It will be clearly seen from this that the calendering of such sole-sheet presents certain difficulties. In particular, the calenders (fig. 84) must be of great strength, and therefore the rolls are comparatively narrow—only a little wider than the length of the soles. On the final roll are engraved the necessary markings, which are repeated at convenient intervals so as to leave room to enable each sole to be cut out well. Since a sheet of uneven thickness is to be calendered, the rolls cannot be run at equal speeds, but only in such a way that there is always plenty of rubber in front of the final pair of rolls, from between which the finished sheet, bearing the requisite makings, emerges. Furthermore, the rubber must be kept very warm, to ensure the sheet being absolutely homogeneous and free from air-bubbles. Nevertheless, if the rubber has been well-worked beforehand, and is kept warm, the sole sheet can generally be successfully run from the engraved rolls. The sheets then pass on to tenters, the size of which is regulated by the length of the cutting-out table or the cutting-out machine. Before the individual soles are cut out, the sheet is submitted to a certain treatment which is most advantageous, but in rubber goods is restricted to this instance and to the manufacture of unvulcanised Para strips for cables. This consists in dipping the sole-sheet for a short time (five minutes) into boiling water, the result being that during subsequent vulcanisation there is practically no perceptible shrinkage, and the shoe, which is stretched tightly on the last, is thus prevented from cracking and becoming distorted.

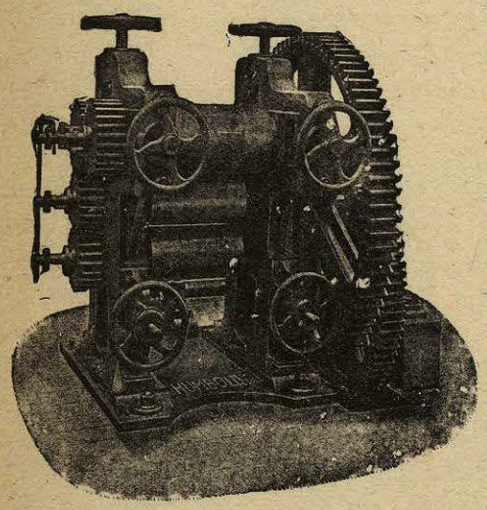

FIG. 84.

The soles are cut out either by hand or by machine, the advantage of the one method over the other being dependent upon the kind of trade done; for the machines, however ingeniously constructed, can in any case only cut out one sole at a time, because the edges must be cut obliquely to ensure a perfect join between the upper and the sole. Hand labour is just as certain as regards this detail, and when performed by skilled hands is very nearly as

rapid as machine labour. In both methods zinc templates, of size and shape corresponding to those of the shoes to be made, are used.

The following are current sole-mixings:—

A.	West Indian	5,000	gms.
	Reclaimed	2,500	,,
	Substitute (odourless)	2,000	,,
	Carbon-black	800	,,
	Litharge (free from peroxide)	2,500	,,
	Barytes	10,000	,,
	Whiting	30,000	,,
	Sulphur	250	,,

B.	Ceara I*a*	4,000	gms.
	Substitute (odourless)	3,000	,,
	Carbon-black	800	,,
	Litharge (free from peroxide)	2,700	,,
	Whiting	25,000	,,
	Barytes	5,000	,,
	Sulphur	150	,,

Of course the sole mixing varies with the quality of the shoe.

(b) *The Upper.*—Like the sole, the upper includes several parts bearing distinctive names; the front part, the side pieces, and the back part, surround the whole shoe in a single piece. This does not get such hard wear as the sole, but, on the other hand, it is subject to a great deal of stretching, bending, and twisting, and must therefore be quite pliable, so as not to crack. Consequently the thickness of the upper need only be small; it is hardly ever more than 0·4 mm., and is generally just the same for all kinds of galoshes turned out by any one factory. An ordinary set of three-roll calenders is all that is required to run the sheet, but these should work absolutely smoothly and evenly. The slightest amount of vibration will result in the production of stripes and other inequalities in the soft rubber; of course these are to be found on other kinds of sheet, but are not so detrimental to its usefulness, whereas in this instance a smooth surface is the chief desideratum. The rubber should be particularly well mixed, and in this the soft nature of the mixing due to the pitch which it contains will be of assistance; otherwise it would need to be worked too long and heated too much to do it any good. The comparatively soft state of the mixing also determines the nature of the further handling of the sheet. The sheet is first of all not rolled up like others, because it would stick together; and even if a layer of cloth were run in between successive layers of sheet, the impression of the cloth and other roughnesses would be formed on the sheet when it had lain for a short while. It is therefore cut off as it comes from the calenders in lengths of 2 to 3 metres, according to circumstances, and the pieces are spread out on cloth-covered frames, which can then be packed on top of one another.

Calenders are also made which cut out the uppers direct, but, of course, the two rolls which carry the knives have to be changed for every different size of shoe. One cannot superimpose several layers

of sheet for cutting purposes, because the rubber is too tacky, and the use of chalk, which one would adopt in the ordinary way, is prohibited by the circumstance that the upper portions of the whole surface have afterwards to be stuck on. The upper parts must be carefully treated after being cut out, until they are used, each separate piece being placed between cloths bound together in book form.

The mixing for the uppers has the following composition :—

Peruvian Para . .	5,000 gms.	"Angel red" . .	1,000 gms.
Barytes . . .	5,000 ,,	Sulphur . . .	200 ,,
Lithopone . . .	5,000 ,,	Carbon-black . .	200 ,,
Litharge (free from peroxide) . . .	2,000 ,,	Pitch mixture . .	1,200 ,,

The "Pitch mixture" consists of—

Pitch	10,000 gms.	American resin I*a* .	250 gms.
Carnauba wax . .	500 ,,	Trinidad asphalt .	50 ,,

(c) *The Inside.*—Under this heading are classed all those portions which are covered by the upper and the sole, and of which only the lining is visible in the finished shoe. All the parts belonging to this category consist, in order to give the necessary support to the galosh, of more or less thickly proofed materials, of the most varied kinds, such as webbing, canvas, cloth, and even wadding and fur. These materials are generally proofed on the calenders; in the case of webs, which are only very thinly coated, the spreading-machine may also be used. With regard to the quality of the mixings the following classification of the various parts can be made: inner-soles, half-soles, caps, heel-pieces, instep pieces, and the so-called German or Russian spurs. The mixings used are of the cheapest; they need be possessed of no remarkable properties, either because the fabrics on which they are spread are very strong, the rubber on them being only present as a cement to unite them to the other parts of the shoe, or because they have a double covering, and are sometimes, also, completely enclosed between other strong parts as a filling-up material. On the other hand, a certain amount of toughness is necessary, and this is produced by the admixture of fibrous material, the waste from unvulcanised proofed cloth being used for the purpose. The following mixing is about a standard quality:—

West Indian . .	10,000 gms.	Carbon-black . .	500 gms.
Reclaimed . . .	15,000 ,,	Sulphur . . .	600 ,,
Substitute, brown .	10,000 ,,	China-clay . . .	15,000 ,,
Pitch	1,500 ,,	Whiting . . .	10,000 ,,
Proofed cloth waste .	5,000 ,,	Borneo mixture (from Besk) . . .	2,000 ,,
Litharge (free from peroxide) . . .	12,000 ,,		

For the inner soles, as will be noticed in rubber shoes of quite different makes, red and light-grey cottons of various shades are in favour, but other fabrics are also used, in brown and other colours. The coating of rubber should be about 1 mm. thick. After they have been taken from the calenders the cloths are rolled up ready for cutting out. There are no special precautions to be observed in the latter process, and it is the general practice to punch them out by machinery, about 10 thicknesses at a time. The inner sole covers the whole length of the sole inside the shoe, whereas the half-sole, which comes between this and the outer sole, and corresponds roughly with the welt of a leather shoe, extends only from the toe to the instep. It has neither insertion nor outer layer of cloth; it is cut out by machinery, but also partly by hand, as are the instep pieces and the heel-pieces. The cap which surrounds the heel and forms the thickest part of the upper shoe may be as much as 5 mm. in thickness, and has fabric on both sides. Greater difficulty attends the cutting-out of this part and its preparation for use than is experienced with the parts already mentioned. For it must be sloped off quite gradually down to the two sides of the shoe which meet it in front, or uncomfortable ridges and sharp edges would be formed where the two parts join, that is, about one-third of the length of the shoe from the back. On this account the two front edges of the cap are cut obliquely, leaving a cut edge about 10 mm. wide which laps over the canvas of the side piece. This cutting can be done best by hand, because the caps for different shoes are of different thicknesses. The spurs which have been mentioned, and which are attached to this part, are cut out of sheet which has been run on calenders with engraved rolls similar to those on which the sole-sheet is calendered, with the individual spur-moulds at short distances from one another.

On account of the low quality of the mixing used, and of the great strain put upon the spurs when the galosh is being taken off, the spurs are covered by hand with proofed linen. This is intimately united with the rubber of the spurs by tightly pressing the whole for a few minutes in a heated press, the plates of which are provided with holes into which the spurs fit. The remainder of the inside parts are proofed with a different mixing. These parts include the lining of the upper, the web lining, the web sole, the toe-cap, the thin cap, and the proofed fabric which is used for covering over the seams. All these fabrics have a thin coating of a good mixing, which may be described as a Para quality with

a little litharge added; the following is the composition of the mixing:—

Para	1,500 gms.	Rape oil substitute (brown)	1,500 gms.
Manaos, negroheads .	500 ,,	Litharge (free from peroxide)	900 ,,
Kassai, Upper Congo .	5,000 ,,	Sulphur	300 ,,

The proofing is in each case on one side only. The lining of the upper consists, as a rule, of webbing of the same colour as that used for the sole lining, and is prepared for use in the same way. In both instances besides the fabrics mentioned, special linings are sometimes used, such as wool, wadding, and fur. The web lining is identical in size with the lining of the upper, and unites the latter with the upper itself. The same relation holds between the web sole and the thin cap. The toe-cap forms the toe of the shoe, and serves both to give strength and as an ornament, its shape being visible on the outside; it is generally heart-shaped. The proofed fabric used for covering over the seams is cut into strips about 6 mm. wide for use. A component part which is only occasionally used remains to be mentioned, viz. rubber-coated twine. This is used in the manufacture of rubber galoshes, the method adopted being to lay short pieces of it under the outer coating of rubber. It is prepared by dipping twine into rubber solution.

Two parts of the rubber shoe which occupy an exceptional position, and cannot be brought under either of the above headings, remain to be mentioned; they are the cap-lining and the so-called French spurs. Cap-linings are only used in making up men's shoes. They form the inside of the heel-piece, and are made from approximately the same mixings as the soles, the amount of raw rubber being increased, however, by a good 5 per cent. They are united on the outer side directly to the upper. The French spurs are made from a mixing which is very much the same as that from which the uppers are made, but which contains no tar. The sheet from which they are cut is run in the same way as that used for Russian spurs, and the spurs are also pressed in moulds in the same way, but they are not covered with cloth. They are fastened to the outside of the shoe by means of rubber solution.

(d) *Making-up.*—Just as the various parts of the shoe are carried to the cutting-out room on endless conveyor bands, they are taken in the same way, after they have been cut out, to the making-up room. The making-up of a rubber shoe is not at all a simple matter. An ordinary shoe consists of eight different parts, a high-buttoned shoe of seventeen parts, whereas, on the other hand, a rubber boot is made up of twenty-three parts, and not one

of these is superfluous. The most interesting part of the manufacture is carried out in the making-up rooms. Making-up is a difficult process, requiring accurate knowledge, and it is carried out almost entirely by female labour. First of all the separate parts, with the exception of the webs, are spread with solution, and the inside portions, in particular the linings of the uppers, are laid on the lasts. On top of these the caps are rolled down by means of the ordinary hand rollers as used in other parts of the factory, and then the inner sole is put on. The places where these meet, and in particular all inside seams, are covered with the proofed strip mentioned above, in order to make them more durable, but the seams must also be made perfect before this is put on. The half-sole is now put on, and then the instep-pieces and heel pieces, after these the web lining and, if required, the German or Russian spurs; the uppers, and finally the soles, are added, the French spurs being put on if required. All the parts must adhere firmly to one another without air-spaces between them, and without interspaces. The ornamentation seen on the upper is produced, so far as it is not due to the outlines of the toe-cap or to pieces of twine which have been put under the outer coat, by means of a small toothed wheel, which is also used to press the seams together. An average woman worker can turn out a maximum quantity of about forty pairs of shoes per day.

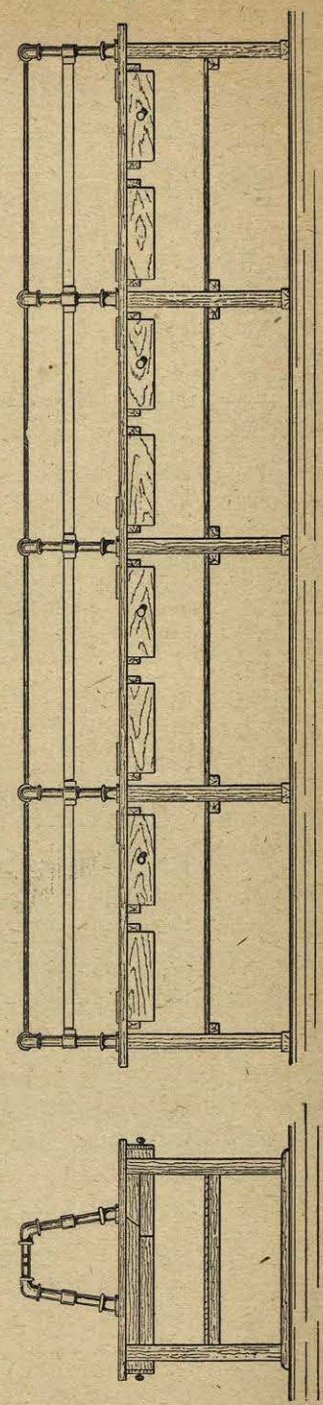

FIG. 85.

(e) *Varnishing.*—This is the final operation before the shoes are

vulcanised. The varnish itself is an important secret of every rubber shoe factory. A deep black, non-brittle, elastic varnish is difficult to prepare. It consists in general of linseed oil, litharge, and sulphur, with a little oil of turpentine, and is painted over the whole of the shoe, including the sole, by means of a large marten's-hair brush, the solution being made sufficiently thin not to froth. If frothing takes place the solution must be diluted. Varnishes containing a ready-made black ingredient, such as asphaltum, are not, as a rule, so valuable, and are generally used only for after-varnishing. In America shoes are varnished in the following way. The shoes are arranged on their lasts on iron racks, and are taken to the varnishing-room, where they are removed from the racks; the top edge is rapidly run over with the brush, and the whole shoe is then dipped in the thin solution of varnish, and immediately afterwards is put back on the rack. It is essential that the lacquer should not flake off, and the pliability of the upper is a valuable factor in this connection, since the varnishes make intimate contact

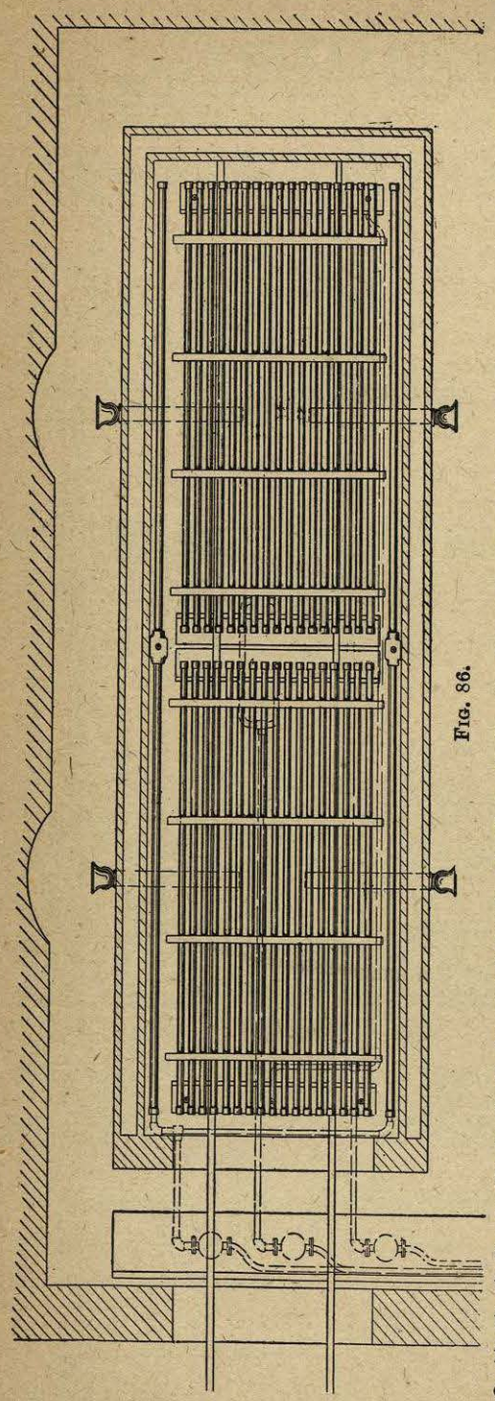

Fig. 86.

with it. The varnish has to go through the vulcanising process, and is therefore subjected to a very high temperature; all volatile constituents (with the exception of the very volatile benzine with which it was diluted) must therefore be completely driven off by heat before it is used, so that no vapours can possibly be given off during vulcanisation, and form blisters. In spite of this precaution a varnish may go wrong on heating so that to make absolutely sure that it is all right it is tested before actual use, by coating a small piece of the shoe rubber with it, and subjecting this to vulcanisation.

(f) *Vulcanisation of Galoshes.*—This is carried out exclusively

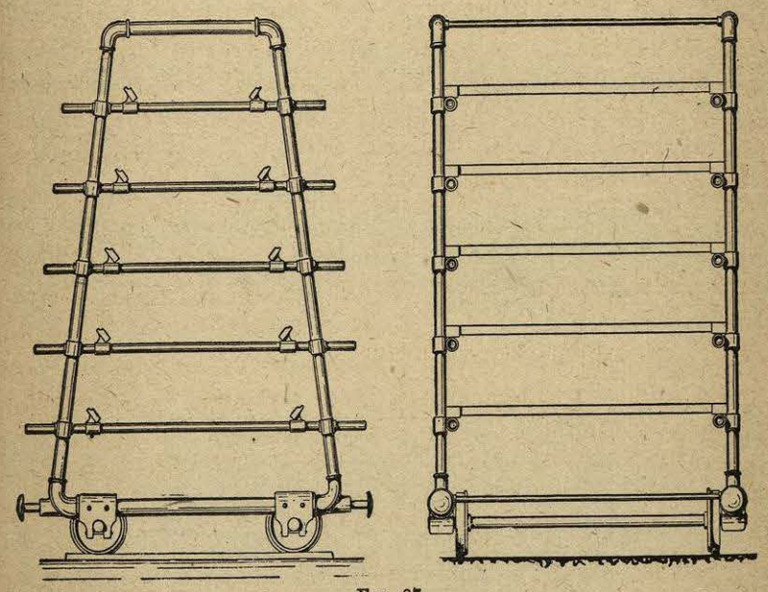

Fig. 87.

in hot-air chambers, since the shoes have to be cured without any protective covering. The stove is generally traversed by heating coils on the floor and walls (fig. 86). The walls should be lagged with some insulating material to prevent loss of heat, and so to enable the temperature of the chamber to be kept absolutely constant. Special care must be taken with the air-outlets, which must be distributed over the top of the oven in such a way that no variation of temperature is brought about in the process of drawing off the air from the chamber, for the temperature must be kept absolutely constant in every part of the oven. The rubber shoes are put on mandrels on iron cross-rods, supported on trolleys (fig. 87), on which they can be run into and withdrawn from the vulcanising chamber. As is always the case with hot-air vulcanisation, where the space is only slowly heated up, the length of time required for

a cure is comparatively long, from eight to ten hours being occupied in gradually raising the temperature up to 130° to 140° C., according to whether the rubber is quick- or slow-curing. This temperature must be maintained for at least an hour and a half, but must not be allowed to exceed 140° C.; in the first place, because the fabrics would begin to lose strength and change in colour; and, secondly, because the polish of the varnish would be dulled thereby.

The so-called "sulphuring-up" does not often occur with shoes; but when it does, its effect on their appearance is more objectionable than in many other articles; further, when insufficiently vulcanised the varnish may remain tacky. The temperature of the heating chamber is controlled by the use of a long thermometer; in order to make sure that vulcanisation is complete the chamber is provided with flaps through which test-pieces can be withdrawn. Before attempting to empty the chamber the foul air is exhausted from it; the trolleys are then run out into a room to cool down. When cool, the shoes are examined for defects, sorted, branded (generally with vermilion) and packed ready for dispatch.

16. **Manufacture of Insulated Wires and Cables.**—Except in the case of submarine cables, vulcanised rubber is at present used for the insulation of the metallic wires used for cables, etc.; the principal rubbers employed in the mixings used for this purpose are Para, Mozambique, and the best Congos. In this manufacture it is essential that the rubber should be very thoroughly washed; but the mistake should not be made of washing it for too long a time, and in too thin a sheet, since the rubber suffers by overworking on the washing-rolls. The rubber used should not be dried in the vacuum-drier; this point has been specially referred to in the chapter on the drying of raw rubber. The ingredients, French chalk, china-clay, and zinc oxide, must be well dried and sifted. In mixing, the formation of nibs must be avoided, and the rubber should not be worked for too long a time. For calendering the sheet the four-roll calenders, as specially designed by the firm of Haubold (p. 52) are employed, the chief aim being to avoid the formation of blisters; to achieve this the mixing must be well warmed up and calendered immediately. The calendered sheet is allowed to remain wrapped in its cloth for at least a day to cool down, and is then lightly chalked on the machine already described. The most usual and the most convenient method for covering the copper wire is by pressing the rubber round it in the coating machine (shown in fig. 88). This machine has been introduced everywhere, and as many as twelve wires, or even more, can be

covered by it at a time. The ordinary machines in use are those with three pairs of rollers, but there are others with as many as six pairs, with diameters between 150 and 250 mm., and breadth of face from 100 to 200 mm. Working under normal conditions, the rollers are driven with a peripheral speed of from 7 to a maximum of 19 metres per minute. The speed of the apparatus for carrying away the cable as it passes from the machine must be capable of regulation, and the cable should not be drawn away faster than it is paid out by the machine, or both wire and covering will be weakened, and the rubber insulation may leave the wire

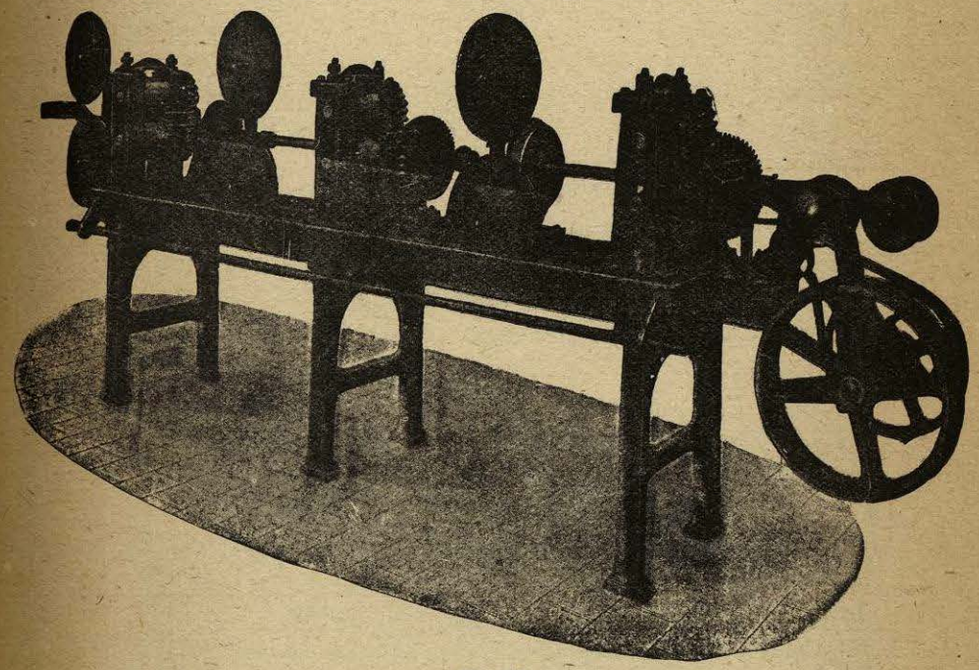

FIG. 88.

or be torn off. The circular knives must be turned clean and free from notches, otherwise the covering will not be very reliable. Again, the rollers should not be set up too tight. The sheet to be used for covering, which is from 0·2 to 0·3 mm. thick, is run free from blisters on the calenders, cooled down, and then rolled round cylindrical mandrels and cut into rolls of strip of the desired width, on automatic lathes. These rolls are inserted in the covering machine; the wire passes between two plates through the first pair of cutting rollers, and above and below the wire are run strips of rubber from the rolls inserted in the machine, and the wire is thus covered by the strips. The wire and its covering pass between the cutting rollers, running in grooves on their surfaces, where com-