process every fragment of the rubber is broken up, and the water, penetrating all interstices, washes out every particle of foreign substance. The usual practice is now to sheet the loose fragments of rubber together on the same rolls, but it is better not to do so (indeed with the rolls shown in fig. 9 the difference in speed of the two rolls would be too great to allow of the formation of a sheet). The small irregular pieces into which the rubber has been broken up should rather be put into the washing

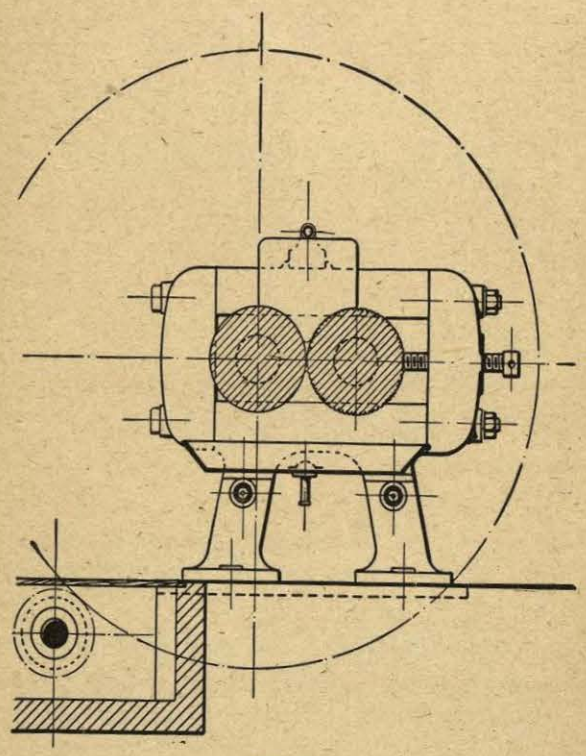

FIG. 8.

hollander (fig. 10). This machine does not, like those formerly used, serve to break up the rubber, but rather to remove the fibrous matter as well as the particles of sand and wood which adhere to it, by swirling it up with water. To this end the two rolls of the hollander are designed, not for crushing, but rather for beating and stirring up the rubber. The hollanders formerly used for actually washing the rubber have not proved to be particularly serviceable. As will be gathered later, from the design of the hollander, all sand, etc., adhering to the rubber is able to settle out from it, without being again taken up. After separating the sand and wood from the rubber and renewing the bath, the mass may be treated with

a weak soda solution, a process which is particularly advantageous in the case of qualities which are impregnated with large quantities of salts in mechanical admixture. The soda-washing must of course be followed by washing in clean water. After being washed in the hollander the raw material is put through a pair of washing rolls (fig. 11), where the fragments are united into the form of a sheet, a gentle stream of water flowing over them the while. The rubber must be run through more than once, if necessary, until all the separate fragments have united to form a wide band, resembling in appearance a pelt, and having a uniform crêpe-like surface. The ease or difficulty of this sheeting process varies with the kind of raw rubber being washed. The various sorts of Para are the easiest to wash, while Mid- and Central-American sorts, which are very dry, as also Guayaquil, often cause difficulties. In these cases the water used must be slightly warmed before a sheet can be obtained. The same difficulty occurs with "scrappy" sorts—*e.g.* "Arracaty scraps," which cannot be caused to unite at all, and have to be dried as they are, a mass of little pieces. Specially low grades, such as Liberian flakes and Angolas, can only be washed with very great difficulty, and it is advisable to go to work with the greatest possible care in these cases.

The mechanical washing process being designed to free the raw material from all mechanical impurities, and from impurities soluble in water, it must be carried through conscientiously, so that no foreign matter is left in or on the washed rubber, and nothing but water remains to be removed by drying. Before speaking of the drying process, however, the plant and arrangement of a washing shop must first be dealt with in technical detail, and a few words said about the machines.

(a) *The Washing Shop.*—The washing plant is now to be briefly considered. As may be gathered from fig. 1, this plant is shut off from the other mills, so that the steam, water, and dirt which accompany the washing process may not come in contact with them. It should also be mentioned here that the shafting which drives all washing and milling rolls runs in a trough beneath the rolls. The rolls are mounted on rails over a trough 70 cm. deep, (as in fig. 8, except that the trough containing the shaft would be better placed vertically beneath the rolls). Coming to the separate pieces of apparatus set up in this department, fig. 6 represents the heating apparatus, made of sheet iron, and heated by means of a steam coil at the bottom of the tank; in this tank is suspended a second smaller iron bucket, the sides and bottom of which are

made of perforated galvanised iron, and which can be raised and lowered by means of a crane. Two such pieces of apparatus are sufficient for a daily production of 500 kilos. of washed rubber. The bucket is filled with the rubber to be washed, the water let in until it covers the rubber, and then the lid is closed down and steam turned on.

Then, after the steam-valve has been closed, and the hot water, which often has a very unpleasant smell, has been run off, the bucket is hoisted half-way out, the spray fixed above it is turned on, the bucket swilled through with water at a suitable pressure, and then let down into the heater and steeped in cold water.

The preliminary washing rolls (figs. 7 and 8) now generally in use consist of a strong under-frame on which rest the bearings for the support of the cast-iron rolls. The bearings of the back roll are supported by the back frame-cap, whilst those of the front roll are movable, and rest against the ends of the setting-up screws. The fixed roll is driven from the shafting by means of the large spur-wheel, whilst the movable roll is driven from the axle of the back roll by toothed-wheel gearing. The rolls revolve inwards at unequal speeds. The back roll is grooved, or channelled, to assist in crushing up the rubber passing between it and the front roll. It is advisable to insert a safety-block between the loose bearing and the setting-up screw, to safeguard the teeth and frames against fracture by undue pressure; the block, which will be the first to go, can be replaced at a small cost. The approximate size of a pair of modern washing rolls is about 75 cm. long on the roll, with a diameter of 45 cm. The speed of the back roll is about twelve revolutions per minute, whereas the working roll makes only about six revolutions per minute. The bearings are protected by scrapers set into the sides of the rolls and pressed against them by steel springs fixed at the back. The scrapers are capable of being adjusted to make up for wear.

A collecting tank of galvanised iron is placed under the rolls to collect the water and the disintegrated rubber. About 4 cm. below the edge of the tank is a perforated sheet-iron tray, and about 10 cm. below that a coarse movable sieve. At the bottom of the tank, which is at a depth of about 45 cm. and slopes slightly downwards from front to back, is the outlet pipe, and vertically above it an overflow pipe. Both pipes lead into the first catch-pit, which is common to all the washing rolls, and in which any pieces of rubber which get washed away are recovered. The second pair of washing rolls (fig. 9) is of similar construction and size, but the rolls themselves are smooth, and work with still greater friction; the back roll makes about twelve revolutions per minute, whilst the greatest number made by the front roll is four. The collecting tank of this machine has two sieves movable towards one another, of which the upper one is inclined towards the front, the tank itself sloping towards the back, and the excess of water is in this case led off, not from the bottom, but from a point at a short distance below the upper edge of the tank. The lower outlet is only used for the purpose of cleaning out the tank. On this account the tank is so constructed that the particles of dirt and wood, after passing

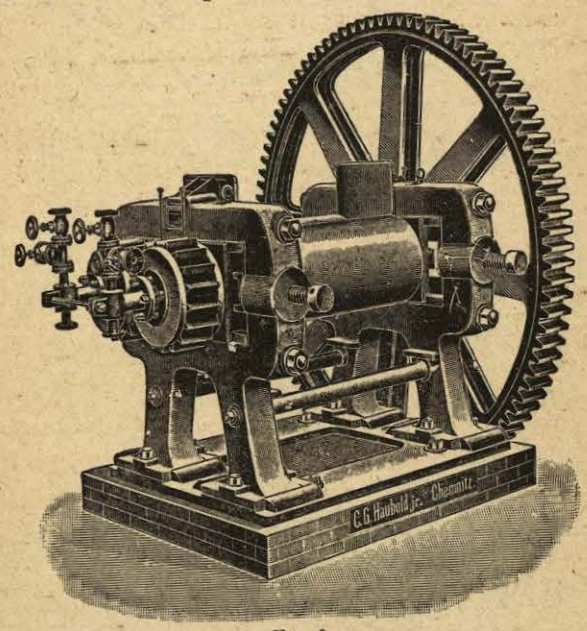

Fig. 9.

through the rolls with the water, are washed away at once towards the outlet at the back, whilst the rubber drops towards the front. By this means the impurities washed out are prevented from falling on to the pieces of rubber again. Over the middle of each pair of rolls and about 60 cm. above them is a spray-pipe with a number of small holes; from this flows the clean washing water under a high pressure. Condensed steam, which is used in some factories, is not to be recommended, on account of the dirt and oil which is nearly always present in it. Fig. 10 shows the present-day type of hollander. It is best walled round with cement to a depth of $\frac{3}{4}$ metre below and a height of $\frac{1}{2}$ metre above the ground level, and every part should be carefully plastered. The roll is to be regarded rather as an agitating and rubbing apparatus

than as a disintegrating roll. Beneath the blades of the roll the bottom of the hollander slopes upwards, falling away steeply on the other side and terminating in a sand-trap in connection with

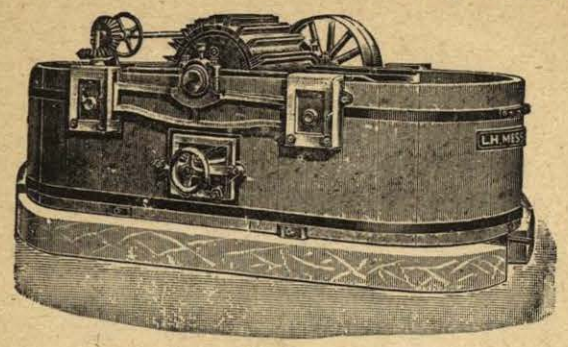

Fig. 10.

the outflow trough. In this manner the sand is directly removed and so cannot come into further contact with the rubber.

Finally, the washing rolls, illustrated in fig. 11, in which one roll is placed vertically over the other, are brought into use.

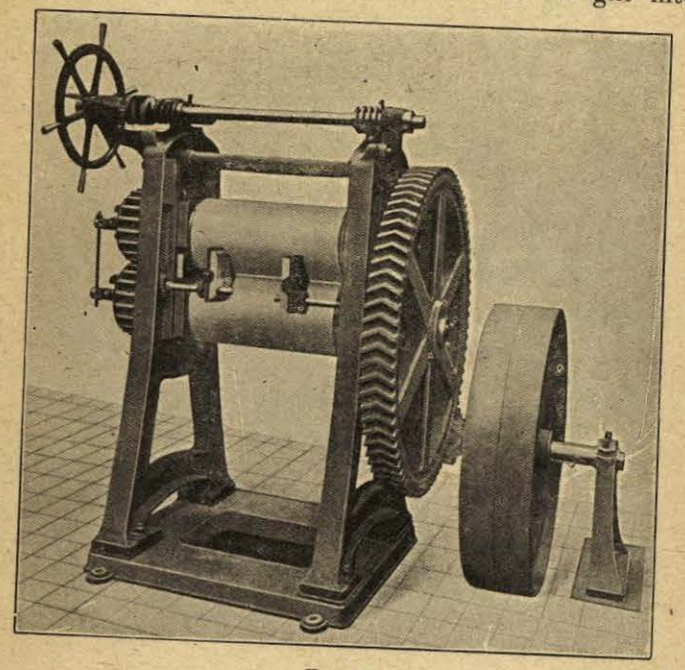

Fig. 11.

Whereas the rolls of the machines previously described have a diameter of 45 cm., in this case 25 cm. is ample, the length of the roll being 80 cm. The speed of the lower roll is twelve revolutions per minute, that of the upper ten revolutions. A spray-pipe is

arranged about half-way up the top roll, the spray being directed downwards on to the lower roll. In front of the latter, and level with the top of it, is a small movable tinned-iron table on which the loose pieces of rubber are heaped and from which they are pushed into the mouth of the rolls by means of a scraper. On the opposite side of the roll, the sheeted rubber, directed to some extent by guides fixed at the back of the rolls, falls on to a conveyor, by which it is carried under the lower roll back to the man in front; a cover protects it from the water running off the lower roll. In this way any small particles of dirt are completely

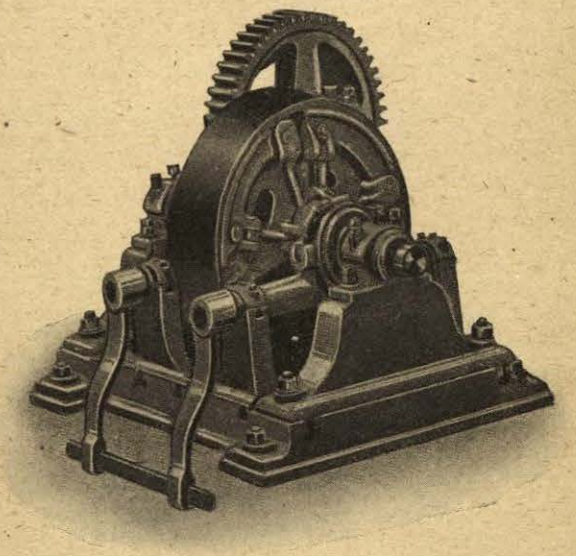

Fig. 12.

removed, being carried away by the water from the lower roll without coming into contact with the rubber again.

It may be mentioned that an automatic coupling is inserted between the series of washing rolls and mixing mills; the hand-pull or the wire rope above each mill can be easily reached and the whole series of mills be stopped at once by means of the automatic coupling with which the wire is connected. There are other equally reliable devices for rapidly throwing the rolls out of action; for example, an instantaneous release by Fr. Gebauer of Berlin, illustrated in fig. 12. This is an exceedingly practical device, and the release can be operated in any position, even with the foot, on all sides of the rolls. This release acts by means of a friction-clutch, which can be at once thrown in, without any difficulty, by a sharp pull of the chain.

Heywood and Bridge's friction-clutch (fig. 12A) consists of an inner casting, comprising a boss B, which is keyed on to the shaft A, and from which are two arms C and a rim D. The rim is divided transversely, but retains its unity through its connection with the arms, and through them with the boss. In the rim, at the transverse divisions, sockets G G_1 are cast, and in these are placed nuts H, in which work the ends of right- and left-handed screws F. These screws are actuated by means of levers L L_1, attached to a sliding sleeve M, on the shaft. When the sleeve is moved nearer to the face of the clutch, the rim D is caused to expand, and binds upon the internal surface of an external shell N, rigidly attached

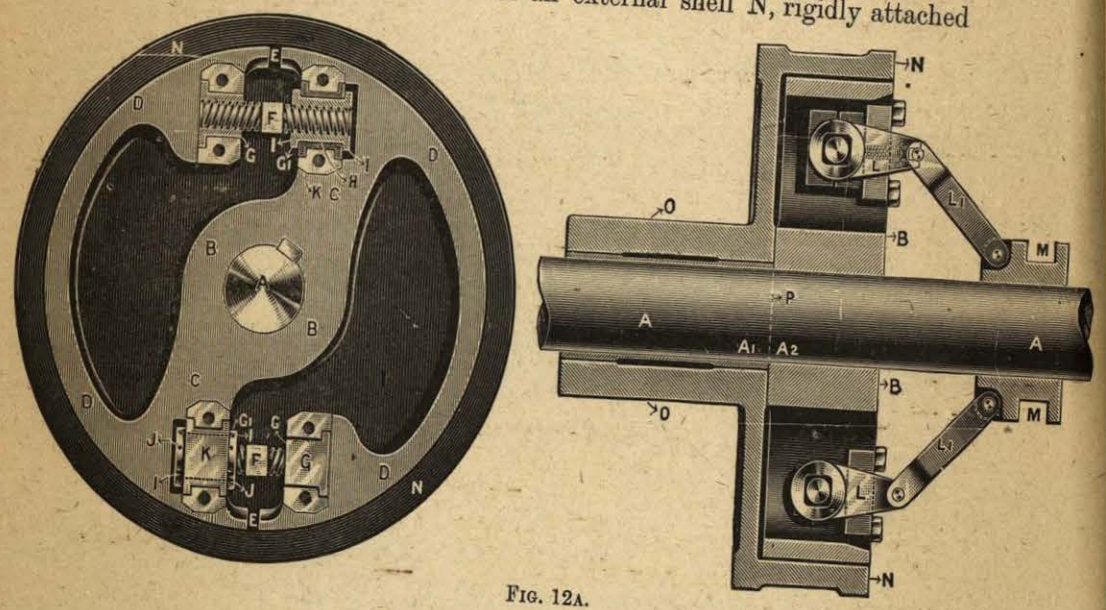

FIG. 12A.

to the other shaft-end. On moving the sliding-sleeve away from the clutch-face, the rim contracts, and the machinery is thrown out of gear. Coupling and uncoupling can be effected without any jarring by means of this contrivance.

In this department there are also centrifugal machines (fig. 13) for whirling the rubber as free from water as possible before transferring it to the drying-room and vacuum-drying chambers. The advantages and disadvantages of the vacuum-drying apparatus are fully dealt with in the next section.

(b) *Loss on Washing and Drying.*—The loss, or wastage, undergone by raw rubber in the course of purification and drying is sometimes very considerable, reaching in many cases as much as 65 or 68 per cent. It is very unequal in the different sorts, and frequently,

also, different parcels of the same sort vary considerably, differences of 14 to 18 per cent. being not uncommon.

TABLE SHOWING THE LOSS ON WASHING OF A NUMBER OF RAW RUBBERS.[1]

Trade Name.	Maximum Loss.	Normal Loss.	Minimum Loss.
	per cent. about	per cent about	per cent. about
Bolivian and Peruvian Para	16	14	14
Upriver, fine Para, hard cure	17	15	13
Islands, fine Para, soft cure	20	18	15
Entrefine, medium Para	25	22	18
Manaos negroheads	28	26	23
Scrappy negroheads	40	30	26
Cameta negroheads and scrap	35	28	23
Caucho or Peruvian ball	25	21	18
Caucho or Peruvian slab	40	35	32
Mattogrosso Para, genuine	25	22	20
Mattogrosso sheet	40	35	30
Ceara or Maniçoba scrap, I.*a*	25	20	18
,, ,, ,, II.*a*	35	30	24
Columbian strip	12	10	8
Equador, Esmeralda, Guayaquil sausages, and strip.	32	28	24
Centrals, West Indian, Columbian, Guatemala, Nicaragua strips, scrap, sheet and slab.	42	32	24
Rio, Santos, Mangabeira, Bahia, Pernambuco, Maranham sheet.	50	40	30
Guayule	35	28	20
Gambia, Senegal, Bissao ball, I.*a*	45	35	25
,, ,, ,, II.*a*	50	40	35
Cape Coast, Benin, Accra lump, I.*a*	45	38	32
,, ,, ,, II.*a*	50	45	40
Sierra Leone, Massai, Conakry niggers or twist.	24	22	20
Kassai, red and black, Lopori, Equateur I.*a* sorts.	10	7	4
Aruwimi, Mongalla, Sankuru, Lake Leopold	15	12	10
Thimbles	55	45	38
Batanga marbles and clusters	45	38	30
Mozambique, Donde, Mohorro spindles	20	16	10
,, II.*a* marbles and balls	30	25	22
Madagascar pinky	35	30	28
,, black	38	32	30
,, niggers	65	60	50
Borneo I.*a*	50	43	38
,, II.*a*	53	45	43
,, III.*a*	65	60	55
Dead Borneo, Pontianac, Jelutong, Besk	77	70	60
Assam, Rangoon I *a*	18	15	12
,, ,, II.*a*	40	35	30
Java I.*a*	18	15	12
,, II.*a*, Penang II.*a*	40	35	32
Ceylon Plantation Para	4	2	0
Red Tonquin	12	10	8

[1] *Cf.* also the raw rubber tables given in Herbst's *Gummikalender*, 1908, pp. 96-113.

Drying Washed Rubber.—The method of drying the sheets of washed rubber must depend entirely upon the properties of the different kinds of rubber, and upon the uses to which they are to be put. To state in general terms that such and such a method is the best would hardly be fair, for each of the ordinary methods of drying has its own special advantages and disadvantages. The method of drying to be employed in any given case must therefore be decided upon for that individual case.

Generally speaking, far too little attention is devoted to drying washed rubber in a rational way. The drying is still frequently carried out in a very unworkmanlike manner, clearly showing how

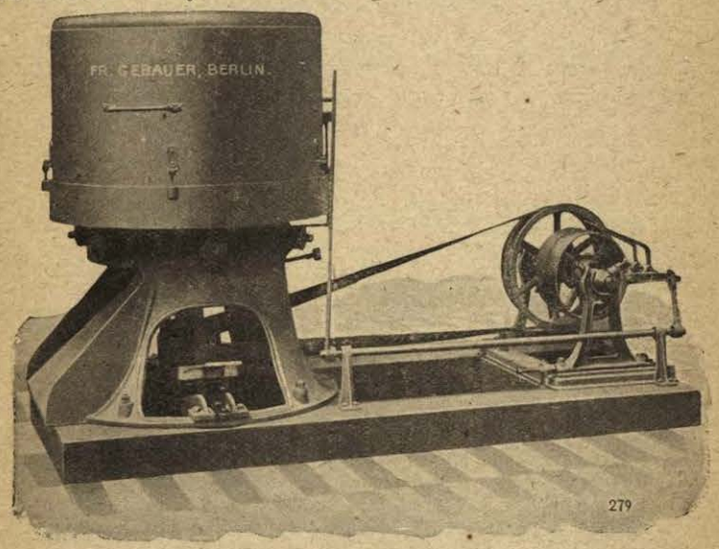

FIG. 13.

little intelligence is brought to bear upon this important subject. Raw rubber dried in such an unsuitable way exhibits absolutely no good properties; the places in which it is dried are generally of quite insufficient dimensions, so that it looks as if one were drying rags instead of dealing with an expensive material like rubber, sensitive to the most diverse influences. Very often no special drying-rooms are provided at all, in order to economise space; and it is not an infrequent occurrence to find the boiler-house serving as a drying-room. The value of raw rubber dried in such places is very doubtful, the dust which settles on it being the least of the evils to which it is exposed. The vacuum chambers introduced some years ago have not proved to be of practical advantage in all cases.

The best apparatus for drying rubber is the drying-room, designed and constructed throughout in the way best adapted to

the properties of the washed rubber which is to be dried in it. This is not so simple a matter as it would appear to be. It will be well, therefore, to consider somewhat more fully the characteristics of the washed raw rubber which is to be dried. The greater part of the water which has to be removed is merely superficial, and its removal presents no difficulty. On the other hand, the water actually occluded within the rubber can only be removed with great difficulty, if one does not wish to fall into the error of vacuum-drying. The mechanically held, superficial moisture can be readily removed from the rubber sheet in a few days by means of a gentle heat; it is not advisable, however, at this stage to raise the temperature above 50° to 60° C., since resinous rubber will not stand that amount of heating. The temperature should therefore not be raised to such a degree as would be most favourable to superficial drying, and the complete drying of the sheet of rubber should be carried out at as low a temperature as possible. It is a well-known fact that as soon as the superficial moisture is evaporated the surface of the sheet contracts so that the water still present gets completely enclosed, and can only be driven off, through the rubber which surrounds it, with great difficulty, or not at all. The diffusion-pressure depends very little on the temperature or on the atmospheric pressure, but, on the other hand, the condition of the warm air in the drying-room, especially its hygrometric state, is a matter of essential importance. High temperatures are therefore not necessary for complete drying, provided that proper care is taken to see that the air is kept dry, and in this way the detrimental effect of high temperatures upon the rubber may be avoided.

The conditions of the drying-room must, therefore, be such as to (1) render possible safe and rapid drying of the washed rubber, and (2) prevent further oxidation of the rubber. It must be remarked that goods made from rubber which has not been thoroughly dried are subject to rapid deterioration, and that imperfectly dried rubber may also, under certain circumstances, lead to the production of porous goods. Then it should also be remembered that highly oxidised rubber is always of less value, and, as is well known, the oxidation of the washed rubber by atmospheric oxygen proceeds very rapidly. The large surface-area of the washed sheet is very favourable to this oxidation. These facts should be taken into account in designing the drying chambers. Spacious drying-rooms are disadvantageous and unsuitable, since they cannot be filled or emptied in one operation. To fill them gradually with wet