way between Nice and Toulon. Saint-Raphael is one and one-half miles distant to the southeast. Although Frejus contains only 2,791 inhabitants it was considered necessary to supply it with plenty of water free from all contamination. This only necessitated a reconstruction of an important work of the Romans, which was sufficient to supply a city of 100,000 inhabitants. In Roman times Frejus or Forum Julii, as it was named, was the most important and flourishing port of Gaul. This accounts for the imposing ruins of walls and aqueducts which remain. Frejus still preserves the main lines of an aqueduct constructed by Julius Cæsar or Augustus, historians being not quite agreed on this point. A comparison of this grand work with our modern canals will easily prove that a vast number of workmen would be necessary to accomplish such a result without the aid of the modern machinery which we consider so essential in all engineering works. In constructing the canals and aqueducts to supply the city and the militia, the Romans followed a course from the river Siagnole to the city, a distance of 50 kilometers (31 miles), a course so direct and so logical that modern engineers have adopted it, and they could not have made a better choice. Siphons, of course, replace the aqueducts. At every step the laborers found curious traces of the ancients. In the live rock they found the marks of the iron pick, stumps of props and, above all, a series of arcades admirably preserved on which the ancient aqueduct rested.

The new canal brings the waters of the Siagnole, which rise at the base of the foothills of the Alps, to the city. The captive waters are carefully isolated from all contamination and infiltration. The canal is vaulted the entire distance. For 12 kilometers the old Roman canal is used. In parts where it was injured it was repaired. After this 12 kilometers the canal arrives at the summit of a hill, on which the picturesque village of Callian is situated. From this point it traverses the valley by a siphon 4 kilometers long. From this point on the water is conducted by a series of tunnels and siphons by way of the Esterel Mountains, until, after a total distance of 54 kilometers, the canal ends on the last summit of the Esterel Mountains, near the sea, from whence the waters are conducted to Frejus and Saint-Raphael, where monumental fountains were erected in honor of the work, which has been executed in little less than a year, by two distinguished engineers of the Ponts et Chaussees, MM. Perrier and Rebuffel. For our engravings and the foregoing particulars we are indebted to L'Illustration.

EIGHT HORSE POWER OIL ENGINE.

ONE of the few novelties in the Smithfield Club show is the oil engine exhibited by Messrs. Howard, of Bedford. It is a well finished eight brake horse power oil engine, the mechanical details of which are very simple. Like all others, it works on what is known as the Otto cycle. It is of the type which is included in classes 4 and 6 of our classification of these engines, namely, one which receives and converts the oil into a gaseous vaper in a vaporizer separately heated by an oil lamp with forced air combustion; and in which ignition is effected by an ignition tube, heated by an oil lamp with forced air combustion.

The oil is injected into a heated vaporizer, where it is met by a current of heated air and vaporized before it enters the cylinder, there to be mixed with the proper volume of air to form the combustible charge, which, when compressed by the return stroke of the piston, is fired by the ordinary ignition tube. A screw adjustment, varying the stroke given to the pump plunger, determines the quantity of oil for each explosion in the cylinder, the oil being admitted by an oil regulator, which is controlled by the hit-and-miss finger of the Holt governor. The arrangement and form of the vaporizer are shown by the engravings, Figs. 1 and 2, herewith, the vaporizer being shown partly in section from a rough sketch. In this A is the back end of the cylinder, to which an inclined casting, B, is fixed. In the casting, section of which on the line, N N, is given in Fig. 2, there are two long round passages, and at the lower part is a flat passage, G, this passage being the final gasifying chamber. Oil enters at D through a fine hole, through which it is injected under a small pressure into and hits the lower surface of the passage, E. A small quantity of air is admitted by the valve, V, into the passage, F, where it is heated. At the upper end of the passage, F, it enters the passage, E, where it is further heated and comes into contact with the oil jet from the pipe, D.

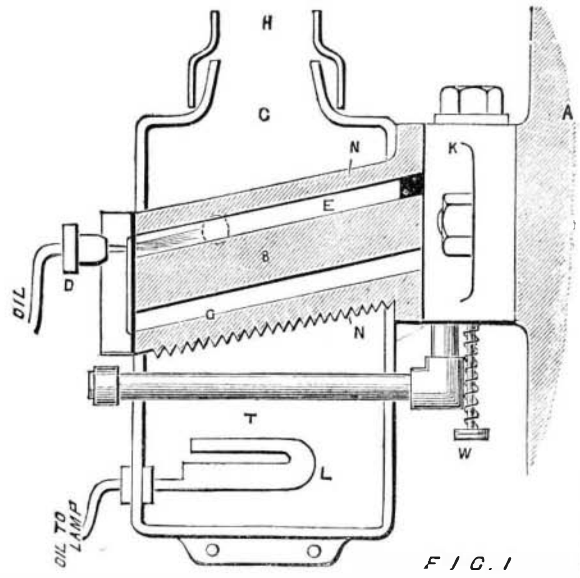


FIG. 1.—VAPORIZER, HOWARD OIL ENGINE.

By a connecting port at the lower end of the passage, E, the air vapor passes into the hottest passage, G, where the vapor is converted into a gas and passes into the working cylinder, when permitted to do so by the lifting of the valve, W. The vaporizer is surrounded by an asbestos lined case, C, surmounted by a chimney, H, and below the vaporizer is a lamp, L, which heats the ignition tube, T, as well as the vaporizer. The bottom surface of the latter has cast upon it a number of pointed projections, which increase the heat receptivity of the bottom part of the chamber, C. The passage, G, when it enters the valve case, K, is

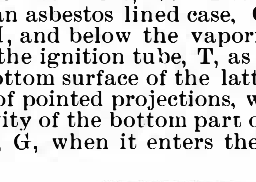
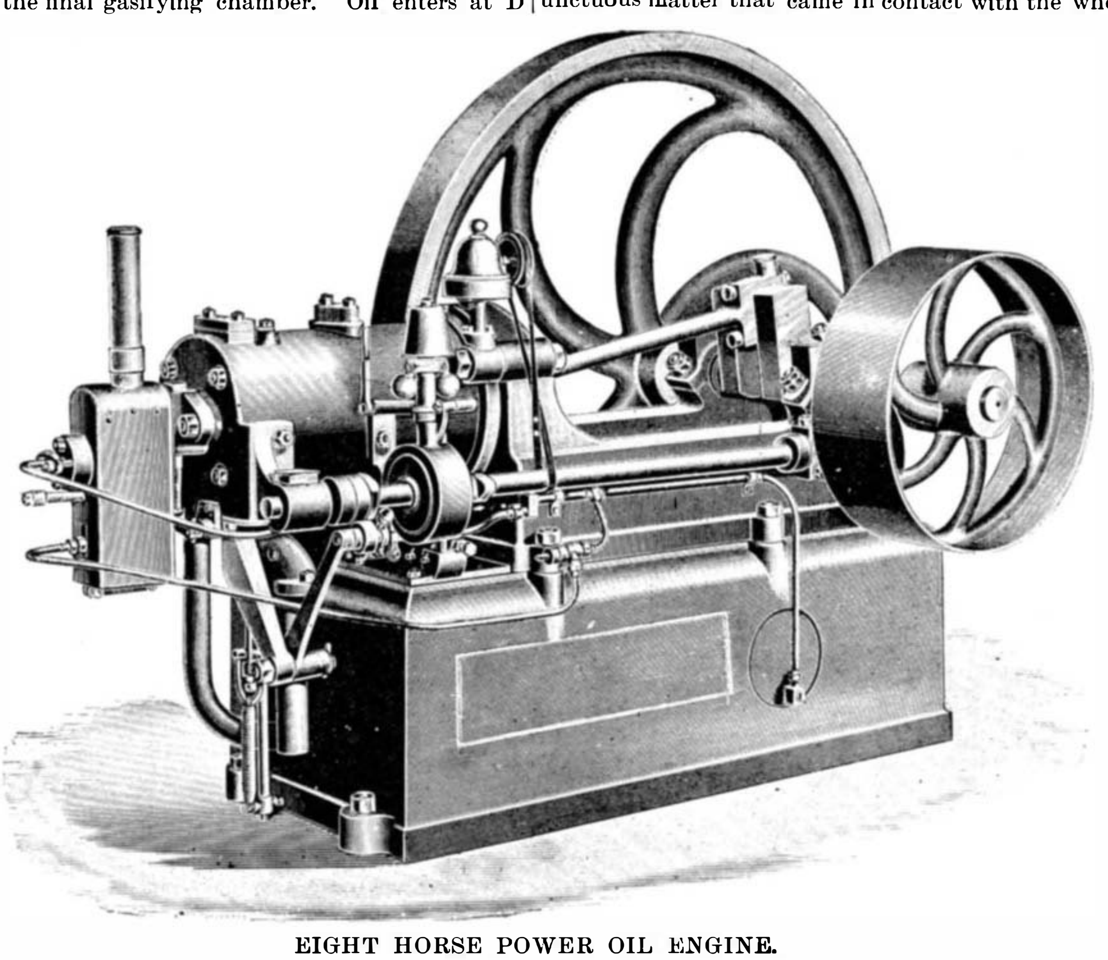


FIG. 2.—SECTION N N.

directed so that it passes over the valve, and the ignition tube, T, enters a separate port open to the cylinder.—The Engineer.



EIGHT HORSE POWER OIL ENGINE.

EMERY WHEELS.

By W. SAMUEL WORSSAM, C.E.

PROBABLY no tool has developed more rapidly or attained greater prominence in the department of arts and manufactures than the emery wheel or disk for grinding and abrasive purposes.

Some thirty years since, such a tool was comparatively unknown. Compositions of certain materials in a solidified state, in the form of wheels, had unquestionably been employed for various grinding and abrasive purposes, but with a comparatively limited application by reason of their inferior quality. The amalgamating agents being in most cases glue and treacle, were not proof against the decomposing effects of any unctuous matter that came in contact with the wheel while working. An American (C. Goodyear) subsequently hit on a better system of concretion by making the medium of consolidation India rubber or gutta percha. While of a plastic or doughy consistency, any formation could be given to this substance, after which it underwent certain processes of induration by heat to give it the requisite hardness. The chief defect of this vulcanite, or ebonite as it was termed by the inventor, lay in the fact that the matter forming the grit, being of a tough, horny character, and not very friable, instead of disintegrating in the act of cutting, softened under the friction. The result of this was the glazing of the cutting edge of the wheels, with a proportionate lessening of its powers of attrition, which could only be partially restored by applying red hot iron to the deteriorated parts.

Matters remained in this state until 1862, when among other important inventions brought to light at the London International Exhibition of that year was one which engaged a good deal of attention. This was a compound of oxidized linseed oil, sulphur, and some gritty material, preferably corundum or emery, and termed by the exhibitors "consolidated emery."

Corundum is the earth alumina found in a crystalline state. It is octahedral, rhomboidal, or prismatic. In hardness it is next to the diamond. The amethyst, ruby, topaz, and sapphire are considered as varieties of this mineral, differing from one another chiefly in color.

It is found in India and China, and is most usually in the form of a six-sided prism or pyramid. It is nearly pure anhydrous alumina (Al_2O_3), and its specific gravity is about four times that of water. Its color is various, green, blue, or red inclining to gray, due to traces of iron, copper, etc.

Emery is an amphorous variety of corundum and sapphire, found concrete or fairly granular, its color varying from a deep gray to a bluish or blackish gray, sometimes brownish. Its constituents are alumina 82, oxide of iron 10, silica 6, lime 2. The emery of commerce comes chiefly from the Isle of Naxos, in the Ægean Sea.

As previously remarked, one of the chief difficulties with the earlier wheels was the glazing of the surface. This was obviated almost completely in the new wheels by the invention of Jacques & Fanshawe, chemists, who succeeded in adapting a peculiar material discovered by F. Walton (of Lincrusta Walton fame) as a substitute for the India rubber or gutta percha heretofore used as the concreting agent, and for the grit they employed emery or corundum. The base of the binding material referred to was boiled linseed oil, which, being spread in a thin layer on wood or metal, was exposed to heat. This caused a revulsion to take place in its elementary constitution, the fluid being converted into a semi-dry body by the absorption of oxygen and the disengagement of carbonic acid. On the addition of gummy or mucilaginous matter, such as shellac, asphalt or bitumen, a thick paste was formed, which, after being kneaded and worked between powerful rollers, formed the composition for binding the gritty cutting substances, such as corundum, emery, steel or iron filings, glass, etc., together. One of the advantages this substance had over vulcanite or ebonite was its indifference to changes of temperature, thus rendering it suitable for service in hot climates. It was also unaffected by oil or grease, whereas India rubber or gutta percha is readily destroyed by these unguents. The discoverers of this remarkable body were not long in availing themselves of its characteristics, in the manufacture of wheels or disks for cutting and grinding.

In 1862 they (Jacques & Fanshawe, since L. Sterne & Co.) obtained a patent for "Improvements in the Manufacture of Grinding and Polishing Tools and Surfaces," and, after a number of experiments and crucial tests, succeeded in producing wheels and disks which have subsequently proved so invaluable.

The procedure adopted in the manufacture of these consolidated emery wheels may thus be briefly described. Camplicon or oxidized linseed oil is mixed with about half its weight or other suitable proportion of shellac, asphalt or bitumen, so as to produce a thick paste or dough that may serve as a good agglomerating medium for binding the emery, corundum, pulverized glass, fine granulated iron, or iron and steel filings or borings, or other hard cutting and gritty material, reduced to a finely divided condition, together in one homogeneous bulk. To this must be added 10 per cent. of powdered sulphur when iron for steel filings form no portion of the composition, but when these constituents are employed, sulphur must be omitted. Care should be exercised that all the component elements be well assimilated, and incorporated for homogeneity. The mass is then submitted to about 350 degrees of heat in an oven with a dry heat, or an atmosphere of steam of the requisite temperature, in order to harden and solidify it. As anterior to the baking or heating process the compound is soft and plastic, it may be moulded into wheels or disks of any form or shape, suitable to the configuration of the work for which they may be required. The nature of this "consolidated emery" is such that it may not alone be employed for grinding or cutting metals, but also for glass, flint, slate, marble, and similar substances. It can be used dry or with water. Dry, if the material to be operated on can withstand the friction, with water where heating would be injurious. Many other kinds of wheels and disks have been introduced within recent years, such as the Tanite, Norton, Bateman, Luke & Spencer, Diamond, Sterling, Sundale, Naxor, Detroit, Celluloid, etc., but the original wheels of Jacques & Fanshawe and called the "Sterne"—the name of the maker—will hold their ground. They are, particularly when thin, more reliable, and do not split and fly when running at the high speed necessary to obtain the best results, as happens in the case of some others.

The emery wheel, as an adjunct to every workshop where grinding has to be done and machine tools are used, is now considered indispensable, and its usefulness and economy are yearly becoming better understood and appreciated; it has not been inaptly described as "a rotary file whose cutting points never grow dull."

To such perfection has the manufacture of these wheels reached, that they are made in sizes varying from $\frac{1}{16}$ in. to 8 in. in thickness and from $\frac{3}{4}$ in. to 40 in. in diameter. Their economy in working is marvelous; a man can drive a file about 60 ft. a minute over a flat metallic surface, but it is soon worn out, whereas a well made emery wheel will work up a surface of 5,000 ft., and last a considerable time without appreciable wear. It has been proved repeatedly by practical men, after careful experiments and observation, that to remove a pound weight of iron with a file costs about 2s. 6d., while the same amount of work can be done by a good wheel at the moderate expenditure of 4d.; and, further, the latter will execute the work in about one-eighth less time than the file. An emery wheel will frequently cut away twelve times its own weight in metal before becoming useless. As an instance of the great cutting power of consolidated emery may be mentioned the fact, that a disk, 12 in. in diameter and only $\frac{1}{16}$ in. thick, will cut slits 4 in. long in tough cast steel ½ in. thick.

The "Sterne" wheel is made in four distinct classes, entirely different in composition and method of manufacture, each class being made of ten gradations of quality, from very coarse to superfine, to suit for heavy work or the light grinding of fine metal work, knives, and other instruments and purposes.

1. The consolidated emery wheels are made in sizes from $\frac{1}{16}$ in. to 6 in. thick, and from ¾ in. to 36 in. diameter. A special feature of these wheels is that they can be run either dry or with water, making them very suitable for all kinds of tool grinding and sharpening. They are invaluable for saws, fettling, and trimming castings.

2. The amalgamated emery wheels are specially adapted to grinding brass, copper, and other soft metals and alloys.

3. Composition burr emery wheels are specially suited for decorticating and grinding rice and other grain, and are found superior and more economic than the French burr stones, which they are generally superseding.

4. Compound emery wheels are available for many particular operations, and for dry grinding of hot or chilled cast iron rolls. It is difficult to enumerate the varieties of work for which these wheels, in their different grades, are available; there is a constantly increasing demand for them, and not only have they become a necessity when once adopted, but new fields of application are daily opening to them.

They are of the greatest service for all kinds of engineer's tool grinding, saw sharpening, fettling and trimming castings, grinding chilled rolls, locomotive slot links, plane irons, knives, India rubber rolls for wringing, printing, and other machines, bushes, eyes, female mandrels, straight and spiral reamers, milling cutters, taps, circular knives and slitters, lathe centers, twist drills, etc.

For polishing this type of wheel is unsuited, as even with superfine grit, they will cut or grind. For this operation it is necessary to first grind the article to a perfectly flat surface with an emery wheel and subsequently to make use of a buff wheel or glazier—a wooden wheel having a leather periphery coated with a mixture of the finest washed emery powder and thin glue, spread on as evenly as possible; after the first coat of the mixture is dry, a second and third may be added. When this composition has worn away, the rim should be washed with warm water, and when dry, the covering process may be repeated. The finishing polish is best obtained by daubing the leather rim with rouge composition and oil. Some buff wheels have a ring of metal consisting of an alloy of lead and tin instead of the leather; in this case loose powdered emery is used, after the manner of an ordinary lead lap or grinder.

With regard to the treatment of the emery wheel in work, this, when worn oval or out of circular shape, must be trued up or redressed in situ by a diamond tool or other suitable appliance, which gradually effaces all protuberances and irregularities, and again brings the cutting edge to the general circumference; or it may be removed from the machine and turned true in a lathe, or filed or chipped. At one time a heated iron was used for this purpose, but this method is unsatisfactory, and obsolete in any workshop claiming to be modern and up to date. The hot iron glazes or greases the composition, and the wheel will consequently not "bite" the material, until it has been several times used; whatever mode is used, the wheel must be true, for if out of balance, it loses greatly both in serviceableness and safety. Undoubtedly the best plan for redressing is by means of the diamond tool. This consists of a Brazilian black carbon or diamond, weighing about one carat, inserted in one end of a suitable holder, usually carried by a slide rest, having compound movements, like that of an ordinary lathe for metal, and constructed to be bolted to the standard of the machine carrying the wheel, which should be reduced in speed from 4,000 to 6,000 feet to 60 to 80 feet per minute; although the diamond can be used at the ordinary running speed, if care be exercised and a very light cut taken. The diamond should be fed slowly to the work to prevent shock; the harder the diamond, the more brittle it is, and anything like shock must be guarded against. A deeper cut of more than $\frac{1}{32}$ inch should not be attempted. The diamond only must touch the wheel, otherwise the setting will be ground away, and allow the carbon to fall out of the holder.

In the States a diamond tool is in vogue which can be wielded like a lathe hand turning tool, such as a graver or heel tool, with a long haft. There is likewise an instrument called the Huntingdon dresser, which consists of a lever having at one end instead of a diamond a small serrated steel wheel or rowel, which, on being pressed against the edge of the rotating emery wheel, revolves by the contact and hacks away the projecting grains of emery, leaving the wheel in good cutting order.

By the employment of the diamond tool, the periphery of the wheel can be turned to almost endless varieties of shapes—round, concave, beveled, pointed, etc., as are required. The wheels usually leave the moulds square-edged, and are afterward turned to the necessary shape in the manner explained. Still, they can be moulded into any form in the course of manufacture as decided on beforehand.

The peripheral velocity of these wheels is from 4,000 to 6,000 angular feet per minute. The wheel, before being mounted on its spindle, should, if thin, be examined, to see that it is perfectly flat, and the outer crust removed. Care must be taken that it does not fit too tightly on the mandrel, or it will be liable to crack when running. Wooden collar, India rubber, or one or more thicknesses of paper well soaked in water, should be inserted between the wheel and the iron flanges or washers which retain it in place, and these must not be too tightly screwed up. Neglect of these precautions is oftener a source of fracture than any inherent defect in the wheel itself.

Not the least call on these wheels is that for sharpening machine saws. A well made and mounted emery disk, properly worked and running from six to nine hours a day, will last some three months, and will gullet, sharpen and top on the average 200 deal frame saws each day of nine hours. It is found in practice that the action of the disk on the teeth hardens the cutting points, with the result that the saws last longer when machine than when hand sharpened.

No saw mill can be reckoned fully equipped which is without a saw-sharpening machine; it pays even when there is only one frame or saw bench. A great economy is effected in labor and files; a man at the machine will do as much work as six sharpeners by hand simply. In respect of the cost of files, it may be said that this is almost entirely saved, each disk costing but a few shillings, and lasting in constant work for several months. Some workmen are so skilled in the use of the machine as to be able to turn out the saws topped ready for working. Another great merit of the machine is that the tooth spaces or throats can easily be maintained at a uniform depth, whereby the saw not alone works better and quicker, but less power is required to drive it, and the risk of buckling in regulleting or toothing, which is needful when the teeth are allowed to become stunted or stumpy, is absent.

In concluding this article I cannot refrain from observing that in the discovery or invention of "consolidated emery" we have a striking illustration of the beneficent and far-reaching results which sometimes spring from small causes. The inventors, in all probability, never for one moment anticipated the great diversity of uses to which their invention would ultimately become applicable.—Industries.

THE FRIEDEBERG APPARATUS FOR BURNING COAL DUST.

MR. FRIEDEBERG, of Berlin, has devised for the burning of coal dust an apparatus which is exploited by the Allgemeine Kohlenstaubfeuerung Actiengesellschaft, and the arrangement of which is shown in the accompanying figure.

The idea of introducing coal dust into furnaces through an insufflation of air is not new. For the burning of coal in powder derived from the residua of bins, Mr. Corbin, years ago, conceived the idea of sending it into a hopper at the base of which there was a charger provided with a wide cavity. At every revolution of this charger, its cavity became filled with coal dust, which it emptied into a conduit, whence the dust was forced by a blast of air into the flames of a coal furnace.

In certain applications also the coal has been pulverized by crushing cylinders that discharged it upon the vanes of a blower, whence it was thrown into the flames of a furnace.

The general features of the Friedeberg process are likewise found again in the Molinos and Prounier furnace. Finally, Messrs. Baumert and Wegmer have very recently made some interesting tentatives with a view to the heating of boilers by powdered coal.

Mr. Friedeberg has resumed the study of the arrangements to be employed for feeding the furnaces of manufactories, and the apparatus that he has devised to this effect is as follows.

The vertical tube, a, for introducing the air serves as a pivot to the system, which comprises: 1, the movable jacket, b, to which are bolted the primary air conduit, c, and the secondary air conduit, d; 2, the hopper, e, supported by the chest, f; the inlet pipe, g, and, finally, the conical chamber, h. The chest, f, is supported by the conduit, d, but is not in communication with it. The fixed pipe, a, is provided at the side with two apertures in front of which the two conduits, c and d, coincide when the apparatus is in operation. At a stoppage, a rotary motion is given the system and the apertures of the pipe, d, are closed by the sides of the movable jacket.

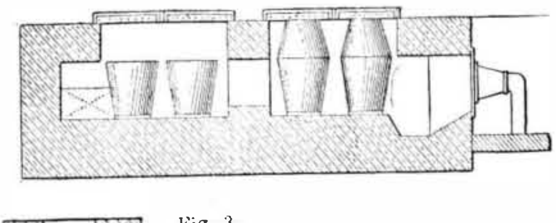
The conduit, c, is divided into two branches which enter the chest, f, through tuyeres so arranged that the blast of air sets the dust in motion and carries it through the square passages, i, into the inlet pipe, g. All the fine coal that may chance to be in the dust falls to the bottom of the pipe, g, whence it may be removed through the maneuver of a slide valve.

The large horizontal pipe, d, ends at a vertical conduit which, through a tuyere, debouches in the conical chamber, h. The conduits, c and d, are provided with valves that serve to regulate the discharge of the air blown in.

During the running, the mixture of air and coal dust that enters the conical chamber through i and g meets a current of air therein that has been led by the pipe, d. It is then thoroughly mixed and carried in the direction of the furnace, as shown by the arrows.

In default of precise results derived from official trials, we give the renderings obtained in some particular experiments, although these present some anomalies that are difficult to explain.

FIG. 2.—APPLICATION TO A CRUCIBLE FURNACE.



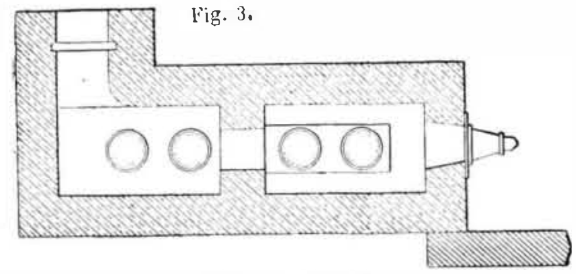


FIG. 3.—PLAN.

The ventilator absorbs from ½ to 1½ horse power, according to the dimensions of the apparatus and the quantity of coal dust to be introduced into the furnace. For burning 10 pounds of dust it would require but from 10 to 15 pounds of air. The supplementary expenses occasioned by the use of a blower would therefore not be very heavy and would be covered by the perfect combustion attained with this process of heating. Such combustion would be so regular and so complete that the sides of the fire box might be raised to a white heat in a very short time.

Up to the present, this apparatus has been constructed according to two types only, one of them capable of blowing from 10 to 100 pounds of coal dust into a furnace per hour and the other from 20 to 330 pounds. The arrangements taken permit of exactly regulating the introduction of the fuel. The emission of the dust is regulated by the pressure of the air and no smoke is produced. The fineness of the dust employed depends upon the nature of the coal. It is possible to employ sieves with 0·25 mm. meshes, but the best results are obtained with 0·1 mm. meshes. It is possible also to charge the blown-in air with a certain quantity of humidity, according to the nature of the fuel employed.

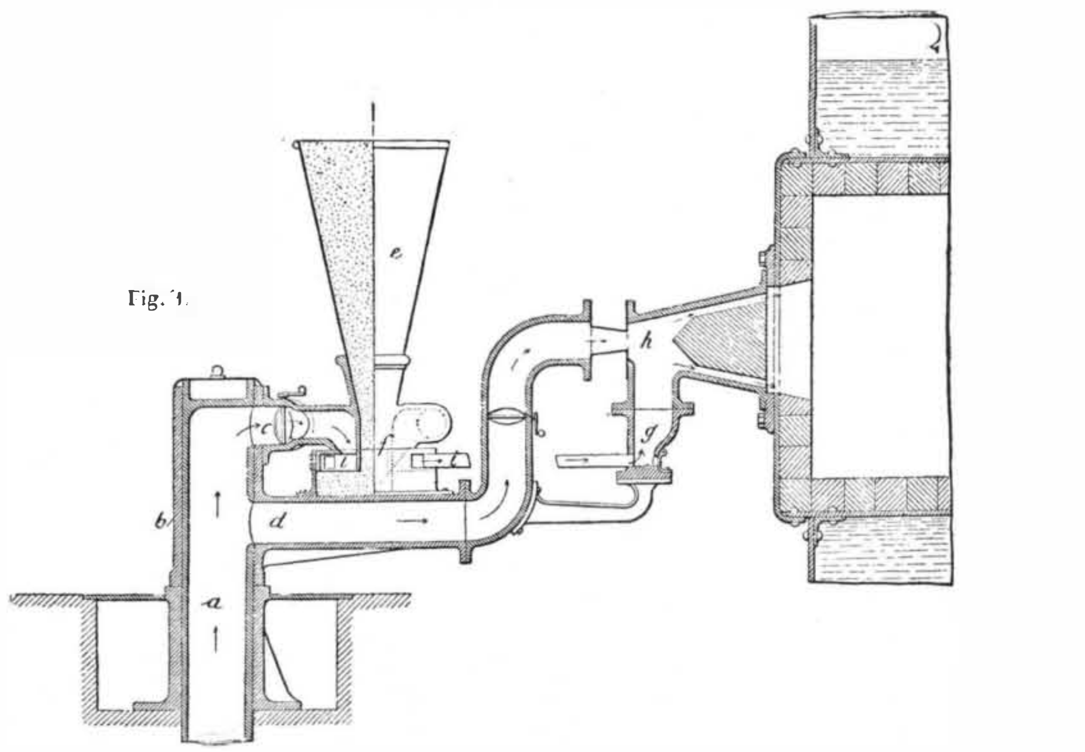


FIG. 1.—FRIEDEBERG APPARATUS FOR BURNING COAL DUST.

One of the first applications of this process has been made, in the establishment of Messrs. Arndt Brothers, at Berlin, to a 16 horse power tubular boiler operating at 16 lb. The steam is furnished to a 12 horse power engine which does not give its full power. The consumption of dust per 12 hours of work is, on an average, 715 pounds, which corresponds to 4,950 pounds of fuel per horse and per hour, inclusive of the coal employed for putting the boiler under pressure. This apparatus has been operating with success since the beginning of the present year.

Two apparatus of the largest size have more recently been applied to a two furnace boiler in the glass works of Messrs. Ebert and Neumann, at Stralau, near Berlin.