# MAKERS OF MANY THINGS

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# PREFACE

The four books of this series have been written not merely to provide agreeable reading matter for children, but to give them information. When a child can look at a steel pen not simply as an article furnished by the city for his use, but rather as the result of many interesting processes, he has made a distinct growth in intelligence. When he has begun to apprehend the fruitfulness of the earth, both above ground and below, and the best way in which its products may be utilized and carried to the places where they are needed, he has not only acquired a knowledge of many kinds of industrial life which may help him to choose his life-work wisely from among them, but he has learned the dependence of one person upon other persons, of one part of the world upon other parts, and the necessity of peaceful intercourse. Best of all, he has learned to see. Wordsworth's familiar lines say of a man whose eyes had not been opened,—

"A primrose by a river's brim
A yellow primrose was to him,
And it was nothing more."

These books are planned to show the children that there is "something more"; to broaden their horizon; to reveal to them what invention has accomplished and what wide room for invention still remains; to teach them that reward comes to the man [iv] who improves his output beyond the task of the moment; and that success is waiting, not for him who works because he must, but for him who works because he may.

Acknowledgment is due to the Diamond Match Company, Hood Rubber Company, S. D. Warren Paper Company, The Riverside Press, E. Faber, C. Howard Hunt Pen Company, Waltham Watch Company, Mark Cross Company, I. Prouty & Company, Cheney Brothers, and others, whose advice and criticism have been of most valuable aid in the preparation of this volume.

Eva March Tappan.

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[1]
THE INDUSTRIAL READERS

BOOK III

# MAKERS OF MANY THINGS

## I

## THE LITTLE FRICTION MATCH

I remember being once upon a time ten miles from a store and one mile from a neighbor; the fire had gone out in the night, and the last match failed to blaze. We had no flint and steel. We were neither Indians nor Boy Scouts, and we did not know how to make a fire by twirling a stick. There was nothing to do but to trudge off through the snow to the neighbor a mile away and beg some matches. Then was the time when we appreciated the little match and thought with profound respect of the men who invented and perfected it.

It is a long way from the safe and reliable match of to-day back to the splinters that were soaked in chemicals and sold together with little bottles of sulphuric acid. The splinter was expected to blaze when dipped into the acid. Sometimes it did blaze, and sometimes it did not; but it was reasonably certain how the acid would behave, for it would always sputter and do its best to spoil some one's clothes. Nevertheless, even such matches as these were [2] regarded as a wonderful convenience, and were sold at five dollars a hundred. With the next kind of match that appeared, a piece of folded sandpaper was sold, and the buyer was told to pinch it hard and draw the match through the fold. These matches were amazingly cheap—eighty-four of them for only twenty-five cents! There have been all sorts of odd matches. One kind actually had a tiny glass ball at the end full of sulphuric acid. To light this, you had to pinch the ball and the acid that was thus let out acted upon the other chemicals on the match and kindled it—or was expected to kindle it, which was not always the same thing.

Making matches is a big business, even if one hundred of them are sold for a cent. It is estimated that on an average each person uses seven matches every day. To provide so many would require some seven hundred million matches a day in this country alone. It seems like a very simple matter to cut a splinter of wood, dip it into some chemicals, and pack it into a box for sale; and it would be simple if it were all done by hand, but the matches would also be irregular and extremely expensive. The way to make anything cheap and uniform is to manufacture it by machinery.


THE ENDLESS MATCH MACHINE

The match splints are set in tiny holes like pins in a pincushion, and the belt revolves, passing their heads through various chemicals.

The first step in making matches is to select some white-pine plank of good quality and cut it into blocks of the proper size. These are fed into a machine which sends sharp dies through them and thus cuts the match splints. Over the splint cutter a carrier chain is continuously moving, and into holes [4] in this chain the ends of the match splints are forced at the rate of ten or twelve thousand a minute.

The splints remain in the chain for about an hour, and during this hour all sorts of things happen to them. First, they are dipped into hot paraffin wax, because this will light even more easily than wood. As soon as the wax is dry, the industrious chain carries them over a dipping-roll covered with a layer consisting partly of glue and rosin. Currents of air now play upon the splint, and in about ten minutes the glue and rosin on one end of it have hardened into a hard bulb. It is not a match yet by any means, for scratching it would not make it light. The phosphorus which is to make it into a match is on another dipping-roll. This is sesqui-sulphide of phosphorus. The common yellow phosphorus is poisonous, and workmen in match factories where it was used were in danger of suffering from a terrible disease of the jaw bone. At length it was discovered that sesqui-sulphide of phosphorus would make just as good matches and was harmless. Our largest match company held the patent giving them the exclusive right to certain processes by which the sesqui-sulphide was made; and this patent they generously gave up to the people of the United States.

After the splints have been dipped into the preparation of phosphorus, they are carried about on the chain vertically, horizontally, on the outside of some wheels and the inside of others, and through currents of air. Then they are turned over to a chain divided [5] into sections which carries them to a packing-machine. This machine packs them into boxes, a certain number in each box, and they are slid down to girls who make the boxes into packages. These are put into wooden containers and are ready for sale.

As in most manufactures, these processes must be carried on with great care and exactness. The wood must be carefully selected and of straight grain, the dipping-rolls must be kept covered with a fresh supply of composition, and its depth must be always uniform. Even the currents of air in which the splints are dried must be just warm enough to dry them and just moist enough not to dry them too rapidly.

The old sulphur matches made in "card and block" can no longer be bought in this country; the safety match has taken their place. One kind of safety match has the phosphorus on the box and the other igniting substances on the match, so that the match will not light unless it is scratched on the box; but this kind has never been a favorite in the United States. The second kind, the one generally used, may be struck anywhere, but these matches are safe because even stepping upon one will not light it; it must be scratched.

A match is a little thing, but nothing else can do its work.

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# II

# ABOUT INDIA RUBBER

When you pick a dandelion or a milkweed, a white sticky "milk" oozes out; and this looks just like the juice of the various sorts of trees, shrubs, and vines from which India rubber is made. The "rubber plant" which has been such a favorite in houses is one of these; in India it becomes a large tree which has the peculiar habit of dropping down from its branches "bush-ropes," as they are called. These take root and become stout trunks. There is literally a "rubber belt" around the world, for nearly all rubber comes from the countries lying between the Tropic of Cancer and the Tropic of Capricorn. More than half of all that is brought to market is produced in the valley of the Amazon River; and some of this "Para rubber," as it is called, from the seaport whence it is shipped, is the best in the world.

Courtesy General Rubber Co.

TAPPING RUBBER TREES IN SUMATRA

The plantation on which this photograph was taken has 45,000 acres of planted rubber trees, and employs 14,000 coolies.

The juice or latex flows best about sunrise, and so the natives who collect it have to be early risers. They make little cuts in the bark of the tree, stick on with a bit of clay a tiny cup underneath each cut, and move on through the forest to the next tree. Sometimes they make narrow V-shaped cuts in the bark, one above another, but all coming into a perpendicular channel leading to the foot of the [8] tree. Later in the day the collectors empty the cups into great jugs and carry them to the camp.

When the rubber juice reaches the camp, it is poured into a great bowl. The men build a fire of sticks, and always add a great many palm nuts, which are oily and make a good deal of smoke. Over the fire they place an earthen jar shaped like a cone, but without top or bottom. Now work begins. It is fortunate that it can be done in the open air, and that the man can sit on the windward side, for the smoke rises through the smaller hole thick and black and suffocating. The man takes a stick shaped like a paddle, dips it into the bowl, and holds it in the smoke and heat, turning it rapidly over and over till the water is nearly dried out of the rubber and it is no longer milky, but dark-colored. Then he dips this paddle in again and again. It grows heavier at each dipping, but he keeps on till he has five or six pounds of rubber. With a wet knife he cuts this off, making what are called "biscuits." After many years of this sort of work, some one found that by resting one end of a pole in a crotched stick and holding the other in his hand, a man could make a much larger biscuit.

For a long time people thought that rubber trees could not be cultivated. One difficulty in taking them away from their original home to plant is that the seeds are so rich in oil as to become rancid unusually soon. At length, however, a consignment of them was packed in openwork baskets between layers of dried wild banana leaves and slung up on deck [9] in openwork crates so as to have plenty of air. By this means seven thousand healthy little plants were soon growing in England, and from there were carried to Ceylon and the East.

On the rubber plantations collecting juice from trees standing near together and in open ground is an altogether different matter from cutting a narrow path and forcing one's way through a South American or African jungle. The bark of the trees is cut in herringbone fashion. The collector simply slices a thin piece off the bark and at once milk begins to ooze out.

On the great plantations of the East the rubber is collected chiefly by Chinese and Indians. They are carefully taught just how to tap the trees. They begin four or five feet from the ground, and work down, cutting the thinnest possible slice at each visit. When they have almost reached the ground, they begin on the opposite side of the trunk; and by the time they have reached the ground on that side the bark on the first side has renewed itself. The latex is strained and mixed with some acid, usually acetic, in order to coagulate or thicken it. It is then run between rollers, hung in a drying house, and generally in a smokehouse.

The rubber arrives at the factory in bales or cases. First of all it must be thoroughly washed in order to get rid of sand or bits of leaves and wood. A machine called a "washer" does this work. It forces the rubber between grooved rolls which break it up; and as this is done under a spray of water, the [10] rubber is much cleaner when it comes out. Another machine makes it still cleaner and forms it into long sheets about two feet wide.

Having thoroughly wet the rubber, the next step is to dry it thoroughly. The old way was to hang it up for several weeks. The new way is to cut it into strips, lay it upon steel trays, and place it in a vacuum dryer. This is kept hot, and whatever moisture is in the rubber is either evaporated or sucked out by a vacuum pump. It now passes through another machine much like the washer, and is formed into sheets. The square threads from which elastic webbing is made may be cut from these sheets, though sometimes the sheet is wound on an iron drum, vulcanized by being put into hot water, lightly varnished with shellac to stiffen it, then wound on a wooden cylinder, and cut into square threads. Boiling these in caustic soda removes the shellac. To make round threads, softened rubber is forced through a die. Rubber bands are made by cementing a sheet of rubber into a tube and then cutting them off at whatever width may be desired. Toy balloons are made of such rubber. Two pieces are stamped out and joined by a particularly noisy machine, and then the balloon is blown out by compressed air.

Early in the nineteenth century it was known that rubber would keep out water, but it was sticky and unmanageable. After a while a Scotch chemist named McIntosh succeeded in dissolving rubber in naphtha and spreading it between two thicknesses of [11] cloth. That is why his name is given to raincoats made in this way. Overshoes, too, were made of pure rubber poured over clay lasts which were broken after the rubber had dried. These overshoes were waterproof,—there was no denying that; but they were heavy and clumsy and shapeless. When they were taken off, they did not stand up, but promptly fell over. In hot weather they became so sticky that they had to be kept in the cellar; and in winter they became stiff and inelastic, but they never wore out. How to get rid of the undesirable qualities and not lose the desirable ones was the question. It was found out that if sulphur was mixed with rubber, the disagreeable stickiness would vanish; but the rubbers continued to melt and to freeze by turns until an American named Charles Goodyear discovered that if rubber mixed with sulphur was exposed to about 300° F. of heat for a number of hours, the rubber would remain elastic, but would not be sticky and would no longer be affected by heat or cold. This is why you often see the name Goodyear on the bottom of rubbers.

Rubber overshoes were improved at once. As they now are made, the rubber is mixed with sulphur, whiting, litharge, and several other substances. An honest firm will add only those materials that will be of service in making the rubber more easy to mould or will improve it in some way. Unfortunately, substances are often added, not for this purpose, but to increase the weight and apparent value of the articles. That is why some rubber overshoes, [12] for instance, wear out so much faster than others.

To make an overshoe, the rubber is run through rollers and formed into thick sheets for soles and thinner sheets for uppers. Another machine coats with gum the cloth used for lining and stays. Rubber and rubber-lined cloth go to the cutting-room, where all the different parts of the shoes are cut out. They are then put together and varnished. While still on the last, they are dipped into a tank of varnish and vulcanized—a very simple matter now that Goodyear has shown us how, for they are merely left in large, thoroughly heated ovens for eight or ten hours. The rubber shoe or boot is now elastic, strong, waterproof, ready for any temperature, and so firmly cemented together with rubber cement that it is practically all in one piece.

During the last few years there have been frequent calls from various charities for old rubber overshoes, pieces of rubber hose, etc. These are of considerable value in rubber manufacturing. They are run through a machine which tears them to shreds, then through a sort of fanning-mill which blows away the bits of lining. Tiny pieces of iron may be present from nails or rivets; but these are easily removed by magnets. This "reclaimed" rubber is powdered and mixed with the new, and for some purposes the mixture answers very well. Imitation rubber has been made by heating oil of linseed, hemp, maize, etc., with sulphur; but no substitute for rubber is a success for all uses.

[13]
Click here to see a larger version of this photo.

Courtesy U. S. Tire Co.

HOW RUBBER GOES THROUGH THE FACTORY

Splitting Para biscuits, mixing the rubber, rolling the rubber fabric on cylinders, and building tires on the tire machines.
[14]

There are many little conveniences made of rubber which we should greatly miss, such as the little tips put into pencil ends for erasing pencil marks. These are made by filling a mould with rubber. Rubber corks are made in much the same manner. Tips for the legs of chairs are made in a two-piece mould larger at the bottom than at the top, and with a plunger that nearly fits the small end. Often on chair tips and in the cup-shaped eraser that goes over the ends of some pencils you can see the "fin," as the glassworkers call it, where the two pieces of the mould did not exactly fit. Rubber cannot be melted and cast in moulds like iron, but it can be gently heated and softened, and then pressed into a mould. Rubber stamps are made in this way. The making of rubber heels and soles is now a large industry; hose for watering and for vacuum and Westinghouse brakes is made in increasing quantities. The making of rubber tires for automobiles and carriages is an important industry. The enormous and increasing use of electricity requires much use of rubber as an insulator. Rubber gloves will protect an electrical workman from shock and a surgeon from infection. Rubber beds and cushions filled with air are a great comfort in illness. Rubber has great and important uses;

but we should perhaps miss quite as much the little comforts and conveniences which it has made possible.

Rubber and gutta-percha are not the same substance by any means. Both of them are made of the milky juice of trees, but of entirely different trees. [15] The gutta-percha milk is collected in an absurdly wasteful manner, namely, by cutting down the trees and scraping up the juice. When this juice reaches the market, it is in large reddish lumps which look like cork and smell like cheese. It has to be cleaned, passed through a machine that tears it into bits, then between rollers before it is ready to be manufactured. It is not elastic like rubber; it may be stretched; but it will not snap back again as rubber does. It is a remarkably good nonconductor of electricity, and therefore it has been generally used to protect ocean cables, though recently rubber has been taking its place. It makes particularly excellent casts, for when it is warm it is not sticky, but softens so perfectly that it will show the tiniest indentation of a mould. It is the best kind of splint for a broken bone. If a boy breaks his arm, a surgeon can put a piece of gutta-percha into hot water, set the bone, bind on the softened gutta-percha for a splint, and in a few minutes it will be moulded to the exact shape of the arm, but so stiff as to keep the bone in place. Another good service which gutta-percha renders to the physician results from its willingness to dissolve in chloroform. If the skin is torn off, leaving a raw surface, this dissolved gutta-percha can be poured over it, and soon it is protected by an artificial skin which keeps the air from the raw flesh and gives the real skin an opportunity to grow again.

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# III

# "KID" GLOVES

There is an old proverb which says, "For a good glove, Spain must dress the leather, France must cut it, and England must sew it." Many pairs of most excellent gloves have never seen any one of these countries, but the moral of the proverb remains, namely, that it takes considerable work and care to make a really good glove.

The first gloves made in the United States were of thick buckskin, for there was much heavy work to be done in the forest and on the land. The skin was tanned in Indian fashion, by rubbing into the flesh side the brains of the deer—though how the Indians ever thought of using them is a mystery. Later, the white folk tried to tan with pigs' brains; but however valuable the brains of a pig may be to himself, they do not contain the properties of soda ash which made those of the deer useful for this purpose.

CUTTING HIDES INTO GLOVES

The hides are kept in racks, and before cutting are stretched by hand. Then the steel die cuts out the shape of the glove. Notice the curiously shaped cut for the thumb.

Years ago, when a man set out to manufacture gloves, usually only a few dozen pairs, he cut out a pattern from a shingle or a piece of pasteboard, laid it upon a skin, marked around it, and cut it out with shears. Pencils were not common, but the glovemaker was fully equal to making his own. He melted some lead, ran it into a crack in the kitchen floor—and cracks were plentiful—and then used [18] this "plummet," as it was called, for a marker. After cutting the large piece for the front and back of the glove, he cut out from the scraps remaining the "fourchettes," or *forks*; that is, the narrow strips that make the sides of the fingers. Smaller scraps were put in to welt the seams; and all this went off in great bundles to farmhouses to be sewed by the farmers' wives and daughters for the earning of pin-money. If the gloves were to be the most genteel members of the buckskin race, there was added to the bundle a skein of silk, with which a slender vine was to be worked on the back of the hand. The sewing was done with a needle three-sided at the point, and a stout waxed thread was used. A needle of this sort went in more easily than a round one, but even then it was rather wearisome to push it through three thicknesses of stout buckskin. Moreover, if the sewer happened to take hold of the needle too near the point, the sharp edges were likely to make little cuts in her fingers.

After a while sewing machines were invented, and factories were built, and now in a single county of the State of New York many thousand people are at work making various kinds of leather coverings for their own hands and those of other folk. Better methods of tanning have been discovered, and many sorts of leather are now used, especially for the heavier gloves. Deer are not so common as they used to be, and a "buckskin" glove is quite likely to have been made of the hide of a cow or a horse. [19] "Kid" generally comes from the body of a sheep instead of that of a young goat. Our best real kidskin comes from a certain part of France, where the climate seems to be just suited to the young kids, there is plenty of the food that they like, and, what is fully as important, they receive the best of care. It is said that to produce the very finest kidskin, the kids are fed on nothing but milk, are treated with the utmost gentleness, and are kept in coops or pens carefully made so that there shall be nothing to scratch their tender skins.

Glovemakers are always on the lookout for new kinds of material, and when, not many years ago, there came from Arabia with a shipment of Mocha coffee two bales of an unknown sort of skin, they were eager to try it. It tanned well and made a glove that has been a favorite from the first. The skin was found to come from a sheep living in Arabia, Abyssinia, and near the headwaters of the river Nile. It was named Mocha from the coffee with which it came, and Mocha it has been ever since. The Suède glove has a surface much like that of the Mocha. Its name came from "Swede," because the Swedes were the first to use the skin with the outside in.

Most of our thinner "kid" gloves are made of lambskin; but dressing the skins is now done so skillfully in this country that "homemade" gloves are in many respects fully as good as the imported; indeed, some judges declare that in shape and stitching certain grades are better. When sheepskins and lambskins [20] come to market from a distance, they are salted. They have to be soaked in water, all bits of flesh scraped off, and the hair removed, generally by the use of lime. After another washing, they are put into alum and salt for a few minutes; and after washing this off, they are dried, stretched, and then are ready for the softening. Nothing has been found that will soften the skins so perfectly as a mixture of flour, salt, and the yolk of eggs—"custard," as the workmen call it. The custard and the skins are tumbled together into a great iron drum which revolves till the custard has been absorbed and the skins are soft and yielding. Now they are stretched one way and another, and wet so thoroughly that they lose all the alum and salt that may be left and also much of the custard.

Now comes dyeing. The skin is laid upon a table, smooth side up, and brushed over several times with the coloring matter; very lightly, however, for if the coloring goes through the leather, the hands of the customers may be stained and they will buy no more gloves of that make. The skins are now moistened and rolled and left for several weeks to season. When they are unrolled, the whole skin is soft and pliable. It is thick, however, and no one who is not an expert can thin it properly. The process is called "mooning" because the knife used is shaped like a crescent moon. It is flat, its center is cut out, and the outer edge is sharpened. Over the inner curve is a handle. The skin is hung on a pole, and the expert workman draws the mooning knife down [22] it until any bit of dried flesh remaining has been removed, and the skin is of the same thickness, or, rather, thinness throughout.

All this slow, careful work is needed to prepare the skin for cutting out the glove; and now it goes to the cutter. There is no longer any cutting out of gloves with shears and pasteboard patterns, but there is a quick way and a slow way nevertheless. The man who cuts in the quick way, the "block-cutter," as he is called, spreads out the skin on a big block made by bolting together planks of wood with the grain running up and down. He places a die in the shape of the glove upon the leather, gives one blow with a heavy maul, and the glove is cut out. This answers very well for the cheaper and coarser gloves, but to cut fine gloves is quite a different matter. This needs skill, and it is said that no man can do good "table-cutting" who has not had at least three years' experience; and even then he may not be able to do really first-class work. He dampens the skin, stretches it first one way and then the other, and examines it closely for flaws or scratches or weak places. He must put on his die in such a way as to get two pairs of ordinary gloves or one pair of "elbow gloves" out of the skin if possible, and yet he must avoid the poor places if there are any. No glove manufacturer can afford to employ an unskilled or careless cutter, for he will waste much more than his wages amount to. There used to be one die for the right hand and another for the left, and it was some time before it occurred to [23] any one that the same die would cut both gloves if only the skin was turned over.

CLOSING THE GLOVE

When sewing time comes, the glove goes from hand to hand down the workroom, each stitcher doing a certain seam or seams.


WHERE THE GLOVE GETS ITS SHAPE

After inspection the glove goes to a row of men who fit it on a steam-heated brass hand, giving it its final shape and finish.

Now comes the sewing. Count the pieces in a glove, and this will give some idea of the work needed to sew them together. Notice that the fourchettes are sewed together on the wrong side, the other seams on the right side, and that the tiny bits of facing and lining are hemmed down by hand. Notice that two of the fingers have only one fourchette, while the others have two fourchettes each. Notice how neatly the ends of the fingers are finished, with never an end of thread left on the right side. The embroidery must be in exactly the right place, and it must be fastened firmly at both ends. This embroidery is not a meaningless fashion, for the lines make the hand look much more slender and of a better shape. Sewing in the thumbs needs special care and skill. There must be no puckering, and the seam must not be so tightly drawn as to leave a red line on the hand when the glove is taken off. No one person does all the sewing on a glove; it must pass through a number of hands, each doing a little. Even after all the care that is given it, a glove is a shapeless thing when it comes from the sewing machines. It is now carried to a room where stands a long table with a rather startling row of brass hands of different sizes stretching up from it. These are heated, the gloves are drawn upon them, and in a moment they have shape and finish, and are ready to be inspected and sold.

The glove is so closely associated with the hand and [24] with the person to whom the hand belongs that in olden times it was looked upon as representing him. When, for instance, a fair could not be opened without the presence of some noble, it was enough if he sent his glove to represent him. To throw down one's glove before a man was to challenge him to a combat. At the coronation of Queen Elizabeth, as of many other sovereigns of England, the "Queen's champion," a knight in full armor, rode into the great hall and threw down his glove, crying, "If there be any manner of man that will say and maintain that our sovereign Lady, Queen Elizabeth, is not the rightful and undoubted inheritrix to the imperial crown of this realm of England, I say he lieth like a false traitor, and therefore I cast him my gage."

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[25]

# IV

# HOW RAGS AND TREES BECOME PAPER

It was a great day for the children on the farm when the tin peddler came around. He had a high red wagon, fairly bristling with brooms, mop-handles, washtubs, water-pails, and brushes. When he opened his mysterious drawers and caverns, the sunshine flashed upon tin pans, dippers, dustpans, and basins. Put away rather more choicely were wooden-handled knives, two-tined forks, and dishes of glass and china; and sometimes little tin cups painted red or blue and charmingly gilded, or cooky-cutters in the shape of dogs and horses. All these rare and delightful articles he was willing to exchange for rags. Is it any wonder that the thrifty housewife saved her rags with the utmost care, keeping one bag for white clippings and one for colored?

These peddlers were the great dependence of the paper mills, for the finest paper is made from linen and cotton rags. When the rags reach the factory, they are carefully sorted. All day long the sorters sit before tables whose tops are covered with coarse wire screens, and from masses of rags they pick out buttons, hooks and eyes, pins, bits of rubber, and anything else that cannot possibly be made into paper. At the same time they sort the rags carefully into different grades, and with a knife shaped like a small sickle fastened upright to the table they cut [26] them into small pieces. Some of the dust falls through the screen; but to remove the rest of it, the cut-up rags are tossed about in a wire drum. Sometimes they are so dusty that when they come out of the drum they weigh only nine tenths as much as when they go in. The dust is out of them, but not the dirt. To remove that, they are now put into great boilers full of steam; and here they cook and turn over, and turn over and cook for hours. Lime and sometimes soda are put with them to cleanse them and remove the coloring material; but when they are poured out, they look anything but clean, for they are of a particularly dirty brown; and the water that is drained away from them looks even more uninteresting. Of course the next step is to wash this dirty brown mass; and for at least four hours it is scrubbed in a machine which beats it and rolls it and chops it and tumbles it about until the wonder is that anything is left of it. All this while, the water has been flowing through it, coming in clean and going out dirty; and at length the mass becomes so light a gray that making white paper of it does not seem quite hopeless. It is now bleached with chloride of lime, and washed till it is of a creamy white color and free from the lime, and then beaten again. If you fold a piece of cheap paper and tear it at the fold, it will tear easily; but if you do the same thing with paper made of linen and cotton, you will find it decidedly tough. Moreover, if you look closely at the torn edge of the latter, you will see the fibers clearly. It is because of [27] the beating that the fibers are so matted together and thus make the paper tough. While the pulp is in the beater, the manufacturer puts in the coloring matter, if he wishes it to be tinted blue or rose or lavender or any other color. No one would guess that this white or creamy or azure liquid had ever been the dirty rags that came into the mill and were sorted on the wire tables. Besides the coloring, a "filler" is usually added at this time, such as kaolin, the fine clay of which china is made. This fills the pores and gives a smoother surface to the finished paper—a good thing if too much is not put in. A little sizing is also added, made of rosin. Save for this sizing, ink would sink into even the finished paper as it does into blotting paper. After this, more water is added to the pulp and it is run into tanks.

Now the preparation is completed, and the pulp is pumped to large and complicated machines which undertake to make it into paper. It first flows through screens which are shaken all the while as if they were trembling. This shaking lets the liquid and the finer fibers through, but holds back the little lumps, if any remain after all the beating and straining and cutting that it has had. The pulp flows upon an endless wire screen. Rubber straps at the sides keep it in, but the extra water drops through the meshes. The pulp is flowing onward, and so the tiny fibers would naturally straighten out and flow with it, like sticks in a river; but the wire screen is kept shaking sideways, and this helps the [28] fibers to interlace, and the paper becomes nearly as strong one way as the other.

If you hold a sheet of paper up to the light, it will show plainly what is next done to it. Sometimes you can see that it is marked by light parallel lines running across it close together, and crossed by other and stouter lines an inch or two apart. Sometimes the name of the paper or that of the manufacturer is marked in the same way by letters lighter than the rest of the sheet. Sometimes the paper is plain with no markings whatever. This difference is made by what is called the "dandy," a cylinder covered with wire. For the first, or "laid" paper, the small wires run the length of the cylinder and the stouter ones around it. Wherever the wires are, the paper is a little thinner. In some papers this thinness can be seen and felt. For the second kind of paper the design, or "watermark," is formed by wires a little thicker than the rest of the covering. For the third, or "wove" paper, the dandy is covered with plain woven wire like that of the wire cloth; so there are no markings at all. This work can be easily done because at this point the paper is so moist.

The paper is now not in sheets, but in a long web like a web of cloth. It passes between felt-covered rollers to press out all the water possible, then over steam-heated cylinders to be dried, finally going between cold iron rollers to be made smooth, and is wound on a reel, trimmed and cut into sheets of whatever size is desired. The finest note papers are [29] not finished in this way, but are partly dried, passed through a vat of thin glue, any excess being squeezed off by rollers, then cut into sheets, and hung up to dry thoroughly at their leisure.

Paper made of properly prepared linen and cotton is by far the best, but there are so many new uses for paper that there are not rags enough in the world to make nearly what is needed. There are scores of newspapers and magazines where there used to be one; and as for paper bags and cartons and boxes, there is no limit to their number and variety. A single manufacturer of pens and pencils calls for four thousand different sorts and sizes of boxes. School-children's use of paper instead of slates, the fashion of wrapping Christmas gifts in white tissue, and the invention of the low-priced cameras have increased enormously the amount of paper called for. In the attempt to supply the demand all sorts of materials have been used, such as hemp, old rope, peat, the stems of flax, straw, the Spanish and African esparto grass, and especially wood; but much more paper is made of wood than of all the rest together. Poplar, gum, and chestnut trees, and especially those trees which bear cones, such as the spruce, fir, balsam, and pine are used. There are two methods of manufacturing wood pulp; the mechanical, by grinding up the wood, and the chemical, by treating it chemically. By the mechanical method the wood is pressed against a large grindstone which revolves at a high speed. As fast as the wood is ground off, it is washed away by a [30] current of water, and strained through a shaking sieve and a revolving screen which drives out part of the water by centrifugal force. In a great vat of pulp a drum covered with wire cloth revolves, and on it a thin sheet of pulp settles. Felting, pressed against this sheet, carries it onward through rolls. The sheets are pressed between coarse sacking. Such paper is very poor stuff. In its manufacture the fiber of the wood is so ground up that it has little strength. It is used for cardboard, cartons, and packing-papers. Unfortunately, it is also used for newspapers; and while it is a good thing for some of them to drop to pieces, it is a great loss not to have the others permanent. When we wish to know what people thought about any event fifty years ago, we can look back to the papers of that time; but when people fifty years from now wish to learn what we thought, many of the newspapers will have fallen to pieces long before that time.

Courtesy S. D. Warren Co.

WHERE RAGS BECOME PAPER

The vat where the rags cook and turn over, and the big room where the web of finished paper is passed through rollers and cut into a neat pile of trimmed sheets.

There is, however, a method called the "sulphite process," used principally in treating the coniferous woods, by which a much better paper can be made. In all plants there is a substance called "cellulose." This is what gives strength to their stems. The wood is chipped and put into digesters large enough to hold twenty tons, and is steam-cooked together with bisulphite of magnesium or calcium for seven or eight hours. Another method used for cooking such woods as poplar and gum, is to boil the wood in caustic soda, which destroys everything except the cellulose. Wood paper of one kind or another [32] is used for all daily papers and for most books. Whether the best wood paper will last as long as the best rag paper, time only can tell.

The Government of the United States tests paper in several ways before buying it. First, a single sheet is weighed; then a ream is put on the scales to see if it weighs four hundred and eighty times as much. This shows whether the paper runs evenly in weight. Many sheets are folded together and measured to see if the thickness is regular. To test its strength, a sheet is clamped over a hole one square inch in area, and liquid is pressed against it from below to see how much it will stand before bursting. Strips of the paper are pulled in a machine to test its breaking strength. A sheet is folded over and over again to see whether holes will appear at the corners of the folds. It is examined under the microscope to see of what kind of fibers it is made and how much loading has been used in its manufacture. To test blotting paper, strips are also put into water to see how high the water will rise on them.

Besides writing and wrapping papers and the various kinds of board, there are many sorts which are used for special purposes. India paper, for instance, is light, smooth, and strong, so opaque that printing will not show through it, and so lasting that if it is crumpled, it can be ironed out and be as good as new. This is used for books that are expected to have hard wear but must be of light weight. There are tissue papers, crêpe papers for napkins, [33] and tarred paper to make roofs and even boats water-tight. If tar is brushed on, it may make bubbles which will break afterwards and let water in; but if tar is made a part of the paper itself, it lasts. Paper can easily be waxed or paraffined, and will then keep out air and moisture for some time. Better still, it can be treated with oil and will then make a raincoat that will stand a year's wear, or even, if put on a bamboo frame, make a very good house, as the Japanese found out long ago. Paper coated with powdered gum and tin is used for packing tea and coffee. Transfer or carbon papers so much used in making several copies of an article on the typewriter are made by coating paper with starch, flour, gum, and coloring matter. Paper can be used for shoes and hats, ties, collars, and even for "rubbers." It has been successfully used for sails for light vessels, and is excellent made into light garments for hospital use because it is so cheap that it can be burned after wearing. Wood pulp can be run through fine tubes into water and made so pliable that it can be twisted into cord or spun and woven into "silk." Not only water but also fire can be kept out by paper if it is treated with the proper substances. An object can be covered with a paste of wood pulp, silica, and hemp; and when this is dry, a coat of water-glass will afford considerable protection. There has been some degree of success in making transparent paper films for moving pictures; and if these are coated with water-glass, they will not burn. Paper can be so treated that [34] it will either conduct electricity or become a nonconductor, as may be desired. In Germany, a "sandwich paper" has been made by pressing together four layers—felt, pulp, cotton, pulp—which is cheap and strong and useful for many purposes.

When we come to papier maché, there is no end to the kinds of articles that are made of it. The papier maché, or *paper pulped*, is made by kneading old newspapers or wrapping papers with warm water into a pulp. Clay and coloring are added and something of the nature of glue; and it is then put into a mould. Sometimes to make it stronger for large mouldings, bits of canvas or even wire are also used. The best papier maché is made of pure wood cellulose. The beautiful boxes and trays covered with lacquer which the Japanese and Chinese make are formed of this; but it has many much humbler uses than these. Paper screws are employed in ornamental wood work, and if a hole is begun for such a screw, it will twist its way into soft wood as well as steel would do. Barrels of paper reinforced with wire are common. Gear wheels and belt pulleys are made of papier maché, and even the wheels of railroad coaches; at least the body of the wheels is made of it, although the tire, hub, and axle are of cast-steel. Circular saws of pulp are in use which cut thin slices of veneer so smoothly that they can be used without planing. Papier maché is used for water pipes, the bodies of carriages, hencoops, and garages. Indeed, it is quite possible [35] to build a house, shingle it, decorate it with elaborate mouldings and cornices, finish it with panels, wainscoting, imitation tiling, and furnish it with light, comfortable furniture covered with imitation leather, silk, or cloth, and spread on its floors soft, thick carpets or rugs woven in beautiful designs—and all made of wood pulp. Even the window panes could be made of pulp; and if they were not perfectly transparent, they would at least let in a soft, agreeable light, and they would not break. Pails, washtubs, bathtubs, and even dishes of paper can be easily found. There are not only the paper cups provided on railroad trains and the cheap picnic plates and saucers, but some that are really pretty. Ice cream is sometimes served in paper dishes and eaten with paper spoons. Milk bottles are successfully made of paper, with a long strip of some transparent material running up and down the side to show how much—or how little—cream is within. Napkins and tablecloths made of paper thread woven into "cloth" are cheaper than linen and can be washed as easily. Paper towels and dishcloths are already common; but when paper shall fully come to its own, it is quite possible that there will be little washing of dishes. They can be as pretty as any one could wish, but so cheap that after each meal they can be dropped into the fire. Indeed, there are few things in a house, except a stove, that cannot be made of some form of paper,—and perhaps that too will be some day.

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# V

# HOW BOOKS ARE MADE

The first step in making ready to print a manuscript is to find out how many words there are in it, what kind of type to use, how much "leading" or space between the lines there shall be, and what shall be the size of the page. In deciding these questions, considerable thinking has to be done. If the manuscript is a short story by a popular author, it may be printed with wide margins and wide leading in order to make a book of fair size. If it is a lengthy manuscript which will be likely to sell at a moderate but not a high price, it is best to use only as much leading as is necessary to make the line stand out clearly, and to print with a margin not so wide as to increase the expense of the book. The printer prints a sample of the page decided upon, any desired changes are made, and then the making of the book begins.

Courtesy The Riverside Press.

WHERE THIS BOOK WAS SET UP

The monotype girl wrote these words on her keyboard, where they made tiny holes in a roll of paper. The roll went to the casting-room where it guided a machine to make the type much as a perforated music-roll guides a piano to play a tune.

The type is kept in a case at which the compositor stands. This case is divided into shallow compartments, each compartment containing a great many e's or m's as the case may be. The "upper case" contains capitals; the "lower case," small letters. Those letters which are used most often are put where the compositor can reach them most readily. He stands before his case with a "composing [38] stick" in his hand. This "stick" is a little iron frame with a slide at the side, so that the line can be made of any length desired. The workman soon learns where each letter is, and even an apprentice can set the type in his stick reasonably rapidly. On one side of every piece of type there is a groove, so that he can tell by touch whether it is right side up or not. He must look out especially to make his right-hand margins regular. You will notice in books that the lines are all of the same length, although they do not contain the same number of letters. The compositor brings this about by arranging his words and spaces skillfully. The spaces must be as nearly as possible of the same length, and yet the line must be properly filled. If a line is too full, he can sometimes place the last syllable on the following line; if it is not full enough, he can borrow a syllable, and he can at least divide his space so evenly that the line will not look as if it were broken in two.

Not many years ago all type was set in this manner; but several machines have now been invented which will do this work. In one of the best of them the operator sits before a keyboard much like that of a typewriter. When he presses key *a*, for instance, a mould or matrix of the letter *a* is set free from a tube of *a*'s, and slides down to its place in the stick. At the end of the line, the matrices forming it are carried in front of a slot where melted type metal from a reservoir meets them. Thus a cast is made of the matrices, and from this cast the printing [39] is done. This machine is called a linotype because it casts a whole line of type at a time.

Most book work is done on the monotype machine. When a manuscript goes to the press to be set up in this way, the copy is given to the keyboard operator who sets it up on a machine which looks much like a typewriter. Instead of writing letters, however, the machine punches tiny holes in a strip of paper which is wound on a roll. When the roll is full it goes to the casting room where it is put on another machine containing hot type metal and bronze matrices from which the letters of the words are to be cast. The holes in the paper guide the machine to make the type much as a perforated music roll guides a piano to play a tune. The reason why the machine is called a monotype is that the letters are made one at a time, and *monos* is the Greek word for *one*.

By the linotype and monotype machines type can be set in a "galley," a narrow tray about two feet long, with ledges on three sides. When a convenient number of these galleys have been filled, long slips are printed from them called "galley proofs." These have wide margins, but the print is of the width that the page of the book will be. They are read by the proof-readers, and all such mistakes as the slipping in of a wrong letter, or a broken type, the repetition of a word, or the omission of space between words are corrected. Then the proof goes to the author, who makes any changes in his part of the work which seem to him desirable; and it is also [40] read by some member of the editorial department. If there are many changes to be made, another proof is usually taken and sent to the author.

The reason for this extreme carefulness is that it costs much less to make changes in the galley proof than in the "page proof." This latter is made by dividing the galley into pages, leaving space for the beginnings of chapters and for pictures, if any are to appear on the printed pages, and setting up the numbers of the pages and their running titles. Page proof also goes to proof-readers and to the author. Corrections on page proof are more expensive than on galley proof because adding or striking out even a few words may make it necessary to change the arrangement on every page to the end of the chapter.

Years ago all books were printed directly from the type; and some are still printed so. After printing, the letters were returned to their compartments. If a second edition was called for, the type had to be set again. Now, however, books are generally printed not from type, but from a copper model of the type. To make this, an impression of the page of type is made in wax and covered with graphite, which will conduct electricity. These moulds are hung in a bath of copper sulphate, where there are also large plates of copper. A current of electricity is passed through it, and wherever the graphite is, a shell of copper is deposited, which is exactly like the face of the type. This shell is very thin, but it is made strong by adding a heavy back of [41] melted metal. From these plates the books are printed. A correction made in the plate is more expensive than it would have been if made in the galley or in the page, because sawing out a word or a line is slow, delicate work; and even if one of the same length is substituted, the types spelling it have to be set up, a small new plate cast, and soldered in.

Courtesy The Riverside Press.

WHERE THIS BOOK WAS PRINTED

The girls are feeding big sheets of paper into the presses, thirty-two pages being printed at one time. The paper is fed into many modern presses by means of a machine attached to the press. The pressmen see that the printing is done properly.

Printing one page at a time would be altogether too slow; therefore the plates are arranged in such a way that sixteen, thirty-two, or sometimes sixty-four pages can be printed on one side of the paper, and the same number on the other side. Every page [42] must come in its proper place when the sheet is folded for binding. Try to arrange a sheet of even sixteen pages, eight on each side, so that when it is folded every page will be in the right place with its printing right side up, and you will find that it is not very easy until you have had considerable experience. If the sheet is folded into four leaves, the book is called a "quarto," or "4to"; if into eight, it is an "octavo," or "8vo"; if into twelve, a "duodecimo," or "12mo." Books are sometimes advertised in these terms; but they are not definite, because the sheets of the different varieties of paper vary in size. Of late years, publishers have often given the length and width of their books in inches.

After the sheets come from the press, they are folded to page size. Sometimes this is done by hand, but more often by a folding machine through which the sheet of paper travels, meeting blunt knives which crease it and fold it. If you look at the top of a book you will see that the leaves are put together in groups or "signatures." These signatures usually contain eight, sixteen, or thirty-two pages. If the paper is very thick, not more than eight leaves will be in a signature; if of ordinary thickness, sixteen are generally used. The signatures are piled up in order, and a "gatherer" collects one from each pile for every book.

The book is now gathered and "smashed," or pressed enough to make it solid and firm for binding.

Next the signatures are sewed and the book is trimmed so the edges will be even. If the edges are [43] to be gilded, the book is put in a gilding press and a skillful workman covers the edges with a sizing made of the white of eggs. Gold leaf is then laid upon them and they are burnished with tools headed with agate and bloodstone or instruments of various sorts until they are bright. Sometimes the edges are "marbled," and this is an interesting process to watch. On the surface of a vat of thin sizing the marbler drops a little of many colors of paint. Then he draws a comb lightly across the surface, making all sorts of odd figures, no two alike. The book is held tight and the edges are allowed to touch the sizing. All these odd figures are now transferred to the edges of the leaves and will stand a vast amount of hard use before they will wear off.

Thus far the book is flat at the edges of the leaves and at the back. Books are sometimes bound in this way, but the backs are usually rounded into an outward curve, and the fronts into an inward curve. This is done by a machine. At each end of the outward curve a deep groove is pressed to receive the cover. To make the covers of a cloth-bound book, two pieces of pasteboard of the right size are cut and laid upon a piece of cloth coated with glue. The edges of the cloth are turned over and pressed down, as you can often see if the paper lining of the cover is not too heavy. The cover needs now only its decorations to be complete. A die is made for these, and the lettering and ornamentation are stamped on in colors. If more than one color is used, [44] a separate die has to be made for each. If this work is to be done in gold, the design is stamped on lightly and sizing made of white of eggs is brushed on wherever the gold is to come. Gold leaf is laid upon this sizing, and the cover is stamped again. The same die is used, but this time it is hot enough to make the gold and egg stick firmly to the cover. To put the cover on, a piece of muslin called a "super" is glued to the back of the book with its ends projecting over the sides, and a strip of cartridge paper is glued over the super. Then the book is pasted into the cover. It is now kept under heavy pressure for a number of hours until it is thoroughly dry and ready to be sent away for sale.

So it is that a well-made cloth-bound book is manufactured. Leather-bound books are more expensive, not only because their materials cost more, but also because the greater part of the work of binding and decorating has to be done by hand. If a book is to be illustrated, this must also be attended to, the number and style of the pictures decided upon, and the artist engaged before the book is put in press, in order that there may be no delay in completing it.

Many publishers do not print at all, but have their work done at some printing establishment. Where all the making of a book, however, from manuscript to cover, is in the hands of one firm, there is a certain fellow-feeling among the different departments, and a wholesome pride in making each one of "our books" as excellent as possible in every [45] detail. As one of the women workers in such an establishment said to me, "I often think that we become almost as interested in a book as the author is."

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# VI

# FROM GOOSE QUILLS TO FOUNTAIN PENS AND LEAD PENCILS

Whenever there was a convenient goosepond on the way to school, the children of less than one hundred years ago used to stop there to hunt for goose quills. They carried these to the teacher, and with his penknife—which took its name from the work it did—he cut them into the shape of pens. The points soon wore out, and "Teacher, will you please mend my pen?" was a frequent request.

When people began to make pens of steel, they made them as nearly like quill pens as possible, with pen and holder all in one. These were called "barrel pens." They were stiff, hard, and expensive, especially as the whole thing was useless as soon as the pen was worn out, but they were highly esteemed because they lasted longer than quills and did not have to be mended. After a while separate pens were manufactured that could be slipped into a holder; and one improvement after another followed until little by little the cheap, convenient writing tool that we have to-day was produced.

A pen is a small thing, but each one is worked upon by twenty to twenty-four persons before it is allowed to be sold. The material is the best steel. It comes in sheets five feet long and nineteen inches wide, and about one fortieth of an inch thick, that is, [47] three times as thick as the finished pen. The first machine cuts the sheet crosswise into strips from two to three inches wide, varying according to the size of the pen to be made. These strips are put into iron boxes and kept at a red heat for a number of hours to anneal or soften them. Then they pass between heavy rollers, a process which not only helps to toughen them, but also stretches the steel so that it is now fifty inches long instead of nineteen.

At least six or seven people have handled the material already, and even now there is nothing that looks like pens; but the next machine cuts them out, by dies, of course. The points interlap; and the cutting leaves odd-shaped openwork strips of steel for the scrap-heap. This part of the work is very quick, for the machine will cut thousands of pens in an hour. Now is when the little hole above the slit is punched and the side slits cut. To make the steel soft and pliable, it must be annealed again, kept red hot for several hours, and then cooled. Thus far it has looked like a tiny fence paling, but at length it begins to resemble a pen, for it is now stamped with whatever letters or designs may be desired, usually the name of the maker and the name and number of the variety of pen, and it is pressed between a pair of dies to form it into a curve. The last annealing left the metal soft so that all this could be done, but too soft to work well as a pen; and it has to be heated red hot again, and then dropped into cold oil to harden it. Centrifugal force, [48] which helps in so many manufactures, drives the oil away, and the pens are dried in sawdust. They are now sufficiently hard, but too brittle. They must be tempered. To do this, they are placed in an iron cylinder over a fire, and the cylinder revolved till the pen is as elastic as a spring.

The pen is of the correct shape, is tough and elastic; and now it is put into "tumbling barrels" which revolve till it is bright and ready for the finishing touches. If you look closely at the outside of a steel pen just above the nib, you will see that across it run tiny lines. They have a use, for they hold the ink back so that it will not roll down in drops, and they help to make the point more springy and easier to write with.

The pen must be slit up from the point. This is done by a machine, and a most accurate one, for the cut must go exactly through the center of the point and not reach beyond the little hole that was punched. Only one thing is lacking now to make the pen a useful member of society, ready to do its work in the world; and that is to grind off the points and round them in order to keep them from sticking into the paper.

After so much careful work, it does seem as if not one pen out of a thousand could be faulty; but every one has to be carefully examined to make sure that the cutting, piercing, marking, forming, tempering, grinding, and slitting, are just what they should be. These pens carry the maker's name, and a few poor ones getting into the market might spoil the sale of thousands [49] of boxes; therefore the examiner sits before a desk covered with black glass and looks at every pen. The faulty ones are heated so that they cannot be used, and they go to the scrap-heap.

Now the pens are ready so far as usefulness goes, but people have preferences in color. Some prefer bronze, some gray, and some black; so off the pens go to the tempering-room, their last trip, and there are heated in a revolving cylinder till the right color appears; then they are chilled and lacquered, put into boxes, labeled, packed, and sold for such low prices that the good folk of a century ago, who paid from twenty-five to fifty cents for a pen, would have opened their eyes in amazement. When the typewriter was invented, some people said, "That will be the death of the steel pen"; but as a matter of fact, it has greatly increased its sale. The typewriter makes writing so easy and so quick that many more letters are written than formerly. All these letters have to be answered, and few people compared with the whole number own typewriters, and therefore the pen still holds its place.

The lacquer on a steel pen protects it until it has been used for a while. After that, it will rust, if it is not wiped, and it will wear out whether it is wiped or not. All that the gold pen asks is not to be bent or broken, and it will last almost forever. It has the flexibility of the quill, but does not have to be "mended." Gold pens are made in much the same way as are steel pens; but just at the point a tiny shelf [50] is squeezed. Upon this shelf a bit of the alloy of two exceedingly hard metals, iridium and osmium, is secured by melting the gold around it; and it is this bit which stands all the wear of rubbing on the paper. When gold pens were first made, tiny bits of diamonds or rubies were soldered on for points; but they were expensive, and they had a disagreeable fashion of falling off.

A century ago, writers would have thought it the height of luxury to have a gold pen; but now they are not satisfied unless they can be saved the trouble of dipping it into an inkstand, and they look upon the fountain pen as their special friend. The fountain pen carries its supplies with it. The pen itself is like any other gold pen, but the barrel is full of ink. A little tube carries the ink to the point, and the slight bending back of the pen as one writes lets it run out upon the paper. At the end of the slit, at the back of the pen, is a hole to let air into the barrel as the ink runs out. A perfect fountain pen ought to be prepared to write—without shaking—whenever the cap is taken off, and not to refuse to work so long as a drop of ink remains in the barrel. It should never drop ink at the point and, whether the point is up or down, it should never leak there or anywhere else.

The stylographic pen is quite a different article. There is no pen to it; the writing is done with the end of a needle which projects through a hole at the point. The barrel and point are full of ink; but even if the pen is held point down, it will not leak because the [51] needle fills up the hole. When you press the point on paper to write, the needle falls back just enough to let out what ink is needed. The flow stops the instant the pen ceases to touch the paper. The special advantage of the stylographic is that the mere weight of the pen is sufficient pressure, and therefore many hours of writing do not tire the muscles of the hand. The advantage of the fountain pen is that it has the familiar action of the gold pen, and that it will adapt itself to any style of handwriting.

A pen of almost any kind is a valuable article, but for rough-and-ready use we should find it hard to get on without its humble friend, the lead pencil. A lead pencil, by the way, has not a particle of lead in it. The "lead" is all graphite, or plumbago. Years ago sticks of lead were used for marking, and made a pale-gray line. When graphite was introduced, its mark was so black that people called it black lead, and the name has stuck. No one who has ever tried to use a pencil of real lead could fail to appreciate graphite, and when a graphite mine was discovered in England, it was guarded by armed men as watchfully as if it had been a mine of diamonds. That mine was exhausted long ago, but many others have been found. The best graphite in the world comes from Ceylon and Mexico.

When graphite was first used for pencils, it was cut into slabs and these slabs into small strips. The broken and powdered graphite was not used until it was discovered that it could be mixed with clay and so [52] made into sticks. In a lead pencil there are only three substances, graphite, clay, and wood, but a really good one must be manufactured with as much care as if it were made up of twenty. First of all, the graphite is ground and ground and ground, until, if you take a pinch of it between your thumb and finger, you can hardly feel that anything is there. It is now sifted through fine silk and mixed with water and finely powdered clay, and becomes a wet, inky mass. This clay comes from Austria and Bohemia and is particularly smooth and fine. The amount put in is carefully weighed. If you have a hard pencil, it was made by using considerable clay; if your pencil is soft, by using very little; and if it is very soft and black, it is possible that a little lampblack was added.

This inky mass is ground together between millstones for several weeks. Then it goes between rollers, and at length is squeezed through a die and comes out in soft, doughy black strings. These are the "leads" of the pencils. They have been thoroughly wet, and now they must be made thoroughly dry. They are laid on boards, then taken off, cut into pieces the length of a pencil, and put into ovens and baked for hours in a heat twenty times as great as that of a hot summer day. They certainly ought to be well dried and ready for the wood. The red cedar of Florida, Tennessee, Georgia, and Alabama is the best wood for pencils because it is soft and has a fine, straight grain. It is cut into slabs about as long as one pencil, as wide as six, and a little thicker [54] than half a pencil. Every piece must be examined to make sure that it is perfect, and it must be thoroughly seasoned and kiln-dried to free it from oil. Then it goes through a grooving-machine which cuts out a groove half as deep as the lead. The lead is laid into one piece, another is glued on top of it; and there is a pencil ready for work.

Courtesy Joseph Dixon Crucible Co.

HOW THE LEAD GETS INTO A PENCIL

(1) The cedar slab. (2) Planed and grooved. (3) The leads in place. (4) Covered with the other half of the slab. (5) The round pencils cut out. (6) The pencil separated and smoothed. (7) The pencil varnished and stamped.

Such a pencil would be useful, but to sell well it must also be pretty; and therefore it goes through machinery which makes it round or oval or six-sided, as the case may be, rubs it smooth, and varnishes it, and then, with gold leaf or silver leaf or aluminum or ink, stamps upon it the name of the maker, and also a number or letter to show how hard the lead is.

The pencil is now ready for sale, but many people like to have an eraser in the end, and this requires still more work. These erasers are round or flat or six-sided or wedge-shaped. They are let into the pencil itself, or into a nickel tip, or drawn over the end like a cap, so that any one's special whim may be gratified. Indeed, however hard to please any one may be, he ought to be able to find a pencil to suit his taste, for a single factory in the United States makes more than six hundred kinds of pencils, and makes so many of them that if they were laid end to end they would reach three times across the continent.

There are many exceedingly cheap pencils, but they are expensive in the end, because they are poorly made. The wood will often split in sharpening, [55] and the lead is of poor materials so badly mixed that it may write blacker in one place than another, and is almost sure to break. Good pencils bearing the name of a reliable firm are cheapest.

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# VII

# THE DISHES ON OUR TABLES

If any one should give you a lump of clay and ask you to make a bowl, how should you set about it? The first thing would be, of course, to put it on a table so you could work on it with both hands. You would make a depression at the top and push out the sides and smooth them as best you could. It would result in a rough, uneven sort of bowl, and before it was done, you would have made one discovery, namely, that if the table only turned around in front of you, you could see all sides of the bowl from the same position, and it would be easier to make it regular. This is just what the potter's wheel does. It is really two horizontal wheels. The upper one is a disk a foot or two in diameter. This is connected by a shaft with the lower one, which is much larger. When the potter was at work at a wheel of this sort, he stood on one foot and turned the lower wheel with the other, thus setting the upper wheel in motion. This was called a "kick-wheel." As wheels are made now, the potter sits at his work and turns the wheel by means of a treadle.

Almost any kind of clay will make a dish, but no one kind will make it so well that the addition of some other kind would not improve it. Whatever clays are chosen, they must be prepared with great care [57] to make sure that not one grain in them is coarser than any other. Sometimes one will slip through, and you can see on the finished dish what a bad-looking place it makes. Even for the coarsest earthenware, such as flower-pots, the moist clay is forced down a cylinder and through a wire sieve; and for stoneware and porcelain it has to go through several processes. When flint and feldspar are used, they are ground fine at the quarry. On reaching the factory, they are mixed with the proper quantities of other clays—but in just what proportions is one of the secrets of the trade. Then they go into "plungers" or "blungers," great round tanks with arms extending from a shaft in the center. The shaft revolves and the arms beat the clay till all the sand and pebbles have settled on the bottom, and the fine clay grains are floating in the water above them. These pass into canvas bags. The water is forced out through the canvas, and on every bag there is left a thin sheet of moist clay. If this is to be used for the finest work, it is ground and pounded and washed still more, until it is a wonder that any of it survives; then it is sifted through a screen so fine that its meshes are only one one hundred and fiftieth of an inch across. Now it becomes "slip," and after a little more beating and tumbling about, it is ready to go to the man at the wheel.

This man is called the "thrower," because he lifts the lump of clay above his head and throws it down heavily upon the center of the wheel. The things that happen to that lump of clay when he touches it and [58] the wheel revolves seem like the work of magic. He presses his thumbs into it from above and draws the walls up between his thumbs and fingers. He clasps his hands around it, and it grows tall and slender. He lays his finger on the top of the little column of clay, and it flattens in a moment. He points his finger at it, barely touching it, and a little groove appears, running around the whole mass. He seems to be wasting considerable time in playing with it, but all the while he is making sure that the clay is perfectly uniform and that there are no bubbles of air in it. He holds a piece of leather against the outside surface and a wet sponge against the inside, to make them perfectly smooth; and in a moment he has made a bowl. He holds his bent finger against the top of the bowl, and it becomes a vase. With another touch of his magical finger the top of the vase rolls over into a lip. If he makes a cup or a mug, he models a handle in clay and fastens it in place with slip. When it is done, he draws a wire deftly between the article and the table, and puts it on a board to dry.

When you watch a potter at work, it all looks so simple and easy that you feel sure you could do it; but see how skillfully he uses his hands, how strong they are, and yet how lithe and delicate in their movements. See into what odd positions he sometimes stretches them; and yet these are plainly the only positions in which they could do their work. See how every finger does just what he wishes it to do. Notice all these things, and you will not be so certain [59] that making pottery is the easiest thing in the world.

No two pieces of hand work are exactly the same; and skillful as the potter is, his pieces are not precisely alike. Many of them therefore are passed over to the turner for finishing. He uses an ordinary lathe, and with this he thins any place that may be a little too thick, rounds the edge, and smooths it. The article is partly dried when he takes it, and so its walls can be cut thinner. When it leaves his lathe, all signs of hand work have vanished, but the dish is exactly like the others of the set, and this is what the greater number of people want. In some potteries there is hardly a throwing wheel in use, and articles are formed in plaster of Paris moulds. There are two ways of using these moulds. By one method, the mould is put upon a "jigger," a power machine which keeps it revolving, and clay is pressed against its walls from within. Above the mould is a piece of iron cut in the shape of the inside curve of the bowl or whatever is being made. This skims off all the extra clay from the inside of the walls. Plates and saucers are made on a jigger. The mould used for this work is a model of the top of the plate. The workman makes a sort of pancake of clay and throws it upon the mould. A second mould, shaped like half of the bottom of the plate, is brought down close and revolves, cutting off all the extra clay and shaping the bottom of the plate.

When the very finest ware is to be made, the mould is used in quite another fashion. If a pitcher, for [60] instance, is to be cast, the mould is made in two sections and tied tightly together. Then the slip is poured into it and left for a while. The plaster of Paris absorbs the water and a layer of clay is formed all about the walls. When this is thick enough, the liquid is poured out, and after the pitcher has dried awhile, the mould is carefully opened and the pitcher is very gently taken out. The handle is made in a little mould of its own and fastened on with slip. "Eggshell" porcelain is made in this way. The clay shell becomes smaller as it dries, so there is no trouble about removing it from the mould—if one knows how. If a large article is to be cast, the mould is made in sections. Of course this fine ware must all be made by hand, especially as machines do not work well with the finest clays; but cheap dishes are all made by machinery.

After any clay article is thrown, or moulded, or cast, it is passed through a little doorway and set upon a shelf in a great revolving cage. The air in this cage is kept at about 85° F.; but this heat is nothing to what is to follow; and after the articles are thoroughly dry, they are placed in boxes of coarse fire-clay, which are called "saggers," piled up in a kiln, the doors are closed, and the fires are lighted. For a day and night, sometimes for two days and two nights, the fires burn. The heat goes up to 2000° or 2500° F. Every few hours test pieces, which were put in for this purpose, are taken out. When they are found to be sufficiently baked, the fire-holes are bricked up and the furnace is left for two [61] days longer to cool. The ware is then called "biscuit."

Biscuit is dull and porous. It is soon to be glazed, but first whatever underglaze decorating is desired may be done. Sometimes the decorations are painted by hand, and sometimes they are printed on thin paper, laid upon the ware, and rubbed softly till they stick fast. After a while the paper is pulled off, but the colors remain. Gold must be applied over the glaze, and the article fired a second time.

After this decorating, the ware is generally passed to a man who stands before a tub of glaze, and dips in each article, though sometimes he stands before the pieces of ware and sprays them with an air brush. Many different kinds of glaze are used, made of ground flint, feldspar, white clay, and other substances. Common sea salt works exceedingly well, not in liquid form, but thrown directly into the fire. The chief thing to look out for in making a glaze is to see that the materials in it are so nearly like those in the ware that they will not contract unevenly and make little cracks. This glaze is dried in a hot room, then looked over by "trimmers," who scrape it off from such parts as the feet of cups and plates, so that they will not stick to the saggers in firing. Besides this, little props of burned clay are used to hold the dishes up and keep them from touching one another. These props have fanciful names, such as "spurs," "stilts," "cockspurs," etc. Often you can see on the bottom of a plate the marks made by these supports.

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IN THE POTTERY

Pieces of coarse pottery being delivered to the kiln for firing.

The articles now are sent to a kiln to be fired. When they come out there is another chance for decorating, for colors may be put on, and another firing will make them look like underglaze painting If the decorator wishes the ware to have the appearance of being ornamented with masses of gold, he can trace his design in yellow paste, fire it, cover it with gold, and fire it again. To make the "gilt-band china" so beloved by the good housewives of the last century, the decorator puts the plate upon a horizontal wheel, holds his brush full of gold against it, and turns the wheel slowly. Sometimes the outlines of a design are printed and the coloring put in by [63] hand. When broad bands of color are desired to be put around a plate or other article, the decorator sometimes brushes on an adhesive oil where the color is to go, and paints the rest of the plate with some water-color and sugar; then when the oil is partly dry, he dusts on the color in the form of powder. A plunge into water will wash away the water-color and leave the oil with the powder sticking to it. Shaded groundwork is made with an atomizer. Indeed, there are almost as many methods of decorating wares of clay as there are persons who work at it. The results are what might be expected from the prices; some articles are so cheap and gaudy that any one will soon tire of them. Others are really artistic and will be a "joy forever"—until they break.

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# VIII

# HOW THE WHEELS OF A WATCH GO AROUND

If an electric automobile could be charged in fifteen seconds and then would run for forty hours without recharging, it would be looked upon as a great wonder; but to wind a watch in fifteen seconds and have it run for forty hours is so common that we forget what a wonder it is. When you wind your watch, you put some of the strength of your own right hand into it, and that is what makes it go. Every turn of the key or the stem winds up tighter and tighter a spring from one to two feet long, but so slender that it would take thousands to weigh a pound. This is the main spring. It is coiled up in a cup-shaped piece of metal called a "barrel"; and so your own energy is literally barreled up in your watch. The outer end of this spring is held fast by a hook on the inside of the barrel; the inner end is hooked to the hub of a wheel which is called the "main wheel," and around this hub the spring is coiled.

This spring has three things to do. It must send the "short hand," or hour hand, around the dial or face of the watch, once in twelve hours; it must send the "long hand," or minute hand, around once an hour; and it must also send the little "second hand" around its own tiny circle once a minute. To [65] do this work requires four wheels. The first or main wheel is connected with the winding arrangements, and sets in motion the second, or center wheel, so called because it is usually in the center of the watch. This center wheel revolves once an hour and turns the minute hand. By a skillful arrangement of cogs it also moves the hour hand around the dial once in twelve hours. The center wheel moves the third wheel. The chief business of the third wheel is to make the fourth turn in the same direction as the center wheel. The fourth wheel revolves once a minute, and with it turns the tiny second hand.

Suppose that a watch has been made with only the main spring, the four wheels, and the three hands, what would happen when it was wound? You can tell very easily by winding up a mechanical mouse or a train of cars or any other toy that goes by a spring. It will go fast at first, then more and more slowly, then it will stop. This sort of motion might do for a mouse, but it would not answer for a watch. A watch must move with steadiness and regularity. To bring this about, there is a fifth wheel. Its fifteen teeth are shaped like hooks, and it has seven accompaniments, the balance wheel, the hair spring, and five others. This wheel, together with its accompaniments, is able to stop the motion of the watch five times a second and start it again so quickly that we do not realize its having been stopped at all. A tiny arm holds the wheel firmly, and then lets it escape. Therefore, the fifth wheel and its accompaniments are [66] called the "escapement." This catching and letting go is what makes the ticking.

A watch made in this way would run very well until a hot day or a cold day came; then there would be trouble. Heat makes metals expand and makes springs less elastic. Therefore in a hot day the watch would go more slowly and so lose time; while in a cold day it would go too fast and would gain time. This fault is corrected by the balance, a wheel whose rim is not one circle, but two half-circles, and so cunningly made that the hotter this rim grows, the smaller its diameter becomes. In the rim of the wheel are tiny holes into which screws may be screwed. By adding screws or taking some away, or changing the position of some of them, the movement of the watch can be made to go faster or slower.

All this would be difficult enough to manage if a watch was as large as a cart wheel, with wheels a foot in diameter; but it does seem a marvel how so many kinds of wheels and screws and springs, one hundred and fifty in all, can be put into a case sometimes not more than an inch in diameter, and can find room to work; and it is quite as much of a marvel how they can be manufactured and handled.

Remembering how accurate every piece must be, it is no wonder that in Switzerland, where all this work used to be done by hand, a boy had to go to a "watch school" for fourteen years before he was considered able to make a really fine watch. He began at the beginning and was taught to make, first, wooden handles for his tools, then the tools themselves, [67] such as files, screw drivers, etc. His next work was to make wooden watchcases as large as dinner-plates. After this, he was given the frame to which the various wheels of a watch are fastened and was taught how and where to drill the holes for wheels and screws. After lessons in making the finer tools to be used, he was allowed to make a watch frame. All this took several years, for he had to do the same work over and over until his teachers were satisfied with it. Then he was promoted to the second room. Here he learned to adjust the stem-winding parts, to do fine cutting and filing, and to make watches that would strike the hour and even the minute. Room three was called the "train room," because the wheels of a watch are spoken of as "the train." The model watch in this room was as large as a saucer. The young man had to study every detail of this, and also to learn the use of a delicate little machine doing such fine work that it could cut twenty-four hundred tiny cogs on one of the little wheels of a watch. In the fourth room he learned to make the escapement wheel and some other parts; and he had to make them, not merely passably, but excellently. In the fifth and last room, he must do the careful, patient work that makes a watch go perfectly. There are special little curves that must be given to the hair spring; and the screws on the balance wheel must be carefully adjusted. If the watch ran faster when it was lying down than when it was hanging up, he learned that certain ones of the bearings were too coarse and must be made [68] finer. In short, he must be able to make a watch that, whether hanging up or lying down, and whether the weather was hot or cold, would not vary from correct time more than two and a half seconds a day at the most. Then, and not till then, was the student regarded as a first-class watchmaker.

The graduate of such a school knew how to make a whole watch, but he usually limited his work to some one part. Every part of a watch was made expressly for that watch, but sometimes a hundred different persons worked on it. The very best of the Swiss watches were exceedingly good; the poorest were very bad, and much worse to own than a poor American watch because it costs more to repair a Swiss watch than an American watch.

Courtesy Waltham Watch Co.

WHERE WATCHES ARE MADE

Once a single man made a whole watch by hand. Now one watch may be the product of a hundred hands, each man doing his particular part.

Even though in America the parts of watches are made by machinery, an apprentice has to undergo just as careful and just as extended training here as in Switzerland. A poor watch is worse than none at all, and careless work would not be tolerated in any watch factory. Of late even Switzerland has been importing American machinery in order to compete with the United States. These machines do such careful, minute, intricate work that, as you stand and watch them, you feel as if they must know what they are about. One of them takes the frame,—that is, the plates to which the wheels are fastened,—makes it of the proper thinness, cuts the necessary holes in it, and passes it over to the next machine, which is reaching out for it. The feeder gives [70] the first machine another plate; and so the work goes on down a whole line of machines. At length the plate is taken in hand by a machine, or rather a group of machines, which can do almost anything. Before they let it go, they actually perform one hundred and forty-two different operations, each bringing it nearer completion. These machines are automatic, but nevertheless they must be constantly watched by expert machinists to keep them in order and make sure of their turning out perfect work.

While one line of machines has been perfecting the plate, others have been at work on screws and wheels and springs. As many of these as are needed for one watch are put into a little division of a tray and carried to another room for its jewels and the rest of its outfit. The jewels, which are pieces of rubies, sapphires, garnets, or even diamonds, are very valuable to a watch. When you know that the little wheels are in constant motion, and that the balance wheel, for instance, vibrates eighteen thousand times an hour, it is plain that a vast amount of wear comes upon the spot where the pivots of these wheels rest. No metal can be made smooth enough to prevent friction, and there is no metal hard enough to prevent wear. The "jewels" are smoother and harder. They are sawed into slabs so thin that fifty of them piled up would measure only an inch. These are stuck to blocks to be polished, cut into disks flat on one side but with a little depression on the other to receive oil, bored through the center, and placed wherever the wear is greatest—provided [71] the purchaser is willing to pay for them. A "full-jeweled" watch contains twenty-three jewels; that is, in twenty-three of the places where the most severe wear comes, or where friction might prevent the watch from going with perfect smoothness, there will be practically no wear and no friction. A low-priced watch contains only seven jewels, but if you want a watch to last, it pays to buy one that is full-jeweled.

And now these plates and wheels and screws are to be put together, or "assembled," as this work is called. This is a simple matter just as soon as one has learned where the different parts belong, for they are made by machinery and are sure to fit. After the assembling comes the adjusting of the balance wheel and the hair spring. There is nothing simple about this work, for the tiny screws with the large heads must be put into the rim of the balance wheel with the utmost care, or else all the other work will be useless, and the watch will not be a perfect time keeper; that is, one that neither loses nor gains more than thirty seconds a month.

It is said that the earliest watches made in Europe cost fifteen hundred dollars and took a year to make. There has always been a demand for a cheap pocket timepiece, and of late this demand has been satisfied by the manufacture of the "dollar watch." Properly speaking, this is not a watch at all, but a small spring clock. It has no jewels, and its parts are stamped out of sheets of brass or steel by machinery. The hair springs are made in coils of eight and then broken [72] apart; and the main springs are made by the mile. Twenty holes are drilled at a time, and the factory in which "dollar watches" were first manufactured is now able to turn out fifteen thousand a day.

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# IX

# THE MAKING OF SHOES

Did you ever stop to think how many different qualities you expect in a shoe? You want the sole to be hard and firm so as to protect your feet in rough walking; and also soft and yielding so as to feel springy and not board-like. You want the upper leather to keep the cold air from coming in; and also porous enough to let the perspiration out. Your feet are not exactly like those of any one else; and yet you expect to find at any shoe store a comfortable shoe ready-made. You expect that shoe to come close to your foot, and yet allow you to move it with perfect freedom. You expect all these good qualities, and what is more remarkable, it does not seem difficult for most people to get them. There is an old saying, "To him who wears shoes, the whole earth is covered with leather"; and although many different materials have been tried in shoemaking, leather is the only one that has proved satisfactory, for the sole of the shoe at least. Of late, however, rubber and rubber combinations and felts and felt combinations have been used.

Most hides of which soles are made come from the large beef packing-houses or from South America. Goatskins come from Africa and India. The greater part of a hide is made up of a sort of gelatine. This easily [74] spoils, and therefore it has to be "tanned"; that is, soaked in tannin and water. When a man set out to build a tannery, he used to go into the woods where he could be sure of enough oak trees to supply him for many years with the bark from which tannin is made; but it has been found that the bark of several other kinds of trees, such as larch, chestnut, spruce, pine, and hemlock, will tan as well as that of oak. Tannin is now prepared in the forest and brought to the tanners, who put their tanneries where they please, usually near some large city. The hides are first soaked in water, and every particle of flesh is scraped away. They are laid in heaps for a while, then hung in a warm room till the hair loosens and can be easily removed, then soaked in tannic extract and water. The tannin unites with the gelatine; and thus the hide becomes leather. This process requires several months. Hides are also tanned by the use of chemicals, in what is called "chrome" tanning. This process requires only a few hours, but it is expensive.

In earlier times the shoemaker used to go from house to house with his lapstone, waxed end, awl, and other tools. The farmer provided the leather, which he had tanned from the hides of his own cattle. Now, however, manufacturers can buy the soles of one merchant, the heels of another, the box toe and stiffenings of another, and so on. In the United States there are many factories which do nothing but cut soles, or rather stamp them out with dies, a hundred or more in a minute. These soles and also the less [75] heavy inner soles go through machines that make all parts of them of a uniform thickness. The traveling shoemaker always hammered his sole leather to make it wear better; but now a moment between very heavy rollers answers the same purpose. Another machine splits the inner sole for perhaps a quarter of an inch all the way around, and thus makes a little lip to which to sew the welt. A number of layers or "lifts" of leather are cemented together for the heel, and are put under heavy pressure.

The upper parts of a shoe, the "uppers," as they are called, are the vamp or front of the shoe, the top, the tip, and (in a laced shoe) the tongue. Nearly all the upper leather that shows when a shoe is on is made from the hides of cattle, calves, goats, and sheep; but besides the parts that show there are stiffeners for the box toe and the counters to support the quarters over the heel; there are linings, and many other necessary "findings," forty-four parts in all in an ordinary shoe. Much experimenting and more thinking have gone into every one of these forty-four parts; and much remembering that shoes have harder wear than anything else in one's wardrobe. The cotton linings, for instance, must be woven in a special way in order to make them last and not "rub up" when they are wet with water or perspiration. They are bleached with the utmost care not to weaken them, and they are singed between red-hot copper plates to remove all the nap.

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Then, too, a good deal of metal is used in making a shoe, not only the ornamental buckles on dress shoes and the heavy, useful buckles on storm boots, but various pieces that help to make the shoe strong and enduring. There are nails, shanks to strengthen the arch of the shoe, metal shanks to the buttons, and eyelets. Not many years ago, eyelets soon wore brassy, and then the shoe looked old and cheap. They are now enameled, or the top of them is made of celluloid in a color to match the shoe. The tags on lacings and the hooks for holding lacings are also enameled. A "box-toe gum" is used to support the box-toe stiffening. Cement covers the stitches; and many sorts of blacking are used in finishing the work. It is by no means a simple operation to make a pair of shoes.

At a busy shoe factory it is always "tag day," for when an order is received, the first step in filling it is to make out a tag or form stating how the shoe is to be made up and when it is to be finished. These records are preserved, and if a customer writes, "Send me 100 pairs of shoes like those ordered October 10, 1910," the manufacturer has only to read the record in order to know exactly what is wanted.

Courtesy United Shoe Mchy. Co.

THE GOODYEAR PULLING-OVER MACHINE

This machine cost $1,500,000 and five years of experiment to perfect. It shapes the forepart of the upper of a shoe over a wooden last.

Next, the leather is selected, first grade or second grade, according to the price to be paid. The patterns for the uppers are now brought into play—and, by the way, it is no small matter to prepare the hundreds of patterns needed for a new line of shoes in all the different widths and sizes. In some factories [78] the cutting is done by machinery; in others the "upper cutter" lays the leather on a block and cuts around the pattern with a small but very sharp knife. It needs skill and judgment to be a cutter; for a careless workman can easily waste the skins badly by not laying the patterns on to the best advantage. While this work is going on, the linings, trimmings, soles, and other parts are also being prepared, and all these many pieces now meet in the "stitching-room." At the first glance, it does not seem as if the right ones could ever come together, even though they are marked, and sometimes it does happen that a 4a vamp, for instance, is put with 5a quarters, and nobody knows the difference until the experienced eye of the foreman notices that something is wrong with the shoe. The uppers of the shoe are now stitched up, and after a careful inspection, they are sent on to the "lasting-room." The "last" of the earlier times was roughly whittled out, and it was the same for both feet; but the last of to-day is almost a work of art, so carefully is it made and polished. The shoe manufacturers jokingly declare that lasts must be changed three times a day in order to keep up with the fashions. Feet do not change in form, save when they have been distorted by badly shaped shoes; but in spite of this, people insist upon having their shoes long and narrow, or short and wide, with high heels or with low heels, with broad toes or with pointed toes, as the whim of the moment may be. It really is a big problem for the shoe manufacturers to suit people's [79] fancies and yet give them some degree of comfort.

While the uppers are being stitched, the soles and inner soles and counters have been made ready and brought to the lasting-room. The toe stiffeners and also the counters are now cemented into their places. The inner sole is tacked to the last, and the uppers are put in place and held there by a tack at the heel. This is done by machines; but their working is simple compared with that of the machine which now takes charge of the half-made shoe. This machine puts out sturdy little pincers which seize the edge of the uppers, pull it smoothly and evenly into place, and drive a tack far enough in to keep it from slipping. Now comes the welting. A welt is a narrow strip of leather which is sewed to the lower edge of the upper all the way around the shoe except at the heel. This brings the upper, the lip of the inner sole, and the welt together. The inside of the shoe is now smooth and even, but around the outside of the sole is the ridge made by the welt and the sewing, and within the ridge a depression that must be filled up. Tarred paper or cork in a sort of cement are used for this. The shank is fastened into its place and the welt made smooth and even. The outer sole is coated with rubber cement, put into position under heavy pressure to shape it exactly like the sole of the last, and then sewed to the welt. If it was not for the welt, the outer sole would have to be sewed directly to the inner sole. The nailing and pegging of the old-fashioned shoemaker [80] are also reproduced by the modern machine.

The shoe is still open at the heel; but now the heel parts of both sole and uppers are fastened together; the edges have been nicely trimmed, and next the heels are nailed to the shoe by another machine which does the work at a blow, leaving the nails standing out a little below the lowest lift. Another lift is forced upon these; and that is why the heel of a new shoe shows no signs of nails. The heel is trimmed, and then come the final sandpapering and blackening. The bottom of a new shoe has a peculiar soft, velvety appearance and feeling; and this is produced by rubbing it with fine emery paper fastened upon a little rubber pad. A stamping-machine marks the sole with the name of the manufacturer. Last of all, the shoe is put upon a treeing machine, where an iron foot stretches it into precisely the shape of the wooden last on which it was made.

This is the method by which large numbers of shoes are made, but there are many details which differ. Laced shoes must have tongues as well as eyelets, while buttoned shoes must have buttons and buttonholes. "Turned" shoes have no inner sole, but uppers and outer sole are sewed together wrong side out and then turned. In shoemaking, as in all other business, if a manufacturer is to succeed, he must see that there is no waste. He has of course no use for a careless cutter, who would perhaps waste large pieces of leather; but even the tiniest scraps [81] are of value for some purpose. They can be treated with chemicals, softened by boiling, and pressed into boards or other articles or made into floor coverings. At any rate, they must be used for something. No business is small enough or large enough to endure waste.

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# X

# IN THE COTTON MILL

If you ravel a bit of cotton cloth, you will find that it is made up of tiny threads, some going up and down, and others going from right to left. These threads are remarkably strong for their size. Look at one under a magnifying glass, in a brilliant light, and you will see that the little fibers of which it is made shine almost like glass. Examine it more closely, and you will see that it is twisted. Break it, and you will find that it does not break off sharp, but rather pulls apart, leaving many fibers standing out from both ends.

Cotton comes to the factory tightly pressed in bales, and the work of the manufacturer is to make it into these little threads. The bales are big, weighing four or five hundred pounds apiece. They are generally somewhat ragged, for they are done up in coarse, heavy jute. The first glance at an opened cotton bale is a little discouraging, for it is not perfectly clean by any means. Bits of leaves and stems are mixed in with the cotton, and even some of the smaller seeds which have slipped through the gin. There is dust, and plenty of it, that the coarse burlap has not kept out. The first thing to do is to loosen the cotton and make it clean. Great armfuls are thrown into a machine called a "bale-breaker." Rollers with spikes, blunt so as not to injure the fiber, [83] catch it up and tear the lumps to pieces, and "beaters" toss it into a light, foamy mass. Something else happens to the cotton while it is in the machine, for a current of air is passing through it all the while, and this blows out the dust and bits of rubbish. This current is controlled like the draft of a stove, and it is allowed to be just strong enough to draw the cotton away from the beater when it has become light and open, leaving the harder masses for more beating. When it comes out of the opener, it is in sheets or "laps" three or four feet wide and only half an inch thick. They are white and fleecy and almost cloudlike; and so thin that any sand or broken leaves still remaining will drop out of their own weight.

In this work the manufacturer has been aiming, not only at cleaning the cotton and making it fluffy, but also at mixing it. There are many sorts of cotton, some of longer or finer or more curly or stronger fiber than others, some white and some tinged with color; but the cloth woven of cotton must be uniform; therefore all these kinds must be thoroughly mixed. Even the tossing and turning and beating that it has already received is not enough, and it has to go into a "scutcher," three or four laps at a time, one on top of another, to have still more beating and dusting. When it comes out, it is in a long roll or sheet, so even that any yard of it will weigh very nearly the same as any other yard. The fibers, however, are lying "every which way," and before they can be drawn out into thread, they must be made to lie [84] parallel. This is brought about in part by carding. When people used to spin and weave in their own houses, they used "hand cards." These were somewhat like brushes for the hair, but instead of bristles they had wires shaped much as if wire hairpins had been bent twice and put through leather in such a way as to form hooks on one side of it. This leather was then nailed to a wooden back and a handle added. The carder took one card in each hand, and with the hooks pointing opposite ways brushed the cotton between them, thus making the fibers lie parallel. This is just what is done in a mill, only by machinery, of course. Instead of the little hand cards, there are great cylinders covered with what is called "card clothing"; that is, canvas bristling with the bent wires, six or seven hundred to the square inch. This takes the place of one card. The place of the other is filled by what are called "flats," or narrow bars of iron covered with card clothing. The cylinders move rapidly, the flats slowly, and the cotton passes between them. It comes out in a dainty white film not so very much heavier than a spider's web, and so beautifully white and shining that it does not seem as if the big, oily, noisy machines could ever have produced it. In a moment, however, it is gone somewhere into the depths of the machine. We have seen the last of the fleecy sheet, for the machinery narrows it and rounds it, and when it comes into sight again, it looks like a soft round cord about an inch thick, and is coiled up in cans nearly a yard high. This cord is called "sliver."

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IN A COTTON MILL

The "sliver" coming through the machine, and the "roving" being twisted and wound on bobbins. [86]

The sliver is not uniform; even now its fibers are not entirely parallel, and it is as weak as wet tissue paper. It now pays a visit to the "drawing-frame." Four or six slivers are put together and run through this frame. They go between four pairs of rollers, the first pair moving slowly, the others more rapidly. The slow pair hold the slivers back, while the fast one pull them on. The result is that when the sliver comes out from the rollers, its fibers are much straighter. This process is repeated several times; and at last when the final sliver comes out, although it looks almost the same as when it came from the carding-machine, its fibers are parallel. It is much more uniform, but it is very fragile, and still has to be handled with great care. It is not nearly strong enough to be twisted into thread; and before this can be done, it must pass through three other machines. The first, or "slubber," gives it a very slight twist, just enough to suggest what is coming later, and of course in doing this makes it smaller. The cotton changes its name at every operation, and now it is called "roving." It has taken one long step forward, for now it is not coiled up in cans, but is wound on "bobbins," or great spools. The second machine, the "intermediate speeder," twists it a very little more and winds it on fresh bobbins. It also puts two rovings together, so that if one happens to be thin in one place, there is a chance for it to be strengthened by a thicker place in the other. The third machine, the "fine speeder," simply makes a finer roving.

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All this work must be done merely to prepare the raw cotton to be twisted into the tiny threads that you see by raveling a piece of cotton cloth. Now comes the actual twisting. If you fasten one end of a very soft string and twist the other and wind it on a spool, you will get a spool of finer, stronger, and harder-twisted string than you had at first. This is exactly what the "ring-spinner" does. Imagine a bobbin full of roving standing on a frame. Down below it are some rolls between which the thread from the bobbin passes to a second bobbin which is fast on a spindle. Around this spindle is the "spinning-ring," a ring which is made to whirl around by an endless belt. This whirling twists the thread, and another part of the machine winds it upon the second bobbin. Hundreds of these ring-spinners and bobbins are on a single "spinning-frame" and accomplish a great deal in a very short time. The threads that are to be used for the "weft" or "filling" go directly into the shuttles of the weavers after being spun; but those which are to be used for "warp" are wound first on spools, then on beams to go into the loom.

Little children weave together strips of paper, straws, and splints,—"over one, under one,"—and the weaving of plain cotton cloth is in principle nothing more than this. The first thing to do in weaving is to stretch out the warp evenly. This warp is simply many hundreds of tiny threads as long as the cloth is to be, sometimes forty or fifty yards. They must be stretched out side by side and close [88] together. To make them regular, they are passed between the teeth of a sort of upright comb; then they are wound upon the loom beam, a horizontal beam at the back of the loom. Here they are as close together as they will be in the cloth. With a magnifying glass it is easy to count the threads of the warp in an inch of cloth. Some kinds of cloth have a hundred or even more to the inch. In order to make cloth, the weaver must manage in some way to lower every other one of these little threads and run his shuttle over them, as the children do the strips of paper in their paper weaving. Then he must lower the other set and run the shuttle over *them*. "Drawing in" makes this possible. After the threads leave the beam, they are drawn through the "harnesses." These are hanging frames, one in front of the other, filled with stiff, perpendicular threads or wires drawn tight, and with an eye in each thread. Through these eyes the threads of the warp are drawn, the odd ones through one, and the even through the other. Then, keeping the threads in the same order, they pass through the teeth of a "reed,"—that is, a hanging frame shaped like a great comb as long as the loom is wide; and last, they are fastened to the "front beam," which runs in front of the weaver's seat and on which the cloth is to be rolled when it has been woven. Each harness is connected with a treadle. The weaver puts his foot on the treadle of the odd threads and presses them down. Then he sends his shuttle, containing a bobbin full of thread, sliding across over the odd threads and [89] under the even. He puts his foot on the treadle of the even threads and sends the shuttle back over the even and under the odd. At each trip of the shuttle, the heavy reed is drawn back toward the weaver to push the last thread of the woof or filling firmly into place.

This is the way cloth is woven in the hand looms which used to be in every household. The power loom used in factories is, even in its simplest form, a complicated machine; but its principle is exactly the same. If colors are to be used, great care is needed in arranging warp and woof. If you ravel a piece of checked gingham, you will see that half the warp is white and half colored; and that in putting in the woof or filling, a certain number of the threads are white and an equal number are colored. If you look closely at the weaving of a tablecloth, you will see that the satin-like figures are woven by bringing the filling thread not "over one and under one," but often over two or three and under one. In drilling or any other twilled goods, several harnesses have to be used because the warp thread is not lowered directly in line with the one preceding, but diagonally. Such work as this used to require a vast amount of skill and patience; but the famous Jacquard machine will do it with ease, and will do more complicated weaving than any one ever dreamed of before its invention, for it will weave not only regular figures extending across the cloth, but can be made to introduce clusters of flowers, a figure, or a face wherever it is desired. By the aid of this, every [90] little warp thread or cluster of threads can be lifted by its own hooked wire without interfering with any other thread. Cards of paper or thin metal are made for each pattern, leaving a hole wherever the hook is to slip through and lift up a thread. After the cards are once made, the work is as easy as plain weaving; but there must be a separate card for every thread of filling in the pattern, and sometimes a single design has required as many as thirty thousand pattern cards.

The machines in a cotton mill are the result of experimenting, lasting through many years. They do not seem quite so "human" as those which help to carry on some parts of other manufactures; but they are wonderfully ingenious. For instance, the sliver is so light that it seems to have hardly any weight, but it balances a tiny support. If the sliver breaks, the support falls, and this stops the machine. Again, if one of the threads of the warp breaks when it is being wound on the beam, a slender bent wire that has been hung on it falls. It drops between two rollers and stops them. Then the workman knows that something is wrong, and a glance will show where attention is needed. Success in a cotton mill demands constant attention to details. A mill manager who has been very successful has given to those of less experience some wise directions about running a mill. For one thing, he reminds them that building is expensive and that floor space counts. If by rearranging looms space can be made for more spindles, it is well worth while to rearrange. He tells [91] them to study their machines and see whether they are working so slowly that they cannot do as much as possible, or so fast as to strain the work. He bids them to keep their gearings clean, to be clear and definite in their orders, and to read the trade papers; but above everything else to look out for the little things, a little leak in the mill dam, a little too much tightness in a belt, or the idleness of just one spindle. Herein lies, he says, one of the great differences between a successful and an unsuccessful superintendent.

Weaving as practiced in factories is a complicated business; but whether it is done with a simple hand loom in a cottage or with a big power loom in a great factory, there are always three movements. One separates the warp threads; one drives the shuttle between them; and one swings the reed against the filling thread just put in.

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# XI

# SILKWORMS AND THEIR WORK

About silk there is something particularly agreeable. There are few people who do not like the sheen of a soft silk, the sparkle of light on a "taffeta," and the richness of the silk that "can stand alone." Its delicate rustle is charming, and the "feel" of it is a delight. It has not the chill of linen, the deadness of cotton, or the "scratchiness" of woolen. It pleases the eye, the ear, and the touch.

The caterpillars of a few butterflies and of many moths are spinners of fibers similar to silk. Among these last is the beautiful pale-green lunar moth. Spiders spin a lustrous fiber, and it is said that a lover of spiders succeeded, by a good deal of petting and attention, in getting considerable material from a company of them. Silkworms, however, are the only providers of real silk for the world. Once in a while glowing accounts are published of the ease with which they can be raised and the amount of money which can be made from them with very small capital. This business, however, like all other kinds of business, requires close attention and skill if it is to be a success. An expert has said that it needs more time to build a spool of silk than a locomotive.

The way to begin to raise silkworms is first of all to provide something for them to eat. They are very [93] particular about their bill of fare. The leaf of the osage orange will answer, but they like much better the leaf of the white mulberry. Then send to a reliable dealer for a quarter of an ounce of silkworm eggs. That sounds like a small order, but it will bring you nine or ten thousand eggs, ready to become sturdy little silkworms if all goes well with them. Put them on a table with a top of wire netting covered with brown paper, and keep them comfortably warm. In a week or two, there will appear some little worms about an eighth of an inch long and covered with black hairs. These tiny worms have to become three inches or more in length, and they are expected to accomplish the feat in about a month. If a boy four feet tall should grow at the silkworm's rate for one month, he would become forty-eight feet tall. It is no wonder that the worms have to make a business of eating, or that the keeper has to make a business of providing them with food. They eat most of the time, and they make a queer little crackling sound while they are about it. They have from four to eight meals a day of mulberry leaves. The worms from a quarter of an ounce of eggs begin with one pound a day, and work up to between forty and fifty. Silkworms like plenty of fresh air, and if they are to thrive, their table must be kept clean. A good way to manage this is to put over them paper full of holes large enough for them to climb through. Lay the leaves upon the paper; the worms will come up through the holes to eat, and the litter on their table can be cleared away. As [94] the worms grow larger, the holes must be made larger. It is no wonder that their skins soon become too tight for them. They actually lose their appetite for a day or two, and they slip away to some quiet corner under the leaves, and plainly wish there were no other worms to bother them. Soon the skin comes off, and they make up for lost time so energetically that they have to drop their tight skins three times more before they are fully grown. Wet mulberry leaves must not be given them, or they will become sick and die, and there will be an end of the silkworm business from that quarter-ounce of eggs. They must have plenty of room on their table as well as in their skins. At first a tray or table two feet long and a little more than one foot wide will be large enough; but when they are full-grown, they will need about eighty square feet of table or shelves. At spinning time, even this will not be enough.

After the worms have shed their skins four times and then eaten as much as they possibly can for eight or ten days, they begin to feel as if they had had enough. They now eat very little and really become smaller. They are restless and wander about. Now and then they throw out threads of silk as fine as a spider's web. They know exactly what they want; each little worm wants to make a cocoon, and all they ask of you is to give them the right sort of place to make it in. When they live out of doors in freedom, they fasten their cocoons to twigs; and if you wish to give them what they like best, get plenty of dry twigs and weave them together in arches standing [95] over the shelves. Pretty soon you will see one worm after another climb up the twigs and select a place for its cocoon. Before long it throws out threads from its spinneret, a tiny opening near the mouth, and makes a kind of net to support the cocoon which it is about to weave.

The silkworm may have seemed greedy, but he did not eat one leaf too much for the task that lies before him. There is nothing lazy about him; and now he works with all his might, making his cocoon. He begins at the outside and shapes it like a particularly plump peanut of a clear, pale yellow. The silk is stiffened with a sort of gum as it comes out of the spinneret. The busy little worm works away, laying its threads in place in the form of a figure eight. For some time the cocoon is so thin that one can watch him. It is calculated that his tiny head makes sixty-nine movements every minute.

The covering grows thicker and the room for the silkworm grows smaller. After about seventy-two hours, put your ear to the cocoon, and if all is quiet within, it is completed and the worm is shut up within it. Strange things happen to him while he sleeps in the quiet of his silken bed, for he becomes a dry brown chrysalis without head or feet. Then other things even more marvelous come to pass, for in about three weeks the little creature pushes the threads apart at one end of the cocoon and comes out, not a silkworm at all, but a moth with head and wings and legs and eyes. This moth lays hundreds of eggs, and in less than three weeks it dies.

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This is what the silkworm will do if it is left alone; but it is the business of the silk-raiser to see that it is not left alone. About eight days after the cocoon is begun, it is steamed or baked to kill the chrysalis so that it cannot make its way out and so spoil the silk. The quarter of an ounce of eggs will make about thirty pounds of cocoons. Now is the time to be specially watchful, for there is nothing in which rats and mice so delight as a plump, sweet chrysalis; and they care nothing whatever for the three or four thousand yards of silk that is wound about each one.

To take this silk off is a delicate piece of work. A single fiber is not much larger than the thread of a cobweb, and before the silk can be used, several threads must be united in one. First, the cocoon is soaked in warm water to loosen the gum that the worm used to stick its threads together. Ends of silk from half a dozen or more cocoons are brought together, run through a little hole in a guide, and wound on a reel as one thread. This needs skill and practice, for the reeled silk must be kept of the same size. The cocoon thread is so slender that, of course, it breaks very easily; and when this happens, another thread must be pieced on. Then, too, the inner silk of the cocoon is finer than the outer; so unless care is taken to add threads, the reeled silk will be irregular. The water must also be kept just warm enough to soften the gum, but not too hot.

The silk is taken off the reel, and the skeins are packed up in bales as if it were of no more value than [98] cotton. Indeed, it does not look nearly so pretty and attractive as a lap of pure white cotton, for it is stiff and gummy and has hardly any luster. Now it is sent to the manufacturer. It is soaked in hot soapy water for several hours, and it is drawn between plates so close together that, while they allow the silk to go through, they will not permit the least bit of roughness or dirt to pass. If the thread breaks, a tiny "faller," such as are used in cotton mills, falls down and stops the machine. The silk must now be twisted, subjected to two or three processes to increase its luster, and dyed,—and if you would like to feel as if you were paying a visit to a rainbow, go into a mill and watch the looms with their smooth, brilliant silks of all the colors that can be imagined. After the silk is woven, it is polished on lustering machines, singed to destroy all bits of free fibers or lint, freed of all threads that may project, and scoured if it is of a light color; then sold.

Click here to see a larger version of this photo.

Courtesy Cheney Bros.

HOW SPUN SILK IS MADE

Every manufacturer saves everything he can, and even the waste silk which cannot be wound on reels is turned into a salable product

The moth whose cocoon provides most of our silk is called the "bombyx mori." There are others, however, and from some of these tussah silk, Yamamai, and Shantung pongee are woven. These wild moths produce a stronger thread, but it is much less smooth than that of the bombyx.

There is also a great amount of "wood silk," or artificial silk, on the market. To make this, wood pulp is dissolved in ether and squirted through fine jets into water. It is soon hard enough to be twisted into threads and woven. It makes an imitation of silk, bright and lustrous, but not wearing so well as the [99] silk of the silkworm. Nevertheless, for many purposes it is used as a substitute for silk, and many braids and passementeries are made of it. Then, too, there are the "mercerized" goods, which often closely resemble real silk, although there is not a thread of silk in them. It was discovered many years ago that if a piece of cotton cloth was boiled in caustic soda, it would become soft and thick and better able to receive delicate dyes. Unfortunately, it also shrank badly.

At length it occurred to some one that the cloth might be kept from shrinking by being stretched out during the boiling in soda. He was delighted to find that this process made it more brilliant than many silks.

The threads that fasten the cocoon to the bush and those in the heart of the cocoon are often used, together with the fiber from any cocoons through which the worms have made their way out. This is real silk, of course, but it is made of short fibers which cannot be wound. It is carded and spun and made into fabric called "spun silk," which is used extensively for the heavier classes of goods. Then, too, silks are often "weighted"; that is, just before they are dyed, salts of iron or tin are added. One pound of silk will absorb two or three pounds of these chemicals, and will apparently be a heavy silk, while it is really thin and poor. Moreover, this metallic weighting rubs against the silk fiber and mysterious holes soon begin to appear. A wise "dry cleaner" will have nothing to do with such silks, lest he should be held responsible for these holes. It [100] is this weighting which produces the peculiar rustle of taffeta; and if women would be satisfied with a taffeta that was soft and thin, the manufacturers would gladly leave out the salts of iron, and the silks would wear much better. Cotton is seldom mixed with the silk warp thread; but it is used as "filling" in a large class of goods with silk warp. The custom has arisen of advertising such goods as "silk," which of course is not a fair description of them. Advertisements sometimes give notice of amazing sales of "Shantung pongee," which has been made in American looms and is a very different article from the imported "wild silk" pongee.

With so many shams in the market, how is a woman to know what she is buying and whether it will wear? There are a few simple tests that are helpful. Ravel a piece of silk and examine the warp and woof. If they are of nearly the same size, the silk is not so likely to split. See how strong the thread is. Burn a thread. If it burns with a little flame, it is cotton. If it curls up and smells like burning wool, it is probably silk. Another test by fire is to burn a piece of the goods. If it is silk, it will curl up; if it is heavily weighted, it will keep its shape. If you boil a sample in caustic potash, all the silk in it will dissolve, but the cotton will remain. If the whole sample disappears, you may be sure that it was all silk. Soft, finely woven silks are safest because they will not hold so much weighting. Crêpe de chine is made of a hard twisted thread and therefore wears well. Taffeta can carry a large amount of weighting, [101] and is always doubtful; it may wear well, and it may not. There is always a reason for a bargain sale of silks. The store may wish to clear out a collection of remnants or to get rid of a line of goods which are no longer to be carried; but aside from this, there is usually some defect in the goods themselves or else they have failed to please the fashionable whim of the moment. Silk is always silk, and if you want it, you must pay for it.