Only such colours should be used for the production of these coloured patterns as are not affected by the vulcanising liquor. The proofed cloths are treated in exactly the same way as others, being powdered with French chalk, flour, or potato starch on the special chalking-machine (fig. 78) in order to take away the tackiness from the surface, and then vulcanised by means of the cold cure.

Spreading-machines are now being partly displaced by calenders. The special advantage of the latter over the former is that when they are used no solvent is needed, and the loss occasioned by the

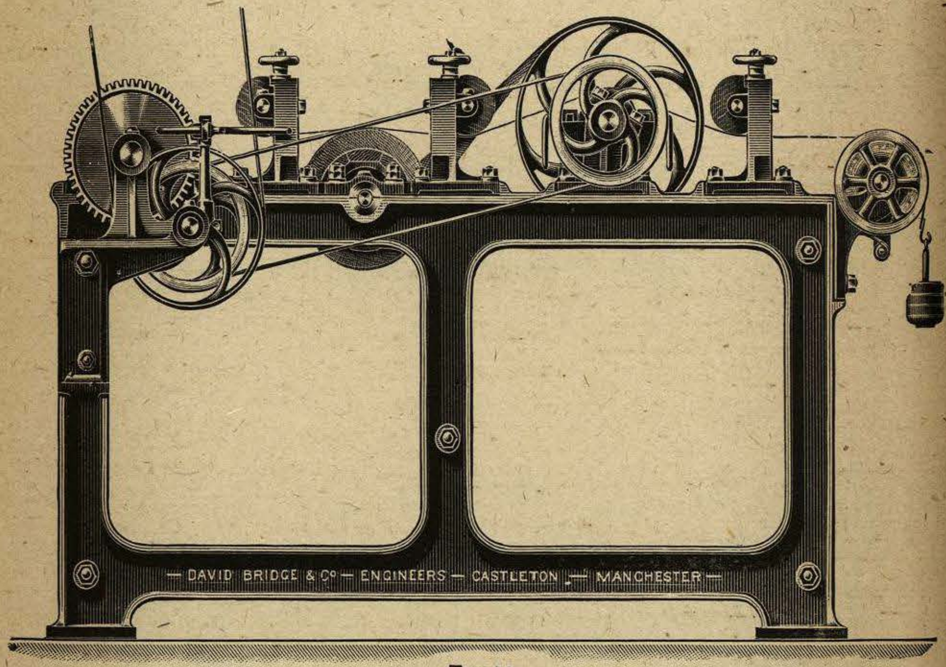

Fig. 78.

evaporation of such solvent is therefore entirely avoided. But in addition, and especially in the case of proofed material of medium thickness, the work turned out is far more uniform than is the case with spread material, and the work can be done very much quicker with the calenders, since no time is taken up by the drying process. The spreading-calenders are, however, not to be preferred to the other type of machine unless the rolls are most fully suited to one another, as regards both their circumference and their hardness, and unless the motion of the rolls is perfectly even and capable of being accurately regulated. Only solidly-built machines should be used for this purpose, and they should be driven by an electric motor, so that they can be run continuously at a uniform speed. The greatest

difficulties are encountered in spreading very thin coats of rubber, for the fabric is apt to get caught up and torn, the rolls being of necessity very close together. But in any case, with well-trained hands, the spreading-calenders can be used for most kinds of materials, and in America this is almost exclusively the practice; moreover, much lower qualities can be used for spreading on the calenders, qualities which could not be used at all in the form of solution at the same price.

After being spread or calendered the cloth has still to be vulcanised. This part of the manufacture has already been fully dealt with.

13. **The Manufacture of Imitation Leather Cloth.**—In the following pages this manufacture, which quite comes within the province of rubber manufacture, will be described.

Formerly the fabric to be used as a basis—a good bleached diagonal cotton is the most suitable—was proofed on the spreading-machine, which has already been described in other sections, but these cloths can no longer be produced by this method at a sufficiently low price; besides, the quality of the cloth prepared in this way is not nearly as good, the cloth feeling considerably softer after vulcanisation than cloth spread on the calenders, and so largely losing its resemblance to leather cloth because of its lack of hardness. The "friction process," which is to be briefly described, is therefore decidedly to be preferred.

The cloth to be proofed must be dried, stretched, and glazed, in order to free it from knots. It is then spread on the calenders with an ordinary mixing as a foundation, weighing about 400 to 450 grams per square metre. On this the outer coat is frictioned, to a weight of about 150 to 200 grams per square metre, and the coated cloth, after the whole length has gone through the calenders, is passed through the embossing-machine (fig. 79), provided with engraved rolls which can be changed as desired. By this machine the pattern is impressed on the cloth. The embossing calenders are of similar construction to those used in paper manufacture, in which a bronze or steel roller, on which the design is engraved, is mounted between two large paper rollers which take up the pressure, generally produced by means of a weighted lever. This arrangement possesses the advantage that a comparatively small engraved roller can be used.

On passing through the calenders the engraving on the roller is sharply imprinted on the proofed cloth. Care must naturally be taken to see that the different qualities of mixing used have the necessary relative plasticity, and that the outer coat of rubber is extremely firm and extensible, so that it is only very slightly weakened in the hollows. If there is not sufficient substance in the outer coat, it would easily be broken or torn at these places on bending or folding. On the other hand, the rubber should not be too hard, or the outer coat will be cut through by the engraved roller, while the use of too plastic a mass will lead to blurred impressions. After leaving the embossing-rolls the cloth passes

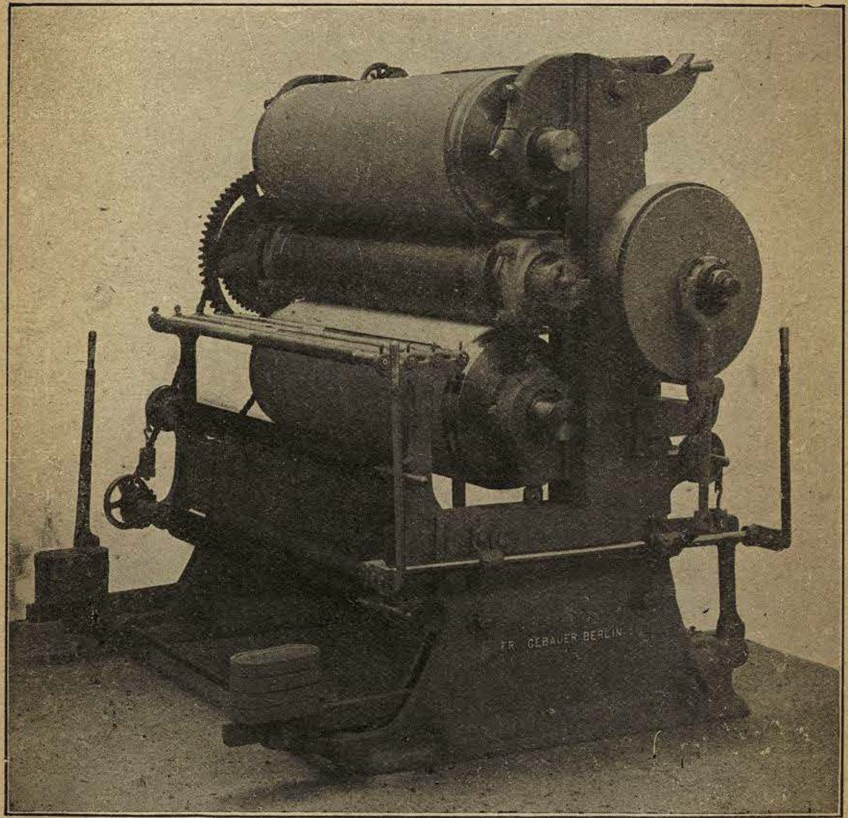

Fig. 79.

over the varnishing machine, where it is slightly moistened with the varnish, and from this direct to the vulcanising room, where it is hung up and vulcanised. These two processes go hand in hand, because the varnished cloth must be hung up immediately on leaving the machine, and cannot be rolled up while the varnish is still fresh. The best varnish is one mixed with linseed oil, varnish, and hard resin, this being harder than shoe varnish, and possessing better drying qualities, which prevent it from afterwards sticking together. The varnish should, when absolutely dry, give a highly polished appearance to the cloth.

The stove already described (fig. 40) is used for vulcanisation, which is effected by means of hot air. After vulcanisation the cloth is allowed to cool for twelve to fifteen hours, and is then hung up in the air, so as partly to rid it of the smell of rubber, and to do away with the tacky feel of the varnish.

14. **Manufacture of "Cut-Sheet."**—This product, invented by Charles Macintosh, is a very fine article of commerce, chiefly used in the manufacture of surgical goods. It has been produced in a variety of ways from time to time, and it seems desirable to put before the reader the different methods of manufacture from which the rational methods at present in use have been evolved. In the first place, pure Para rubber without any added sulphur or surrogates

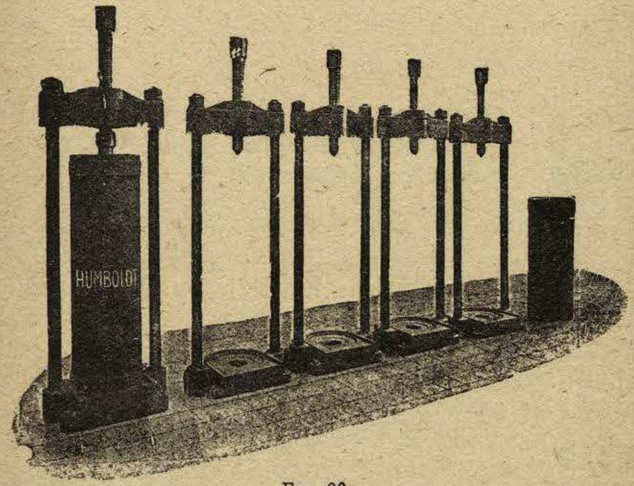

Fig. 80.

was worked up into a soft mass by mastication between hot rolls; this mass was forced into a cast-iron pot about 2 metres long and 35 cm. wide, and the process was repeated until the pot was filled, when it was submitted to a high pressure. By this means a large homogeneous block was obtained; this block was kept at the temperature of a cool cellar for as long a period as four months, whereby the original good mechanical properties of the rubber were restored to it. Sheet was afterwards cut from these blocks, by fixing them on a horizontal moving bed, which was then driven against a sharp knife making about 700 to 800 oscillations per minute, a copious flow of water being kept up over the knife. In this way sheet of different thicknesses was cut by altering the adjustment of the bed. The surface of cut-sheet is marked, as a result of this mode of cutting, with ripple-like knife-cuts. The finer these markings are in the finished sheet the more rapidly has the block been pushed against the knife, or the faster has the machine been run. When a complete sheet had been cut off, the block was raised up on its supporting bed through a distance equal to the thickness of the next sheet to be cut.

This method has been replaced by that about to be described, because by its use it was only possible to prepare short lengths of sheet of medium width. The method now in use is as follows:—

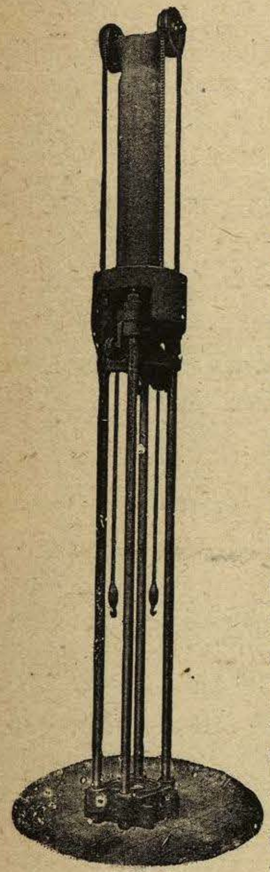

Fig. 81.

The sheets of washed rubber are worked in masticators into the form of solid masses; when these masses are quite homogeneous, and while they are still plastic, they are forced into vertical steel cylinders which have previously been heated (fig. 80). These cylinders are 120 cm. long and 35 cm. inside diameter, and have loose bottom-plates. The cylinders are stood under a cross-bar through which there passes a screw-spindle which is used to force down the cover of the cylinder on to the mass of rubber in it. A steel spindle runs centrally through the cylinder, and forms when withdrawn the hollow axis for the reception of the cutting spindle. But this method has again been improved upon by employing a cylinder of about 43 cm. in diameter, completely filling it with the masticated rubber, and only then forcing the steel spindle through the whole mass of rubber, the compactness of which is by this means increased (fig. 81). The pressure necessary to drive the spindle through is about 260,000 kilos. The moulds are then subjected to a gradually increasing pressure under the presses illustrated in fig. 80 until the whole has become quite cool and a block free from pores is produced. The cylinders containing the compressed rubber are no longer cooled down in a chamber by means of ice or cold air, on account of the large amount of expensive raw material which is kept lying idle during such a process, but they are immersed in a freezing-tank containing salt water cooled down to a temperature of $-5°$ C.

In fig. 82 is shown diagrammatically a modern freezing plant for "cut-sheet" blocks (Haubold's system); with the aid of this plant 320 kilos. of rubber can be completely frozen per diem.

In this diagram we see the compressor *a*, built in one piece with the condenser, the evaporation pipes *b* in the refrigerator (salt-water reservoir) *c*, in which the freezing mixture (brine) is cooled down till the temperature falls to $-12°$ C. in the evaporator. In general, the scale on which it is advisable to design the freezing plant is one which allows 30 to 35 square metres for the floor area and $2\frac{1}{2}$ metres for the height of the cooling and storage space, and provides for an artificial cooling capacity of 4000 calories at a salt-water temperature of $-12°$ C. A small pump *d* is coupled to the compressor in order to supply the cooling water necessary for the condenser. If a supply of main water is available for this purpose this pump is not necessary. The blocks are lifted in and out of the

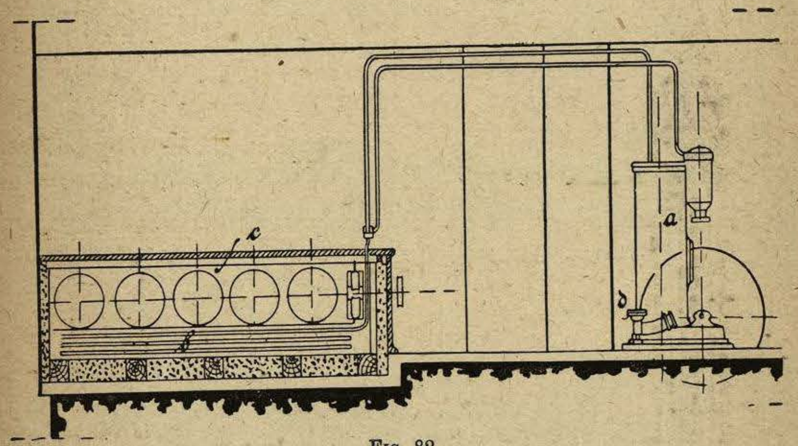

Fig. 82.

tank by means of lifting tackle; the steel spindle is forced out by hydraulic pressure, and the cutting spindle having been inserted in its place, the block is ready for cutting. The machine on which these blocks are cut differs essentially in design from the earlier form of machine; in fig. 83 a cutting machine of the latest construction is shown; in this machine the cone-drive is again used instead of the friction-drive, because the desired results were not achieved satisfactorily on all sides. The machine can also be used for double blocks.

The block is cut spirally by the knife of the machine into the form of a sheet, the speed of rotation of the block and the throw of the knife being regulated and adjusted according to the thickness of the sheet. The knife oscillates at the rate of up to 1200 times per minute; it is therefore most important to keep it well lubricated, and to see that the apparatus for keeping the knife and block wet with soap solution is in perfect working order. The knives are sharpened on a special emery-wheel machine, and the production of a uniform sheet of rubber depends upon their having a true sharp cutting-edge. Soap solution is used in order to prevent the sheets

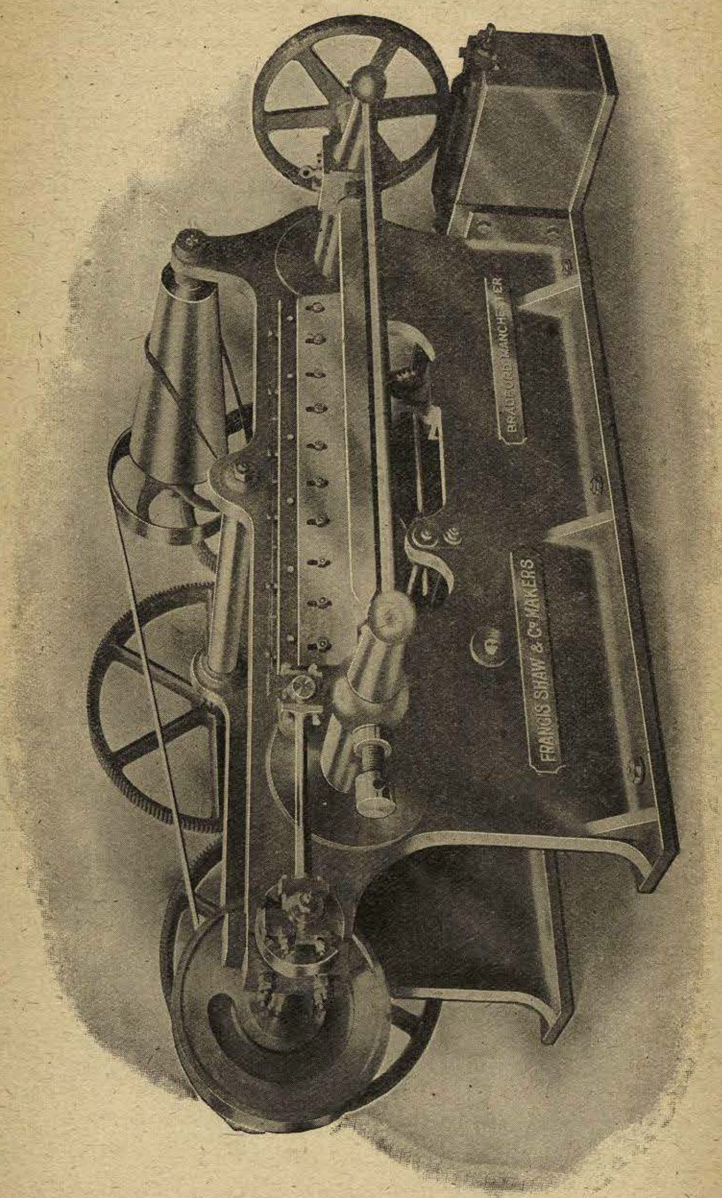

Fig. 83.

from sticking together when they are laid on one another while warm. The soap solution has no effect upon the later processes of manufacture. The various thicknesses of cut-sheet are distinguished by numbers as indicated in the following table:—

No.	mm.	No.	mm.	No.	mm.	No.	mm.
1 .	. 4·15	6 .	. 1·66	11 .	. 0·63	16 .	. 0·33
2 .	. 3·26	7 .	. 1·40	12 .	. 0·54	17 .	. 0·20
3 .	. 2·58	8 .	. 1·15	13 .	. 0·44	18 .	. 0·18
4 .	. 2·35	9 .	. 0·95	14 .	. 0·41	19 .	. 0·165
5 .	. 1·85	10 .	. 0·84	15 .	. 0·37	20 .	. 0·143

The quality of cut sheet (German, *Patentplatte*; Italian, *foglia segata*; French, *feuille anglaise*) has undergone considerable reduction. Sheet formerly made from pure Para has been gradually lowered in price, other mixtures of raw rubber being used instead of Para, and at present sheet containing as much as 30 per cent. of surrogate is sold. Red cut-sheet is prepared by the addition of vermilion to the rubber. Green sheet has disappeared again from the market.

The cost of working a cut-sheet plant is not very high.

It requires altogether six men for a monthly production of about 2500 kilos. of medium thickness. The consumption of ammonia or carbonic acid is quite insignificant, but lubrication must be reckoned at about 30 kilos. of oil per month. To cut a block weighing about 75 to 80 kilos. into No. 18 sheet takes about twenty hours; but, on the other hand, a similar block can be cut into No. 9 sheet in about five hours. Once the block is fixed in position on the machine and trimmed, it pays to keep the machine running continuously until the whole block is cut out, on account of the saving of time, on the one hand, and on the other hand, of the reduction of waste.

15. **Manufacture of Rubber Shoes.**—The manufacture of rubber shoes or galoshes forms a separate branch of rubber manufacture. Special methods are demanded in most of the operations connected with it, leaving the preparation of the raw rubber out of account. The reasons for this are as follows:—

1. The use to which galoshes are put differs greatly from that of other rubber goods, and puts great demands upon the strength and elasticity in every direction, especially in the seams, while at the same time elegance, a good finish, comfort and ease of manipulation are necessary qualities.

2. In the manufacture of galoshes, mixings of the most varied nature, from the finest to the lowest qualities, in all possible thicknesses of sheet, as well as in the form of sheet spread on fabrics of all kinds, the rubber layer varying both in quality and in thickness, have to be made up together from a comparatively large number of small separate parts, and this must be done in such a way that the finished article shall appear as if it came from a

mould; indeed the uninitiated often actually look upon the rubber shoe as a moulded article.

3. The making-up—that is to say, the manufacture proper of rubber shoes—can only be carried out by hand. The machines invented by the American, Doughty, have not come into use in spite of their ingenious design, the cost of working them being too high.

4. Such large quantities as 4000 to 12,000 pieces, according to the size of the factory, are vulcanised at a time, so that the greatest care must be given to mixing, labour, and organisation.

Before passing on to a description of the manufacturing processes, a few points of general importance may be discussed. Galoshes, like all other kinds of shoes, are made up on lasts; the size and shape of the last determines that of the shoe, and since rubber shoes are made in an extraordinary number of shapes and sizes, it is necessary in a galosh factory to have a considerable stock of lasts, in the first place of different sizes and shapes, and secondly, a sufficient number of pairs of each size and shape. The lasts are made either of wood, iron, or aluminium. Iron lasts possess the advantage of heating up rapidly in the vulcanising chamber, and of not being subject to appreciable wear or to fracture. On the other hand, their great weight adds considerably to the labour of making up the shoes, and of carrying them to and fro in the factory. The expansion of the metal by heat is also a disadvantage, because it always results in some distortion of the seams. Wooden lasts, though more subject to wear than metal ones, are lighter to handle, and do not undergo any appreciable expansion on heating, provided they have been well dried beforehand. To ensure that this is so, the wood, in the form of small blocks, is stored for a long time in a very warm place—directly over the boilers, with advantage—before it is shaped out; from this stock the oldest blocks are always taken for use first, blocks which have sometimes been drying for a year and which neither shrink nor crack, nor otherwise alter in the heat. Maple is the most suitable material to use.

Another point of general importance is the uniform colour of the whole shoe, and every mixing used should either be black in itself, or should become black during vulcanisation. These black mixings are prepared by the addition of carbon-black, as well as by the addition of pitch prepared on the factory by heating coal-tar. In this operation the tar is heated and kept continually stirred until it forms, on cooling, a tough mass; resin and wax are some-

times added while the heating is going on in order to impart a bright polish to the mixings in which the pitch is used. The resin-content should, however, be extremely limited, and if it is put in at all, should not exceed about 5 per cent., otherwise the mixings will easily crack. Thickened coal-tar pitch communicates to the mixings in which it is used a greater degree of tackiness and softness in an unvulcanised state than one usually meets with, even when the soft kinds of raw rubber are used. This is certainly an advantage in the case of certain mixings, but it necessitates the most stringent adhesion to the proportions of a mixing which has been found by trial to be satisfactory; for if the right quantity be exceeded to the smallest extent, the rubber may become so soft that it is impossible to work it, and after vulcanisation it may not possess the necessary elasticity. In Para mixings and others of approximately equal quality, such as are used for proofing many of the fabrics, neither pitch nor carbon-black is employed, but instead of these litharge is added; such mixings do not, of course, become black until they are vulcanised. Oil-black and gas-black are the kinds of carbon-black used; this pigment is the one for mixings which need show no particular polish, and which might also show up grey. An addition of more than ¾ per cent. of black is rarely necessary, since all these mixings also contain lead compounds; when pitch is present the black is added in still smaller quantities, and reduces the tackiness of the pitch in some degree.

Coming now to the manufacture itself, we see that the separate parts of which a rubber shoe is composed can be grouped under three distinct headings, viz. the sole, the upper, and the inside.

(a) *The Sole.*—The foundation of the shoe is with rubbers, as with leather shoes, the sole. This part is subject to the greatest amount of wear, and must therefore not only be made of tough, firm rubber, but must also be fairly thick, as much, sometimes, as 7 mm., the actual thickness varying according to whether it is a child's, a woman's, or a man's shoe. In all other kinds of rubber goods which are made up from sheet, sheet of such thickness is always built up from several layers of thinner sheet, because it is too difficult a matter to calender such thick sheets. The sheet rubber for the soles of shoes, however, is not only run on the calenders to the desired thickness, but these also impart to it the usual well-known pyramidal impression and the manufacturer's brand; moreover, the sheet has to be run of uneven thicknesses, because the instep and the heel are all in one piece with the sole; the sheet has therefore to be thickest at the heel and thinnest at the instep.