Rayon Staple Fiber and Manufacture of Spun Rayon Yarns

Article II. Producing Staple Fiber

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Present Position of Spun Rayon

The general survey of staple fiber published in the April issue of THE MELLIAND, p. 117, has directed attention to the potentialities of this textile. In conjunction with this, an explanation of the position that has been reached at the present time is desirable.

In the first place mention should be made of the use of staple fiber yarns by the Central European powers during the late war. This was, however, essentially a war measure, and stocks of rayon yarns were guillotined without primary reference to their actual suitability. The use at this time should, therefore, be regarded as an isolated instance without any great influence on the commercial development which has taken place under more normal conditions since the war.

The lead in the development of staple fiber, both in its initial manufacture and subsequent spinning, weaving, or knitting, still remains in Europe. In England, the cotton districts of Lancashire and the woolen districts of Yorkshire, in particular, are developing the use of staple fiber to an increasing extent. In both these districts rayon staple fiber is used in conjunction with cotton or wool in the production of mixed yarns. In the case of wool, the resultant mixed yarn is improved in appearance, and gives a general appearance to the cloth of a much finer grade of wool than has actually been employed.

In the production of mixed yarns the rayon is mixed with the cotton or wool as early in the process as possible, usually in the scutcher.

The production of all-rayon staple fiber yarns has chiefly been developed in Lancashire, where many thousands of spindles are now being employed on this material, while in several cases the whole output of individual cotton spinning mills is devoted to spun rayon yarns.

The use of these yarns is mainly for woven fabrics and especially for woven underwear. The finer counts are used for hosiery, while mixed cloths, composed of a cotton warp and spun rayon filling, are also increasing in popularity. The development of all spun rayon or mixed yarns for woven underwear is particularly attractive and offers very great possibilities.

One of the chief difficulties in this direction, which is, however, being steadily overcome, consists in the relative weak wet strength of rayon cloths, which has resulted in laundering problems. There is no doubt whatever that this objection is in process of solution, and will yield to modern research.

Manufacture of Staple Fiber by the Viscose Process

The process of rayon manufacture which is of preponderating importance for staple fiber is the viscose process. In common with the other commercial processes, the essential of the viscose process consists in the formation of chemical compounds of cellulose, whereby this may be reduced into solution. From this solution, cellulose is regenerated into the desired form of continuous filaments or threads. Broadly speaking, therefore, the result of the process is the reformation of short fibers of cellulose into continuous threads of similar composition to that of the initial raw material. Up to the preparation of the cellulose solution, or viscose, the processes for both continuous filament yarn and staple fiber yarn follow similar lines. The method whereby the regenerated

EDITOR'S NOTE: This is the second article in the series by Mr. Pellatt covering the field for staple rayon, properties and production of the fiber, and the processes of yarn manufacturing. It shows why the material can be produced cheaper than continuous filament yarns and makes the interesting statement that comparatively small plants can be operated with a satisfactory return on the investment. From a development point of view this is of great importance. Later articles will take up yarn manufacturing.

thread, intended for staple fiber, is collected and subsequently processed, differs from continuous filament yarn.

A considerable proportion of the staple fiber produced at the present time is made in conjunction with continuous filament yarn, any spare viscose, or viscose which is not quite up to standard being commonly utilized for staple fiber.

While the requirements of staple fiber are not so exacting, and advantage of this fact may be taken in speeding up certain stages of processing—in particular, mercerization and ripening—the manufacture of staple fiber in this way does not assist in maintaining a high standard, either of uniformity or of physical properties. Attention is now being increasingly devoted to the separate manufacture of staple fiber, and this is undoubtedly in the best interests of the industry.

The specialized manufacture of rayon staple fiber offers attractions which can hardly be overlooked. Not only are the spinning machines capable of very high productions—as high as ten times greater per spindle than continuous filament yarn of average denier—but the finishing plant also is capable of greater production. This means that the capital expenditure per unit of production is much less than for continuous filament yarn.

Further, the fundamental and paramount importance of uniformity at all stages of process, which must be attained for the successful production of continuous filament yarn, is materially relaxed, with a corresponding simplification and reduction in expenditure on technical control.

One result of these considerations is that it is possible to operate smaller plants with a satisfactory return on capital. From a development point of view, this is of very great importance in assisting in broadening the basis of the industry.

For the reasons already stated, the following description of the process deals with the production of staple fiber as a distinct manufacture.

The Preparation of Viscose

Although cotton provides the purest form of cellulose available commercially, it is relatively costly and consequently its use is restricted.

Further, one of the advantages that the viscose process possesses, as compared with the alternative methods of rayon production by the acetate and cuprammonium processes, is its capability of utilizing cellulose in a form which is relatively degraded. It is possible by the viscose process to produce high grade rayon yarn from wood pulp or wood cellulose, the cost of which is only about one-third that of cotton linters pulp. The source of cellulose of preponderating importance for viscose rayon is, therefore, wood cellulose; cotton cellulose being restricted to special yarns, and even then only as a proportion of the cellulose charge.

Wood cellulose in suitable form for viscose has already passed through a sequence of processes with the object of removing impurities and producing a regular product of high purity. The timber used consists of picked spruce of 25 to 30 years growth which, after seasoning, is washed and debarked. Subsequent processes include chipping the wood and digesting this with Calcium Bisulphite to remove the 20 percent of lignin which the original wood contained. The pulp is then bleached, washed, and formed into sheets about 2 ft. x 3 ft. in size.

These processes are invariably carried out in the country of growth; the sources from which the greater proportion of wood cellulose for rayon is drawn being Scandinavia, Canada, and U. S. A.

It is sometimes erroneously stated that the rise of the rayon industry is seriously threatening the world supplies of timber for wood pulp. This is hardly the case, as the total consumption for rayon forms about two percent only of the world production for the paper industry. Little reflection is needed to assure oneself that the consumption of paper for newspapers, books, and all its various uses far outweighs the consumption of rayon. This economic fact has a further manifestation in the futility of exploiting alternative sources of cellulose as a raw material for rayon.

It is most unlikely that so long as wood cellulose is available as a highly developed and highly commercialized industry, new and untried alternatives will meet with any great success, especially as the cost of wood pulp bears only a smal proportion of the cost of manufacture of rayon. A similar economic fact worth recording is the true relation of rayon to the older textile industries, the estimated comparison being that rayon production is 2½ per cent of cotton production and 1½ per cent of total world textile production.

lulose without chemical change of greater or less complexity is not commercially soluble in any liquid.

Formation of Alkali Cellulose

The formation of alkali cellulose is commenced by the immersion of the wood cellulose sheets in caustic soda solution which has previously been brought to requisite temperature and strength, and carefully purified.

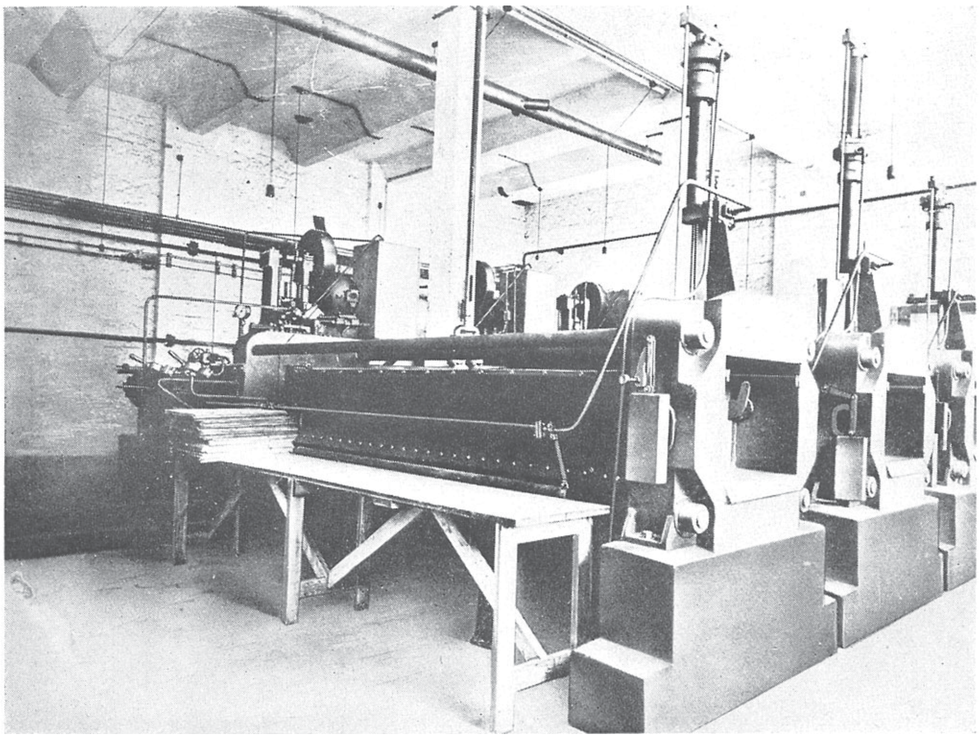

Figure 1. Battery of Hydraulic Cellulose Presses

Divisions of Process

Passing from these preliminary considerations to the actual manufacture of the viscose solution from which the yarn is formed, three stages are necessary. The first consists in the preparation of Alkali Cellulose, which is a compound of caustic soda and cellulose. The second stage is the formation of a second chemical compound — Cellulose Xanthate — which may be brought into solution in caustic soda and water, this dissolution forming the third stage in the process. This sequence of chemical change is necessary in order to form a cellulose compound which is soluble, as cel-

As the next operation consists in pressing the steeped pulp, both operations are usually carried out in a specially designed horizontal hydraulic cellulose press (see Fig. 1). This consists of a tank in which the pulp sheets are immersed vertically or on edge. One end of this tank forms the head of the horizontal press, while the ram passes through the opposite end.

After immersing for some two hours, the ram of the press is sent forward to press out a proportion of the caustic soda, which it is possible to re-use after filtration and strengthening. This caustic soda is then run off, after which a second pressing follows; the caustic soda from this is then discarded on account of the high content of dissolved hemicellulose. A proportion of caustic soda, however, still remains after the second operation, and this is permitted to remain in the pulp.

The pulp is next discharged through the head of the press, which is lifted hydraulically for this purpose. After pressing, the pulp sheets are disintegrated in powerful kneading machines (see Fig. 2) specially designed to tear apart the fibers of the wood cellulose rather than to crush them.

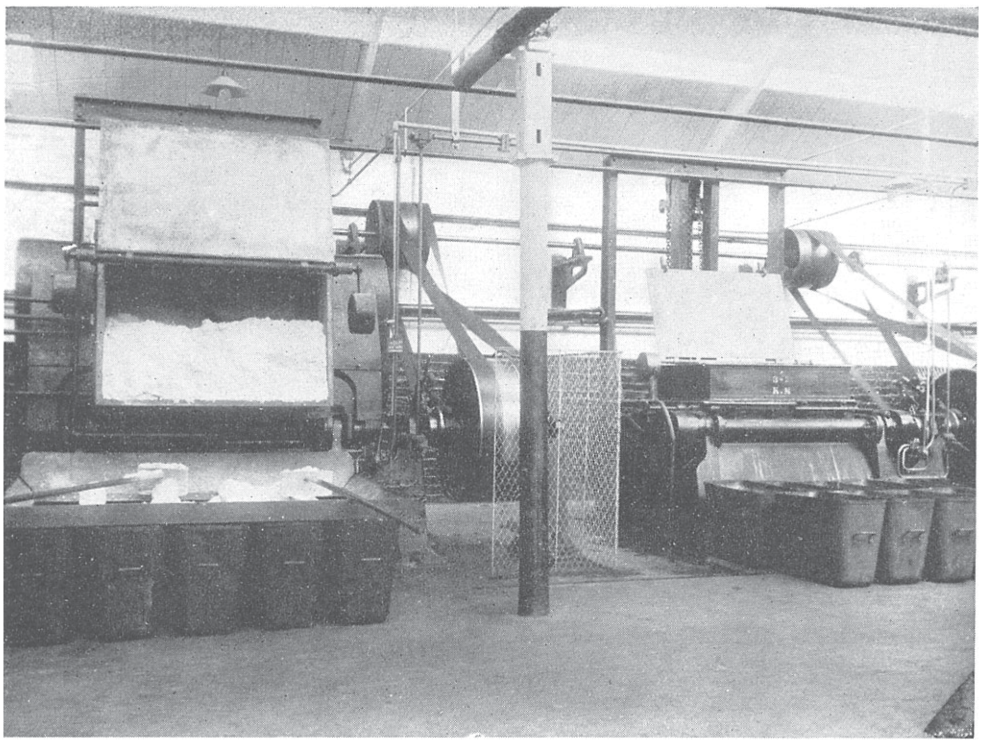

Figure 2. Kneading Machines, Showing Discharge Into Maturing Tins

The final stage in the formation of alkali cellulose consists in the maturation or mercerization of the "crumbs"—which term adequately describes the form in which the alkali cellulose leaves the kneading machines. This process consists in storing the crumbs in suitably sized tins or boxes at a definite temperature for two or three days. During this period the reaction between the soda and cellulose continues, and is controlled by the time allowed. It is necessary for the production of a viscose of suitable viscosity or thickness for the degradation of the cellulose to be controlled, and although this might be accomplished at other stages, maturing, which employs no special machines and depends only upon a time factor, provides the obviously convenient opportunity for this control.

Formation of Cellulose Xanthate

After the appropriate period the alkali cellulose crumbs are conveyed to the churn room, where individual charges from the press and kneader are transferred into churns. (See Fig. 3). These consist of either round or hexagonal drums which may be either wood lagged or water jacketed, and which are equipped with suitable driving mechanism for revolving at a speed of about one revolution in two minutes. The churn bodies are built of steel and must be free from all internal projections and be completely gas tight. After charging the crumbs the churn door is closed down and a measured quantity of carbon disulphide in liquid form is admitted into a central tube running axially the length of the churn. The liquid is quickly gasified, and the reaction which follows takes place between the solid alkali cellulose crumbs and carbon disulphide in gas form.

During churning, cellulose xanthate is formed, which is a compound capable of being dissolved in water and caustic soda; the main object of the whole of the preparation processes being, as already stated, the reduction of cellulose into solution form. The reaction in the churn is exo-thermic, and a temperature rise is permitted to a controlled extent, from about 21° C. to about 28° C.

caustic soda, water, and sodium sulphite for its solution has been made up and brought to the desired temperature of about 14° C.

The viscose dissolver is jacketed for brine circulation in order that the temperature may be controlled and the viscose brought to the temperature of the ripening room, namely 16 to 17° C., before leaving the dissolver. The time for solution is between two and three hours, after which the viscose may be passed direct to the ripening room (See Fig. 5) or, alternatively, into a blender, where a number of charges may be mixed in order to produce as even a viscose as possible. It is usual for the blender to hold about six charges, which may pass forward as a complete charge or only one charge may be passed forward to the ripening room at a time.

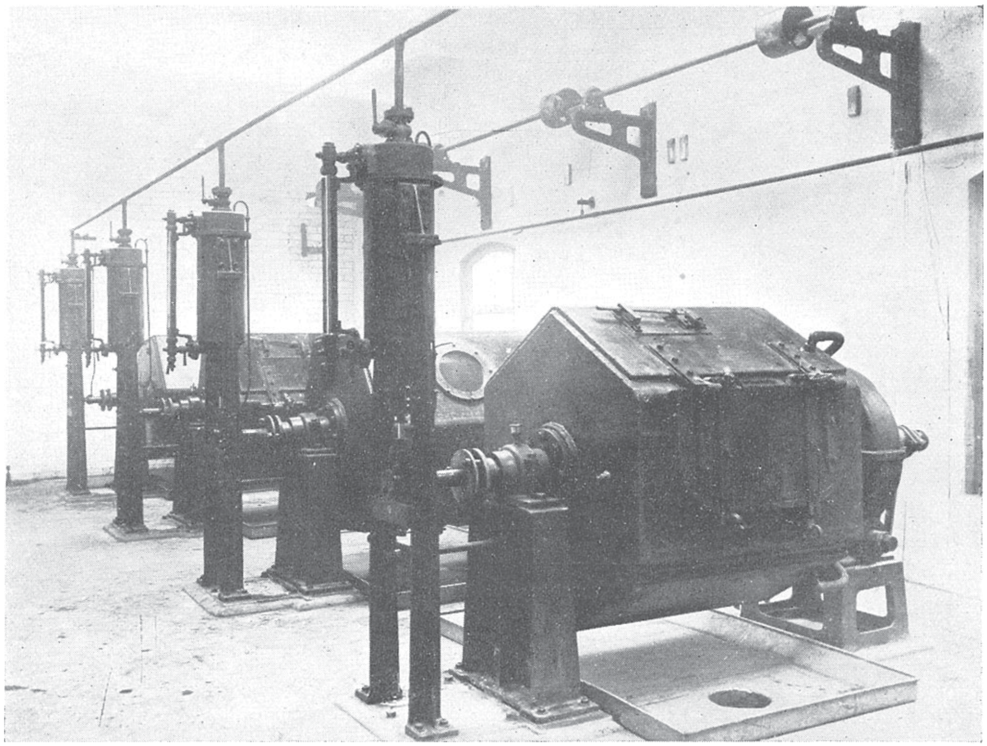

Figure 3. Battery of Churns

The cellulose xanthate formed is inclined to ball up, particularly if any local over-xanthation takes place. The minimizing of this danger is of first importance in the design and control of the churn.

The Solution of Cellulose Xanthate

After churning, the contents are tipped on to a tray connecting to a chute, down which the cellulose xanthate is passed direct into a viscose dissolver. (See Fig. 4). Before the xanthate enters the dissolvers, the charge of

The blender, like the dissolvers, is jacketed for brine circulation, and it should be noted that for the first time in the process separate charges, which have retained their identity direct from the pulp, are mixed together.

Leaving the blenders the viscose enters the ripening room, where reactions of a similar character to maturing are allowed to continue for about 96 hours under definite temperature control. The time is regulated by means of a direct test on the speed of coagulation, and temperature control is maintained to within one-quarter degree C. throughout the year.

Process for Staple Fiber as Distinct from Continuous Filament

It has already been indicated that certain economies are possible in manufacturing viscose for staple fiber which are not usually followed when the viscose is to be used for the production of high grade rayon yarn. These economies depend upon the processing of batches of as large a size as possible, which has a direct effect upon the technical control and labor costs involved.

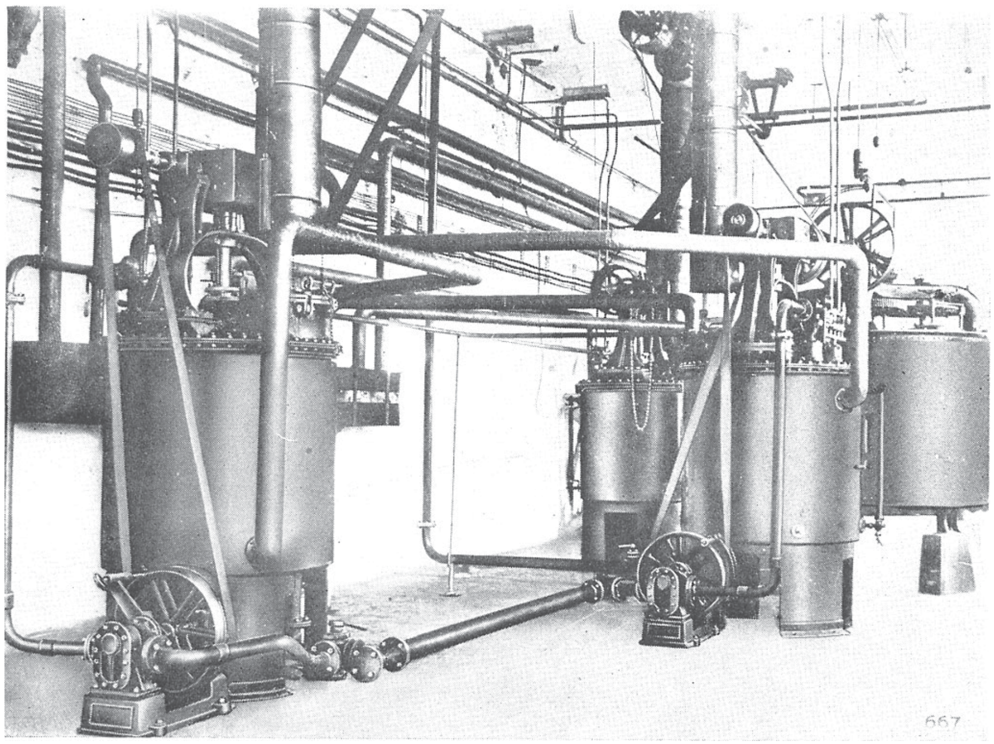

Figure 4. Viscose Dissolvers and Blenders

During its period in the ripening room, the viscose is filtered at least three times, and preferably four times, the object being to remove all solid impurities, undissolved or partially undissolved xanthate, and any other foreign material liable to choke the jets (or spinnerets) in the subsequent spinning process.

The viscose is now ready for feeding to the spinning machines, and may be reformed as continuous filament yarn, or as yarn which will afterwards be cut to suitable length for sale as staple fiber. In either case the principle of spinning consists in extruding the viscose through jets having fine holes, into a coagulation bath, where a thread is formed which is subsequently collected.

The use of larger batches of pulp, of about 50% greater weight than is usual for continuous filament yarn, is possible and these batches may be dissolved in viscose dissolvers designed to hold two or more batches.

In a similar way the capacity of the containers in the ripening room is increased to hold six batches, instead of the normal three, while pipelines and filter presses are simplified.

Economies are also possible by ripening and maturing for shorter periods and at a higher temperature, but this is less desirable, as the resulting speeding up of processes reduces the margin of safety and, therefore, the uniformity of the final yarn.

It will be noted that similar economies are possible at later stages of the process and, therefore, the principle upon which these economies depend should be made clear.

uniformity of filament denier, which are of primary importance in continuous filament yarn, are definitely unimportant for staple fiber. Consequently precautions designed to insure uniformity in this respect may be relaxed.

On the other hand, the general physical

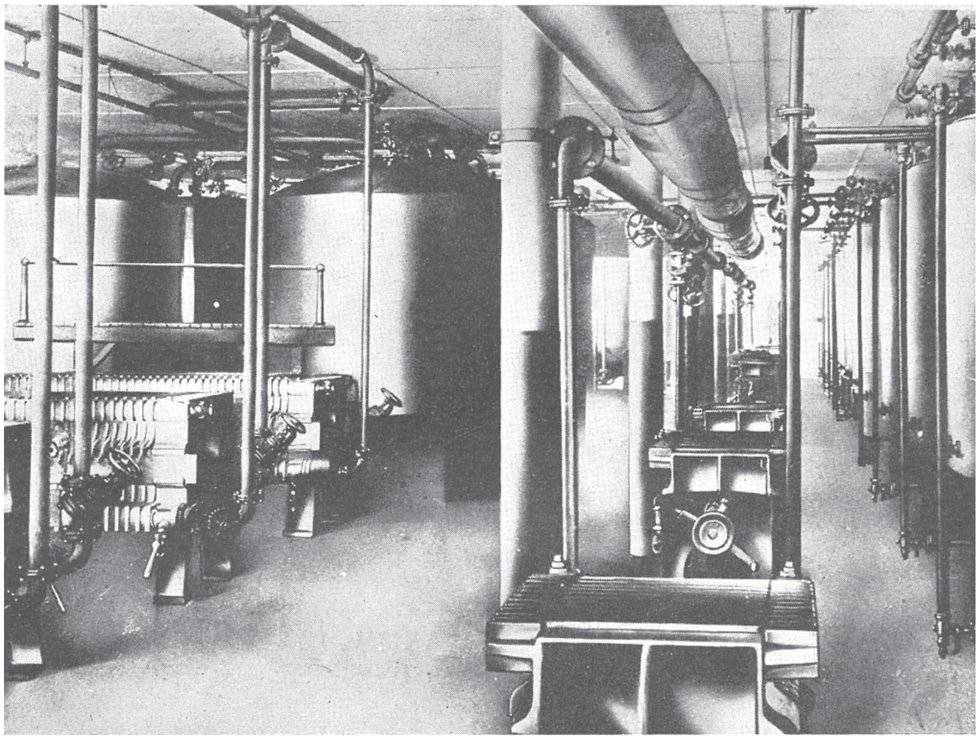

Figure 5. Ripening Room, Showing Filter Presses and Ripening Containers

The main difference between continuous filament yarn and staple fiber yarn in this respect depends upon the mixing together of the individual fibers, which takes place when these are processed and finally spun into a thread.

Such considerations as even dye affinity and

properties of the yarn, particularly the wet strength, are of equal importance to continuous filament yarn. Unfortunately, this fact has not been given sufficient prominence and the general standard of staple fiber yarns produced has suffered in consequence.

THE MECHANICAL DEPARTMENT

While not directly a producer of yarn or cloth that can be sold at a profit, the mechanical department of a textile mill does produce things that are necessary to profitable operation. Its products are economy, efficiency and continued operation. This is realized more and more, as proved by the better quarters that are provided for the mechanical department today. Better equipment is also provided for the various services that are rendered to manufacturing departments, such as supplying power and steam, repair of machinery, building upkeep, policing and fire protection of plants, accident prevention and research work. It is generally the case that the mill with the best equipped mechanical department is the last to feel the effects of a depressed condition in its line.