sheets of rubber often has disadvantages, for it tends to check the drying of those batches which are already in the drying-chamber and which are partly dried, and to prolong the time necessary to dry them completely. A preliminary whirling of the moist sheets in a centrifugal machine, after they leave the final washing rolls, and before they are put into the drying chamber, may be strongly recommended. The drying-rooms should be small chambers which can be filled at one operation, and the drying should be carried out in such a way that the moist air surrounding the rubber is being continuously displaced by a fresh supply as dry as possible. A good circulation of the air inside the chambers must therefore be

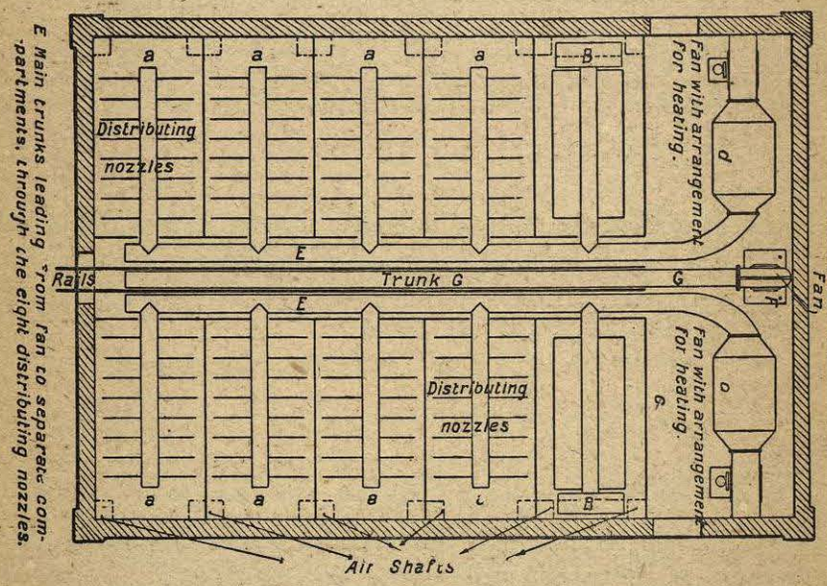

FIG. 14.

maintained, and the air must be as dry as possible and heated to a suitable temperature.

A modern arrangement for drying washed raw rubber is shown in figs. 14 to 17. The size of the complete plant, as well as of the individual drying chambers, depends upon the approximate weight of rubber washed per day. In the diagram fig. 14 the plant is assumed to cover an area of 3×5 metres, and to reach a height of 4 metres, of which about 3 metres is useful space. Sufficient free space is provided for the warm ascending air to collect, and from there it is drawn away upwards. The chambers *a* are warmed and aired from the main air trunk E by means of eight equidistant adjustable air-nozzles, which force the warm air upwards. The chambers are fitted with 20 to 25 drying-poles which can be hoisted

up by means of wire rope; over these the sheets of rubber are loosely hung, the current of warm air streaming past them. The chambers B are fitted with racks, and the current of warm air

Section through portion of drying chamber fitted with racks.

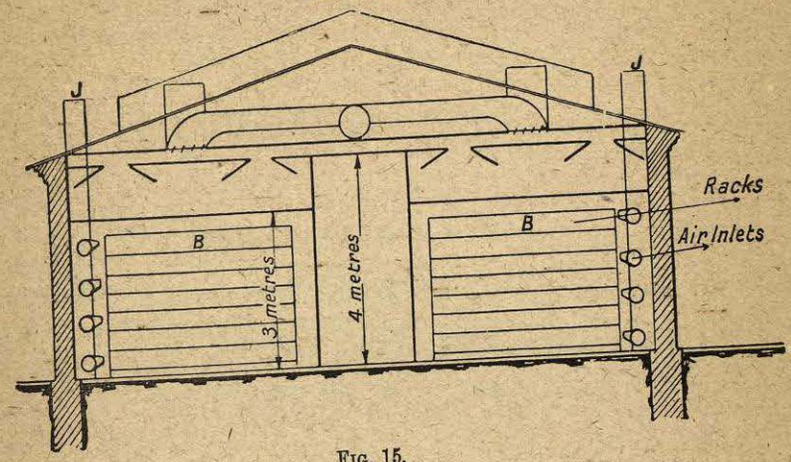

FIG. 15.

enters at the side (fig. 15). The space C contains the heating and ventilating plant; in it are situated two large Sturtevant blowers, with heating attachments D, which supply the necessary warm air.

Section through portion of drying chamber fitted with poles.

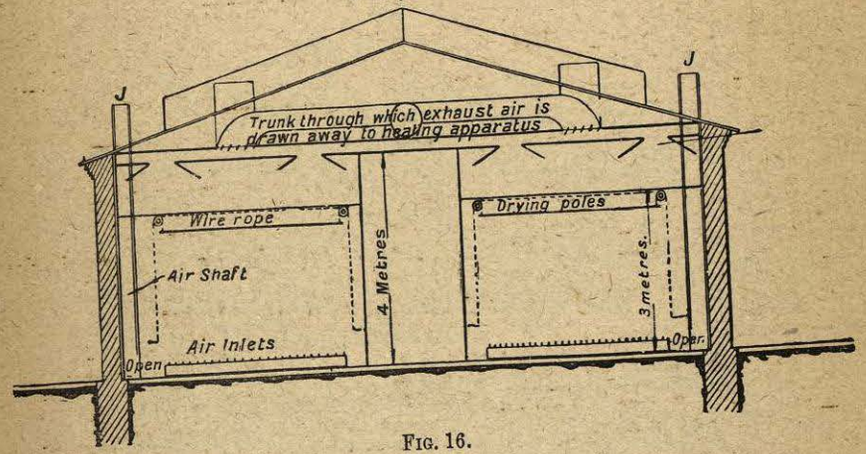

FIG. 16.

The fan F, with trunk G, serves for the supply of cold air and can be connected to the separate chambers as required for cooling purposes. The air-supply to the drying chambers is regulated from the outside. The removal of the spent air is regulated by the trunk H passing through the double top of the chamber; the air is

returned at once to the heating apparatus. On the other hand, the steam is exhausted through the channels I, and led away into the open air. All the drying chambers are without windows; the passage-way down the middle between them, which is provided with rails, is lighted by means of a top-light.

A new mode of drying which looks very promising may still be mentioned. The drying is effected by means of special centrifugal machines, the washed rubber being first broken up into small pieces and not run into the form of a sheet. The particles of water are frozen by means of a special arrangement, on the under frame and outer jacket, and driven from the rubber by gently warming.

A great number of rubbers cannot be obtained in sheets suitable

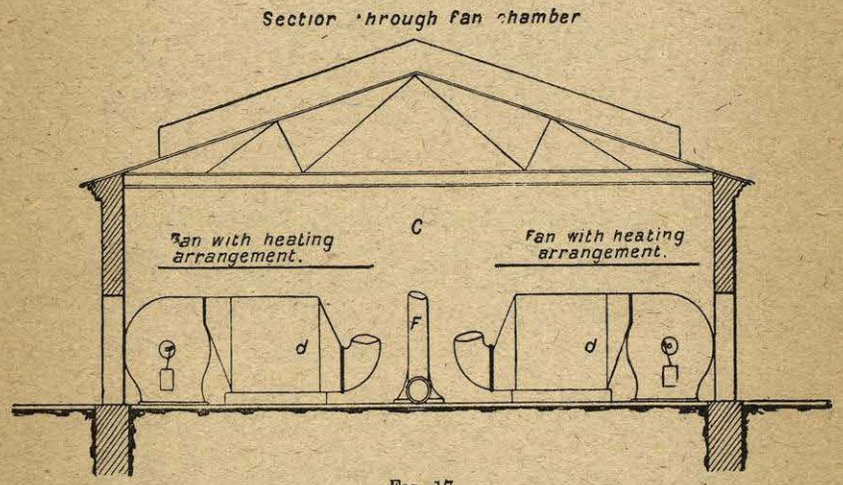

Fig. 17.

for carrying about. The softer sorts, in particular, are so greatly affected by the gentle heat of the drying chamber that even short sheets break away from the drying-poles and fall to the ground. Moreover, considerable quantities of rubber are required for a very large number of rubber goods which present less difficulty in their manufacture, or for such goods as must be pretty highly vulcanised, and for these, as for soft kinds of rubber, drying in a vacuum-chamber (fig. 18) is to be recommended. The sheets are put into the chamber on perforated iron shelves, the door is closed, the temperature raised from 50° to 60° C. or even higher under special circumstances, and the chamber exhausted by means of an air-pump. In the more perfect forms of apparatus, amongst which that of Passburg in particular is in most general use, drying is completed within an hour, provided one starts with sheets which have been centrifugalised. It is strongly recommended to "batch

up" vacuum-dried rubber immediately on its removal from the chamber, in order to prevent oxidation of the hot dry material.

Air-drying may, under certain conditions, bring about slight oxidation of the rubber in some cases, but never results in *depolymerisation*, in consequence of the heating. Vacuum-drying, on the other hand, although not facilitating oxidation, results in quite an appreciable depolymerisation as a result of the high temperature

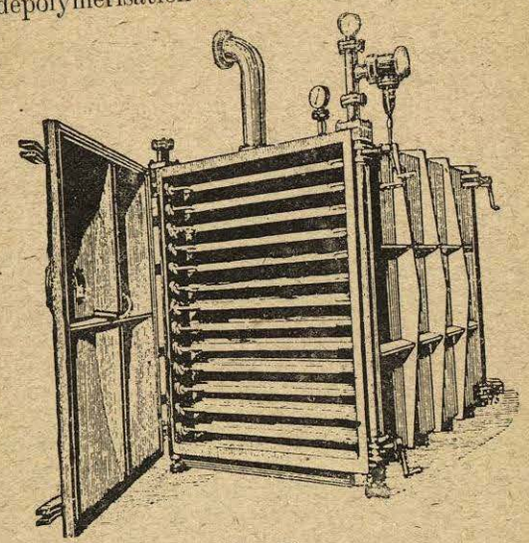

Fig. 18.

to which the rubber is raised, and this effect is the more marked in the softer sorts of rubber.[1]

The Further Working-up of the Dried Rubber.—The practice of running the washed rubber into thin sheets greatly facilitates drying by considerably increasing the surface area. When, however, the rubber has to be stored for any length of time, or when it is to be used for the manufacture of cut-sheet, it is advisable—in the latter case absolutely necessary—to reduce the rubber to some more solid or compact form, in the first place in order to reduce oxidation to a minimum by making the superficial area as small as possible, and secondly, in order to produce homogeneous blocks, free from pores, from which to prepare "cut-sheet." It was formerly the general practice to work or knead all dried rubber into solid masses, but it is nowadays the object of the manufacturer to avoid these processes whenever it is at all possible, experience having shown that it is wise to avoid all unnecessary treatment of rubber on the rolls, not only on the score of expense, but on account of the

[1] *Cf.* on this important subject of the drying of washed raw rubber, articles in the *Gummi-Zeitung*, 1906, xx. pp. 656, 681, 738, 789, 843, 1107.

heating and depolymerisation which is brought about by such treatment. In modern manufacture, on the large scale and by rapid methods, there is generally no need for prolonged storage of rubber after washing, and it may therefore be at once worked up into the various mixings.

To effect this the mixing mill described below is set in motion, steam being passed through the hollow rolls. It is advisable to warm up the rolls to such an extent that mixing may proceed rapidly, and prolonged working, which is so detrimental to the rubber, be avoided. The rolls should not be allowed to get too hot, or the rubber may also suffer from that cause; the temperature must therefore sometimes be brought down by means of the cold water supply through the rolls. During the process of mastication between the rolls the rubber becomes spontaneously heated.

At a first glance, rubber-mixing appears to be a very simple process, the mill itself automatically bringing about a complete admixture even if left unattended. Yet mixing is a process that needs careful watching and intelligent manipulation on the part of the workmen engaged in it, otherwise the rubber can be very easily overworked ("killed"), the ultimate result of which would probably be goods of poor quality and little durability.

As a rule there is one man to each mixing mill; only very occasionally does it happen that one man has to look after two mills at the same time; in that case the mills should be placed opposite one another, so that there is no need for the man to leave his place, but only to turn round. The mixer generally receives the mixed ingredients in galvanised iron boxes or tubs. His tools consist of a scoop, a hand-broom, a spanner for opening out or closing up the rolls, a short knife for cutting the rubber off the roll, and a sieve fitted with a hinged lid, with which he sifts the powdered "compounds" on to the rubber. The actual mixing is carried out in the following way:—The mixer takes from the vessel containing his material, first of all the raw rubber, passing the separate sheets between the rolls and working them up into a fairly smooth sheet surrounding the front roll, which is kept rather hotter than the back one. When this stage is reached and the rubber is sufficiently soft, the other ingredients are gradually added. The mixer now passes his knife obliquely across the rubber sheet on the front roll, lifts up a portion of the sheet and turns it over across the roll, repeating this process a number of times. As the rubber is meanwhile getting hotter, the rolls must be more and more thoroughly cooled. Finally the mixer cuts off strips of the

rubber, rolling them up and laying them aside until the rolls have attained a temperature suited to the last stage of mixing, whereupon the little rolls of rubber are again put through the mill and mixed together to form an apparently homogeneous mass, which is cut from the rolls without delay.

The above method of mixing is, however, by no means one which can be applied generally. Mixings which contain much paraffin, pitch, oil, or the like, must be treated differently from the so-called dry mixings containing much waste and fibrous material. Great damage may be done by unintelligent mixing. The manager should, therefore, train only intelligent men, with keen powers of observation, for the mixing mills, and should always keep a watchful eye upon the mixing department. Moreover, he should very carefully consider what mixing should be carried out on a small pair of rolls, and for what mixings only the large rolls should be used, for more depends upon this than many people imagine. The fact that certain theorists are opposed to the use of large mills because they are not economical, should not prevent anyone from using large mills in order to treat his mixings with care and produce first-class results. One can only utter a strong word of warning against judging machines solely from the engineer's point of view, or from the point of view of most rapid working and lowest possible working cost; the behaviour of the material under the different conditions should be well considered in addition.

The way in which the different raw rubbers behave on the mixing rolls is different in each individual case. The following rules may be taken, in a general way, as a guide:—

Rubber from species of *Hevea, Sapium, Micranda,* and *Castilloa,* and from *Manihot Glaziovii,* requires rather more heat during mixing than rubber from *Hancornia, Ficus, Funtumia,* and most African *Landolphia* species. "Mozambique spindles" and "red Kassai" occupy an intermediate position. It will be seen that the softer and more resinous African and Asiatic kinds must not be treated in exactly the same way as American sorts, which are freer from resin, and possess more "nerve." This is to be explained partly by the solvent and depolymerising action on the rubber of the rubber resins, and partly by the fact that the degree of polymerisation is actually lower in some raw rubbers than in others.

It is very often desirable to thoroughly work the reclaimed rubber in a pair of rolls running at a high speed before adding it to the raw rubber on the mixing rolls. Substitute should be ground up very fine on well-cooled rolls. Sulphur and mineral additions

must be sifted as fine as possible before adding them to the rubber; they are often mixed together in the dry state in special mixers, and are then dusted on to the rubber with the aid of a sieve, fitted with a cover, or by means of a revolving sieve fixed over the mixing rolls, in order to produce a mixing as devoid of granular structure as possible. Such arrangements for the production of mixings absolutely free from granules are to be found to-day in a state of great perfection in nearly all rubber-shoe and pneumatic tyre factories, as well as in rubber-thread factories. The additional cost of such appliances is not great; the improvement in quality brought about by their use is frequently very noteworthy. The greatest care must be taken during the progress of mixing to prevent sulphur, resin, asphaltum, etc., from melting on one of the rolls and getting baked into thick layers.

In the case of mixings which contain oil, vaseline, paraffin wax, and similar substances, it is often advisable to incorporate these materials either by first preparing the waste with them, or by mixing them with the minerals to form a kind of thick dough and then mixing these with the rubber. This method is not only more cleanly, but also less detrimental to the rubber.

The Mixing and Weighing Room.—This room is used for weighing out the separate constituents of the mixings to be subsequently worked up in the mills. A particularly trustworthy man should be placed in charge of this department. On the one hand, the mixings with which this man is entrusted for the manufacture of the different rubber goods are valuable, being the result of great experience and often of costly experiments, and, on the other hand, it is necessary, in order to avoid subsequent troubles in the course of manufacture or even later, that the various constituents of the mixing be weighed out with the greatest possible care. Even slight errors in weighing may have most unpleasant results, particularly in the case of the sulphur for vulcanisation, the magnesia usta, etc., or, in "floating" red goods, the amount of golden sulphide added. The larger quantities of material should be weighed on a large, comparatively rough pair of scales, which when skilfully manipulated will give perfectly satisfactory weighings. Sulphur and other important materials are, on the other hand, weighed out on a small pair of more sensitive scales, the weights being, of course, accurate, and kept scrupulously clean. Platform balances, although they are to be obtained small, are generally rough, and are not to be recommended for the finer weighings. Moreover, they cannot be adjusted by means of screws as can beam scales. In the case of mixings

which the manager wishes to keep secret, a good plan is to tie up the weights for the different items of the mixing in small bags, and to hand these over to the weighing foreman each time a batch has to be mixed. As soon as the ingredients are weighed out they are carried straight away to the mixing rolls and mixed together. Another method of keeping the mixings secret consists in using counterpoises of various shapes which can be readily distinguished from one another. This, however, is not the place to dilate upon the outgrowths of the traffic in works-secrets, which is still carried on here and there, for it is frequently quite possible nowadays to fathom the secrets of the mixing in a perfectly legitimate way, by

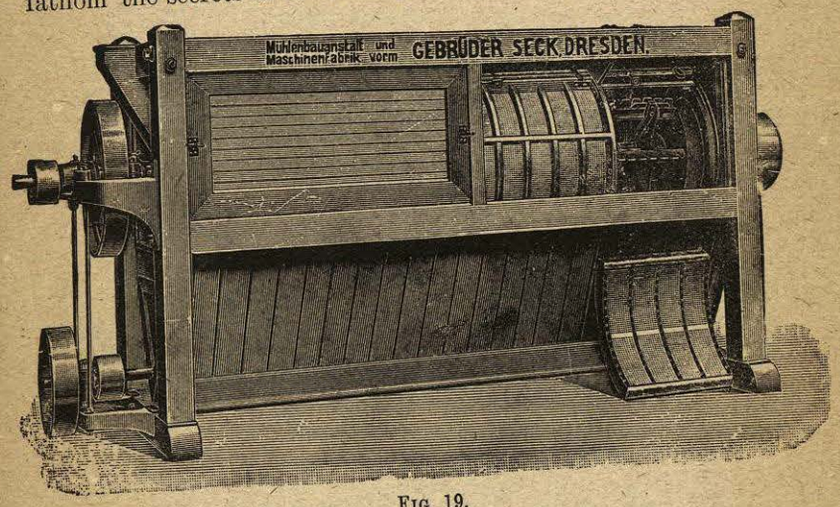

FIG. 19.

carefully devised experiments based on chemical and physical knowledge, in spite of all attempts at preserving secrets.

The ingredients to be mixed with the rubber must be as dry and as finely powdered as possible. The drying is often done simply by heating on stoves. For whiting and other fillers which are used in large quantities special drying plant, consisting of large heaters or long troughs provided with arrangements for stirring, are often used. In dealing with large quantities of material, indeed, the workmen's wages form such an important item that the drying and subsequent sifting are made as far as possible automatic. The object of sifting is to remove all the coarser particles of the substance, as well as pieces of wood which may have got into the material on opening the casks or cases. Sifting apparatus which works continuously, like the cylindrical sieve shown in fig. 19, may be used with advantage; charges of 50 to 100 kilos. (1 to 2 cwt.) at a time can be put through the hopper of this apparatus. The

sifted material is stored in tightly-closed bins. For this purpose it is usual to employ both large wooden zinc-lined bins and galvanised iron ones, as well as small sheet-zinc boxes. It is convenient to keep oils in so-called patent oil-holders, from which they can be pumped out when required. The washed and dried raw rubber is kept in pigeon-holes lined with sheet zinc, and these are best provided with some means of closing them, in order to protect the rubber from dust. Well-galvanised tubs or bins are generally used to hold the weighed materials for the mixing; the bottoms are protected by strong iron rims on which the receptacles can be slid about. Wooden bins lined with sheet zinc are also used sometimes, and in certain cases these are divided into several compartments, so as to keep the constituents of the mixing separate from one another. More will be said as to the composition of the various mixings in a special chapter.

The Mixing Mills.—The machinery for mixing is similar in construction to the washing plant, but on a larger scale. An ordinary mixing mill, such as would satisfy present-day requirements, has rolls 110 cm. long and 450 mm. in diameter, and the approximate weight of such a machine is 3500 kilograms. The cast-iron rolls are hollow, and each is fitted with an independent steam and water supply for heating and cooling respectively. The front, or so-called working roll, runs at 18 revolutions per minute, whilst the back roll makes 26. Fig. 20 shows the form of mill in most general use at the present time; this, on account of its firm build and large size, gets through the work very rapidly, and only slightly affects the properties of the rubber. The setting-up screws should be of fairly large size, and may be provided with pointers moving on discs fixed to the ends of the bearings, and graduated in 5 mm. divisions. This apparatus makes it easier for the mixer to set his rolls regularly at the same distance apart, and when properly used ensures that the two sets of bearings are an equal distance apart.

The sheet-iron boxes beneath the rolls should not be fixtures, but should be provided with wheels so that they can be easily moved backwards or forwards along two rails. The guides at the sides should be of iron; wooden or copper guides are not to be recommended. It is advisable to provide for the removal from the rolls of mixings which readily stick to them, by means of a "doctor," and for this purpose a steel bevelled rail screwed on to a strong wooden base about 6 cm. thick may be recommended. This is suspended, with the bolts fixed to the wooden side, in the bearing-cases. The knife is depressed by means of a lever against the

middle of the roll, and cuts or scrapes off the mass of rubber from it.

The mixing mill should, like the washing rolls, be provided with instantaneous safety-clutches, as already described (figs. 12 and 12A), the most suitable being those based on the friction-clutch principle.

A little further consideration may now be given to the mixing mills fitted with revolving sieves, which have been already men-

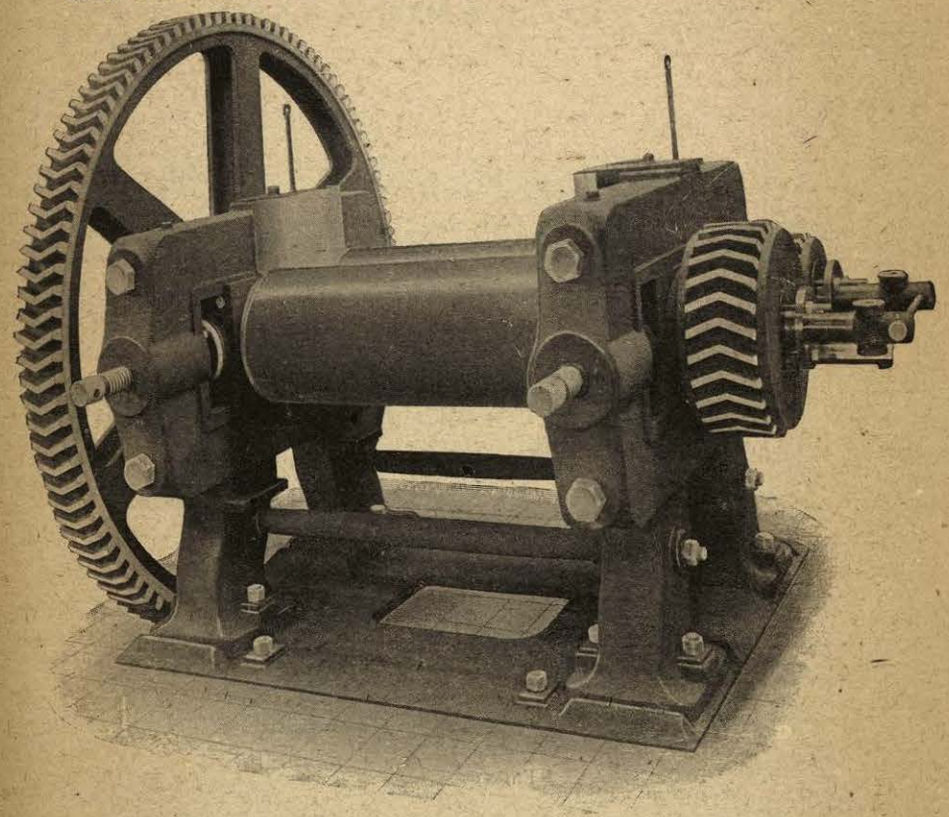

Fig. 20.

tioned. (The rights of manufacturing these machines have been acquired by C. G. Haubold, jun., a firm of engineers in Chemnitz.) The rolls are constructed as in an ordinary mixing mill, but above the front roll at a height of about 20 to 25 cm. (8 to 10 inches) there is fixed a cylindrical sieve containing a revolving brush, driven by toothed-wheel gearing from the axle of the roll (fig. 21). The cylinder can be raised in its bearings in a backward direction by means of an eccentric movement, in order to throw it out of gear. The sifted material falls into a funnel-shaped sieve fixed below the cylinder, and kept in continuous vibration by means of an