

DEPARTMENT OF CHEMICAL ENGINEERING

THESIS

THE ESTABLISHMENT AND OPERATION OF A HOSIERY MILL

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INTRODUCTORY

The student, in undertaking to cover such a large subject as the establishment and the explanation of the workings of an up-to-date hosiery mill, realizes that it is impossible to prepare a thesis that will be free from flaws from the standpoint of an experienced hosiery mill operator.

The writer feels that he has been exceedingly fortunate in having had the opportunity of visiting three of the most modern mills in this section, one situated at Clinton, another at Rockwood, and still another at Lenoir City. The Lenoir City mill has a capacity of 7000 dozen a day and is the third largest mill in the South. The workings of the plants have been fully explained by the managers, and the ideas as well as the plans set forth in this paper are based for the most part upon the opinions of the three mill operators who have been in the business for a period of from ten to twenty years. With a few corrections in places, the floor design as shown in the plans, should permit a very good coordination through the mill.

The student has prepared this thesis with the idea in view of perhaps having a part in establishing a mill at some future date, and for that reason many facts are noted which are not of a chemical nature.

LOCATION.

This proposed mill is to be located in a town with a population of from 15,000 to 20,000 people. If possible a location will be selected near a railroad, a river or some body of water, a pike or wagon road, and near the labor. Also, a number of other points are to be considered, as the obtaining of land at a reasonable price, and the possibility of the town enlarging, the tax rates, the fire protection, school facilities and a number of minor details. All of these steps are to be duly weighed before taking steps toward the erection of a building.

BUILDINGS IN GENERAL

There are only two types of buildings to consider for a hosiery mill, namely, a concrete or a brick structure. According to Mr.-----, a brick structure costs about two and one-half dollars per square foot, while a concrete building can be built for fifteen percent less, at the present time. Mr.----- thinks that a brick building is the more substantial and the only one worth considering.

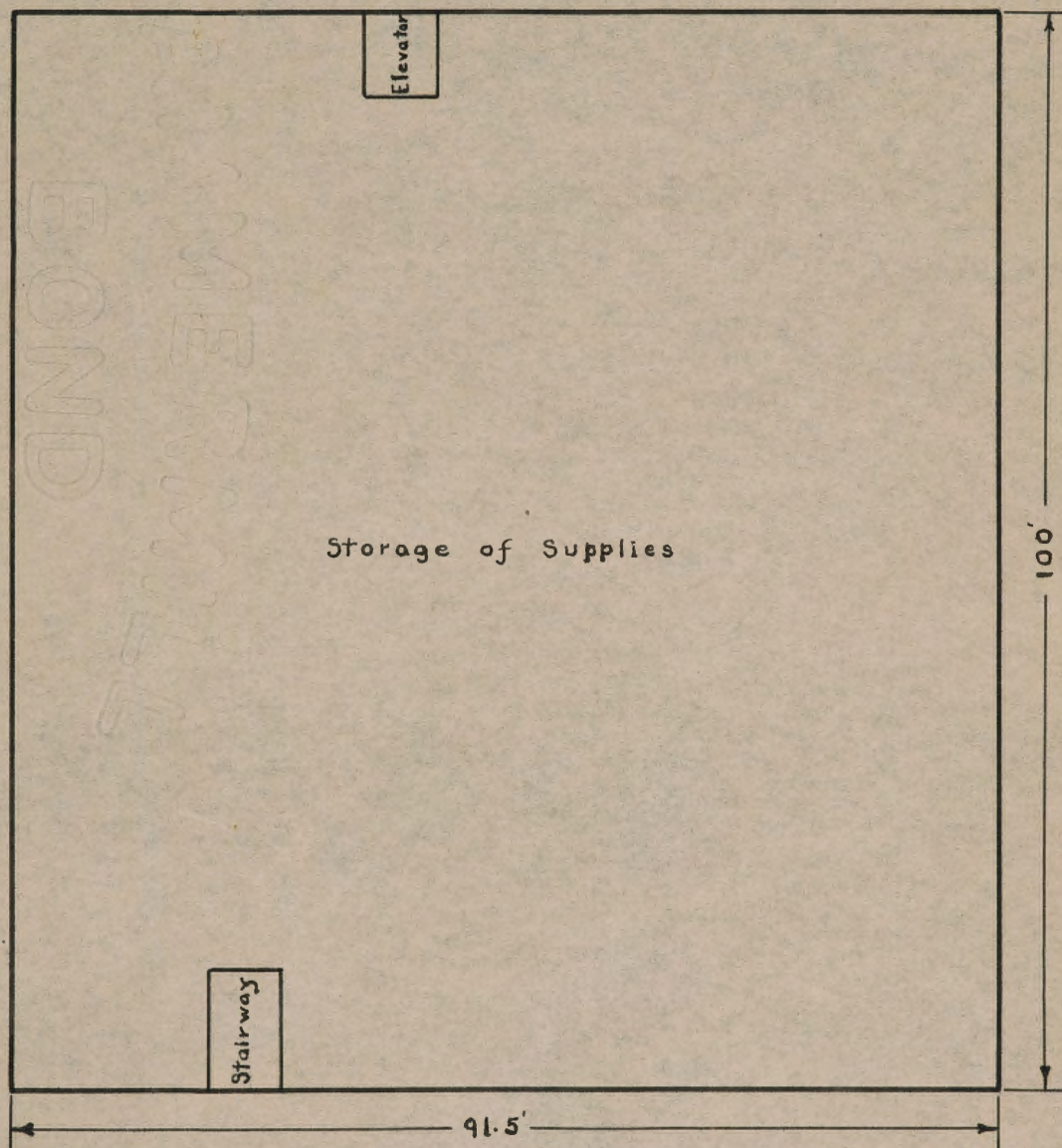
PROPOSED BUILDINGS

All of the buildings including the dye, power and pump houses will be of red brick, fireproof construction.

EXPLANATION OF PLANS

(a) MAIN BUILDING

The main building will be 183 feet long and 100 feet

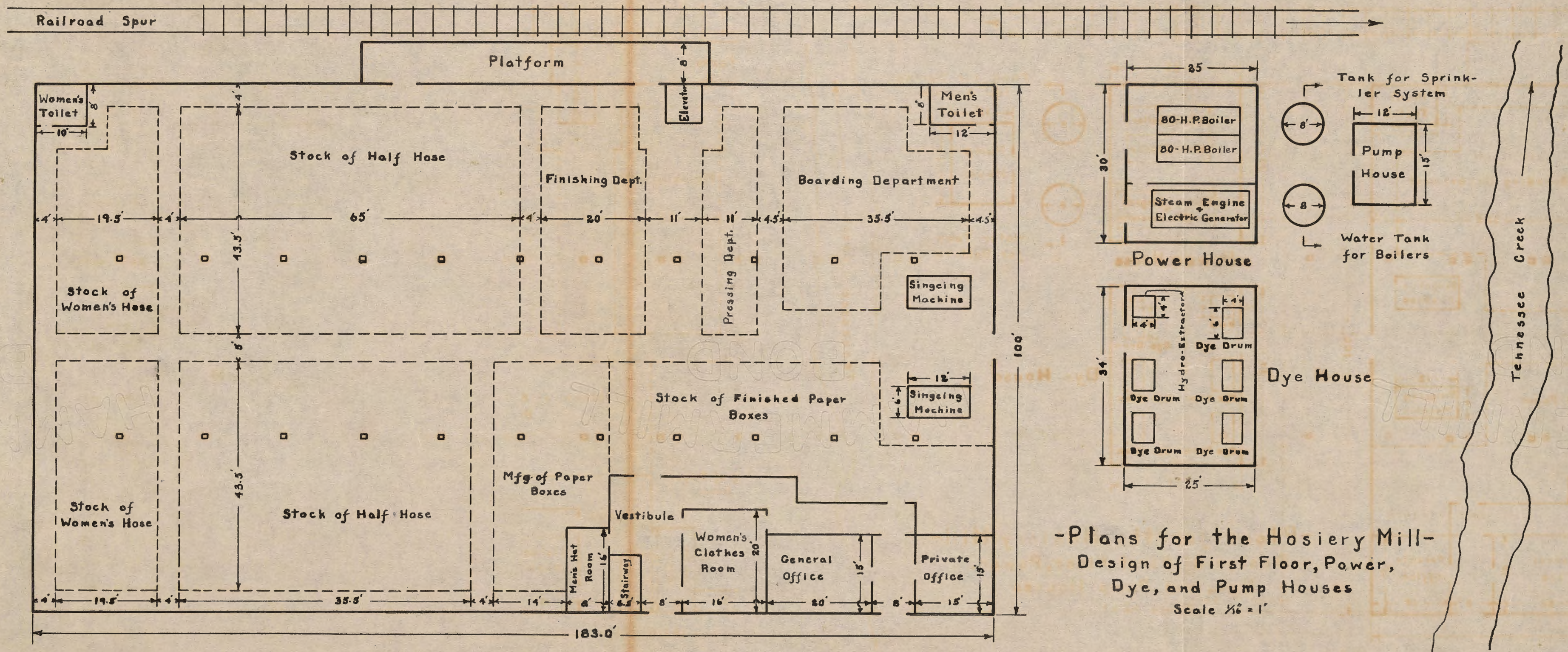


Plans for the Hosier Mill
Design of Basement
Scale $\frac{1}{16}'' = 1'$

wide.

The basement as shown in the accompanying plans will be only a half basement and will be of concrete construction. Mr. ---- thinks that a half basement will be large enough to store supplies such as yarn, wooden boxes, card board, for the making of paper boxes, etc. He also points out that it is usually necessary to do considerable excavation for a basement which means much expense. The mill at Rockwood has only a half basement and the room seems to be ample. The student has assumed that a half basement will be suitable for the proposed building. In the construction of the walls of the basement, special care must be taken to see that they are thick enough and of such a durable nature as to prevent cracks developing. Cracks have developed in the walls at Rockwood and during rainy seasons a limited amount of water gets in. The student merely mentions this fact so that care will be taken in the planning and construction of the proposed building.

The first floor has been divided into definite spaces for the different departments, as shown by the dotted lines, the solid lines indicating partitions. In placing the different departments, care has been taken to allow a proper routing of the hose through the different steps so as to avoid a waste of time. In most of the mills visited, there had been enlargements in the plant which had caused a general muddle in the routing. It becomes a much easier matter when only one kind of hose is made, to have a proper



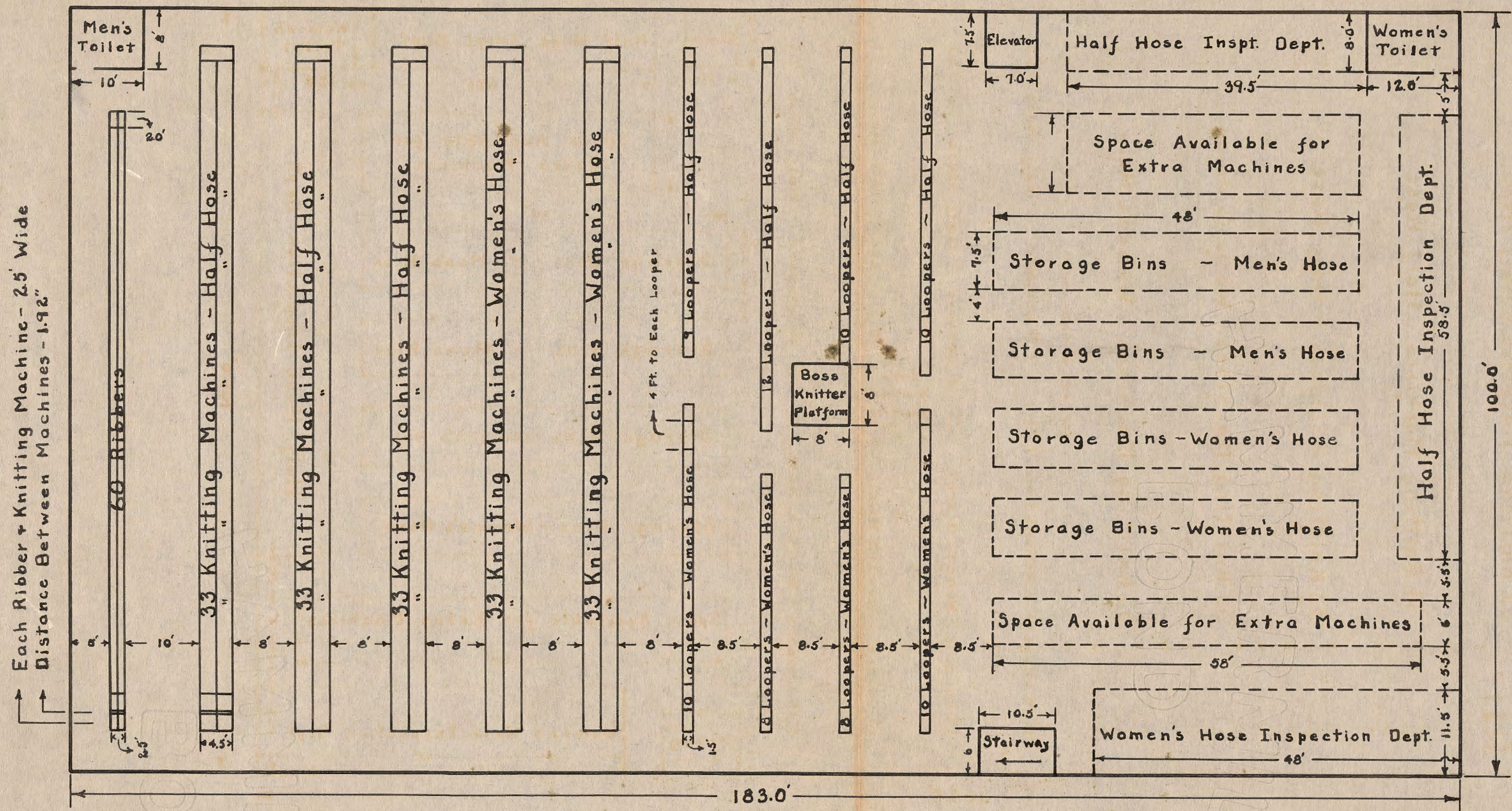
-Plans for the Hosiery Mill-
Design of First Floor, Power,
Dye, and Pump Houses
Scale 1/16" = 1'

routing. Mr. ----, general superintendent of five mills in East Tennessee and Virginia has an ideal system where only one kind of hose is made at each mill with one dye plant for all of the mills centrally located. Where there are a series of mills, of course it is desirable to have each mill to make one kind of hose, but in this proposed mill it is being assumed that it is operating alone. With proper care two kinds of hose, namely, women's mercerized hose, and men's mercerized half hose should be handled with ease.

It will also be noticed in the plans of the first floor that posts have been placed at intervals of sixteen feet, the object being to support the second floor.

As to the placing of the offices, the matter of light and ventilation has been considered particularly. The private office will have the benefit of the light on two sides, while the general office will receive **its** light from the front. There will be a private entrance to the offices as shown in the plans. The employees will have a separate entrance. This plan permits more quiet for the office force.

On the right of the general entrance will be a women's cloak room. The student believes that with such an arrangement as Mr. ---- has at Clinton, that a women cloak room will be a general benefit. The room will be left open until all of the employees arrive in the morning. The room will then



Scale = $\frac{1}{16}$ " to 1'

be locked until the noon hour, when it will be open until the afternoon work begins, whereupon it will be locked again until quitting time. The object for keeping the room locked is to prevent having a place to loaf, and also to eliminate any chance for articles being taken either by employees, or by any strangers that might wander into the mill. On the left of the main entrance, will be a men's coat room. This will be conducted in the same way as the women's cloak room. This room perhaps will not be used very much except in the winter when overcoats will be worn.

In the plan of the second floor, the spacing of the machines has been done upon the assumption that the Scott & Williams make will be used. The student took measurements in the Rockwood mill and has spaced the machines as he found them in use. Also the aisles are about the same width as at the Rockwood mill. The parallel arrangement of the machines is copied after the arrangement at Clinton. At the end of each row of machines, two feet has been allowed for an electric motor which will run the series of machines.

The inspection department has been arranged with the idea in view of giving the workers a maximum amount of light from the side windows; also with such an arrangement as that at Clinton, trusses can be used for the roof support eliminating posts, and by the use of skylight windows, still more light can be made available.

The boss knitter's platform is placed in the center of

the floor where he will have a desk to conduct such duties as he may have. The object for having his desk in the center of the room is that he will be more or less equally distant from the employees. If they have any questions to ask, also, if he has any instruction to give, steps will be saved.

The power, dye, and pump houses will be modeled after those at Clinton. The student has estimated roughly the dimensions for the different buildings. The two water tanks will be utalized to supply the boilers and the sprinkler system. It is being assumed that a creek and a railroad spur pass by the proposed mill.

EQUIPMENT AND SUPPLIES FOR THE MILL

According to Mr.-----, of Clinton, it is difficult to get equipment of any kind on a short notice, at the present time. To get a delivery of knitting machinery, it is necessary to wait perhaps twelve months. The delay for the most part is due to labor conditions.

The student has listed a number of firms whom Mr. ----- recommends as being what he considers the best in their respective lines. The knitting machinery for the proposed mill will be acquired from Scott & Williams, of New York. All of the mills visited used this firm's machinery. As for the electric motors to run the machines, there are a number of makes which are satisfactory. The motors will be

connected to the line of machines by either link belts, made by the W. J. Savage & Company, of Knoxville, Tennessee, or by the Morse Silent Chain Drive. The singeing machines and the dye house equipment will be gotten from Smith & Drum Company of Philadelphia. The hydro-extractor will be obtained from the Philadelphia Drying Machinery Company. There are three dye companies from whom chemicals can be acquired, namely: The National Aniline & Chemical Company of Charlotte, North Carolina, The Dupont Dye Company of Wilmington, Delaware, and The Atlantic Dyestuff Company of Charlotte, North Carolina. Mr.----- states that the above mentioned concerns have given satisfaction in about the order named. The boilers for the power plant will be obtained from The Babcock & Wilcox Company, of New York. Two 80-horse power fire tube boilers will be used. A condenser will also be bought from the last mentioned concern. Condensers show a saving of about ten percent in fuel.

The plant at Lenoir City has a system for giving a forced draft to the fire by the use of an electric fan. Mr.----- states that before putting in this draft that only five pounds of water were being evaporated per pound of coal, whereas now, seven pounds of water are being evaporated. This appliance can be considered when installing the plant. Practically all of the mills were heated by exhaust steam during cold weather. This system can be used in the

proposed mill.

As for the engine and generator, Allis, Chalmers & Company, of Milwaukee, Wisconsin, make an engine and generator directly connected which occupies a small space and gives entire satisfaction in every way. One of the plants visited has an installment of this nature. The details of the installment of this plant with an output of about 2000 dozen a day are as follows: The two boilers used are 125 horse power each; the generator is made to fulfil these requirements, 193 amperes--120 R. P. M.--3 phase alternating current--450 volts. The voltage developed by the machines is about 440 volts. Upon the assumption that this power plant is sufficient for a mill of 2000 dozen a day, the student will further assume that an installation developing two-thirds as much power will be sufficient for the proposed mill.

It was inquired of some of the managers about the feasibility of using power from some central station. It seems to have been their experience that depending upon power from a plant in the same town or from a nearby town, is impracticable because "shut-downs" occur too often. However, where it is possible to be on a direct line from a large power plant like the Cherokee Spinning Mills at Knoxville, which receives its power from Alcoa, this plan from all the student can hear is very satisfactory.

But in the case of this proposed mill, it is being assumed that the town in which this mill is to be located is not near a main power line, so an electrical installment will be made. The reasons why the proposed mill is using electric power to run the machinery are: (1) A real economy in the power used, (2) A reduction in cost of the construction of buildings, which can be made lighter, owing to the fact that there is no need of installing heavy lines of shafting and pulleys, (3) A reduction in the cost of service, such as oiling, depreciation and etc., (4) Access to the machinery is easier from the suppression of belts and pulleys, (5) Hygienic conditions are improved; the noise is lessened, (6) Greater facility in the increase of buildings. Prof. F. B. Crocker outlines the above reasons, and many others in favor of electric transmission.

Another item that must be considered in the equipment for the main building will be a sprinkler system. Insurance companies belonging to the National Board of Fire Underwriters grant a reduction of rates from thirty to fifty percent for sprinkler risks, depending upon the character of the equipment. For a risk of fair size, the cost of installing can be paid for in a few years out of the saving in insurance premiums. The student is not familiar with the different kinds of equipment but he is in favor of installing a modern and reliable sprinkler system.

A supply of high grade mercerized yarn can be obtained from a mill at Knoxville, Tennessee, or Chester, Pennsylvania. For the benefit of anyone who happens to read this paper and does not know about the process of mercerized cotton, a short discussion will be given from a book devoted to industrial chemistry. Thorpe, in his discussion, states that "Boiling in dilute alkalies has no injurious effect upon cotton if the air is excluded; otherwise, there may be more or less formation of oxycellulose, which may weaken the fibre. When treated with caustic soda solution at 50 degrees Tw., the fibre becomes rounded, swollen and semi-transparent, and the interior cavity almost disappears while a marked shrinkage in length takes place. It gains in weight and in strength, while its affinity for coloring matter is much increased. Mercerizing is extensively employed for producing a high lustre so that the cotton has a silky appearance. The yarn is held under tension on a frame while being treated with the caustic soda, and until the caustic is washed out; or tension may be applied after the alkali treatment and before the caustic is washed away. Stretching after washing does not produce a lustre and also excessive stretching is said to decrease the lustre; apparently, less force is required to keep the yarn at its original length during mercerization than to draw it back to its first length afterward. The yarn is thoroughly wet out before mercerizing, to insure even action on the fibre!"

This process of mercerization was discovered by John Mercer, an Englishman,

An item which is worth noticing is the breakage of needles which are used by the machines. Mr.----- manager of a mill of about 2000 dozen hose per day stated that his needle bill for the year of 1919 was \$35,000. He further stated that one German made needle (German needles were used before the war) would last as long as five American needles.

The aluminum forms used in the boarding department can either be bought, the cost being about \$17.50 per form, or a royalty of from one half to three quarters of a cent per dozen, depending upon the output, has to be paid. The majority of the mills visited were using the boards under the royalty scheme. It would perhaps be advisable for the proposed mill to follow the example of most of the mills, until enough money has been made to warrant buying the boards.

In addition to a pump in the pump house, there will also be a process for the softening of the water. The two main companies handling softening equipment are the "Permutit", and the "Refinite", Companies. The student has talked with the managers of mills using the two different equipments and with what has been said pro and con, the student is inclined to believe that the refinite method is the better of the two. For the benefit of anyone who is

not familiar with the refinite process, it might be well to describe it briefly.

Refinite, or Zeolite, is a flinty, porous mineral which has an affinity for calcium and magnesium, and also imparts sodium to the water precipitating the hardness. A mass of refinite fragments, twelve to eighteen inches thick are placed in the bottom of a tank through which the water passes. The hardness of the water is thus precipitated; however, in case the water is muddy, the refinite does not make the water clear. Alum, or some other chemical, must be added to clarify the water. After a time the refinite fragments become saturated with calcium and magnesium and give off all of their sodium. It is then necessary to recharge the fragments. This is accomplished by passing a brine solution of NaCl through the refinite for a period of about eight hours. The recharging of these refinite tanks is usually done at night. The output of a tank four feet in diameter and four feet high is about 2000 gallons per hour.

In concluding the discussion of the equipment and supplies, it might be well to note that in most of the mills visited, the general manager tended to all the correspondence and did the buying for the mill. The manager, of course, has to keep in touch with the head of the departments to see that the supplies are satisfactory. This system of buying seems to be the best for a comparatively small mill.

SEQUENCE OF PROCESS

The mercerized yarn arrives at the hosiery mills wound on cone-shaped paper spools. The dimensions of a spool with the yarn on it are about 4 x 6 x 8 inches. These spools, which come in boxes of a convenient size, will be unloaded from the railroad cars on the side track and taken to the basement. All of the other supplies will also be kept in the basement.

As the yarn is need^{ed}, it will be taken to the second floor and distributed among the employees operating the ribbing and knitting machines. It will be so arranged that each employee will have to return the empty spools in order to get a new issue of yarn. In this way a check will be kept upon the yarn used.

There are three processes in the knitting of men's half hose, namely; (1) Ribbing; the machines known as ribbers knit the top of the hose, (2) Knitting; the ribbed tops are put on the knitting machines which knit the socks as far as the toe, (3) Looping; this step of looping knits the toe of the sock which completes the article. There are only two steps in knitting the women's hose, namely; (1) Knitting; the knitting machines finish the hose as far as the toe, (2) Looping; the loopers complete the toe of the stocking. More skill is required to operate a looper than any other machine. Some available floor space has been left in case it is desired to install machines for putting seams up the rear of stockings. According to one mill

operator, this step is necessary to meet the prevailing style. This step will be considered when selecting the equipment.

The stockings and half hose which have been knit, will be gathered together in convenient bundles and taken to the inspection department.

The women in these inspection departments slip the hose on to dark colored forms which allow any defects in the hose to be detected. Those hose which show no holes are classed as number 1's. Those hose which require mending are put into the second, third or fourth classes, according to their worth. After the hose have been fully inspected, they will be put into the storage bins. These bins of course will be divided into sections with each section taking care of a certain size.

As the boss dye man receives orders, he will have men bring a definite number of pounds of hose to the first floor where they will be singed. The singeing process consists in a machine which burns or singes the loose threads on the inside of the hose. After the singeing process, the hose will be taken to the dye house to be dyed.

The dyeing process is the most difficult operation in the making of hose. One boss dye man, whom the student talked to, however, was inclined to make it appear that the process is even more difficult than it really is, according

to another authority in one of the mills visited; the boss dye man who has been at the same trade for about twenty years, does not follow the directions as specified by the dyestuff manufacturers, claiming that the directions never give satisfaction. According to the other man, who is connected with one of the most modern mills in this section, the dyes when used as the representatives of the particular companies specify, give satisfaction. The way which the modern dye concerns do is to send a man of experience to the dye plant to oversee, instruct, and actually see to every detail as to the hardness of the water, etc. This representative stays with the particular plant until instructions covering all manner of details are outlined to the boss dye man, and until the dyes give entire satisfaction. Mr.-----, who has been connected with a hosiery mill for about ten years, states that he adopted the plan as stated above and that he has had little trouble with the dyeing. The student believes that it is advisable to accept modern methods when they meet all requirements.

Practically all of the mills use direct dyes. Two of the mills visited still use the ageing process to produce black. The more modern method is to use sulphur black, a coal tar dye. The approximate directions for dyeing as set forth by one man using direct dyes are as follows; Weigh the hose. A definite amount of dyestuff correspond-

ing to the weight of the hose is dissolved in soft water in the dye container or drum. The hose are then put into the container which must now be closed and revolved. Steam is turned into the drum for one hour and thirty minutes. The steam is cut off and the revolving continues for twenty-five minutes more. At the end of that time, the drum is brought to rest; the dye water is drawn off (and saved for another lot of hose) and cold water is turned into the drum. The drum is closed and revolved for a few minutes. The water is then drawn off and a fresh supply put in. The hose are rinsed four times in this manner and are then taken out, and put into a hydro-extractor which process takes the water out of the hose. The hose are then put back into the same drum in which the dyeing was done in a two to four percent softening solution. A two percent solution is made by using two pounds of olive oil soap to each 100 pounds of hose. A combination of one pint of Turkey red to 100 pounds of hose is sometimes used. Cottonseed Olive Oil also makes a good softener. The hose are churned in the drum in this softener for a period of from ten to fifteen minutes. The hose are then taken out, "whizzed" in the hydro-extractor, and taken to the boarding department to be dried.

The aluminum boards upon which the hose are dried are hollow aluminum forms into which steam is shot. The boards are maintained at a temperature of about 212 degrees

Fahrenheit. When the hose are nearly dry, they are taken off of the boards and transferred to the pressing department.

The pressing department sees to the placing of the hose between layers of cardboard (while the hose are still steaming), which are put under pressure for a time, thus creasing the hose. The hose are then turned over to the finishing department.

The girls employed in the finishing department pair the hose into like shades of color, sort the hose into the proper class, label and finally put them into paper boxes for shipment. The girls who pair the hose into like shades of color will either be placed near windows, or electric lights with green shades (as recommended by one mill operator) will be provided in case of insufficient light.

NUMBER OF EMPLOYEES REQUIRED

The number of persons employed by the proposed mill will be based upon figures given to the student by Mr.-----.

The number required for each department is estimated by the work that is usually done by an average experienced employee.

(a) KNITTING DEPARTMENT

Ribbing machines for half hose.	2 boys (or girls).
Knitting machines for half hose	.66 Girls
Looping maching for half hose	.41 Girls
Knitting machines for women's hose.	6 Girls

Looping machines for women's hose. 36 Girls.
Machinists for Ribbers and Loopers 2 Men.
Machinists for Knitting Machines 6 Men.
Teachers (one for Loopers and one for Knitters Machines),
2 Women.
Janitor for Knitting room 1 Man.
Employee (To keep supply of yarn on hand) 1 Man.
Boss Knitter 1 Man.
TOTAL. 164 Employees.

(b) INSPECTION DEPARTMENT

Inspection of half hose 5 Women.
Inspection of Women's hose. 3 Women.
Boss Inspector 1 Woman.
TOTAL 9 Employees.

(c) INTERMEDIATE STEP

Operators of Singeing Machines 4 Men.

(d) DYEING DEPARTMENT

Dyers 4 Men.
Boss Dyer 1 Man.
TOTAL. 5 Employees.

(e) BOARDING DEPARTMENT

Employees 8 Men.

(f) PRESSING DEPARTMENT

Employees 3 Men.

(g) FINISHING DEPARTMENT

Employees 5 Girls.

Foreman of Boarding, Pressing and Finishing Depts. . 1 Man
TOTAL 6 Emps.

(h) SHIPPING DEPARTMENT

Employees 3 Men.
Shipping Clerk. 1 Man.
TOTAL 4 Men.

(i) MISCELLANEOUS EMPLOYEES

Paper box makers 3 Men.
Carpenter 1 Man.
Engineers for Power Plant 1 Man.
Asst. Engineer for Power Plant. 1 Man
(Also sees to water softening process).
Janitor for first floor and basement 1 Man
TOTAL 7 Emps.

(j) OFFICE DEPARTMENT

General Manager 1 Man.
Secretary 1 Woman
Filing Clerk. 1 Man
Bookkeeper 1 Man
TOTAL 3 Emps.

Total number of Employees (Approximately) Required. . 215.

PRODUCTION

It is assumed that this proposed mill will work nine hours a day. It is further assumed that all of the equipment will work in exact coordination with the knitting machinery.

(1) OUTPUT OF HALF ROSE PER DAY

(a) Ribbing Machines (110 Needles, 1 by 1)

16 Dozen per Machine.

60 Machines

1000 Dozen (High Estimate).

(b) Knitting Machines (220 Needles).

5 Dozen per Machine.

198 Machines.

990 Dozen (High Estimate).

(c) Looping Machines (22 Points to the Inch).

25 Dozen per Machine.

41 Machines.

1025 Dozen (Average Estimate).

Output of half hose--1000 Dozen (High Est.)

(2) OUTPUT OF WOMEN'S HOSE PER DAY.

(a) Knitting Machines (220 Needles).

3 Dozen per machine.

132 Machines.

396 Dozen (High Estimate).

(b) Looping Machines (22 Points to the inch).

11 Dozen per Machine.

36 Machines.

396 Dozen (Average Estimate).

Output of Women's hose--396 Doz. (High Est.)

TOTAL OUTPUT OF MEN AND WOMEN'S HOSE (APPROXIMATELY)

1400 Doz per Day.

SELLING

Practically all of the mills in this section sell their output through a sales manager whose office is usually located in New York. The representatives of the wholesale houses in the South, Middle West and East always go to New York to do their buying. The proposed mill will dispose of their output in the same way as the other mills.

CONCLUSION

The student with what knowledge he has been able to obtain, has outlined roughly the points to be considered in establishing and operating a hosiery mill. Owing to a limited amount of time only the major points have been considered in this paper.

Charles F. Sexton
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