often happens that the proofing is carried out as a speciality in rubber-works. The manufacture may therefore be briefly dealt with so that the reader may acquire some slight acquaintance with the weaving of canvas hose. Power-driven iron looms have been in use now for about fifteen years for making canvas hose; the old wooden hand-looms, which were formerly to be found in every Thuringian peasant's dwelling, forming one branch of the cottage industry, have entirely disappeared. The manufacture is now carried out in factories only. Flax, cotton, or hemp yarn, spun in different ways according to the size of the hose to be woven, is used. Just as in the case of all other fabrics, a distinction is made in canvas hose between the warp and the weft threads. The former, which are twice as many as are required for the width of the hose,

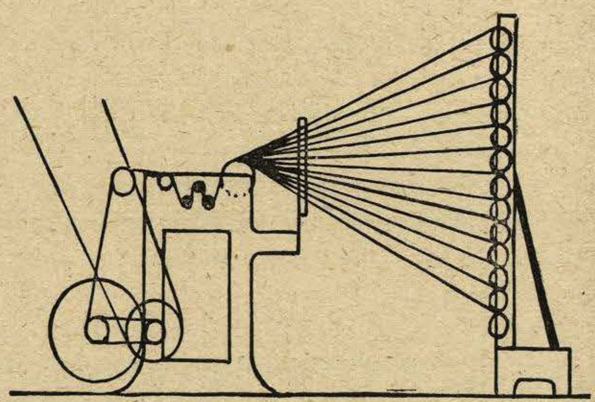

FIG. 55.

are beamed by means of a beaming machine (figs. 55 and 55A) on the warp beam. The mounting with the heddles, through which the separate threads are run, is also arranged exactly as in other looms; only the way in which the individual mountings move is different, the warp first separating into upper and under warp, the mountings then setting the upper warp so that the shuttle carries the thread through on the lathe, whereupon the under warp lifts and the weft thread is shot through in the same way. In this way the seamless hose fabric is produced. The finished tube is rolled up on a reel. About 300 metres can be made with one warp. The rough hose, if it is to be rubber-lined, is finished off in the following way:—

The hose is opened out by a machine (figs. 56 and 56A), and the tape necessary for pulling the rubber lining through is then drawn through it. The rubber lining, made on the tube machine, is partly cured for thirty minutes, then covered with solution, and drawn

through the hose by means of the tape already mentioned. The hose

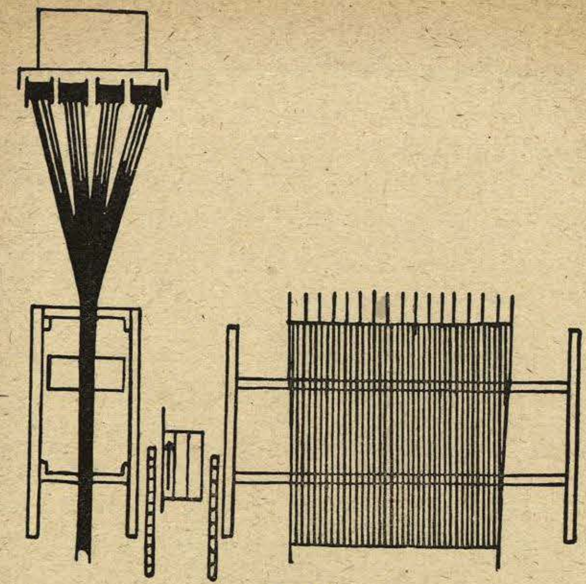

FIG. 55A.

is then fixed on to a vulcanising cone, and firmly clamped on the tube. The lower end is connected to the condensed steam pipe, and

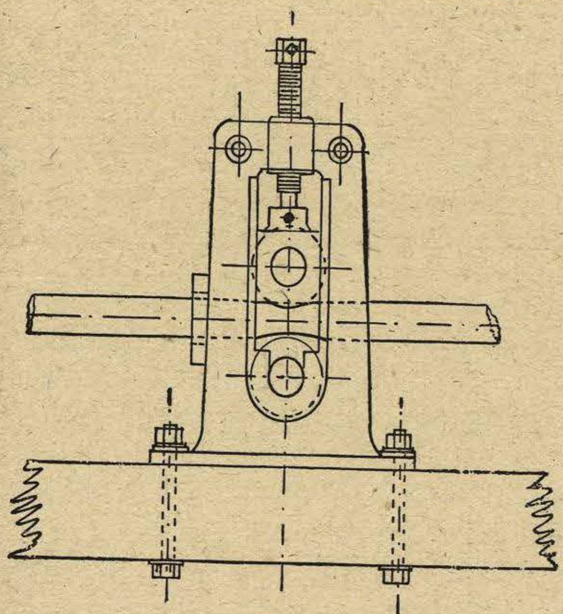

FIG. 56.

the final vulcanisation can then be begun. It is advisable to subject the hose to a steam pressure of about four to five atmospheres.

By the high pressure the hose-lining is forced firmly on to the walls of the canvas hose, the solution penetrating the interstices, and the fabric and the rubber lining are thus intimately united. After lowering the steam pressure the hose is tested with a water pressure of 20 atmospheres, and hot air is then blown through it to thoroughly dry it. This method of lining hose with rubber is, however, being displaced by a new system which has important advantages over the old well-known method, in that there is no possibility of the hose-lining developing leaks. It is not always possible to avoid the formation of thin places in the walls of the

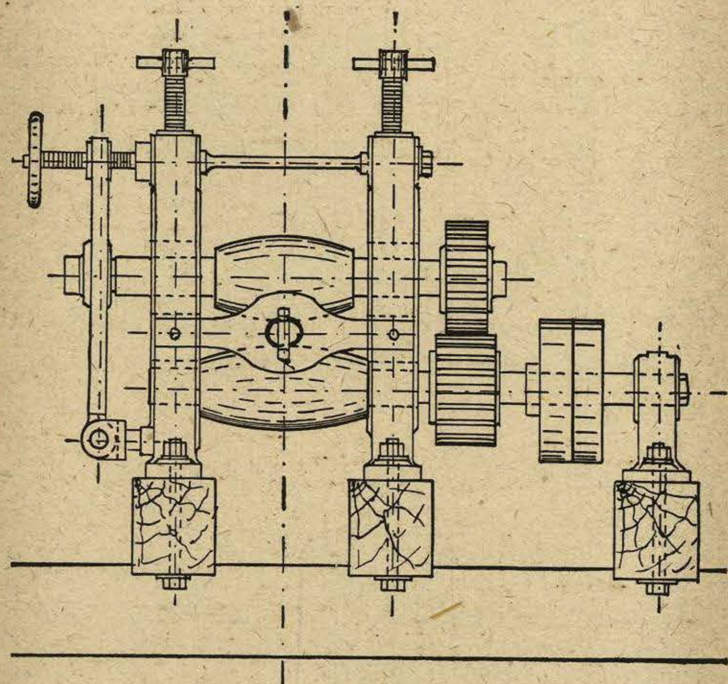

FIG. 56A.

rubber lining when drawn into the hose by the old method, and sometimes little grains or nibs of one or other of the ingredients, which have been introduced into the rubber in the course of mixing, get shot out of their places, leaving holes in the rubber where leakage may afterwards occur. In the new method the canvas hose (figs. 57 and 58) is stretched out in a heating chamber 30 metres long, arranged so as to be used in three sections. The fastening is by means of plates screwed on to the foundation plate by six screws. These plates are fixed to a movable frame, provided with a groove, which can be so adjusted by turning the screws that the hose inside the chamber is tightly stretched. The wires, to which are attached the rubber brushes, the object of which is to draw the

solution evenly along the tube, are run through the hose, and pass over rollers at either end of the apparatus. These rollers can be

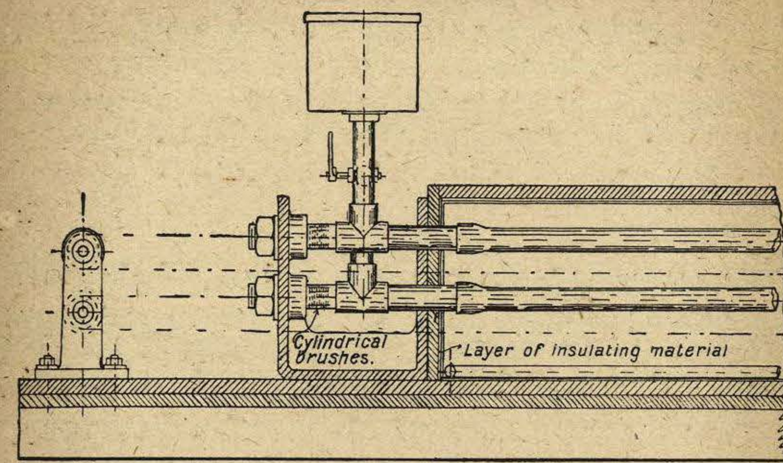

FIG. 57.

mechanically driven in either direction. Between the rollers and the chamber is introduced a piece of apparatus which is connected

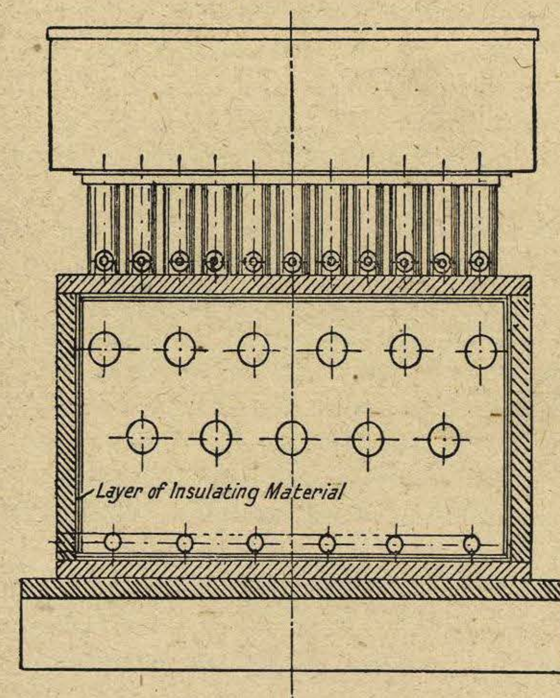

FIG. 58.

to the hose, and into which the amount of solution necessary to put an inner coating of rubber on hose of that particular diameter is forced from the solution-holder by means of compressed air. When the separate boxes are full the driving mechanism is set in motion, and the solution is drawn through the hose by means of the brushes; the brushes are given a rotary motion, and so spread the solution evenly over the inner surface of the hose. The brush, on passing through the hose, carries the excess of solution into the apparatus at the opposite end, which now gets filled with solution, as previously described. Before the brush travels back through the hose in the opposite direction, hot air is blown through the hose, and this, in combination with the internal heat of the chamber, causes the solvent to evaporate. This process must be repeated until the desired thickness of rubber lining is attained. When that is the case, the chamber is closed at both ends and the vulcanisation is proceeded with. Vulcanisation is effected by means of hot air, which is led into the chamber at one end, and at the other end is driven through the hose by means of fans. It takes about five hours to proof 30 metres of hose to a thickness of $1\frac{1}{2}$ to 2 mm., and the vulcanisation occupies another forty minutes at 145° C. It is not advisable to cure the hose on the cone with direct steam; by that means the solution gets forced too far into the meshes of the fabric and the hose does not turn out perfectly smooth inside. The dimensions of the 5 cm. long brush-rollers, as well as those of the steel discs, with rounded edges, behind them, are determined by the internal diameter of the hose.

In spite of the consumption of solvent (benzine) this process works out cheaper, for lower quality mixings can be used and thinner coats can be put on, and still the strength of the hose will be considerably greater than that of similar hose made by the older process, while the finished article will be lighter in weight and more pliable.

2. Moulded Goods, and the Manufacture of Hollow Articles such as Balls and Toys.—Another department of rubber-goods manufacture is that which deals with the manufacture of articles vulcanised in moulds, of which one has to distinguish between two kinds, viz. solid and hollow articles.

The manufacture of solid moulded goods is fairly simple. The articles are built up out of unvulcanised sheet rubber, until they fill the mould; they are then subjected to a preliminary pressing, the waste which is squeezed out being removed, and the articles are then lightly powdered (with French chalk, etc.) and cured in the tightly-closed moulds. It is most important that no air should get shut in, but that it should all be forced out while the mould is

being closed up. For this reason it is advisable to use moulds made in several parts, but such moulds have also a special value when the goods come to be taken out after vulcanisation. Articles with metal, wood or cloth cores—*e.g.*, a ball valve—are prepared in the following way so as to keep the core central:—

The core, after being well-roughened, is given a coat of durable quick-curing solution, and when this is dry a sheet of rubber is laid on it and cut in the form of an 8 round the core, so as to obtain a completely closed layer of rubber. The cut edges having been well pressed together, the process is repeated until the thickness of the superimposed layers of rubber is equal to that of the finished ball. In carrying out this process it is necessary to arrange the 8-shaped seams in such a way that those of successive layers do not lie on top of one another. A ball prepared in this way possesses the advantage of having its cores already in as central a position as possible. After the preliminary pressing, vulcanisation can be begun in the moulds, which must be clamped up tightly for the purpose. Smaller balls can be made up in another way, viz. by cutting a sheet of rubber into strips and winding these round the core. In doing this it often happens that the core gets shifted through the strips not being laid on evenly, or the core may be loose inside its rubber covering.

For the manufacture of rubber stoppers, cord of a suitable size is run on the tube machine, and is then cut into pieces of the right weight and pressed into moulds. In dealing with moulded goods in particular the exact weight of rubber for each article, *plus* 2 or 3 per cent. to allow for that which is squeezed out under the pressure put on the mould, should be taken. In order to avoid turning out faulty work on vulcanisation, care must be taken that all sheet, or shaped-pieces made on the various tube machines, are free from air-bubbles. Whereas small moulds are subjected to great pressure by clamping them tightly in iron clips, and cured either in a steam heater or in the sulphur bath, other moulded goods, such as billiard-strip, deckle-straps, pulsometer valves, etc., are vulcanised under great pressure in a vulcanising press. For larger moulded goods with stout walls the use of hydraulic autoclave presses for vulcanisation is to be recommended: this form of apparatus will be specially referred to in the chapter on pneumatic tyres. In the case of goods to be delivered in long lengths—*e.g.*, deckle-strap, billiard-strip, moulded cord, cab-tyre—vulcanisation must be carried out bit by bit. For this reason the mould should in all cases project at least 20 cm. from each end of the press. Vulcanisation of the first length is commenced with one end of the mould closed, and only one end visible outside the press. In proceeding with the further vulcanisations one end-plate is unscrewed, and the mould is allowed to project from the press at both ends, so that the vulcanised end can be slipped out of the mould from time to time. But in order that the rubber behind it, which has still to be vulcanised, may not move out of position, the finished portion projecting from the mould is firmly bound on, and is thus prevented from slipping out. Deckle-straps are made in the same way, and are then made endless by vulcanising the ends together in a convenient small mould. All joints should be carefully bevelled. Air-markings may result if the mould is not properly closed, or if the air cannot get away easily; also if the deckle is not withdrawn quickly enough when the mould is opened, and air-spaces are formed between the mould and the rubber as the latter cools. Poor, soft qualities, and rubber which has been worked too much, also give rise to air-markings which may be recognised by their considerable depth. Special care should always be taken to have the mould properly cleaned throughout.

The second kind of moulded article is the hollow article. Such articles are either prepared on mandrels, which shape the inside of the article, or are inflated by means of some gas, as in the case of balls and dolls. In each case these articles are made by the union of two or more sections cut out of sheet. This branch of manufacture is carried out essentially by hand labour, though in the case of rubber balls machines are also used to cut or punch out the separate sections. Balls are generally made up of from four to six pieces united along their edges by means of solution. Special machines which effect both the punching out and the making up are also in use, and there are also a number of patented processes in practical operation.

Balls are made up, as already stated, chiefly by hand labour. On the inside of one of the sections is fixed a plug of lightly vulcanised rubber, the object of which will be explained later on. Before the ball is quite closed up, a quantity of ammonium carbonate, varying from 8 to 45 grams, is put in, the amount depending upon the size of the ball, and also upon the tenacity of the rubber mixing. Other methods of inflating balls, depending upon the introduction into the ball of substances which on being heated evolve nitrogen, are in use, but up to the present no method of inflating balls which would simplify existing processes of manufacture by doing away with the need for the use of plugs, and

with the necessity for inflating the balls after vulcanisation, has proved to be adapted to practical use.

Another process which may be employed for inflating hollow articles consists in the use of ammonium nitrite, which, as is well known, is decomposed, on heating, into nitrogen and water, according to the equation—

$$NH_4 \cdot NO_2 = 2H_2O + N_2.$$

The ammonium nitrite may be prepared *in situ*, by the action of alkali nitrite on ammonium chloride, in accordance with the equation—

$$NH_4 \cdot Cl + NaNO_2 = NaCl + NH_4 \cdot NO_2.$$

The most convenient method of inflation is to utilise the production of CO_2 from carbonates. Nitrogen can also be prepared from chloride of lime and ammonia, and ammonium carbonate may be used instead of the latter. In mixings which have not the proper composition, and especially if the rubber has not been worked until perfectly homogeneous, and in which therefore the micro-porosity of the rubber is greater than it should be, ammonia may easily pass through the walls of the article, or fill the pores and decompose the rubber. In this place a crystal of ammonia is formed on the outside of the ball, and the gases and air are allowed to escape. It is therefore considered desirable to add to ball mixings a quantity of pitch, or a mixture of ozokerite and pitch. The use of finely-ground, dry, pulverised waste should not be permitted. If such be used there will always be produced a number of spots which are permeable to air or other gases, whereas none of these can be noticed if reclaimed rubber and pitch be used. The pitch certainly darkens the colour of the rubber a little, but in the case of painted balls that is of no consequence. The following mixings are some which have been used with good results:—

RUBBER BALLS.

(1) Mozambique . .	5,000 gms.	Lithopone . .	12,000 gms.
Massai . . .	5,000 ,,	Talite . . .	10,000 ,,
Sulphur . . .	1,200 ,,	Pitch . . .	300 ,,
Zinc white . .	12,000 ,,		
Whiting . . .	15,000 ,,	(3) West Indian . .	10,000 ,,
Pitch . . .	300 ,,	Ozokerite . . .	400 ,,
		Sulphur . . .	1,200 ,,
(2) Upper Congo . .	4,500 ,,	Reclaimed . .	8,000 ,,
Nicaragua . .	5,500 ,,	Zinc white . .	12,000 ,,
Sulphur . . .	12,000 ,,	Whiting . . .	15,000 ,,
Reclaimed . .	6,000 ,,	Pitch . .	200 ,,

The manufacture of hollow rubber toys, such as dolls and animals, is carried out in the same way, the separate sections being cut out of sheet, and joined together in the form of the portion to be reproduced. They are made up in the same way as balls, but it is preferable to use water as an inflating agent during vulcanisation, or else capsules of gelatine containing sodium bicarbonate and tartaric acid, from which mixture carbon dioxide is evolved.

Vulcanisation proceeds exactly in the same way as in the case of other moulded goods, but the rise of steam pressure should be as rapid as possible, and care should be taken that the temperature and pressure do not recede during the process, so that the hollow articles may not drop in. Of late, ball-presses (fig. 59) have been coming

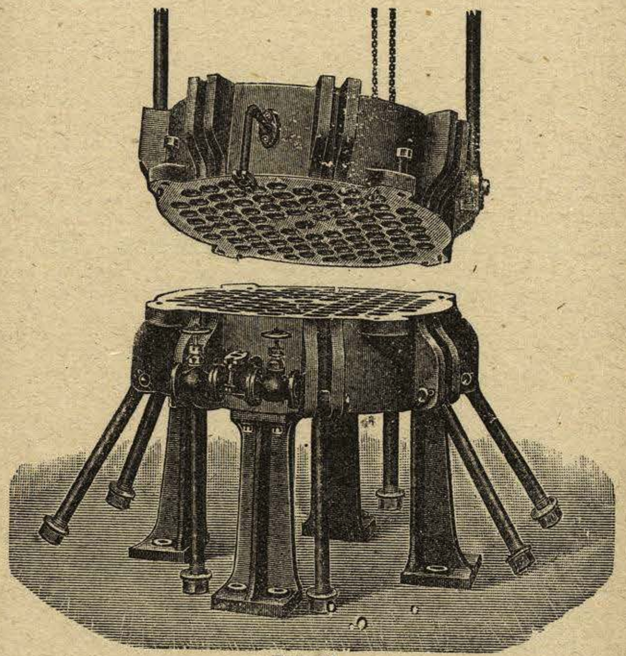

FIG. 59.

into use in place of single moulds, for curing balls both hollow and solid, of reasonably small dimensions, say up to 2½ inches in diameter; with such an arrangement as many as two hundred balls can be cured in a single operation. The simplicity of handling and working this apparatus, together with the fact that means are provided for cooling down rapidly by a flow of cold water through the press-plates, constitute very great advantages. The moulds are opened while they are being vigorously cooled down; by this means the gases present in the ball under considerable pressure are prevented from blowing it out still further, and, on the other hand, from contracting owing to the fall of temperature. For this reason it is also necessary to re-inflate the ball after vulcanisation; this is

only done on the grounds already given, and it is incorrect to assume that all gases diffuse through the ball. After the inflating gases have been removed from the ball it is filled by means of compressed air, which should be as cold as possible, the object of the plug previously referred to being to close up the hole made in it by the hollow needle when the latter is withdrawn. For safety's sake it is best to push a small piece of rubber, soaked in turpentine, into the plug in addition.

In toys the after-inflation is unnecessary, because they are provided with air-valves. The holes into which these are fitted are drilled out on a drilling machine.

Balls and toys are painted by hand. In the case of balls the ground-work and lining can be put in with the aid of a small painting apparatus. The arrangement is extremely simple; the ball, resting on a disc, is rotated whilst a fixed brush marks the lines according to the position in which it is put and the colour with which it is filled. The pictures on the balls are put on with transfers.

The mixings used for the manufacture of dolls should be very soft and elastic, since they must be able to take the impression of the sharpest intricacies of the various moulds. The following may be given as examples:—

RUBBER DOLLS.

(1) Columbian	6,000 gms.	(2) Lopori	6,000 gms.
Sulphur	1,400 ,,	Columbian	4,000 ,,
Ceara	4,000 ,,	Golden sulphide	3,000 ,,
Zinc white	10,000 ,,	Whiting	8,000 ,,
Whiting	8,000 ,,	China-clay	4,000 ,,
China-clay	4,000 ,,		
Paraffin wax	250 ,,		

3. **Manufacture of Seamless Tubing and Shaped Cord.**—In the manufacture of these goods the tube machine depicted in fig. 60 occupies an all-important position, and a very great variety of articles can be produced by means of it according to the die employed. The machine consists of the cylindrical casing, which can be heated, enclosing the screw, and the box, in which a spindle is fixed; this spindle, the form and size of which depend on the article being made, can be centred by means of set-screws, and its thickness corresponds to the internal diameter of the tubing to be made. In addition, we have at the end the die with a circular hole which determines the outside diameter of the tube. If the spindle be removed the machine produces a cord, which may be of circular section or angular, according to the die employed. The machine