

ON THE MECHANICAL TREATMENT OF MOULDING SAND.

BY MR. WALTER BAGSHAW, OF BATLEY.

Literature on the art of Founding and on the materials employed in the Moulding of iron, steel, and brass, is unfortunately scanty, owing no doubt partly to the lack of the same personal interest in the foundry that is taken in other departments of engineering works; and in a large number of instances this want of familiarity with foundry practice causes the production of castings to depend on the experience of individual workmen. If a waster casting be the result, it is invariably and not unnaturally attributed to accident, when it may be more probably due to want of skill; for even moulders themselves are not generally credited with a scientific knowledge of the principles on which their art depends. In large shops there is of course a competent foreman, who is responsible for the execution of orders in the most economical way; whereas in smaller foundries, even important work, such as the preparation of cores and mixture of sand, is not infrequently carried out by unskilled workmen in a rather empiric manner. On the subject of the present paper there seems to be as much difference of opinion as there is diversity in practice; the writer therefore hopes discussion may help to settle debatable points. Some moulders place faith only in kneading or treading the few simple materials composing their facing sand, jealously guarding the preparation as a trade secret, and condemning all machine work; whilst others are equally emphatic in favour of the particular machine for grinding, riddling, or combing, to which they have been accustomed.

Sand.—Before describing the foundry processes in use it may be interesting to examine specimens of the ingredients generally incorporated.

Fig. 1, Plate 25, is a view, magnified 50 diameters, of sand found and much used in the West Riding of Yorkshire. In its natural state it will be noticed that a portion of the grains adhere together in clusters, varying in size from masses containing hundreds of sand grains to smaller groups of three or four grains, most of them small enough to pass through an ordinary fine riddle without disintegration. The form and size of the groups are very irregular, and many are covered with a fine scaly powder. Samples from the bulk show a preponderance of grain groups devoid of any uniformity. There are exactly the same appearances in fine Mansfield and other sands, though the presence of sharp crystals may be more frequent, and the abraded corners not so conspicuous.

Fig. 2, Plate 25, represents new sand mixed with coal dust and burnt sand. The dark spots dotted over the new grains are particles of coal which attach themselves in this manner, and when subjected to the heat of molten metal are converted into coke, often enveloping the sand grain with a crust, as shown in Figs. 3, 4, and 6, Plate 26. In none of the specimens examined was coal found in a separate loose state.

Figs. 3 and 4, Plate 26, show samples of old sand very much like gas coke, with perhaps more of a metallic lustre.

Fig. 5 shows the extent to which sand may be destroyed by burning or chemical action. Numbers of these friable hollow husks occur in a more or less broken condition, and are easily reduced to fine powder by concussion with other particles. If used again in sufficient quantity, they will cake and cause metal to boil.

Fig. 6 illustrates the formation of a shell round a sand grain; the shell may be cracked like a nut, exposing a kernel of clean sand.

Coal dust, as commonly found, takes the form of angular splinters with laminated surfaces. When magnified 50 diameters, Fig. 7, Plate 26, it appears only like a fine powder; the larger pieces are not present in quantities, if the coal has been properly ground.

These materials after incorporation are generally coated with some other substance, plumbago being the most preferred; but it is difficult to give a correct impression of this article in a drawing. The flakes shown in Fig. 8, Plate 26, are taken from a surface polished

with black lead, presenting to the naked eye merely its own peculiar lustre over a large area. When viewed in bulk it is fluffy, like soot; and the outlines of separate flakes are not well defined by the prevailing light and shade.

The chemical composition of sand will obviously affect the nature of the casting, no matter what treatment it undergoes. Stated generally, good sand is composed of 94 parts silica, 5 parts alumina, and traces of magnesia and oxide of iron. Sand containing much of the metallic oxides, especially lime, is to be avoided.

Geographical position is the chief factor governing the selection of sand; and whether weak or strong, its deficiencies are made up for by the skill of the moulder. For this reason the same sand is often used for both heavy and light castings, the proportion of coal varying according to the nature of the casting.

A common mixture of facing sand consists of six parts by weight of old sand, four of new sand, and one of coal dust. Floor sand requires only half the above proportions of new sand and coal dust to renew it. German founders adopt one part by measure of new sand to two of old sand; to which is added coal dust in the proportion of one-tenth of the bulk for large castings, and one-twentieth for small castings. A few founders mix street sweepings with the coal, in order to get porosity when the metal in the mould is likely to be a long time before setting.

Plumbago is effective in preventing destruction of the sand; but owing to its refractory nature it must not be dusted on in such quantities as to close the pores and prevent free exit of the gases. Powdered French chalk, soapstone, and other substances are sometimes used for facing the mould; but next to plumbago, oak charcoal takes the best place, notwithstanding its liability to float occasionally and give a rough casting.

Hand Riddling and Treading.—For the treatment of sand in the moulding shop, the most primitive method is that of hand riddling and treading. Here the materials are roughly proportioned by volume, and riddled over an iron plate in a flat heap, where the mixture is trodden into a cake by stamping with the feet; it is turned

over with the shovel, and the process repeated. There is no doubt that tough sand can be obtained in this manner, its toughness being usually tested by squeezing a handful into a ball and then breaking it; but the process is very slow and tedious, and consequently expensive if tried on a large scale. Other things being equal, the chief characteristics of a good moulding sand are toughness and porosity, qualities that depend on the manner of mixing as well as on uniform ramming; indeed the same result would follow from want of attention to the one as to the other. For instance it is well known that a mould rammed too tightly in one place and loosely in another will cause a swelled uneven surface on the casting. Similarly if quantities of fat sand and poor sand occur alternately through improper mixture, the power of resisting the pressure of the molten metal is not equal, apart from the liability of causing the metal to scab; and a wavy rough surface will be the consequence, as in the casting exhibited from improperly mixed sand. Another casting shows the effect of loose coal-dust on the skin of the metal. In America a moulder will often prepare his own sand by hand riddling and treading, rather than have it put through a machine. For the pneumatic method of moulding with compressed air and flexible pressure-plate it is claimed that it gives sand of uniform density at all points equidistant from the pattern; yet in this system, as in hand moulding, the thorough mixture of the sand is of the first importance. The practice of piercing the mould with a vent rod will never give results equal to those realised with sand having its ingredients properly incorporated.

Power Riddling.—It is only a step from hand riddling to power riddling; and the latter has been made to approach as nearly as possible to the former by a succession of impulsive movements for the purpose of opening out the sand. Usually a power riddle, as shown in Fig. 10, Plate 27, consists of a set of transverse horizontal bars called breakers, placed over a coarse riddle, below which again is a fine riddle, the whole being set slightly sloping downwards towards the outer end. Lumps that do not pass through these roll off into a heap at the lower end. The frame carrying the bars and riddles is

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suspended from straps, and oscillated by a crank or cam at a speed of 120 to 140 revolutions per minute. For quantity, this mode of mixing is a decided advance on the slow hand-process, though it presents the objection of not opening out the groups of grains.

Roller Mill.—Another means of treating sand is the roller mill, Fig. 11, Plate 27, which is said to answer very well for hard sand containing stone. With soft sand the writer's experience has not been favourable to rolling, inasmuch as the castings made with sand so treated show a strong tendency to scab; but other founders state they do not find any serious disadvantage from its use. Viewed through a microscope the effect of slight pressure on sand would tend to confirm the writer's opinion; sand was placed between two slips of glass on the microscope stage, and a gentle sliding movement being given to the upper slip by the thumb of one hand, the rounded grains were seen to fly asunder into sharp crystalline forms, as depicted in Fig. 9, Plate 26. It is true that only those grains in immediate contact with the rollers would be thus violently acted upon, the rest forming a cushion; yet the former must be a considerable percentage of the whole quantity. If all the sand were actually crushed, the result would be the reverse of beneficial, for it would be too fine, and the fragments would form so close and dense a mass as to render it impervious to gas.

Centrifugal Mixer.—Schütze's centrifugal mixer, shown in Figs. 12 to 14, Plates 28 and 29, combines the advantages of all the other plans, besides giving a considerably greater output of sand. The particles of clay or groups of sand grains are so thoroughly disintegrated and mixed with the coal dust that the gas generated in the mould can get round every particle of sand, and so escape easily and equably, which is a desideratum for a fine casting. Agglomerated sand in large lumps, too big to pass through any riddle, comes out of the centrifugal mixer in a fine powdery condition along with the other materials; consequently no previous sifting is required. In ordinary work the materials are placed in layers, sandwich fashion, on the floor, in a convenient position for being shovelled into the hopper

of the machine, through which they are passed as fast as two men can shovel them in. The actual quantity thus mixed is at the rate of twelve tons per hour, or a ton in five minutes.

The action of the machine will be readily understood. The revolving table T, Plate 28, is mounted on the top of a vertical spindle P, and carries on its upper face a number of vertical pins or beaters, fixed alternately in a series of concentric circles, Fig. 12. The table is driven by a 3-inch belt, Fig. 14, Plate 29, at the rate of 1,200 revolutions per minute. The cover of the table has a hinge for turning it up in order to allow pieces of metal or other foreign substances to be readily taken out, which can be done at any time in only a few minutes. Falling upon the centre of the table from the hopper above, the sand is projected at a great speed from one row of pins to the next, until every part has been combed out. Round the outside of the table an india-rubber shield S guides the sand into a circular heap after it has been whirled from the table.

Moulds made with riddled sand and with sand mixed by this centrifugal machine—one half of the mould being made with each kind—certainly induce a preference for the machine mixing, after examination of the skin on the casting. Moreover with the machine one man can do the work of several in the preparation of the sand, thus securing economy in time and wages.

This machine was first seen by the writer when in Germany, where there are four hundred now at work; and he was so much struck with its simplicity and efficiency that he ordered one for his own works, and found the result of its adoption to be a great saving in wages and better work. The prejudice however in favour of existing methods is so great that few other works in England have as yet ventured to adopt it. In response to enquiries concerning the cost of mixing sand by hand labour and by machine, only two firms out of twenty applied to could give any estimate. Longer life of the sand is ensured by the complete intermixing of the materials; the reason for this may be seen in the protecting coat or shell shown in Fig. 6, Plate 26. Moreover a more even surface must result from the fact that, while the clay in the sand contracts under heat, the coal expands. A workman's ready method of testing the admixture of coal dust is to

Mixing 30 tons per day.				s.	d.
One labourer for 9 hours	.	.	.	4	0
3 horse-power for 9 hours	.	.	.	1	1½
Depreciation 10 per cent. on £33	}	.	.	2	½
for 300 working days per year		.	.		
Repairs 5 per cent.	.	.	.	1	½
Interest 5 per cent.	.	.	.	1	½
Total per day.				5	6½

The cost per ton is therefore a little more than twopence. Messrs. Marshall Sons and Co., Gainsborough, have three men employed on one machine to mix sand for 150 moulders and 14 moulding machines; but eventually their system will reduce this to one man's work. Other firms find one man working 9 hours per day can serve 60 moulders.

Equivalent Hand-Labour, &c.—The average output in riddling and treading sand is 4 cwts. per hour per man, which with wages at 5*d.* per hour gives 2*s.* 1*d.* as the cost per ton, or twelve times more than by the centrifugal machine. As no exact cost of mixing sand by other systems at present in use could be ascertained, no allowance is made for power, depreciation, and repairs; for wages only the cost of mixing by power riddling amounts to 1*s.* 3*d.* per ton, and by rollers to 1*s.*

Durability.—After two years' working of the centrifugal mixer, no expense of any kind has yet been incurred for repairs. The working parts are so few that the cost of maintenance leaves nothing to be desired.

Discussion.

Mr. BAGSHAW said that both at the previous meeting, from which the reading of the paper had been adjourned, and also on the present occasion, he was indebted to the kindness of Messrs. R. and J. Beck for lending a large number of their microscopes, under which could be examined specimens of moulding sand and of the various ingredients composing it, in confirmation of the magnified illustrations shown in the drawings, Figs. 1 to 9, Plates 25 and 26. He also showed a collection of samples of moulding sand and of the materials used; and specimens both new and worn of the pins or beaters in the centrifugal mixer.

Mr. JAMES PLATT said the custom had gone out of fashion for apprentices to spend part of their time in the foundry; at any rate it was not so general now as it was forty years ago. All the more therefore was the paper an interesting one; and it was well illustrated by the magnified drawings shown of the materials. Doubtless many engineers would be surprised to see the forms that moulding sand assumed under the microscope; but on consideration it was obvious that the sand must be composed of particles or grains of stone, coal, and other ingredients, to make it cohesive or fibrous. The riddle and the rollers or revolving runners were of course in general use; but the centrifugal mixer was not yet so generally used. Having seen it at work he believed it was an admirable machine; it certainly got through an astonishing amount of work, and mixed the sand in the right way. The feel of the sand so mixed was very much like that of the sand mixed by treading. The effect of the wear and tear of the pins could be seen from the specimen exhibited, showing with how great force the sand was thrown about in the machine, which much resembled Carr's disintegrator (Proceedings 1872, page 28).

Mr. JOHN G. MAIR-RUMLEY, Member of Council, said that formerly all the riddling and mixing of moulding sand had been done by hand. It was about twelve years ago that a pair of Hetherington's power riddles for riddling sand had first been put up at Messrs. Simpson's

works. After the sand had been riddled, there was the question of mixing it. It used to be mixed by hand, until the roller-mill was used ; but it had been found that the use of the ordinary roller-mill with plain rollers, employed for mixing loam, made the sand so close that the mould could not be vented properly. Therefore, instead of rollers with a plain face, rollers with a grooved or serrated face were substituted, the serrations extending about six inches up, so that the rollers then merely mixed the sand, instead of grinding it. It was found that one man could attend to the riddle and also throw into the roller-mill sufficient sand for thirty or forty moulders, which was about the same that could be done with the centrifugal mixer. The reason he thought was that the sand he was using was of a rather different character, and did not want quite so much riddling and mixing as that described in the paper. In pages 95 and 96 reference had been made to dusting the mould with plumbago. That was undoubtedly an excellent plan for preventing destruction of the sand ; and another important advantage was that the plumbago enabled the casting to be fettled or cleaned much more readily, especially some of the larger castings. If a properly made wash of plumbago were put on the face of the mould, it could all be cleaned off the casting with the scab, and would leave a clean surface underneath. It was astonishing what a difference there was between various sands. When visiting a foundry in America he had seen the making of cores with a peculiar sand, far coarser than what was here called loam but what was really coarse sand. They were small cores, made of a great length without any wires, and a peculiar kind of core-gum was used, which was much stronger than any used here. The sand grains were remarkably large, some nearly up to 1-8th inch diameter, and most of them certainly over 1-16th inch ; and they were all cemented together by the core-gum. He had endeavoured to get sand like it in this country, but had not been able to do so.

Mr. BENJAMIN BROWN, referring to the statement (page 99) that longer life of the sand was ensured by the complete intermixing of the materials, asked whether it was meant that more of the old sand could be used in the mixture of facing sand ; and if so, how much more.

Mr. J. W. WILSON, JUN., mentioned that he had visited Messrs. Cochrane's works at Dudley shortly after one of these machines had been introduced there. At that time certainly the manager, Mr. Houghton, was pleased with the working of the machine. It was stated in the concluding paragraph of the paper (page 101) that after two years' working of the centrifugal mixer no expense of any kind had yet been incurred for repairs. Mr. Houghton however had pointed out to him that even at that early stage a number of the pins had commenced to wear rapidly, and in an irregular manner. Some of the pins in the inner circles had thus deteriorated to a remarkable extent, and apparently without any method as regarded their position; and then perhaps in the next circle or the next but one, the pins showed an equally remarkable extent of wear in quite a different part of the circumference.

Mr. CHARLES COCHRANE, Past-President, being prevented from attending the meeting as he had intended to do, wrote that one of these machines had been in use for many months past at the Woodside Iron Works, Dudley, and was giving unqualified satisfaction.

As to the quantity of sand it is capable of disintegrating, a special test was made there in October last, in which there was weighed a mixture consisting of:—sand 1·087 ton, coal dust 0·119 ton; making a total of 1·206 ton. In six minutes the whole of this mixture passed through the machine in perfect condition for the moulder: thus confirming the statement in page 99 that the machine can turn out a ton in five minutes. Before the machine was employed, a staff of four men was needed at a total cost of 11s. 6d. per day for mixing by hand sufficient to supply about fifty moulders; nor could four men always meet the demand, and it sometimes happened that moulders had to leave their work and help to mix their own sand. Since the machine has been introduced, at a cost of 6s. per day for labour, the whole of the fifty moulders are now supplied; and not only the moulders, but the core-makers and workers in loam are supplied with pulverised loam: the newly ground loam, fresh and wet from the loam mill, is superficially dried in a stove, mixed with a proportion of old, and passed through the machine, with saving of

time and improvement in the character of the work. The machine has been sufficiently long at work to show that the working expenses must indeed be insignificant.

On the other hand there is no prospect of the wrought-iron pins of the centrifugal mixer lasting the two years referred to under the head of durability in page 101. These wrought-iron pins stand $2\frac{1}{2}$ inches above the disc, and are $\frac{5}{8}$ inch diameter; some of them are reduced to half their original diameter in three weeks at half-day work. There is something curious about the irregularity of their wear and tear, as illustrated in Fig. 15, Plate 29. It will here be noticed that they are not arranged strictly as described in page 99, "*alternately in a series of concentric circles.*" The concentric circles are there, it is true; but with the exception of four radial lines of pins or beaters, dividing the disc into four quadrants, no law can be traced in the spacing of the studs filling up the concentric rings of each quadrantal segment. In the third, fourth, and fifth exterior circles it will be noticed there are fourteen pins shown black, which are much undercut after three weeks' wear, as shown in Fig. 16; the wear takes place on the face fronting the direction of motion in the circle of revolution. In the same three circles seventeen beaters marked with a cross + exhibit moderate wear; whilst the whole of the remaining pins show no wear of any notice. Obviously it must be an undue proportion of sand impinging on the worn pins of the three outer rings which occasions their extra wear; but why the special currents should take special directions in these cases, the writer confesses he is unable at present to explain. All he desires to indicate is that a hap-hazard arrangement of the pins must inevitably lead to such irregularities; and that by a scientific study and arrangement of the beaters this slightly objectionable feature in the machine may be removed, and the durability of the pins rendered uniform over the entire disc, and the machine made more efficient. It will probably have occurred to the author of the paper to substitute steel pins for wrought-iron, as a further step towards prolonging their life.

One other suggestion the writer would offer, to prevent accident. The attendant has no means of stopping the machine promptly, when desiring to cleanse it, or to cleanse the lid when thrown back. In

(Mr. Charles Cochrane.)

the former case he is obliged to wait till the machine stops ; in the latter he proceeds to cleanse the lid, whilst the disc is revolving at diminishing speed beneath his hands and arms. Were he to trip or meet with any trifling accident which should throw either or both of his hands on to the revolving disc of beaters, his fingers must be fearfully crushed and broken. A light brake would meet this drawback to the high merits of a machine, than which the writer does not know a more useful one to have been introduced to a founder's notice for many years past.

Mr. BAGSHAW said Mr. Cochrane's letter was highly gratifying to him, for he had been a little afraid of over-stating the merits of the machine ; and he was glad to find he had not done so. With reference to the undercutting of the pins, the specimen shown of a worn pin had been taken from the machine at his own works which had been in operation for three years ; he had not been able to find a worse sample than this, and it would be seen how slight the wear was. From enquiries which he had made at several places where the machines were in operation, he had not learnt that the pins had been undercut to anything like the extent experienced by Mr. Cochrane.

In regard to the suggestion of adding a brake (page 106) he had asked the man who minded the machine at his own works whether a brake would be of any advantage ; and he had told him that on stopping the machine suddenly the belt always flew off, so that he preferred to work the machine without a brake. It was simply a matter of precaution. No attempt was made to clean the machine until it was stationary.

With regard to the longer life of the old sand (page 103), all he meant to say in the paper (page 99) was that the floor-sand was renewed more seldom when mixed by the centrifugal machine than when mixed in the ordinary way.

In one instance he had heard a large employer of labour argue that, if he were to adopt every labour-saving appliance, every fuel economizer, and every other contrivance for effecting economy, he should be able, according to the representations made of their

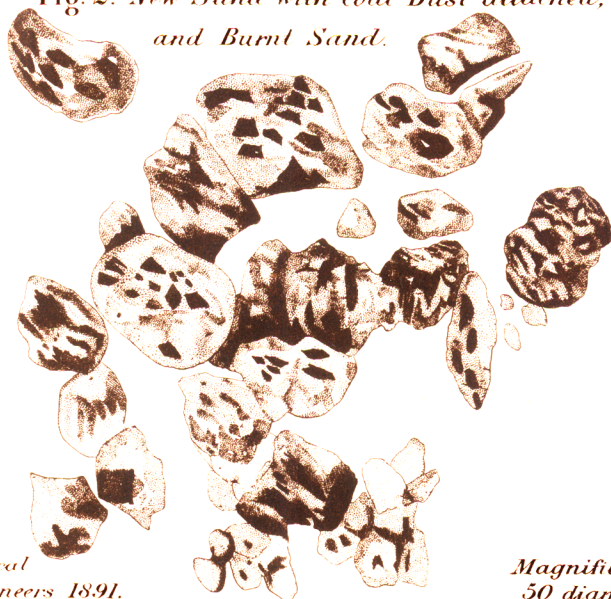
several advantages, to carry on his works for nothing; and therefore he did not care to enquire into the merits of the centrifugal mixer or any other machine. Facts however spoke for themselves; and without wishing to over-rate the value of this machine, he thought the economy it effected in wages was so great as to render it deserving of careful consideration.

The PRESIDENT said this paper was of an interesting and practical character. Any idea of adopting improvements to the extent of saving everything was of course radically absurd; but he thought there was undoubtedly a great advantage in the centrifugal mixer now described, which as already pointed out was on the same principle as Carr's disintegrator. If the sand could thereby be brought to a uniform texture for the foundry, that was no doubt a condition conducive to successful moulding. It seemed to him that this machine had the merit of going in the right direction for accomplishing that object; and he hoped the matter would be taken up by ironfounders generally. He proposed a vote of thanks to Mr. Bagshaw for his paper.

Fig.1. *Sand Grains in Clusters.*



Fig.2. *New Sand with Coal Dust attached, and Burnt Sand.*



*Mechanical
Engineers 1891.*

*Magnified
50 diameters.*



Old Sand.



Fig. 4.

Fig. 5. *Burnt Sand.*

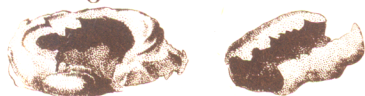


Fig. 6. *Shell round Sand.*



Fig. 7. *Coal Dust.*



Fig. 8. *Plumbago.*

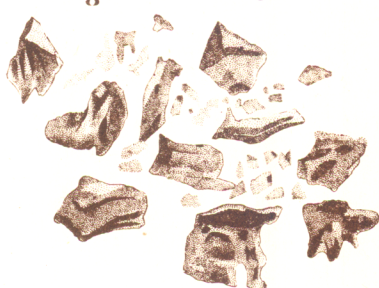


Fig. 9.
*Sand after
crushing.*



Fig. 10. *Power Riddle.*

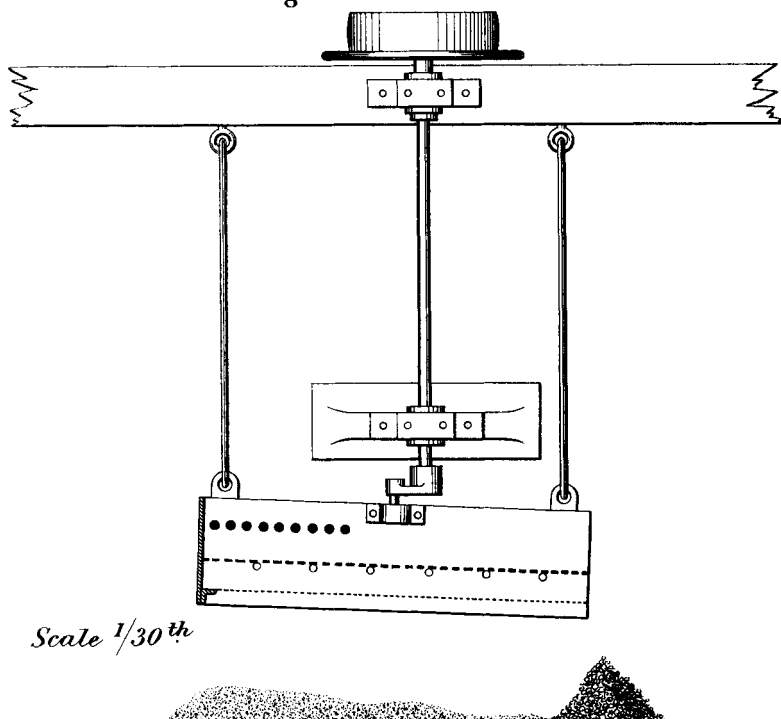
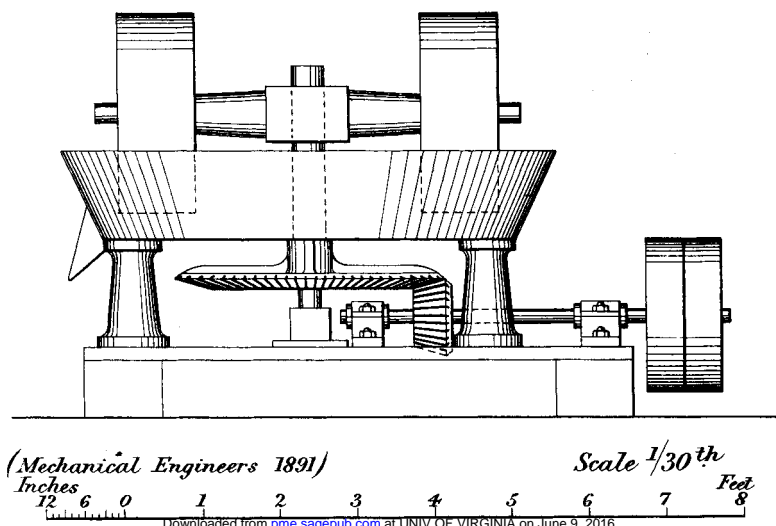


Fig. 11. *Roller Mill.*



MOULDING SAND.

Plate 28.

Fig. 12.
Half Plan of
Revolving Table.

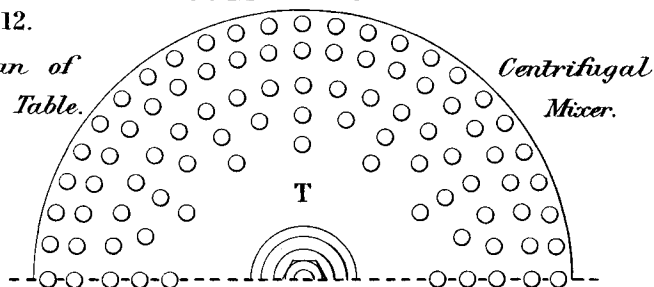
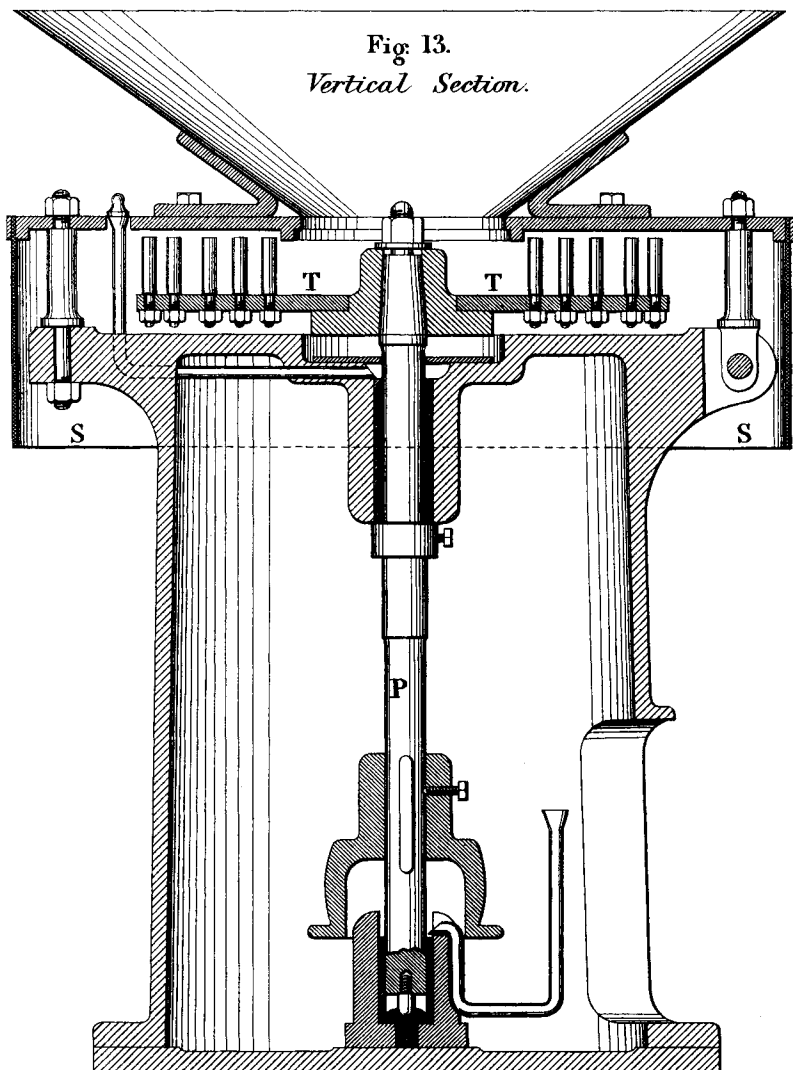


Fig. 13.
Vertical Section.



MOULDING SAND.

Centrifugal Mixer.

Plate 29.

Fig. 15. Plan of Revolving Table.

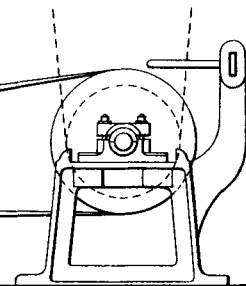
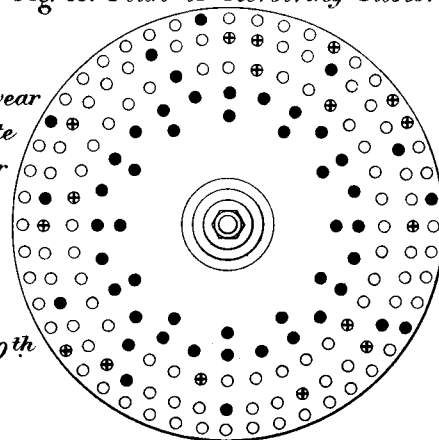
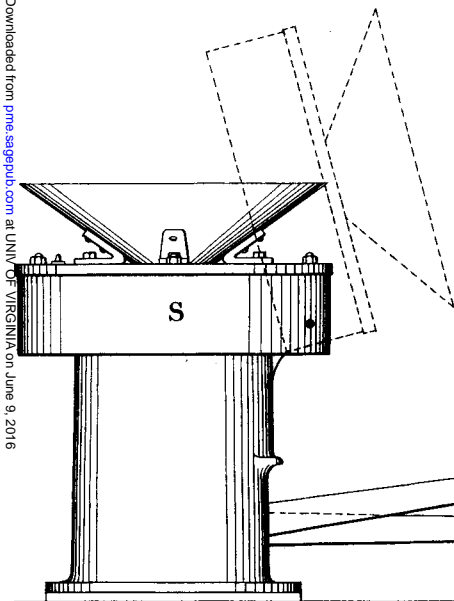
Fig. 14. Elevation.

Fig. 16.
Worn Pin.

Half size

- Much wear
- ⊕ Moderate
- No wear

Scale $\frac{1}{10}^{th}$



(Mechanical Engineers 1891)

Scale $\frac{1}{20}^{th}$

Inches 12 6 0

1

2

3

4

5 Feet

Plate 29.