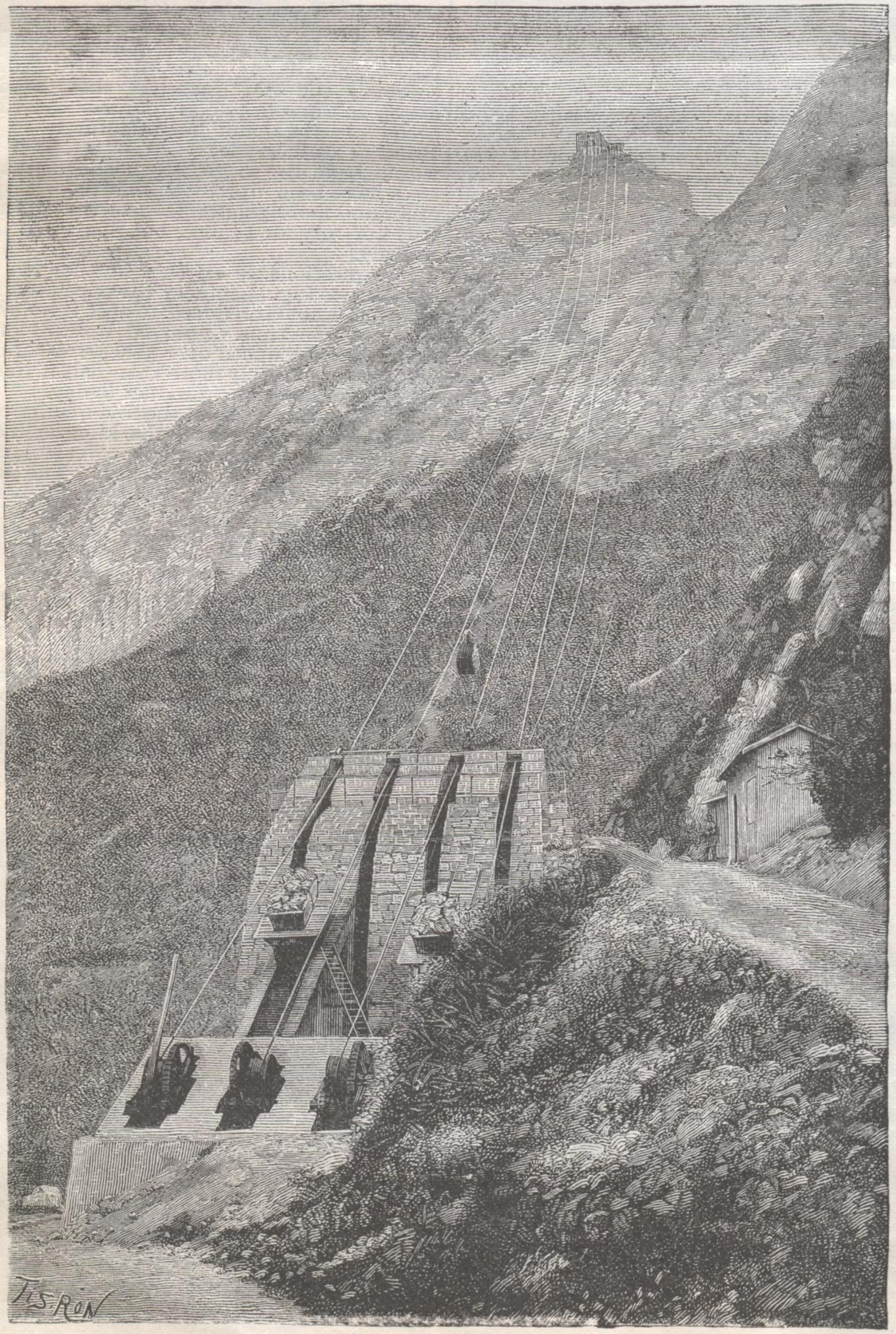


FIG. 1.—GENERAL VIEW OF THE AUTOMATIC AERIAL CABLE ON MT. JALLA.

“Fig. 1. General View of the Automatic Aerial Cable on Mt. Jalla”

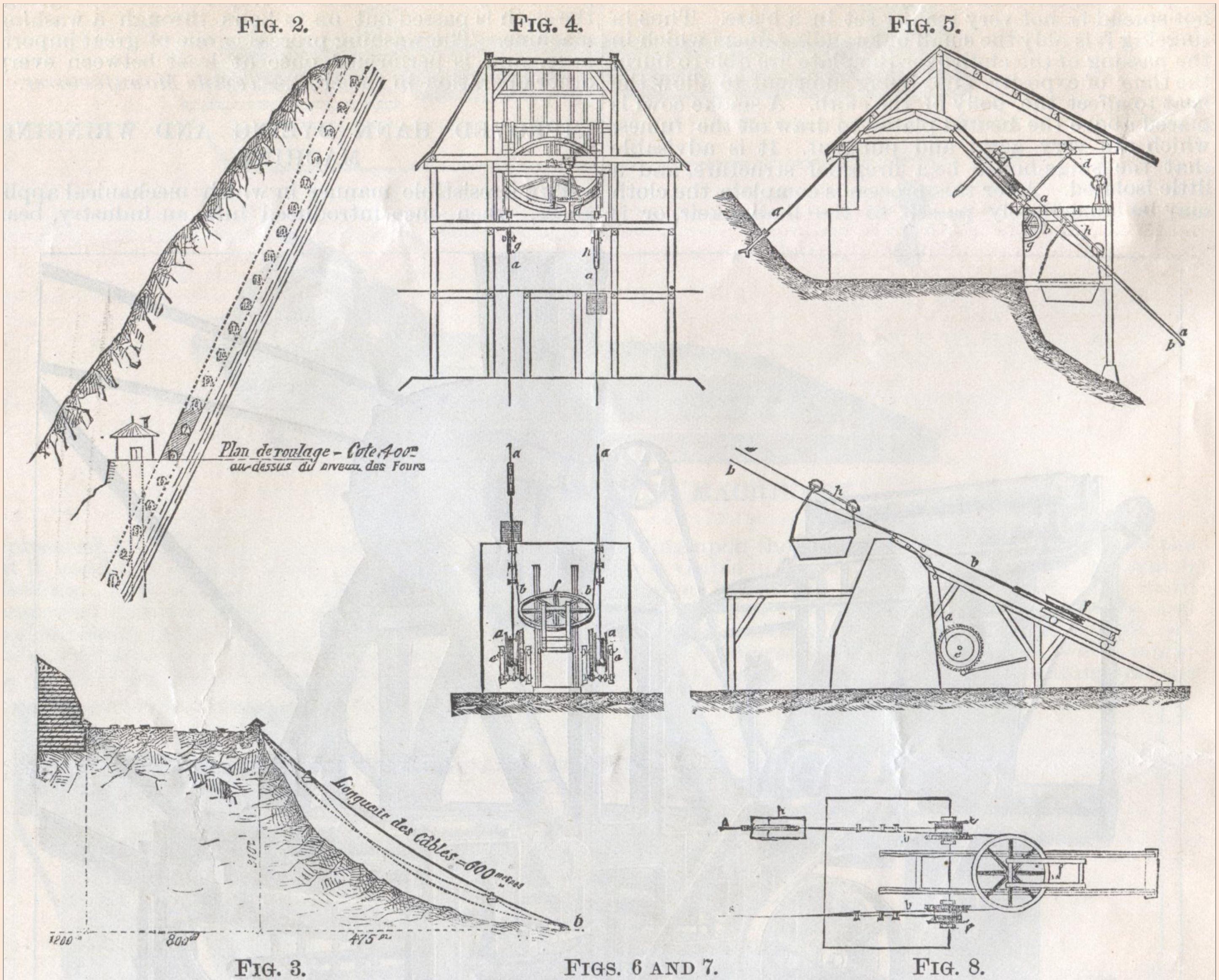


FIG. 2.—VERTICAL SECTION OF THE PRINCIPAL DEPOSIT. FIG. 3.—PROFILE OF CABLES.
FIGS. 4-8.—DETAILS OF CABLES.

(Figs. 1 through 8: "Fig. 2. Vertical Section of the Principal Deposit." "Fig. 3. Profile of Cables." "Figs. 4 -8. Details of Cables."

"From the principal gallery the track runs along the side of the mountain for about 2,600 feet, and terminates on the brink of a precipice (920 feet in depth). Here the stones are placed in boxes, which are carried by an aerial automatic cable 2,000 feet in length (Fig. 3). On reaching the bottom, they are thrown down a vertical shaft that terminates in a horizontal gallery, through which they are carried by car directly to the platform of the furnaces.

"***The Aerial Cable***. – The vertical distance between the starting point of the cable and the receiving station is 1,015 feet. Between these two points the ground is so uneven that it was impossible to establish thereon any direct communication by road or rail. The use of aerial cables was therefore naturally indicated. But such cables up to then had maximum lengths of but from 650 to 1,000 feet, and had carried loads that did not exceed 880 pounds, while at Mt. Jalla the length had to be 1,960 feet without any intermediate support. Besides this, since more than a hundred tons were daily moved, the loads carried could not be less than a ton.

The two stations were connected by two steel cables 1 ¾ inch in diameter that served as a support for the boxes that carried the stones. These cables were anchored into the rock at the upper part, and were wound below over powerful drums that allowed them to be made taut (Figs. 3 to 8).

“Originally, the two boxes were connected by a cable ¾ inch in diameter that wound round a brake pulley at the starting station, and which, was of such a length that one of the boxes was at one station while the second box at the other. Under such circumstances, the full box, on descending, carried along the small cable and caused its empty mate to rise along the other supporting cable. The inconveniences of such a system were at once seen. The small cable, whose weight was 1,320 pounds, acted as a resistance during half the route, and as a motor during the other half. Besides, under the influence of its weight, it took on a pronounced and very variable curve, and owing to this there occurred great irregularities in the motion and sudden changes in the tension of the small cables, that gave rise to numerous accidents and a rapid wear of both them and the brake.

“In order to remedy these inconveniences, the small cable was balanced by connecting the boxes at the lower part by another cable similar to the first, and passing over an inclined pulley located at the bottom station. In this cable, which then had a length of 3,900 feet, a regular tension was secured by mounting the lower pulley, *f*, upon a properly loaded four-wheeled tautening car, which ran up or down an inclined plan 65 feet in length, according as the tension increased or diminished (Figs. 7 and 8). In this way there was obtained a constant equilibrium of the two halves of the small cable, as well as an invariable tension. Besides, these modifications permitted of sending up a useful weight about four-tenths that of the descending load. In case the loads to be sent up possessed a greater weight than those to be sent down, the same system would be applicable by actuating the fixed pulley (which would then be located at the lower station) by means of a steam engine or some other motor.

“The stationary cables are three yards apart and weigh 13,200 pounds. The driving cable weighs about 2,200 pounds. Each box, which has a movable bottom, has a capacity of 31 ¾ cubic feet. The load carried by each is 2,200 pounds. The pulleys, levers, belts, cars, in a word the entire metallic part, save the cables, weighs 18,700 pounds. The velocity is about 19 feet per second; it takes a minute and a half for the box to ascend; and the entire trip, including loading and unloading, takes three minutes. This arrangement permits of handling from 264,000 to 330,000 pounds of rock per day of twelve hours. The total cost of setting up was $3,100, not including masonry and carpenter work, thus making the mean cost of the metallic portion about 9 cents per pound.

“Beneath this establishment is that of Messrs. Arnaud, Vendre and Carriere, comprising 18 galleries. On making their exit from the principal gallery, the cars follow a track about 500 yards in length to an aerial cable arranged in about the same way as the one above described.

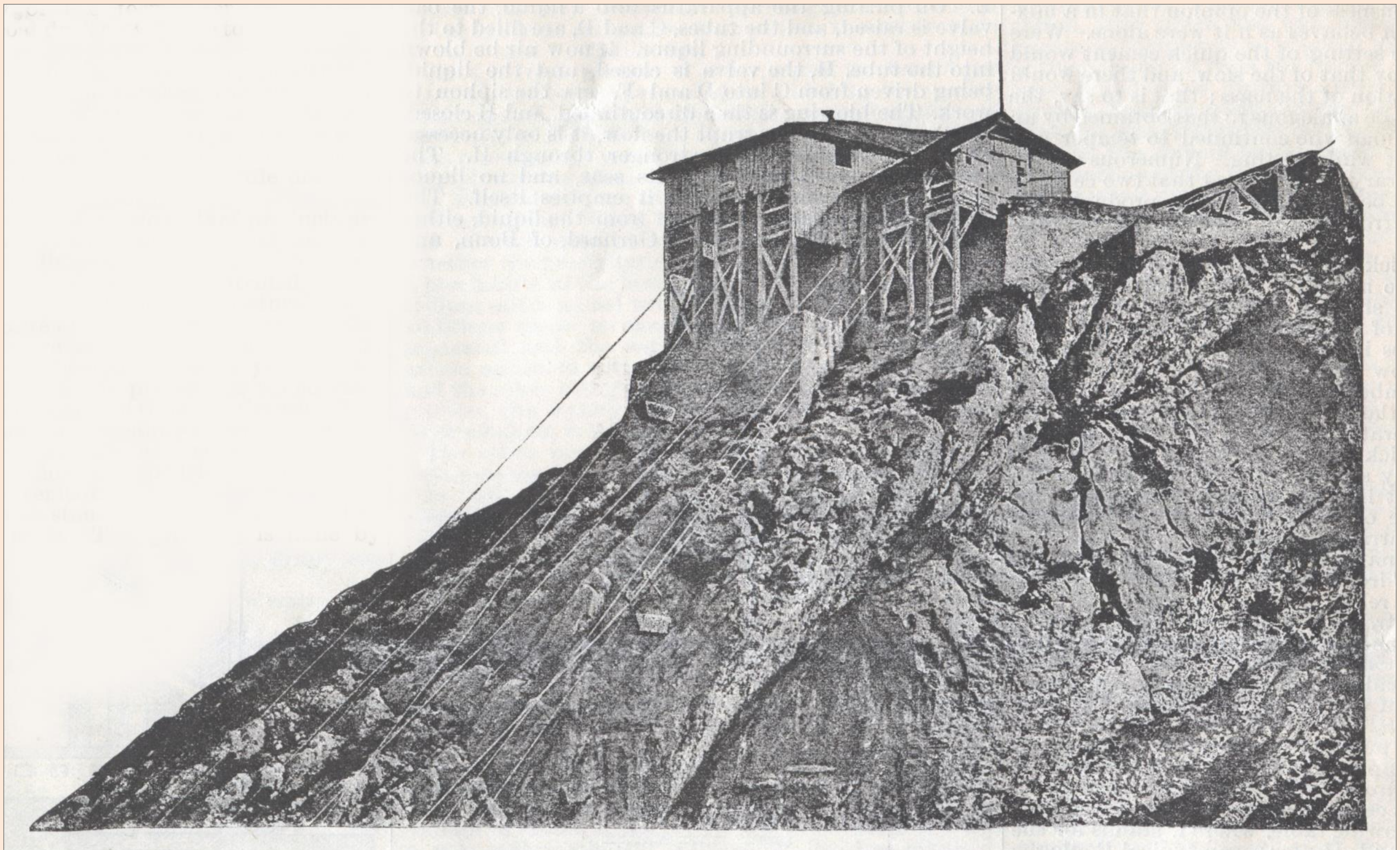


FIG. 9.—AUTOMATIC AERIAL CABLE—SHIPPING STATION.

"Fig. 9. Automatic Aerial Cable – Shipping Station."

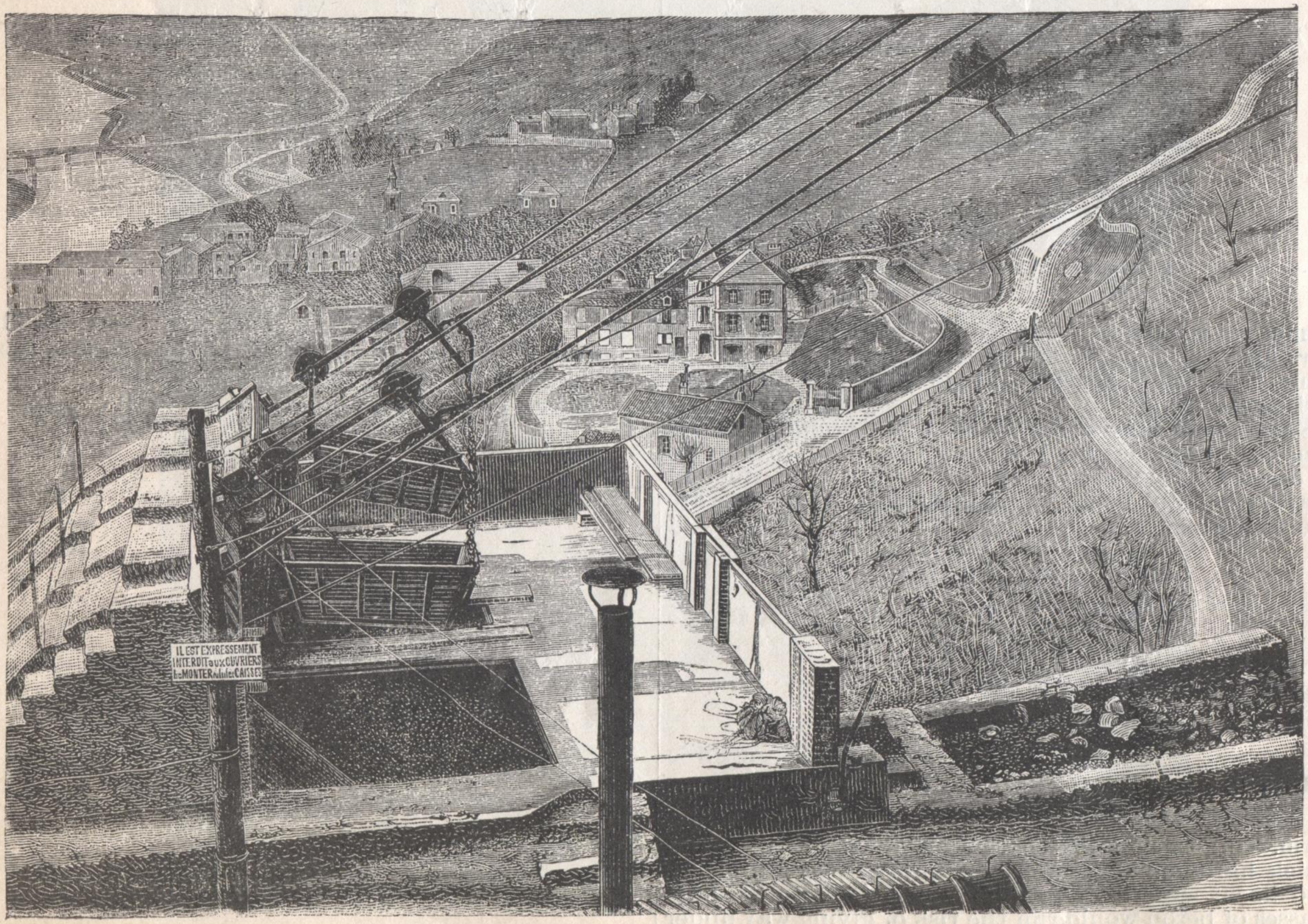


FIG. 19.—AUTOMATIC AERIAL CABLE—RECEIVING STATION.

"Fig. 19. Automatic Aerial Cable – Receiving Station."

"***The Furnaces*** – The furnaces are located at the foot of Mt. Jalla. They are 46 in number, are ovoid in shape, and have a mean capacity of 212 cubic feet. They are capable of being run continuously or at intervals.

"The charges consist of alternate layers of stone and anthracite, in the proportion of about 550 pounds of the latter to 2,200 of the former for slow-setting cement, and 396 of coal dust to 2,200 of stone for quick-setting.

"The duration of the burning is variable, and depends upon the dimensions of the furnace, the size of the materials, and the state of the atmosphere. It may be said, however, approximately that a furnace with intermittent fire daily produces, per cubic foot of capacity, about two pounds of cement, while one with a continuous fire produces about five.

"Upon emptying the furnace, two sorts of products are found that have sensibly the same chemical composition, and that present differences due merely to burning. These are (1) the overburned, vitrified, black stones, of great density, which yield the natural Portland cement of the Gate of France, and which are also used in the manufacture of artificial cement, and (2) the burned but not overheated stones of yellow color (and of a less density than the preceding), which yield the quick-setting cement of the Gate of France. The sorting of these stones can be readily effected by hand. Care is taken to leave a certain proportion of the overburned stones among those designed for the manufacture of quick-setting cement.

"***The Mills*** – After the stones have been sorted, they are carried to the mills. The grinding is done by means of 24 pairs of horizontal stones actuated by powerful turbines, water-wheels, or steam engines, of a total power of 580 horses. These motors serve in addition to set in motion, the crushing machines and the Archimedes screw that carries the finished cement to the storage silos. These latter are 24 in number, and have a total capacity of about 705,000 pounds.

"The Society employs more than 500 persons, including miners, furnacemen, millers, machinists, stokers, coopers, teamsters, etc.

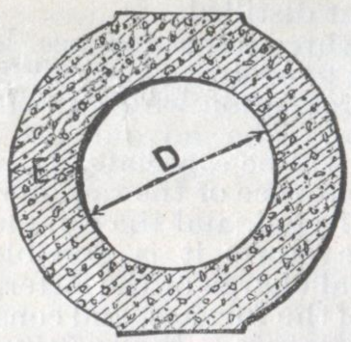


FIG. 10.—SECTION OF BETON WATER MAIN.

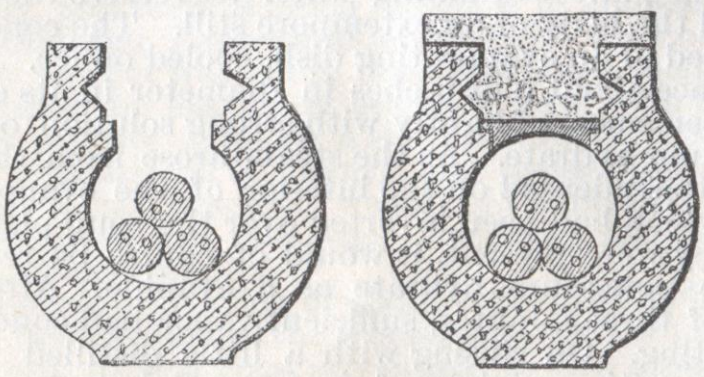
"Fig. 10. Section of Beton Water Main."

Of the Products and Their Applications.

"The lime-rock of the Gate of France yields, upon analysis, the following results:

Clay	Silica	13·3	23·7
	Alumina	5·1	
	Peroxide of iron	2·6	
	Lime	1·7	
	Magnesia	1·0	
	Carbonate of lime		76·3
	Carbonate magnesia		
	Water, bitumen, etc.		
			100·0

"The cements are of four kinds: (1) quick-setting; (2) semi-slow-setting natural Portland; 3) slow-setting artificial Portland; and (4) white Portland.



FIGS. 11 AND 12.—PIPES FOR ELECTRIC CABLES.

"Figs. 11 and 12. Pipes for Electric Cables."

"***Quick-setting cement***. – This is obtained by a simple burning of the limestone. Upon analysis it gives the following results:

Clay	Silica	22·10	40.31
	Alumina	18·21	
	Oxide of iron		trace.
	Lime		55·98
	Magnesia		0·37
	Sulphate of lime		3·34
			100·00

"The formula that gives the thickness of the conduit as a function, of its internal diameter, and of the pressure is $e = \frac{D\,H}{30}$; where E is the thickness expressed in inches, D the internal diameter in i inches, and H the pressure of the water in inches.

"***Beton Conduits for Electric Cables***. – The Society, in 1882, patented a system that consists in the use of beton pipes open longitudinally, assembled in length of about a yard in trenches, and hermetically closed with a mortar of cement after placing the cable in them (Figs. 11 and 12). In a metallic pipe, cables can only be introduced by traction, and at the risk of injuring them. The new system has been under trial at Toulouse since 1882, for telegraphs, and at Lyons for telephones, and has given satisfactory results. The Society is now at work on a system of double piping for electric light wires for the City of Saint Etienne (Fig. 13).

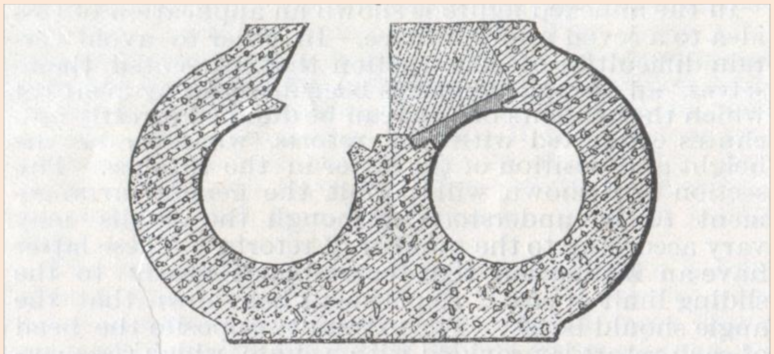


FIG. 13.—DOUBLE PIPE FOR ELECTRIC LIGHT CABLE.

"Fig. 13. Double pipe for Electric Light Cable."

"***Beton Drain Pipes.*** – These consist of two distinct parts (Fig. 14), viz., of a drain, B C D, which allows the water to pass, and of a collector, B A E D, which collects the water that has passed through the drain. This latter is composed of a beton made of 9 pounds of cement and 1 cubic foot of gravel per cubic foot, while the collector is made of a mixture of 31 pounds of cement, ½ cubic foot of sand, and ¾ cubic foot of gravel per cubic foot. As these two parts are moulded at the same time, they form a whole that presents great resistance.

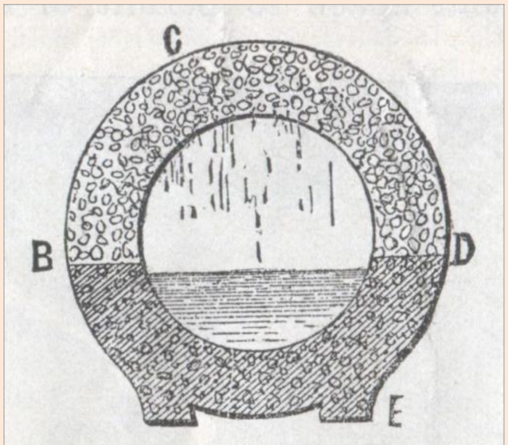


FIG. 14.—DRAIN PIPE.

"Fig 14. Drain Pipe."

“***Sewers and Free Conduits of Wide Section***. – These conduits are made of a beton composed of 25 pounds of cement, ½ cubic foot of sand, and ¾ cubic foot of gravel per cubic foot. Their principal advantages are the following: Rapidity of manufacture, regularity of form, suppression of coating, slight thickness, and quick hardening. The cement must set very quickly and be of superior quality, for otherwise these large masses of beton would run the risk of giving way under their own weight before they had set sufficiently to withstand the pressure.

“The free aqueduct of the city of Nice (Fig 15), the subways for the engineer corps at Grenoble (Fig. 16), and the sewers of Bale, Annecy, Saint Chamond (Fig. 17), etc., were all constructed by this process.

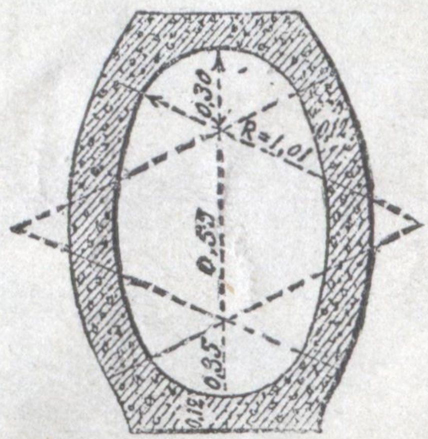


FIG. 15.—AQUEDUCT OF THE CITY OF NICE.

“Fig. 15. Aqueduct of the City of Nice.”

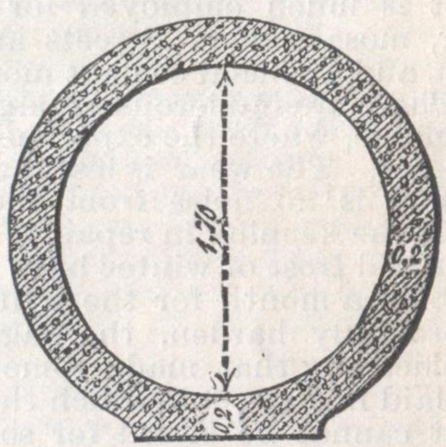
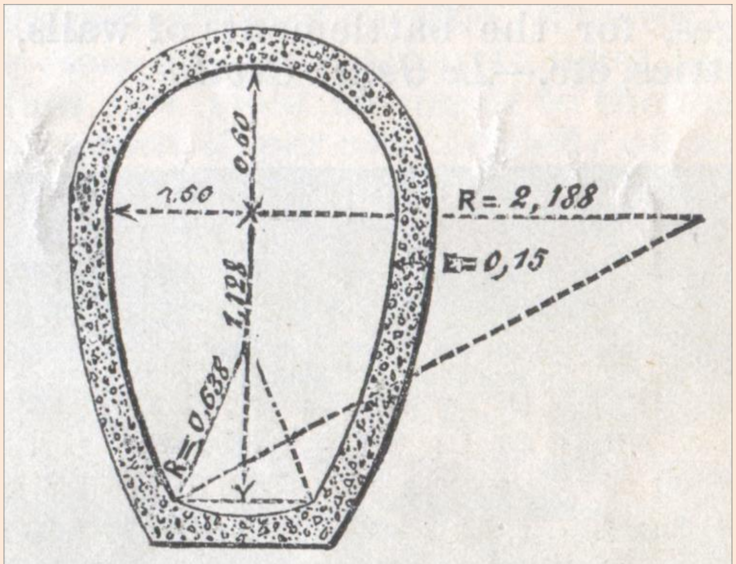


FIG. 16.—SUBWAY.

“Fig 16. Subway.”



"Fig. 17. Sewer."

"***Tunnel Linings of Beton***. – This system is especially advantageous as regards rapidity of execution; besides, in many cases, it is cheaper than rubber lining. If infiltration of water is not to be feared, it is only necessary to use a beton composed of one part of cement to seven of gravel.

"In short, the quickness with which the cement sets, and its exceptional resistance to traction, which is obtained in a few days, give it an undoubtedly superiority in all work that requires first class materials, an adherence equal to that of the hardest stones, and quick execution.

"In addition to its use in those important works that belong to the domain of the engineer, the quick-setting cement has applications that are of less consequence, but none the less interesting. Thus, for example, about twenty years ago a contractor conceived the idea of substituting cement posts for wooden ones for supporting vine trellises. On the line from Genoble (sic) to Lyons, at Saint Robert, there is an application of this system over an area of 40 acres, where about 40,000 of these posts have been set up.

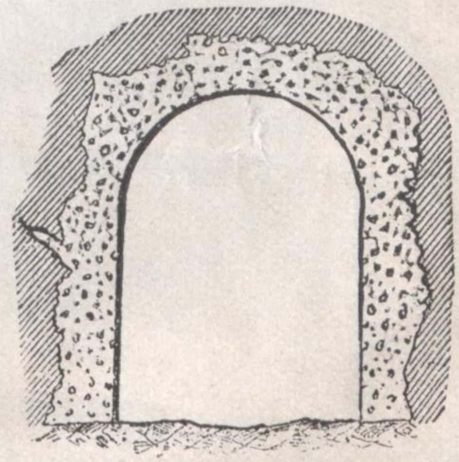


FIG. 18.—TUNNEL LINING.

“Fig. 18. – Tunnel Lining.”

“***Semi-slow-setting Natural Portland Cement***. – This is obtained by an overburning of the cement rock. Upon analysis it yields the following results:

Silica..	22·61	42·40
Alumina.....................................	19·79	
Lime...		51·63
Magnesia		0·37
Sulphate of lime		5·60
		100·00

“This cement in a pure state sets in 30 minutes, and in a short time acquires a greater resistance to traction than that possessed by the quick-setting sort. Yet the last named is preferable in all work that requires rapidity of execution and mounding, such as water-mains under pressure, etc.

“In order to retard the setting in hot weather, the quick-setting cement is sometimes mixed in certain proportions with the natural Portland. The resistance to traction in such a case is about midway between what would have been obtained separately with each of these products. This experimental fact demonstrates the erroneousness of the opinion that in a mixture of cements each behaves as if it were alone. Were such the case, the settings of the quick cement would be interfered with by that of the slow, and there would result a disintegration of the mass; that is to say, the final product would be analogous to that obtained by an inexperience workman who continued to temper and disturb the cement while setting. Numerous experiments, on the contrary, have proved that two cements mixed with water behave like a new product that takes its properties from each of the elements that compose it.

“A mixture of quick and natural Portland cements much facilitates the moulding of artificial stone, and the edges come out sharper, and the surfaces are more perfect. This line of manufacture has assumed quite extensive properties in the region of Dauphine, where such stones are now used as a substitute for dressed stone in a large number of constructions.

"The natural Portland cement is much employed for lining gasometers, water reservoirs, etc. The rapidity with which the quick cement sets would not permit of its being laboriously spread over wide surfaces; and a slow-setting cement like the natural Portland, on the contrary, would be of difficult application to vertical surfaces or to the intrados of vaults.

"This slow-setting natural cement is likewise employed for vaults upon T-irons, which are perfectly adapted for decorations in relief moulded in a piece with the vault, upon the intrados. Work of this kind, among others, has been done by the Society for the Direction d'Artillerie of Clermont-Ferrand.

"Engine frames made of natural Portland beton offer all the advantages of very strong monoliths.

"***Slow-setting Artificial Portland Cement***. – This cement, used in a pure state, sets in 3 hours, and is therefore of easy application, even by inexperienced workmen. It has about the same chemical composition as the artificial cements of Boulogne and England, as seen from the following table, where I. stands for the artificial Portland and II. for seven typical Boulogne and English Portland cements:

	I.	II.
Silica	25·20	24·1
Alumina and oxide of iron	11·40	10·3
Total lime	56·10	61·4
Magnesia	2·40	0·5
Sulphuric acid, alkali, water, and bodies not analyzed	4·90	3·7
	100·00	100·00

"This product is much employed for making sidewalks, flagging, mosaics, etc. Streets and causeways made of beton and artificial cement mortar give very good results. There are numerous examples of them in the city of Grenoble, where the experiments date back about fifteen years. The wear is less than in ordinary paved ways, there is no noise from the passing carriages and carts, the keeping in repair is easy, and the heat of summer and frost of winter have no action.

"As it takes about a month for the artificial Portland mortar to thoroughly harden, the flagging made *in situ* can be replaced by that made somewhere else, in case it is to be laid in a street in which there is so much passing that it cannot be closed for so long a time. Work of this kind has been done by the Society for the Direction d'Artillerie of Clermont-Ferrand, at the frost in the environs of Belfort, in the cavalry stables at Montauban, in the different streets of Grenoble, etc.

"This artificial cement is likewise employed in the construction of walls, in the proportion of one part of cement to seven of gravel. The strength of this beton permits of the thickness usually given to masonry being reduced one-half.

"Among the other special applications of this product, we may cite the following: Mouldings in beton for monolith bridges, for the battlements of walls, artificial blocks for jetties, etc. –
Le Genie Civil."

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Some information about the quarries near Grenoble, France, and photographs of the area are available in the “Bastille (Grenoble)” section of Wikipedia at the link below. Peggy B. Perazzo

“**Bastille (Grenoble)”** section of
http://en.wikipedia.org/wiki/Bastille_%28Grenoble%29