I. C. S.
REFERENCE LIBRARY

A SERIES OF TEXTBOOKS PREPARED FOR THE STUDENTS OF THE INTERNATIONAL CORRESPONDENCE SCHOOLS AND CONTAINING IN PERMANENT FORM THE INSTRUCTION PAPERS, EXAMINATION QUESTIONS, AND KEYS USED IN THEIR VARIOUS COURSES

YARNS
CLOTH ROOMS
MILL ENGINEERING
REELING AND BALING
WINDING

SCRANTON
INTERNATIONAL TEXTBOOK COMPANY
89

PRESS OF
INTERNATIONAL TEXTBOOK COMPANY
SCRANTON, PA.

29483

89

CONTENTS

YARNS

(PART 1)

YARNS FROM VEGETABLE FIBERS

INTRODUCTION

1. The word **yarn** is one of the best known in the textile trades of all English-speaking nations and is used to indicate a continuous strand, spun or otherwise produced from natural fibrous substances, whether vegetable, animal, or mineral; as, for instance, cotton yarn, woolen yarn, asbestos yarn, and so on. Though the term is applied commonly to all fibrous threads, it is more accurately applied to yarns in bulk, or to a quantity of strands or threads, than to small pieces or single lengths of thread. When threads are considered singly, each one is more frequently spoken of as an *end*, as, for example, the expressions *broken end*, *two ends in a dent;* but even in this case it is an end of yarn that is meant. One possible exception is that sewing, embroidery, and such threads, which consist of several ends of yarn twisted together, are usually spoken of as *thread* instead of yarn. The use of the word thread in the sewing-thread and kindred trades instead of the word yarn differs from the custom in many other branches of textile yarn manufacturing where the yarn, even when several ends are twisted together, is still spoken of as yarn. Still another exception is in the case of the various kinds of cordage, which, although technically are continuous strands of fibrous materials, cease to be spoken of as yarn when made up into the form of twines, cords, and ropes owing to their thickness as compared with ordinary yarns. Aside from the exceptions named, the word yarn may be considered as applying to all strands or threads made from fibrous substances.

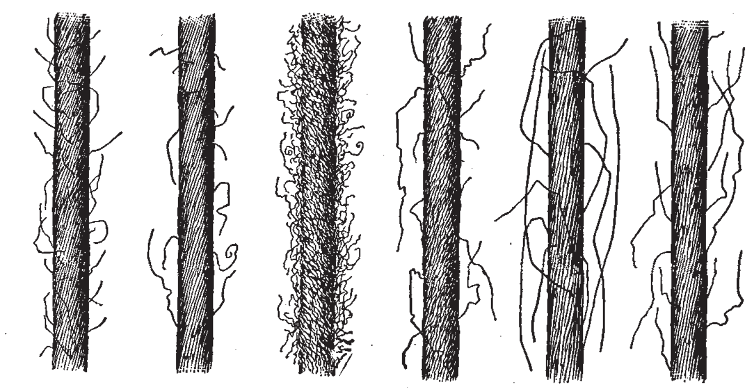
The word yarn is derived from the Anglo-Saxon word *gearn* and bears resemblance to *garn* in the German, Swedish, and Danish languages, which also has the same meaning. These words probably all came from the Teutonic name for yarn, or string, and are allied to the Greek χορδή (chordé), meaning a string, originally one made from the intestines (χολάδεξ—choládez) of animals, which was one of the earliest filaments used by man. It is from χορδή that we have the English word cord.

In its most perfect form, yarn is cylindrical, of the same diameter and evenly twisted, with the same number of turns per inch, throughout its length, and of a uniform strength at all points. Either from the nature of the fiber, from intentionally different construction, or from defective material or manufacture, some yarns do not attain this standard of perfection, but vary in evenness and in strength.

CLASSIFICATION OF YARN

2. Drawn and Condensed Yarns.—The subject of yarns, when dealt with generally, opens up a very wide field and various methods of classification so that the subject may be intelligently considered. Not only do the series of processes for preparing yarns vary according to the material that is to be operated on, but different series of machines or processes are often used even for the same material. Although each series of machines produces yarn different in some respect from yarns produced by other series of processes, all yarns, of whatever material, may be classified in two main divisions, according to their structure; namely, *drawn yarns* and *condensed yarns*. **Drawn yarns** are those in which all fibers are laid parallel, with the ends overlapping one another, which, since the yarn is twisted while in this condition, produces a series of parallel spirals. This method of producing yarn depends on the principle of roll drawing, and such yarns may be described as *drafted* or *multidrafted* yarns. It is by far the larger class of yarn, including most cotton yarns, all worsted yarns, and many others.

The second class—**condensed yarns**—consists of those yarns in which the fibers do not all lie parallel, overlapping one another, but are crossed and laid without any regular order. These yarns are produced by arranging the fibers in loose ribbons at the carding process, rolling these ribbons into roving by a condenser, and completing the operation of spinning with a slight drafting operation between the rolls and spindles of the mule, at which time the twist is also inserted.



(*a*) (*b*) (*c*) (*d*) (*e*) (*f*)

FIG. 1

As the fibers are laid in the thread without regard to their parallelism, such yarns have not the strength of drawn yarns of the same thickness; condensed yarns also have a rougher surface and a more oozy construction, owing to the fact that many of the fibers project from the surface of the yarn.

The appearance of several typical yarns, when magnified, is shown in Fig. 1, where (*a*) represents a single cotton yarn; (*b*), a single flax line yarn (linen); (*c*), a single woolen yarn; (*d*), a single worsted yarn; (*e*), a single mohair yarn; and (*f*), a single spun silk yarn. The parallel, spiral formation is shown in (*a*), (*b*), (*d*), (*e*), (*f*), and the irregularly arranged, crossed formation of the fibers in (*c*). This means of classifying yarns into drawn or condensed yarns is a purely academic one, not obtaining to any large extent in practical mill work; but nevertheless it is an excellent theoretical division.

3. Classification According to Material.—One of the most common classifications of yarns, which is simple and easily made, is according to the material from which the yarns are manufactured. These may first be divided into the three divisions: (1) *vegetable*, (2) *animal*, and (3) *mineral substances*. If vegetable fibers, they may be subdivided according to the portion of the plant from which they are taken: (1) fibers from seeds, (2) fibers from the stem of the plant, (3) fibers from leaves, and (4) fibers from the fruit of the plant.

1. *Vegetable Fibers.*—Seed fibers are represented principally by cotton. Fibers from the stems of plants are flax, hemp, jute, and China grass, ramie, or rhea. Fibers from the leaves of plants are Manila hemp, sisal, and aloe fiber. Fiber from fruit is represented by coconut fiber, or coir. From all these substances yarn can be made, but there are other vegetable materials that are sometimes used for weaving and similar purposes, such as straw, cane, strips of wood or bark of trees, rubber, etc., from which yarn is not made and which will be ignored in this Section.

2. *Animal Fibers.*—Yarns are produced from animal fibers that form the natural covering of certain mammals and have been sheared or clipped from the bodies or pulled from the skins. These fibers consist of a large number of separate filaments varying in length, strength, fineness, waviness, pliability, softness, elasticity, and luster, and may be subdivided into wool and hair, although in some animals the division is difficult to determine, for wool is really a fine, wavy hair. Wool, however, is generally considered as referring exclusively to the fiber obtained from the sheep. The hair materials are mohair (the fleece of the Angora goat),

the fleece of the Cashmere goat, the alpaca, and the vicugna, which, although hair, have much resemblance to wool; also the strictly hair materials, free from waviness commonly considered a feature of true wool, such as goat hair, camel hair, horse hair, cow hair, and the various furs, including cat, rabbit, and hare. Both wool and hair lend themselves, especially in the case of wool, to the manufacture of yarn, which is not the case with the stiffer hairs known as bristles and spines.

A third class of animal fiber is known as silk, which is the exudation of the silk worm. This is divided into natural silk, of which there are two varieties—true and wild—and artificial silk, although this more naturally comes under the vegetable class, as it is produced from vegetable matter.

3. *Mineral fibers* is a small class of thread material, consisting principally of asbestos, glass, and metals.

It is not intended that the foregoing list should be considered complete, as for special purposes other materials are used in small quantities for yarns, and new fibrous substances are constantly being discovered and used for textile purposes. Many of the materials mentioned are of little importance to the ordinary textile student, but others, such as cotton, linen, wool, and silk, are of great importance and require careful study. Under the modern conditions of textile manufacturing, it is not sufficient for a student to have a knowledge of yarn manufactured from one material or one variety of material alone; there is a tendency for one branch of manufacture to merge into another. Designers are often called on to use yarns of more than one material, size, structure, or value in the fabric being designed; a manufacturer of cloth or knit goods is often required to utilize more than one size, structure, or value of yarns, or to incorporate into one fabric yarns made from different materials; a yarn-mill superintendent may be called on to imitate yarns made from some other material than the one from which he has to produce a yarn. The modern millman is therefore expected to have some knowledge of other yarns than those actually used or produced in the mill with which he is connected.

The widest knowledge of yarn is required by those engaged in preparing yarns for the market, in dealing in yarns—either selling or buying them—or in converting yarns by various processes so as to change their appearance or construction, or in combining threads to give special effects.

4. The largest proportion of the yarns produced in most of the textile industries is utilized for weaving purposes, usually by the firm that spins them. Another large percentage is intended for knitting mills. Other yarns are utilized for such purposes as sewing or embroidery thread, lace making, rope and twine making, and electric-wire covering.

Yarns for thread are usually spun by the firm making the thread, but for the other purposes the yarns are often purchased. In some cases, weaving mills buy their yarns; in most cases, knitting mills buy their yarns; and even knitting mills, weaving mills, or thread mills either buy a portion of the yarns they use or sell a portion of their yarn production according to the conditions of the market or for other reasons. Almost every mill making fancy goods at times requires to purchase novelty or special yarns, the production of which is a feature of certain yarn mills possessing the necessary machinery and employing help skilled in such work. Similarly, yarns that are put up in special form or that are dyed, bleached, printed, mercerized, polished, or otherwise prepared are sold to firms requiring the same. Often these processes are conducted in the mill in which the yarns are to be used. The uses found for yarns are increasing every year and it often requires some special method of preparation or handling to prepare them for the purposes for which they are intended. Thus, in the aggregate, the trade in yarns is of large proportions, and requires an expert knowledge on the part of those dealing in them—either as buyers, sellers, or agents.

5. A brief description will be given of the yarns that are produced from each of the principal materials, and some attention paid to their identification and the forms in which they are put up, the purposes for which they are intended, and the effects of the processes through which they are passed after spinning, some of which change the appearance of the yarn, some of which combine threads, while others are intended to put up the yarn in various forms for convenience in transportation or to facilitate the operation of the next process. It is not intended to describe the manufacture of the yarn, but rather to refer to the leading types of yarns as they are placed on the market.

The great variety of yarns used for a large number of processes renders their classification and accurate description a matter of some difficulty. The correct word to use in their description is sometimes difficult to select owing to the fact that the same word may have a different meaning in different textile industries and even in the same industry as conducted in different districts or different countries; as far as practicable, however, these different meanings will be explained. When the counts, or numbers, of yarns are given, they refer to the standard numbering of yarns made from the material under description in each case.

In the case of yarns made from the more important materials, the following general classification will be made, as nearly as possible, in the order given; but for yarns that are less frequently met with a briefer description will be considered sufficient: (1) the material; (2) the various classes of material and the numbers made from each, including the various qualities, growths, or varieties of the material and its suitability for various yarns; (3) the classification of the yarns according to the method of their preparation, which is occasionally found to vary even in yarns made from the same material; (4) the appearance of the thread, which may vary according to the kind of material used, the method of its preparation, or its treatment after spinning; (5) forms in which the yarn is put up for the market or for a succeeding process; (6) the general purposes for which the yarn is used.

COTTON YARNS

CLASSIFICATION ACCORDING TO VARIETIES OF RAW MATERIAL

6. Cotton yarns are those made from the seed fibers of the cotton plant, which belongs to the botanical genus *Gossypium*, of which there are a number of species. The genus Gossypium belongs to the order of *Malvaceæ*. The principal species cultivated for commercial purposes are the *Gossypium herbaceum*, *Gossypium Barbadense*, and the *Gossypium arboreum*. The species known as Gossypium herbaceum grows to a height of from 2 to 6 feet and, like most species of the cotton plant, is an annual, having to be planted each year. It is found largely in northern Africa, Asia, and in the United States of America. The Gossypium Barbadense is a shrub, but attains a height of from 5 to 10 feet; this is also an annual. It produces the longest cotton fiber known and is largely cultivated in the sea islands off the coast of South Carolina and Georgia. The Gossypium arboreum is not of much importance commercially, but is interesting from the fact that it grows to a height of from 15 to 20 feet; the fiber thus derives the name of *tree cotton*. It is a perennial, thus distinguishing it from other species of the cotton plant. While this plant is occasionally found in Asia, it is most largely met with in Central and South America.

Cotton fiber is known to commerce simply under the name of *cotton* in English-speaking countries, although by some people it is spoken of as *cotton wool*. Its German name is *baumwolle;* in French its name is *coton;* in Spanish, *algodon;* and in Italian, *cotóne*.

The botanical classification of cotton is not used commercially, but a geographical classification has been made, which has also been extended to cover the yarns made from such cotton—as, American cotton yarns, Egyptian yarns, Peruvian yarns, Surat yarns—with subdivisions derived either from the name of the seed from which the plant is grown, such as Allan-seed, which is a variety of American cotton, or local names, such as Peelers, uplands, and boweds, which are also varieties of American cotton. It must be understood that the names given in this classification refer to the cotton from which the yarn is made and not the country in which the yarn is spun; thus, Egyptian yarn means yarn spun from cotton grown in Egypt, notwithstanding the fact that the yarn itself may be made in America, England, Japan, or other countries.

7. Yarns From American Cotton.—1. *American cotton yarns* are usually understood to be those produced from the more common varieties of cotton grown in the United States of America, of short and medium staple, and excluding yarns produced from sea-island, Peeler, and Allan-seed cottons, which although they are American, usually give a distinct trade name to the yarns produced from them. American cotton yarns are usually of low and medium numbers, not usually exceeding 40s for the warp or 70s for the filling, and generally spun in much lower numbers. They are almost white in color.

2. *Sea-island yarns* are produced from the long-staple sea-island cotton grown on the islands off the coast of South Carolina and Georgia and, to some extent, on the mainland in districts near the ocean, especially in Florida. Sea-island yarns are almost always fine yarns, from 100s to 400s, although they are sometimes spun for special purposes into low and medium numbers. They are white in appearance and smooth and silky.

3. *Peeler yarns* are produced from a long-staple cotton grown principally in districts near the Mississippi River. Peeler yarns are spun as high as 80s or 90s and from this downwards. They have a very white appearance.

4. *Allan-seed yarns* are produced from American cotton grown from Allan seed; the description of Peeler yarns applies largely to these.

8. Egyptian yarns are prepared from cotton grown in Egypt, and when examined in the natural state can be readily distinguished from most other yarns by their brownish color, They are commonly spun as high as 100s, and even occasionally up to 150s, but are often made into lower numbers, especially for hosiery purposes; as the fibers are very strong in proportion to their size and are long and silky, they enable a solid, strong thread to be made. On the continent of Europe, Egyptian yarns are generally spoken of as Mako, or Maco, yarns, especially in Germany.

9. Peruvian cotton yarns are not spun to any large extent. They are found, however, in coarse numbers from 10s to 20s, although the staple of the cotton is long enough to enable finer numbers to be made. There is more than one variety of Peruvian cotton, but the one chiefly used is known as rough Peruvian and has a harsh feel; it is not so white as the American cotton nor so brown as some of the Egyptian cottons. The yarn made from this cotton exclusively is harsh, woolly feeling yarn, with a brownish appearance. The principal use of Peruvian cotton, on account of its length of staple and harsh feel, is as an adulterant for mixing with wool for the production of merino or similar yarns.

10. Surat yarns are those made from East Indian cotton. Its many varieties are of short staple, and much of it is dirty and of a brownish color, so that when used alone it is made into yarns coarser than 20s, which in most cases have a dirty-white appearance. It is not usually spun alone except in India, although some of it is still used in England and on the continent of Europe, either alone or mixed with short American cotton.

11. Chinese and Japanese yarns, when spun alone, are like Surat yarn, except that both the Chinese and Japanese cottons are cleaner and whiter than the Indian cotton and produce yarn of a better appearance.

12. Many other varieties of cotton yarns could be mentioned, such as those made from Brazilian cotton, Turkestan cotton, West Indian cotton, Smyrna cotton, Bourbon cotton; but with the exception of the Brazilian and Turkestan cottons, these are not of much commercial importance as a rule, being spun only in the countries in which the cotton is grown or in the country of which the one in which it is grown is a dependency. When such cottons are exported to other countries they are as a rule not used alone, but are mixed with other cotton, principally with American, of about the same length of staple. The only yarns spun in the United States of America from imported cottons are Egyptian and Peruvian yarns.

This comprises the list of the principal varieties of cotton yarn as indicated by the name of the cotton from which it is spun. In some cases, however, yarn is produced from a mixing composed of two or more growths of cotton; in this case the yarn is usually named for the variety forming the larger proportion of the mixing; for instance, when a small proportion of Brazilian cotton is blended with American cotton in order to increase the strength of the yarn, the product is still called an American yarn; when American cotton is added to Egyptian for the sake of economy, the product is called an Egyptian yarn, or Maco; or when Indian cotton is used with American in order to cheapen the mixing, the yarn receives the name of American.

CLASSIFICATION OF COTTON YARNS ACCORDING TO THEIR PREPARATION AND APPEARANCE

13. Single Drawn Yarns.—1. Almost all cotton yarns belong to the class of drawn yarns, being produced by the sequence of processes comprising picking, carding, drawing frames, fly frames, and spinning, and any yarn described as cotton yarn without any other qualification, may be considered as being produced by these ordinary processes. Drawn cotton yarns, however, may be subdivided, according to the method of treatment of the stock before spinning, into two classes—*carded* and *combed yarns;* also, according to the methods of spinning, into *mule yarns*, *ring yarns*, or *throstle yarns*.

The processes required for making all cotton yarns up to and including carding are substantially the same, and when the stock is afterwards passed through drawing frames, slubbing frames, and roving frames, and the spinning process, it is described as a **carded yarn.** If, however the combing process is inserted between the carding and the drawing, the yarn is described as a **combed yarn.** The combing process removes short fibers, neps, and small particles of foreign matter, and is ordinarily used in those cotton mills producing fine yarns, and sometimes for coarse and medium yarns that must be of exceptional strength or cleanliness. Combed yarns can usually be distinguished from carded yarns of the same number by their cleanliness and their smooth, silky appearance. To summarize, all cotton yarns are carded, but only a small proportion are combed.

Combing is being introduced to a greater extent every year, and the proportion of combed yarns produced is increasing. In yarn dealing, the word carded or combed is usually prefixed to the description of yarns being sold; as, for instance, carded Egyptian means yarn spun from Egyptian cotton that is not combed; combed Peeler yarn means yarn spun from Peeler cotton that has been both carded and combed.

Cotton yarn is the common name in all English-speaking nations for yarn produced from cotton. The German name is *baumwollengarn;* the French name is *fil de coton;* the Italian name is *filo di cotóne.* The German name for carded yarn is *streichgarn*, and for combed yarns is *kammgarn;* the French name for carded yarn is *fil cardé*, and for combed yarn, *fil peigné.*

2. *Mule-Spun, Ring-Spun, and Throstle Yarn.*—Either carded or combed cotton yarns may be spun in three different ways, giving the three classifications of mule-spun, ring-spun, and throstle yarns. **Mule-spun yarns** are those that have been spun on a mule, in the form of a cop. **Ring-spun yarns** are those that have been spun on a ring frame, ordinarily on a wooden, but sometimes on a paper, bobbin. **Throstle yarns,** according to the strict interpretation of the term, are now only found in Europe in a few districts; they comprise those spun on a throstle spinning frame on the flyer principle and are made on a bobbin with a double head. In England, owing to the fact that the ring frame is

supplanting the throstle frame, it is quite common to speak of ring-spun yarns as ring-throstle yarns or merely as throstle yarns. Strictly speaking, this is an erroneous term, but it is one that is largely in use; ring-spun yarn, or ring yarn, is the more accurate name.

When cotton yarns are examined in the form in which they leave the spinning machine, they can easily be identified, according to whether they are in the form of a cop, a ring bobbin, or a throstle bobbin, but it is more difficult to identify the class to which a cotton yarn belongs after it has been wound into some other form. Generally speaking, coarse and medium weaving yarns in America may be considered as being ring-spun. Fine weaving yarns, especially for filling, are generally mule-spun. Hosiery yarns are almost always mule-spun.

In determining the classification by an examination of the yarn itself, mule-spun yarn can sometimes be identified by its being more elastic and more even than ring-spun yarn, and if yarn is very soft and slackly twisted, it is almost certainly mule-spun. Ring yarn is usually harder twisted and not so even as mule-spun yarn. Throstle yarn has a more nearly round, and a very even, thread.

These descriptions of the differences between the yarns are not absolute, for other conditions occurring during the preparation of the roving may produce an effect that cannot be attributed to the mode of spinning.

3. *Waste-Cotton Yarns.*—The waste produced from the various cleaning processes in cotton-yarn preparation is frequently respun and the material again put through the picking, carding, fly frame, and spinning processes, the number of operations being reduced as compared with the ordinary list of processes. These yarns are usually spoken of as **waste yarns** and are always of coarse numbers, usually not exceeding 8s and often much coarser; they are readily identified by being dirty, weak, uneven, and composed of short-staple material. When the waste yarns are prepared in this way they still come under the class of drawn yarns.

14. Condensed Yarns.—A small proportion of yarn made from cotton, cotton waste, or from a blend of waste and good cotton comes under the classification of condensed yarns. Up to and including the carding process their manufacture is similar to that of drawn cotton yarns, but the material is removed from the card in numerous small ribbons, or slivers, wound on a bobbin. These bobbins are taken to a specially constructed mule and the yarn spun directly from them, the required size being attained by drawing out the end between the rolls and the spindle at the same time that the stock is being twisted.

Condensed yarns are always carded and mule-spun yarns, and are never combed yarns, nor ring- nor throstle-spun. This class of yarn is sometimes spoken of as *wool-spun cotton yarn*, from the fact that the process of manufacture resembles woolen-yarn manufacture. It is also called *imitation yarn*, from the fact that it is produced in order to imitate woolen yarn, and occasionally is called vigogne (vigonia), or imitation vigogne, from the fact that it was first manufactured, in French-speaking countries, to imitate yarns spun from the wool of the vicugna, the French name for which is *vigogne*.

The statement that condensed cotton yarns are always mule-spun ought to be modified, because in Belgium and Germany a continuous-spinning machine is built and used to spin yarn from the card slivers or ribbons on a principle differing from that of the mule. This is used to so small an extent, however, that it is not of much commercial importance and can be ignored.

15. Ply Yarns.—1. All the yarns heretofore mentioned are single yarns; that is, one strand comprises the thread, which if untwisted, resolves itself into loose fibers. All cotton yarns leave the spinning process in the form of single yarn. For certain purposes, it is necessary to combine two or more of these single yarns into one thread, making what is called in the American cotton trade **ply yarn,** and in the English cotton trade **folded yarn,** or, more specifically, *two-fold yarn*, *three-fold yarn*, etc.

The uniting of these single yarns is performed in three different ways: (1) On a machine constructed on the ring-spinning principle, known as a *twister* in the United States or a *doubler* in Europe; (2) on a machine constructed on the flyer-throstle principle, known as a *flyer doubler*, used principally in Europe; (3) on a machine constructed on the mule principle, known as a *twiner*, used only in Europe. *Dry-twisted yarns* are combined without the application of moisture; *wet-twisted yarns* are moistened at the twisting process.

Ply yarn is composed of the necessary number of single yarns usually twisted together in the opposite direction to that in which the twist is inserted in the single yarn; that is, if the single yarn was twisted to the right, the ply yarn is twisted to the left, and vice versa. Two-ply and 3-ply yarns are the varieties most commonly used, although 4- and 6-ply are sometimes made. It is easy to identify ply yarns from single yarns by determining whether the yarn is composed of one strand or more than one.

The German name of ply yarn is *doublirtgarn* or *zwirngarn;* the French name is *fil plié.*

2. *Twist Yarns.*—When ply yarns are made from two colors of single yarns, they are usually spoken of as **twist;** thus, a black and a white thread when twisted together make a *black-and-white twist*, or a blue and a white thread twisted together make a *blue-and-white twist*, thus producing a mottled appearance. The English name for this yarn is *grandrelle.* The word twist in the English cotton trade has a different meaning from the same word as used in the United States; in England it is used to indicate cotton warp yarn in the same sense as the word warp in America.

3. *Cable Yarns.*—For a few purposes, two or more ply threads are cabled, or twisted, together in the opposite direction from the ply twist, making what is known as *cable yarn*, or *cable cord*, or more briefly, *cord.* For instance, suppose that 9-ply 60s were required to be made from single yarn spun with right-hand twist, 3 threads of 60s would be twisted to the left, making 3-ply yarn, and

3 of these yarns would again be twisted, this time to the right, making 9-ply-cable yarn, or 60s nine cord.

16. All the cotton yarns that have been mentioned are spun in their natural state, and when spun from American, sea-island, Chinese, Turkestan, or some kinds of Indian cottons, the yarn is almost white; when spun from Brazilian, some kinds of Peruvian, some kinds of Indian cottons, or from Egyptian, the yarn is of a brownish tint, varying from a yellowish brown to a light brown. Yarn that is spun from cotton in its natural state, unbleached or undyed, or cloth that is woven from such yarn, is usually spoken of, in America, as *brown* cotton yarn or cloth. In the Lancashire district of England, it is spoken of as *gray* cotton yarn or cloth; but in the Midland district of England, where knitting is conducted, it is spoken of as *brown* cotton yarn. The expression *white* cotton yarn or cloth is usually applied only to yarn or cloth that has been bleached.

The above description includes practically all cotton yarns that are produced in any quantity for commercial purposes, but ignores yarns that are composed wholly or in part of fibers that have been bleached or dyed before spinning, or those of special construction produced in what is known as the novelty-yarn trade; these comprise only a small proportion of cotton-yarn production. No attention has been given to the numerous processes through which yarn can be passed after the spinning and twisting to change its appearance, nor to the different forms into which yarn can be placed in readiness for the market.

CLASSIFICATION OF COTTON YARNS ACCORDING TO COUNTS

17. Yarns are frequently spoken of as *fine*, *medium*, or *coarse*, but it is difficult to give an exact definition of what should be comprised under each division, for they are relative terms and their meaning varies even in different branches of the same yarn industry. A manufacturer of combed sea-island yarns would consider 30s coarse, while a spinner of waste-cotton yarns or a manufacturer of cotton blankets would consider it fine. In order that there may be some general definition given of these terms, it may be stated that, in general, cotton yarns are considered coarse up to 30s; from 30s to 60s they are referred to as medium numbers; and from 60s upwards, as fine yarns. Cotton yarns much finer than 200s are not in common use in the United States, but English cotton spinners are regularly making yarns from 200s to 400s, while for experimental purposes cotton has been spun very much finer than this.

Sometimes names of more or less local character are given to cotton yarns as a means of classifying them according to their numbers. Thus, for instance, the term *candle-wick yarns*, while it formerly had a different meaning, is now used to indicate waste yarns of very coarse numbers, so coarse that they are numbered by the yards to the ounce rather than by the hanks to the pound. The word *bump* is also applied to yarns of low counts in general, the name alluding to the rebound or concussion in the loom when these yarns are used for filling and the reed is beaten up against them. The word *rove* is used in the sense of rovê yarns to indicate coarse yarns, usually made from a good quality of cotton and well carded, but which are of such low counts as to resemble roving, although rove yarns are sold in the cop or skein. *Lace yarn* is a term sometimes used to indicate fine numbers of ply yarns, even when they are not intended for use in the manufacture of lace.

These four terms are more particularly used in Great Britain, the names candle wick and bump being used in Lancashire, while rove yarns and lace yarns are Scotch expressions.

CLASSIFICATION OF COTTON YARNS ACCORDING TO THE FORMS IN WHICH THEY ARE PUT UP

18. Cops.—Single yarn as it leaves the spinning machine is in the form of a *cop* or *bobbin*, and in very many cases must have this form changed, either in order to continue the process of manufacture or to be put into suitable form for transportation. A **cop** is a cylindrical coil of yarn with cone-shaped ends, the lower end being called the *cop bottom* and the upper end the *cop nose;* it is produced on the various forms of cotton mules and is sometimes spoken of as a *mule cop*, but more often simply as a cop. It can be made self-contained by means of the method of winding, which builds up the yarn on the bare spindle of the mule sufficiently firm to be handled after removal without requiring any central support. In this case the cop bottom is formed by covering a few closely wound layers of yarn with other open layers used as a binding thread, and covering this portion with paste. More commonly, especially in America, the cop is built on a tube of paper, which may be a *short tube*, slightly over 1 inch in length; a *long tube*, 2 or 3 inches long; or a *through tube*, which is longer than the cop itself. About $\frac{3}{8}$ inch of the tube, in all cases, projects below the bottom of the cop, the remainder being covered with yarn, except in the case of through tubes, which project beyond both top and bottom. The tube, of course, is placed on the spindle before the cop is spun, and the yarn wound on it.

Views of various styles of mule cops and tubes are shown in Fig. 2; (*a*) is a filling cop, often called a *pin cop*, spun without a tube; (*b*) is a mule warp cop without tube; (*c*) is a knitting-yarn cop on a long tube; (*d*) is a larger size of filling cop on a short tube, often called a *bastard cop*, as it is neither the size of a pin cop nor a warp cop; (*e*) is a large filling cop on a through tube, a size used for condensed yarns. Various styles of short tubes are shown in (*f*), long tubes in (*g*), and through tubes in (*h*). Sometimes tubes are perforated, as shown in (*i*), a long tube, and (*j*), a through tube, in order to facilitate cop dyeing and bleaching; (*k*) is a cop skewer, which may be made of hardwood or steel, and is used for holding cops for safe handling or unwinding. Pin cops are about $\frac{3}{4}$ inch in diameter and 5 inches long; bastard cops, 1 inch in diameter and $6\frac{1}{2}$ inches long; warp cops, $1\frac{1}{4}$ inches in diameter and 7 inches long; hosiery cops, $1\frac{3}{4}$ inches in diameter and 8 inches long; cotton-waste yarns are spun into cops occasionally as large as $2\frac{1}{2}$ inches in diameter and 11 inches long. These are

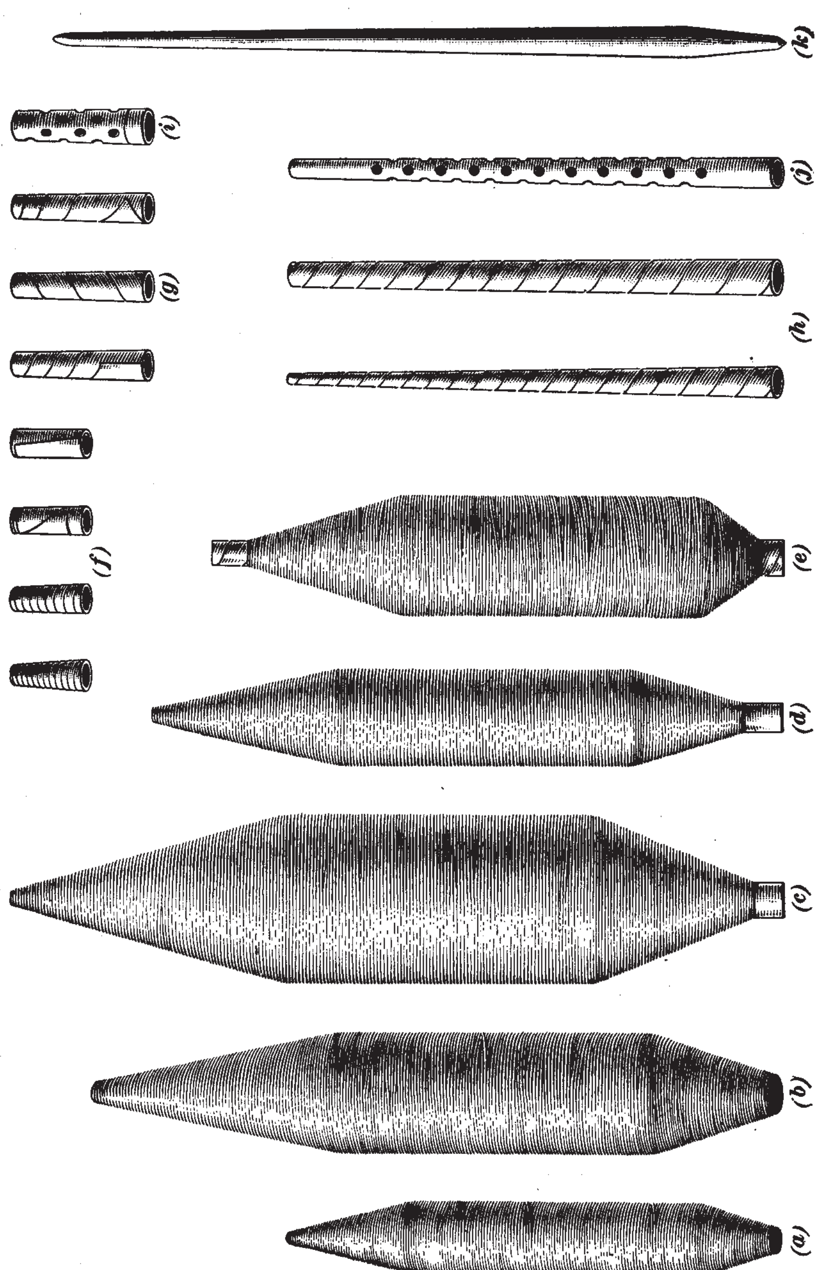


Fig. 2

customary sizes, although other sizes can be made, the maximum diameter depending on the space between the spindles in the mule, and the length depending on the length of that part of the spindle available for building the cop.

In using mule cops, the thread is taken from the nose and unwound until the bottom is reached; these cops are, of course, always single yarn and consist of but one continuous thread.

Another style of cop is a *twiner cop* of ply yarn, which in all other respects resembles a mule warp cop. The name cop is also given to forms of yarn built up for special purposes, among which are cops for carpet- or quilt-loom

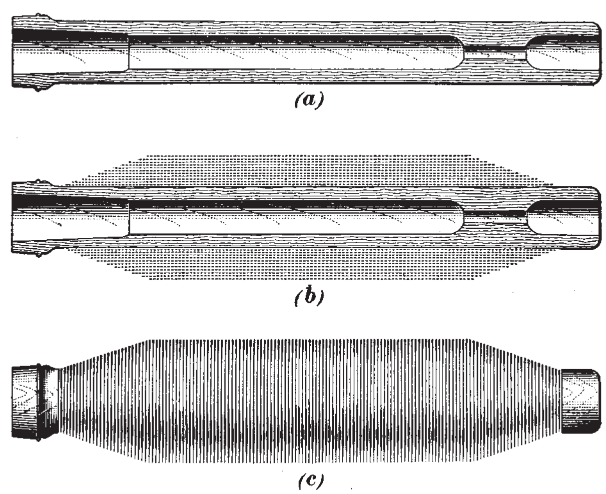
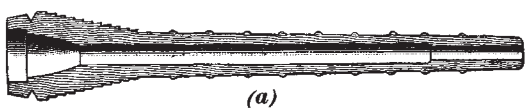


FIG. 3

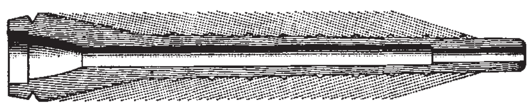
shuttles. Yarn is sometimes wound into cops on a special machine, called a *cop-winding machine;* this, however, must not be confused with another machine, also called a cop-winding machine, that winds the yarn from cops.

The *carpet cop* is produced on this cop-winding machine, which winds yarn on a spindle in the form of a large cop, larger than the regular mule cop. A peculiarity of this cop is that when placed in the shuttle, the filling thread is taken out from the inside of the cop, starting at the bottom, while the cop is held in place in the shuttle by means of an elastic band with an eye at the end, which is drawn over a hook in the shuttle. When carpet-filling yarns, rug-filling yarns, and quilt-filling yarns are spoken of as being sold in cop, a carpet cop is usually referred to.

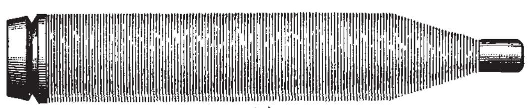
19. Bobbins.—The word *bobbin* is applied to so many forms of wooden contrivances on which yarn is wound, or built up, that it is almost meaningless without a distinguishing word used with it. In the cotton trade, **bobbins** are



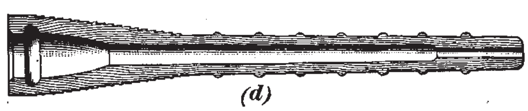
(a)



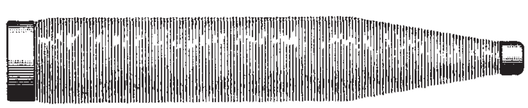
(b)



(c)



(d)



(e)

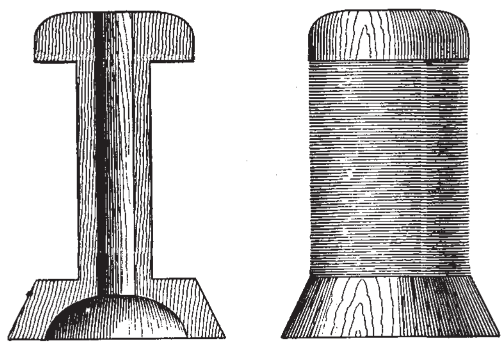
FIG. 4

classified as ring-frame bobbins, throstle bobbins, spinning bobbins, shuttle bobbins, filling bobbins, twister bobbins, etc.

1. *Ring-frame bobbins* are those used on the ring spinning frame, on which the single yarn is wound during spinning. They are usually constructed of wood, although sometimes of paper, and are of two distinct types, known as the *warp bobbin*, shown in Fig. 3, and the *filling bobbin*, shown in Fig. 4. In

each figure, (*a*) is a section through the empty bobbin, (*b*) a section through the full bobbin, and (*c*) a view of the full bobbin. The warp bobbin is arranged to contain coils of yarn wound on it in layers having a long traverse, the first layer extending almost the length of the bobbin, and the traverse being reduced as the yarn is wound on until it ultimately forms a cone at each end; this is called a *warp wind.* The yarn from this bobbin is generally drawn from the side.

In filling bobbins, the traverse is rather short and commences on a cone-shaped projection near the base of the bobbin, so as to wind at an angle. At each traverse, winding occurs a little higher up, with the same angle maintained throughout the winding of the yarn on the bobbin. When it



(*a*) (*b*)

FIG. 5

is completed a cone formation is found only at one end—near the top; this is called a *filling wind.* Another style of ring-filling bobbin used for cotton yarn is shown in Fig. 4, in section in view (*d*), and filled with yarn in (*e*). The yarn from a filling bobbin is drawn over the nose.

2. *Throstle bobbins* are small spools, as shown in Fig. 5, in which (*a*) represents the section of an empty bobbin, and (*b*) a full bobbin. They are used on the throstle spinning frame, the traverse of which is such that it winds the yarn in even layers corresponding to the distance between the heads, and parallel to the barrel of the bobbin.

3. *Twister Bobbins.*—The bobbins on which ply yarn is wound at the twister are of different shapes, depending on the method of twisting that is employed or, in the case of

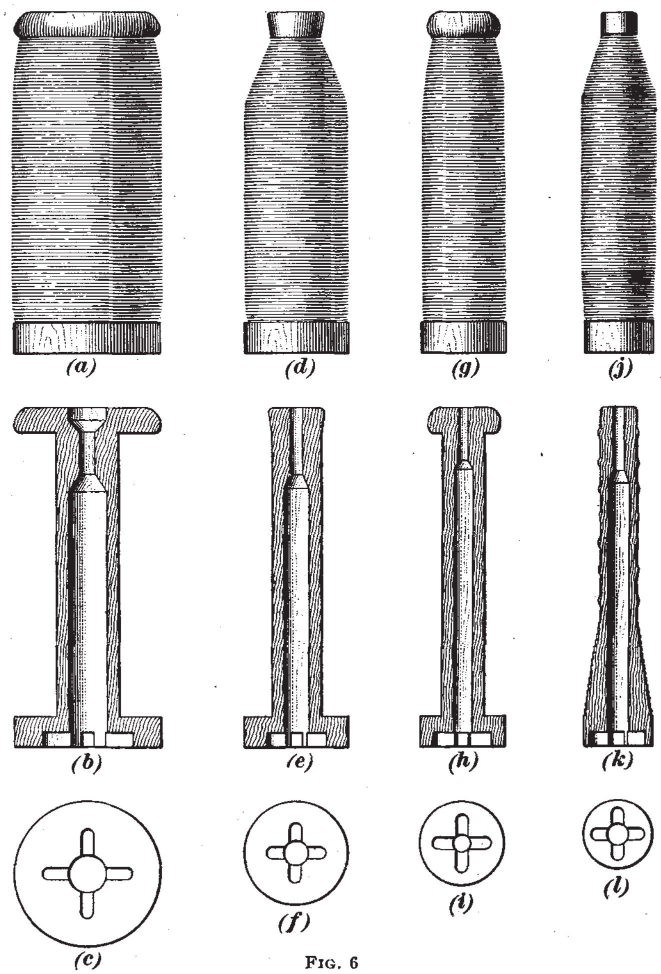


Fig. 6

ring twisting, on whether the frame is intended to build with the warp wind or the filling wind, according to whether it is desired to unwind the yarn from the side or from the top of the bobbin.

The flyer-twister bobbin somewhat resembles the throstle bobbin shown in Fig. 5. Ring-twister bobbins are made in various styles, four of which are shown in Fig. 6; (*b*) and (*h*) are double-headed bobbins, and (*e*) and (*k*) single-headed bobbins, all shown empty and in section; (*b*) is chiefly used for coarse numbers in dry twisting, with a long traverse; (*e*) and (*k*) are commonly used in dry twisting, with a short traverse, so that the yarn can be unwound from the nose of the bobbin; the construction shown in (*k*) is a filling bobbin intended for use in the shuttle of the loom; (*h*) is a style generally used for wet twisting, although (*e*) is also used for this purpose. The full bobbins are shown at (*a*), (*d*), (*g*), (*j*) and the bases of the bobbins at (*c*), (*f*), (*i*), (*l*).

The bobbin (*a*) is sometimes made as large as 4 inches in diameter; the others are from $1\frac{1}{2}$ to 2 inches in diameter at the base. That part of the bobbin that is covered with yarn is usually 6 inches in length, while the bobbin itself is somewhat longer. These dimensions, of course, are varied for different frames and for different kinds of work.

4. *Shuttle Bobbins, or Quills.*—The term shuttle bobbin is frequently used to designate a bobbin of suitable construction to fit inside the loom shuttle, so that the yarn may be unwound from it through the eye of the shuttle and be woven into the cloth as filling. The most common style of shuttle bobbin for cotton yarns is the ring-frame filling bobbin, shown in Fig. 4. This bobbin is so constructed that it will fit either the spindle of the ring spinning filling frame or the shuttle, so that the yarn may be spun directly on to the bobbin from which it is woven in the shuttle. Another form of shuttle bobbin is shown in Fig. 7 (*a*) and (*b*); (*a*) is a section through an empty bobbin and (*b*), a view of a full bobbin; this represents the type commonly used for colored cotton yarns for ginghams and other fabrics. The more common name for this bobbin in the United States is *quill*, or *quiller bobbin;* the name *quill* is used in some parts of Europe, but in Great Britain it is more commonly called a *pirn*. Strictly speaking, the quiller bobbin is used only in connection with long-chain quilling, while the pirn is the bobbin used to

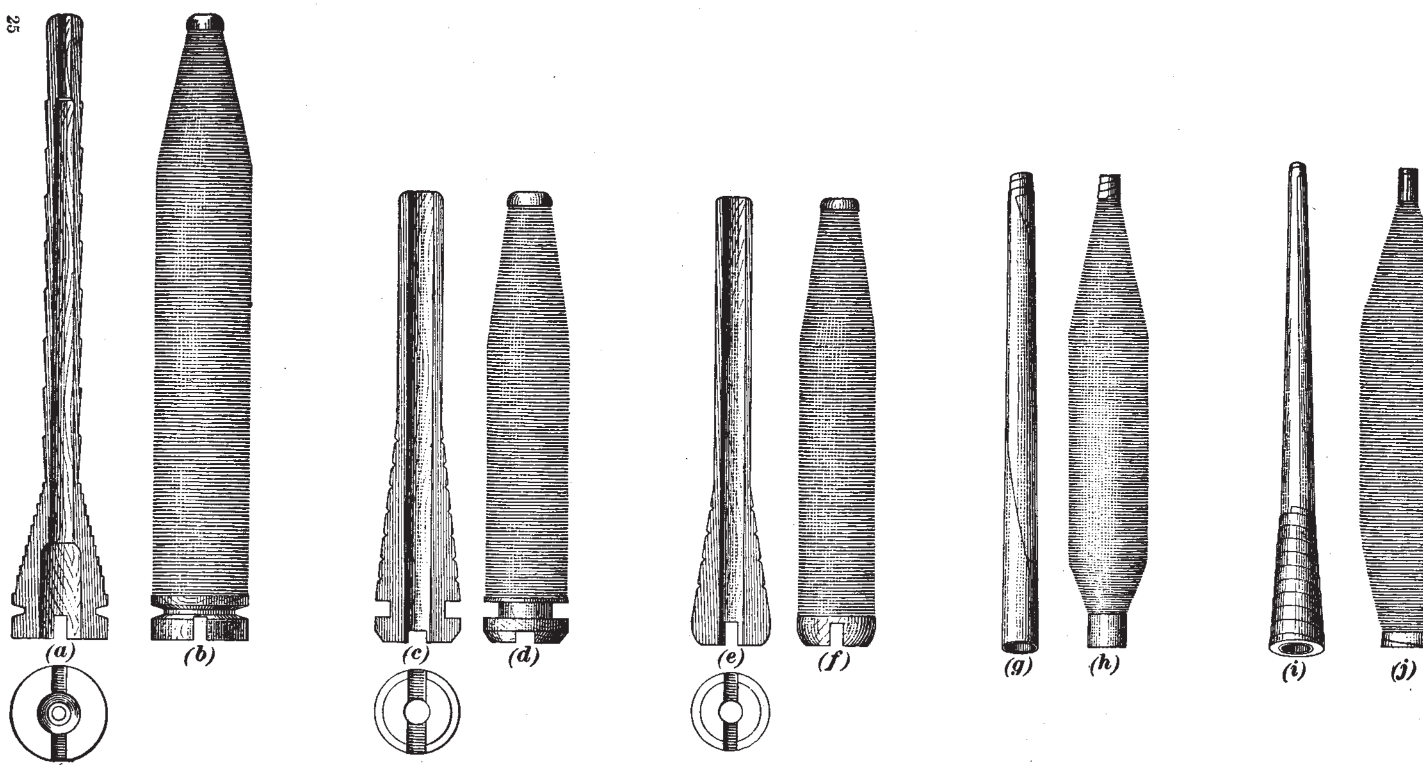
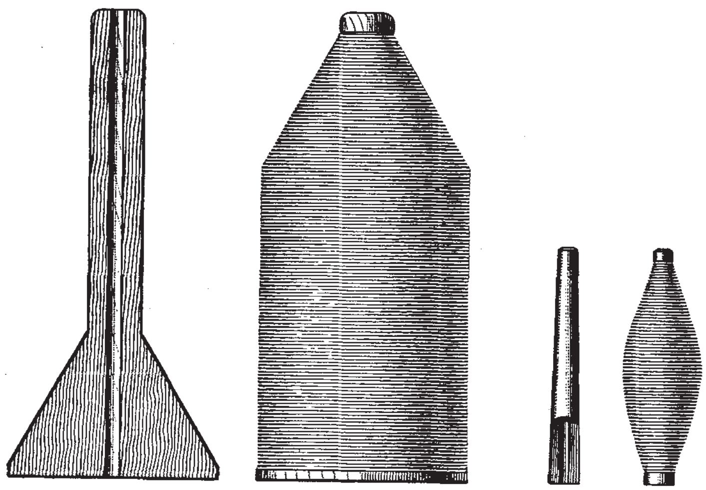


Fig. 7

contain filling yarn that has been unwound from a skein; but much confusion exists in different districts and the names filling bobbins, quills, and pirns are applied indiscriminately. Fig. 7 (*c*) and (*e*) shows sections of empty wooden pirns, while views (*d*) and (*f*) show the pirns when full; (*g*) and (*i*) represent paper tubes used for the same purpose, while (*h*) and (*j*) represent these tubes filled with yarn. After yarns intended for filling have been dyed, bleached, or otherwise dealt with, they are always wound on some style of quill or pirn, ready for use in the shuttle. Quills for cotton are



(*a*) (*b*) (*c*) (*d*)

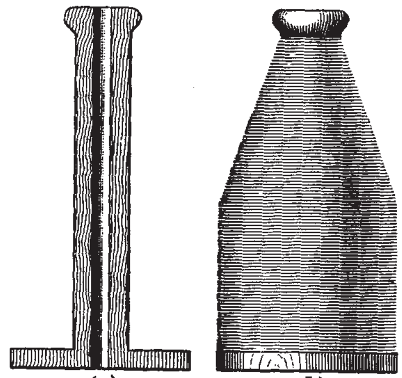
FIG. 8

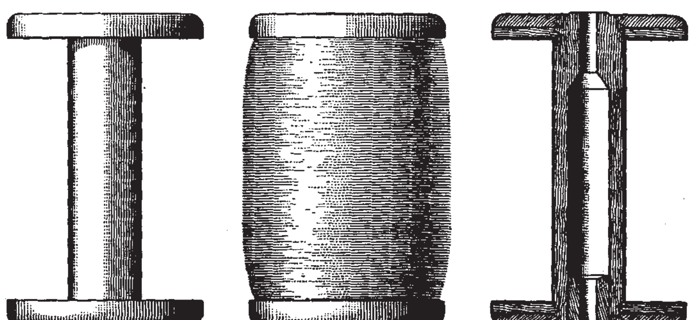
generally $6\frac{1}{2}$ inches long; pirns and paper tubes are from 4 to 7 inches long. Many other shapes and sizes are used in addition to those shown.

5. *Knitting-Yarn Bobbins*.—On various knitting machines, it is necessary to have a large quantity of yarn that can be unwound from the top of the bobbin, and for this purpose wooden bobbins of various shapes are used. One style is shown empty in Fig. 8 (*a*) and filled in view (*b*); this is the kind generally used in the United States, and is 18 or 20 inches long. The tapered part is covered with cloth, as

shown by the heavy outline. Another style, which is used in Europe, sometimes called a hosiery spool, is shown partly in section and empty in view (*c*) and filled in view (*d*).

6. *Taper Bobbins.*—Another style of bobbin, known as the taper bobbin, sometimes called a *taper spool*, since it is made on a spooler, is shown empty in Fig. 9 (*a*) and full in view (*b*). It is used when desired to wind a large quantity of yarn on a bobbin in such a way that it can be wound off at the end, and is filled on the same machine as the double-headed spool by changing the winding arrangement. Such bobbins vary from 3 to 4 inches in diameter and from 6 to 9 inches in length; they are generally used for yarn that has to be gassed—that is, yarn that has to have projecting fibers singed off—or reeled, which is the process of forming skeins.

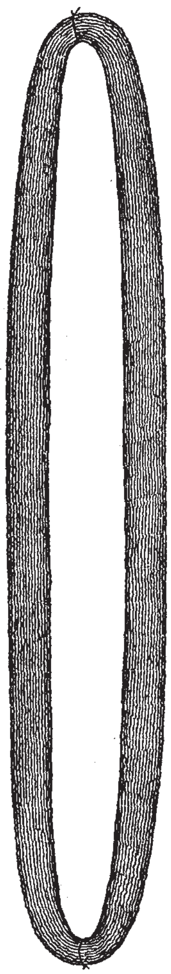

(*a*) (*b*)
FIG. 9


(*a*) (*b*) (*c*)
FIG. 10

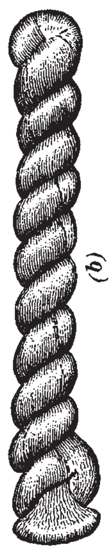
20. Spools.—The word *spool*, when used alone, is almost as ambiguous as the word bobbin, since so many kinds of spools are used in almost all branches of the yarn industry.

In general, the word means a bobbin having a head, or flange, at each end. In the cotton trade, spools vary in size from what is known as a warper spool down to the diminutive spool on which sewing thread is sold in a dry-goods store

Cotton-warp spools, shown in Fig. 10, are double-headed bobbins that are known in Great Britain as bobbins. They are used in the process known as spooling in America and as winding in Great Britain, in which the yarn is wound from the mule cop or the ring-spinning-frame bobbin to the spool in barrel-shaped form, as shown in Fig. 10 (*b*), ready for warping. These spools vary in size from $2\frac{3}{4}$ to $5\frac{3}{4}$ inches in diameter, measured at the head of the spool, and from $3\frac{1}{2}$ to 6 inches between the heads; (*a*) is a view of an empty spool and (*c*), a section through same. This same style of spool is also used on some kinds of drum-winding machines for winding dyed or bleached warp yarns from the skein to the spool.



(*a*)



(*b*)

FIG. 11

21. Skeins.—Cotton yarn is often put up in the form of a skein, which is a continuous thread that has been wound around a revolving framework having a known circumference—such as 54 inches, 60 inches, 72 inches, or 1 meter—so that a certain number of revolutions will give a known length of yarn. The skein when removed from this frame is a continuous coil of yarn, as shown in Fig. 11 (*a*). In the cotton trade, for certain purposes this skein contains a hank of 840 yards. For other purposes, the skein is made of a definite weight, such as 8 ounces, 2 ounces, 1 ounce, $\frac{1}{2}$ ounce, etc.; more frequently, in America, it is made up without regard to any special length or weight. In some methods of skeining, the complete coil consists of seven distinct sections separated by small pieces of thread so that the skeins can be separated without entangling the yarn. The name *hank* is generally given in England to the entire skein when it contains 840 yards in cotton or 560 in worsted, shorter lengths being called skeins. After the skeins have been made, they are twisted by hand and doubled on themselves for convenience in handling and transportation, as in Fig. 11 (*b*). Strictly speaking, a skein of 840 yards is the only kind that should be spoken of as a hank; a number of these hanks twisted together are called a *knot*.

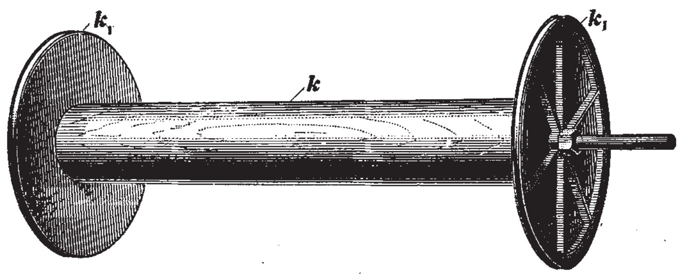


FIG. 12

22. Beam Warps.—A warp may be defined as a number of ends of yarn of equal length, parallel to one another, that go to form the lengthwise series of threads in cloth. Owing to the variations in the processes through which warps pass before being ready for the loom, they are put up in either of two forms—*beam warps* and *chains*. **Beam warps** are subdivided into *section beams*, or *warper beams*, and *loom beams*, sometimes called *slasher beams*, or *weavers' beams*.

When a warp for the loom is formed in a simple manner without having to pass through any bleaching, dyeing, weighting, or other process, it is prepared by winding the ends on a beam so as to form an even sheet between the heads. Beams are of various constructions, generally consisting of a wooden barrel with iron heads, as shown in Fig. 12, which represents a section beam. The yarn is warped from spools to this section beam on a machine known as a *warper*. Afterwards the yarn from several of these section beams is combined and wound on to a loom beam, Fig. 13, at a machine known as a *slasher*. This form of preparing warps is commonly used in mills where the yarn is woven by the same firm that spins it.

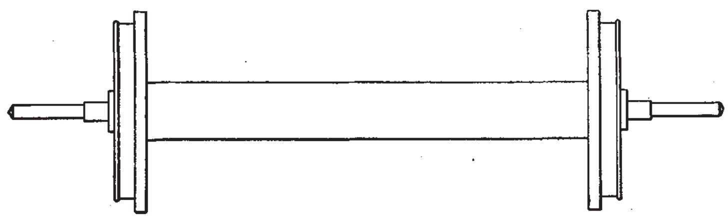


Fig. 13

23. Chains.—When yarn has to be bleached, dyed, printed, mercerized, or otherwise treated and afterwards used for the warp of a fabric, and sometimes when it has to be used as filling, it is put up in the form of a **chain.** For this purpose a large number of ends of yarn, usually several hundred, are gathered together so as to form a loose strand. The ends forming one warp are all of the same length, but the length of warps may vary from a few hundred yards up to several thousand. At each end, and sometimes at intervals throughout its length, a certain method of tying up the ends is adopted, so that they can be suitably separated without entanglement when the yarn is used. These chains can be packed without much risk of damage during transit, and as the mills where the yarn is to be used are generally located a considerable distance from where the yarn is spun, this is an important consideration and gives an advantage over the transportation of yarn on bobbins, spools, or beams. The chain form of warp is also a very convenient one in which to pass the yarn through the bleaching, dyeing, or similar processes before putting it on the loom beam or the filling quiller.

1. *Balled Chains.*—For convenience in transportation chains are coiled in two different ways, resulting in their

delivery in either the *balled* form or the *linked* form, often spoken of as *balled warps* and *linked warps*, although the yarn may be either warp or filling yarn. The loose strand of ends that forms the chain is warped in the same way for either balled or linked chains, the process differing at the final stage, in which the yarn is coiled. Balled chains are of three kinds—hand-made round balls, machine-made round balls, and machine-made cylindrical balls. The hand-made round-ball form, shown in Fig. 14 (*a*), is the oldest style and is now passing into disuse. It resembles a huge ball of twine and is formed on the arm of an operative, who first winds around his hand a small ball, which he gradually increases in size, by coiling other layers around it, until a large ball is formed. If the length is too great for one ball, the warp is sometimes made into two, which are connected by a short length of warp near the middle of its length. A more perfect ball can be made by a round-balling machine, the strands lying more evenly, as shown in Fig. 14 (*b*), and the ball in this case can be made larger than it is possible to do by hand. From the old style of round-ball warp has been derived the cylindrical form of warp, which still has the name of ball warp given to it, although this to some extent is misleading. A cylindrical-ball warp is formed on a balling machine by means of layers built up one on top of another until a large cylindrical form is reached, as shown in Fig. 14 (*c*). The round ball is used principally for short warps made on what is known as the short-chain system on the older form of circular warping mills or reels. The newer form of cylindrical-ball warps is generally used for warps made on the long-chain system and warped on a Denn warper or a common warper with a balling attachment.

2. *Linked Chains*.—The loose strand of ends to form a linked chain is prepared in the same way as for a ball warp, but instead of being coiled in a ball, the strand is linked, or looped, so as to form a continuous chain, so constructed that it can be pulled in one direction through the dyeing, bleaching, or other process to which it has to be subjected, but when it has been so treated, can be pulled from the other end so

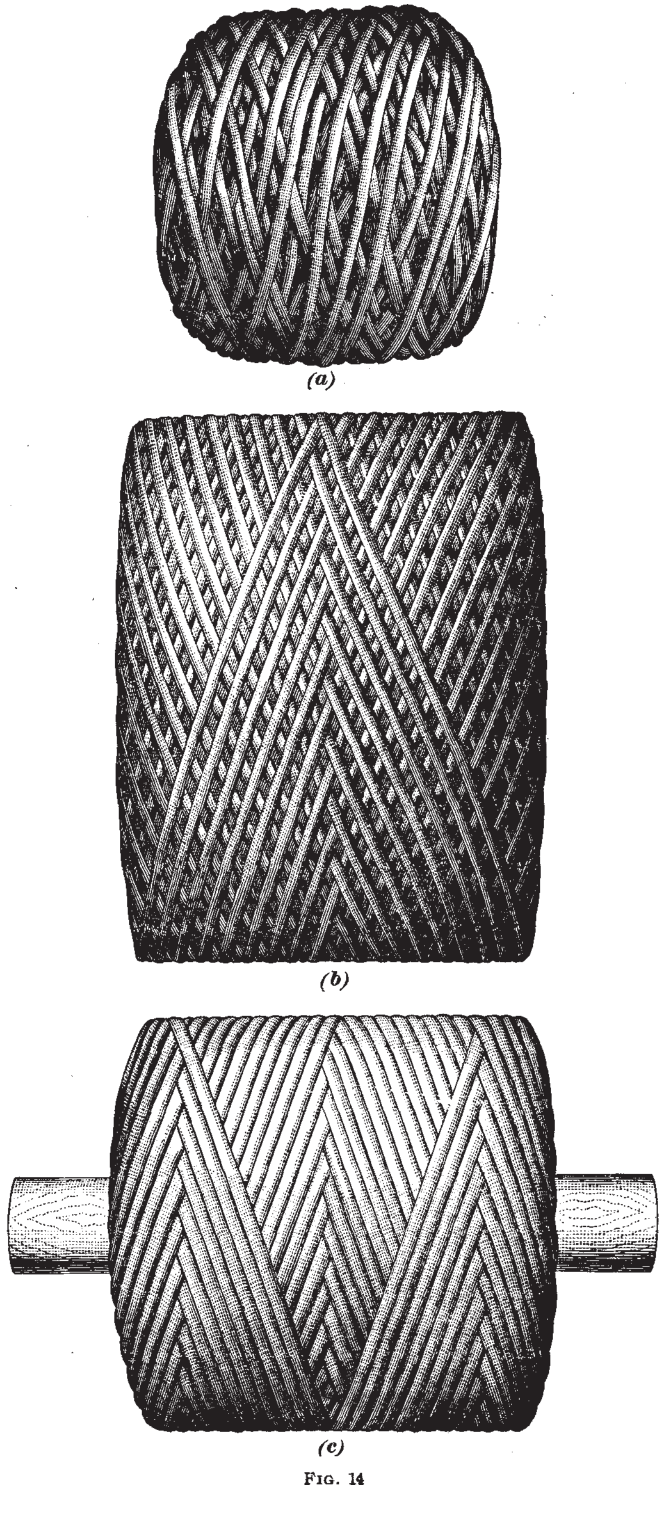


Fig. 14

as to destroy the linked arrangement and allow the warp to assume its original form of a loose strand of ends. By linking a warp in this manner, a 300-yard warp will measure

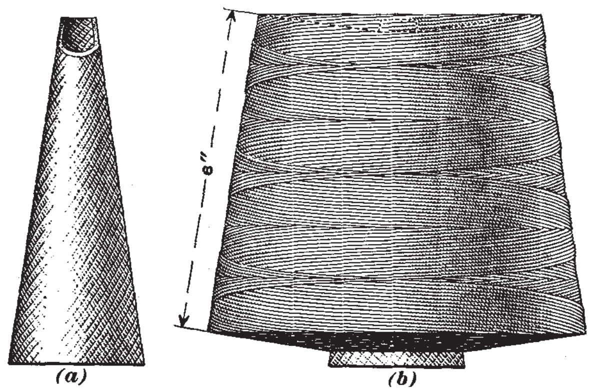


FIG. 15

less than 100 yards when linked, thus shortening the length of time necessary to pass it through any process of bleaching, dyeing, or drying. Chain warps, or linked warps, as they are sometimes called, are usually packed in bags for shipment.

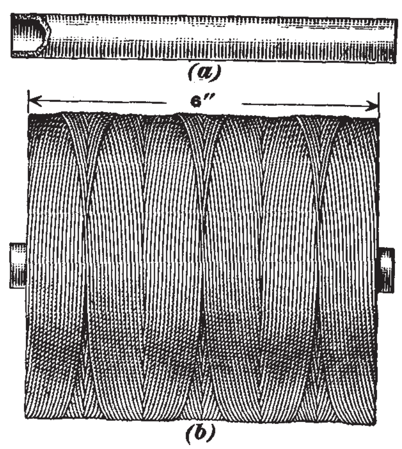


FIG. 16

24. Conical and Parallel Tubes.—The practice of putting up yarns in what are called **cones**, or **tubes**, is very common, and the method is gradually being adopted for many different purposes, but principally for knitting yarns. A full conical tube is shown in Fig. 15 (*b*), while (*a*) is the paper framework on which it is formed. The cone is made on what is known as a quick-traverse cross-winder, the cone tube fitting on the conical arbor, which revolves on a revolving drum in some types of machines. By a suitable construction, the end of yarn being wound on the paper cone is given a horizontal traverse along the surface of the cone, and this being repeated many times builds up the yarn in the cone-shaped formation shown in the illustration. When a straight tube, as in Fig. 16 (*a*), is used as a foundation, the yarn is built up in cylindrical form, as shown in (*b*), commonly called a *cheese*, *parallel tube*, or merely a *tube*.

Two or more threads are wound together on cones when necessary; these, of course, are simply converted into one strand without being twisted. This is commonly done for such purposes as winding yarns for covering electric wires.

One type of machine by which the yarn is wound on the conical or parallel paper tube without coming in contact with the revolving drum is known as the Universal winder, and the name sometimes given to conical or parallel tubes made on such machines is that of Universal cones or tubes.

CLASSIFICATION OF COTTON YARNS ACCORDING TO PURPOSES FOR WHICH THEY ARE INTENDED

25. Weaving Yarns.—Cotton yarns are produced for a great variety of purposes, but principally for weaving into fabrics. Two distinct classes of yarns are made for weaving; namely, the warp and the filling, the warp being used lengthwise in the fabric and the filling crosswise, or from side to side. The English name for cotton warp is *twist*, and for cotton filling *weft*. The German name for warp is *kette*, and for filling *schuss;* while the French name for warp is *chaîne*, and for filling *remplisage*.

Warp yarn, as compared with filling yarn of the same number, is usually spun from longer-staple cotton, is harder-twisted, and possesses greater strength, as it must withstand the bulk of the strain in the loom and the chafing and wear of certain parts of the weaving mechanism. Filling yarn does not require so good a quality of cotton as does warp yarn of the same numbers. In American cotton weaving, yarns for both warp and filling are spun mostly on the ring frame, although fine numbers are frequently spun on the mule, especially when for filling. In England, both warp and filling are usually spun on the mule, although the ring frame is being more widely used now, principally for warp.

No limit as to the numbers of yarn suitable for weaving can be given, as almost all numbers are used for this purpose, the warp usually being of lower counts than the filling. In the cotton trade, it is customary to use single yarn for both warp and filling, although ply yarns are sometimes used, principally for warp but occasionally for filling. In the former case they are mainly 2-ply when used for the side selvages, and usually 2-, 3-, 4-, or 5-ply when forming extra threads, such as leno threads, lappet threads, center selvages, and others used to produce special effects in the fabric. Two-ply cotton warps are largely used in mixed fabrics, the coarser ones being used for fabrics woven with woolen and worsted filling, and the finer ones for those used with silk filling.

26. Knitting Yarns.—Cotton knitting yarns are made in large quantities, are almost always mule-spun with less twist than weaving yarns, and in order to free them as far as possible from all impurities, ought to be well carded, and in some cases combed. They are usually made from longer-staple cotton than would be used for the same numbers of weaving yarns. The thread of the knitting yarn should be distinguished by its fineness, cleanness, and its slack twist, and should be full, round, and even.

Cotton yarns are used by knitters for a large variety of purposes, varying from the low numbers required for coarse miners' socks to the fine yarns for light Balbriggan underwear, and consequently are made in a wide range of numbers, principally, in both carded and combed yarns, from 6s to 30s, although finer numbers than these are made in many cases. Knitting yarns are almost always supplied in single yarns, although a quantity of 2-ply and even 3-ply is used for certain kinds of goods, especially in fabrics that must have what is known as a lisle finish, and for the reenforcing threads that are inserted at the heels of stockings and other parts of knitted garments where extra wear takes place. Knitting yarns are usually supplied in an undyed state, although such mixes as jaegers, silvers, steels, as well as light shades in solid colors spun from cotton dyed in the raw state, form a large percentage of the knitting-yarn trade for underwear in numbers from 22s to 60s.

Many varieties of cotton are used for knitting yarns, including Peeler and Egyptian for the better qualities, American uplands for the medium qualities, and short American mixed with waste or with East Indian cotton for the low qualities; the latter, however, is not spun in the United States.

27. Yarns for Converting.—Cotton yarns are spun in a large variety of numbers for bleaching, dyeing, mercerizing, printing, dressing, and polishing; they are usually ring-spun, and when intended for processes that involve considerable tension or strain, such as mercerizing and polishing, are made from long-staple cottons of extra good quality.

28. Yarns for Export.—Relatively very little yarn is exported from the United States, but the export trade is a very important branch of the yarn business in the European manufacturing countries. This yarn is usually spun from as low a variety of cotton as can be used for the numbers of yarn required, and is in most cases reeled and made into bundles of 10 pounds each. A small quantity, however, is exported in the form of mule cops, packed in casks of about 560 pounds each.

29. Carpet yarns are used for the warp of carpets, particularly for the cheaper classes of floor coverings. They are among the cheapest cotton yarns made, and a low quality of cotton, usually short-stapled American, is used in their manufacture. They are spun on the ring frame and are afterwards twisted into ply yarns, either 3-ply, 4-ply, or 5-ply as a rule. Number 8s is the most common number that is made, thus giving the three standards of 8/3, 8/4, and 8/5, although in some cases they are made coarser or finer as required. As it is customary to dye the warp yarns for carpets, carpet yarns are generally reeled into 72-inch skeins, cross-reel. In the carpet mills, as several of the ply threads are used together, it is found more economical for those mills that make a cheap grade of carpet and do not dye the warps to buy their carpet yarns on tubes containing three ends of either the 3-ply, the 4-ply, or the 5-ply wound together without being twisted.

30. Upholstery Yarns.—In the upholstery trade, a large quantity of slack-reel skein yarn is used. The two standard numbers are 9s and 16s; each of these is put up either in 3-ply or 4-ply, thus giving four standard numbers—9/3, 9/4, 16/3, and 16/4. As these yarns have to be dyed, they are put up in skeins, 54-inch skeins being the standard. One peculiarity of these yarns is that, in making the ply thread, it is very slackly twisted, with a few turns to the foot, while ordinary ply yarns usually have many turns to the inch. Upholstery yarns are made from short-staple American cotton.

31. Cotton Yarns for Rugs.—A line of yarns somewhat similar to the upholstery yarns is made for fringes for rugs, often in 14s, 2-ply.

32. Thread is made from ply yarns in a large variety of numbers, qualities, colors, and forms, comprising sewing thread, seaming thread, covering thread, embroidery thread, mending thread, etc., but is not included within the scope of this Section.

33. Yarns for Cordage.—Cotton yarns are largely used for making twine, cord, and rope, but as such yarns are usually spun by firms that make the cordage, their manufacture is not of much general interest. Cotton yarns for twines are usually coarse numbers of ring-spun yarns that are twisted into either 2-, 3-, 4-, or more, ply, and wound into balls or put on cones or tubes. They are usually sold without being dyed or otherwise treated, the general run being a 2-ply, dry-twisted twine.

Various better classes of twines are made under the name of druggists' twines, macramé twines, cable twines, ply twines, hawser twines, or under other names, which are sometimes private trade names of a particular manufacturer. These are made from finer yarns with a larger number of plies, so as to make a level, smooth, and strong twine. They are often wet-twisted, to further insure the fibers lying close and thus producing a smooth, hard surface. In some cases, for the better classes of twine, they are cabled, and frequently are dyed or polished. As they are used for almost every conceivable purpose, it is almost impossible to state the numbers of yarn that are used, but as a rule the single yarns from which they are made are not finer than 30s.

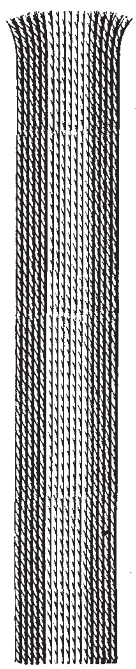


FIG. 17

Cotton cords are usually referred to as *sash cord*, although there are other varieties of cords and rope. They are made from $\frac{3}{16}$ to $\frac{1}{2}$ inch in diameter and are built up of coarse cotton yarns made from low-grade, short-staple cotton or combinations of cotton and waste, usually about number 8s, which are afterwards made into 2-, or more, ply. The central core of the better-class cords or rope, such as sash cord, consists of a number of these ply threads, around which others are braided.

Other ropes are made by twisting heavy strands of cotton together. Cords and ropes of this character are spoken of as *all-thread* ropes, to distinguish them from cheaper grades, such as clothes lines, which are made by twisting yarn around a central core of roving.

34. Cotton Banding and Driving Ropes. In making cotton banding, such as mule banding and power-transmission ropes, sometimes as large as 2 inches in diameter, a large number of threads is formed into a strand and a number of these strands taken to form the rope. The threads are usually not over

30s in fineness, but, especially for the best grades of ropes, good American, or even Egyptian, cotton is used.

35. Parallel ply tapes, as shown in Fig. 17, are a form of yarn that has the appearance, to some extent, of a woven tape, although it has not been woven, but has been made up by arranging several threads of yarn side by side and attaching them with an adhesive paste. It is now used for some purposes for which woven ribbon and woven tape were formerly used. As it is composed of a number of ends, usually of ply yarn, laid side by side, it might be classed as a variety of folded yarn, although it is an imitation tape. It is used for tying parcels, cigars, and for similar purposes where it is only to be used once, as it easily frays and the threads separate if handled. By arranging different colors of thread side by side, ornamental effects can be produced and the names, trade marks, and descriptions of goods printed on it.

YARNS FROM STEM FIBERS

LINEN YARNS

36. Among the fibers spun into yarn are those obtained from the stems of plants, such as flax, hemp, jute, and china grass, ramie, or rhea.

Linen yarns are those procured from fibers obtained from an inner layer of bast in the stem of the flax plant, which belongs to the order *Linaceæ* and is botanically termed *Linum;* strictly speaking, the name *flax yarns* would be more accurate, but the term linen has always been so commonly used that it is generally accepted. The plant is an annual, that is, the seed is sown for it each year, and is cultivated in Holland, Russia, the United States, Ireland, Germany, Austria, and Belgium. The best flax is produced in Ireland and Belgium. Linen yarns are not classified according to the geographical source of supply of the flax, as is common with cotton yarns, but rather according to the methods of spinning and the whiteness of the yarn. When linen yarns are classified according to the origin of the material, the Irish linen and Belgian linen are placed first.

37. Linen Yarns Classified According to the Methods of Preparation.—The flax is obtained from the stem of the plant by means of a retting process, which partly decays the constituent parts of the stem, so that the valuable fiber may be removed, after which, by means of breaking, scutching, and hackling processes, the fiber is obtained and separated into long bunches, varying from 12 to 30 inches in length, known as *line flax*, and also a shorter, tangled mass, containing woody particles and impurities, known as *tow*. Linen yarns may be made either from the line flax or the tow, which gives the two distinct varieties—**line** and **tow**. These may be distinguished by the fact that line yarns are very much finer in number than tow yarns, and have a smoother and more even construction. Common numbers of line yarns are from 10s to 30s, although they are spun both finer and coarser than this. Line yarn is the variety most used for weaving purposes, lace making, thread making, etc. The better qualities of flax have a light yellow, gray, or greenish appearance, while poorer qualities are darker gray or brownish in shade. Tow yarns are made from 10s to 15s dry-spun and from 18s to 30s wet-spun, and coarser. They are used for weaving, twine making, etc.

The division of both line and tow yarns into *wet-spun* and *dry-spun* yarns depends on whether the fibers immediately before spinning are moistened in the spinning machine or not. The wet-spun yarns are spun after the application of cold, warm, or hot water; the fine yarns having a smooth, even thread are made by this process. Ply and sometimes even cable yarns are made both from line and tow yarns. When linen yarn is manufactured into twine, especially of the better qualities, line yarns in either ply or cable form are generally used.

38. Linen Yarns Classified According to the Forms in Which Put Up.—Linen yarns are not put up in so many forms as cotton yarns because the fiber is unsuitable to be spun in so many different ways or to be passed through many after processes.

1. *Bobbins*.—The chief forms in which linen yarn is put up are bobbins, which somewhat resemble the cotton bobbin shown in Fig. 6 (*a*), having a head at each end. Wet-spun linen yarns have to be removed from the bobbin immediately after spinning, in order to dry the yarn, so that these bobbins are only found in the mill in which the yarn is spun and do not form a subject of commercial dealing.

2. *Skeins*.—A common form in which linen yarn is put up is in that of a skein. Skeins are formed in the same way as cotton yarns, but are larger, being made 90 inches in circumference. In countries using the metric system, where yarns are reeled, they are made into slightly larger skeins, running about 91 inches in English measurement.

3. *Cops*.—Linen yarns are not put up in cop form, as the fiber does not lend itself to mule spinning.

4. *Beams*.—Linen yarns are, of course, wound on loom beams when they are intended for weaving purposes.

5. *Pirns*.—When linen yarn has to be used for filling, it is wound on pirns or shuttle bobbins somewhat resembling the larger one in Fig. 7.

6. *Cones and Tubes*.—Linen yarns are sometimes coned or tubed for sale, as the structure of the thread does not render this form of putting up linen yarns impossible.

7. *Spools*.—Linen yarns are found on either large or small spools when in the form of sewing thread; the smaller spools are commonly sold in dry-goods stores, while the larger ones are used in factories where linen thread is used in quantity for power sewing machines.

8. *Balls*.—Linen yarn is sometimes put up in small round balls weighing $\frac{1}{2}$ or 1 pound each.

Neither line nor tow yarns are spun to any large extent in the United States, but are made mostly in Ireland, Scotland, and Belgium. Large quantities of linen yarns are imported into the United States in the form of skeins packed in bales weighing 600 or 700 pounds.

39. Linen Yarns Classified According to Purposes for Which Intended.—Line yarns are used chiefly for weaving, either warp or filling, for which purpose the numbers vary along the whole range of linen numbers; for lace making, which requires the finer yarns; for thread making, which also requires the fine line yarns; and for twine that has to be of considerable strength, such as jacquard-harness twine. Yarns for cordage are almost always tow yarns, although sometimes line yarns are used for this purpose; but as a rule, only the smaller sizes of cords, which are classified as twines, come under the head of flax, and tow yarn is used for this purpose.

HEMP YARNS

40. Hemp yarns are procured from fibers obtained from the bast portion of the stem of the hemp plant—the *Cannabis sativa* of the nettle family (*Urticaceæ*). Hemp is obtained principally from Europe, the better qualities being found in Southern Europe, including Italy and Spain, and the inferior grades in Russia and Germany. Italian hemp is the best and has a long silky fiber, while the Russian crop is one of the most important as to quantity.

Hemp yarns are not usually classified according to the geographical production of the material, excepting that Italian hemp yarns are sometimes so indicated in order to draw attention to their high quality. What has been said with regard to the classification of linen yarns according to their method of production, the forms in which they are put up, their division into line and tow yarns, and the division of the line yarns into wet- and dry-spun applies almost equally well to hemp yarns.

Hemp yarn is found in bobbins, skeins, and beams. The weaving yarns are divided into warp and filling, and are used for weaving coarse bagging, canvas, and other fabrics requiring strength and bulk. It is also used for the warp of certain kinds of carpets. The hemp that is described here should not be confused with what is known as *Manila hemp*, which is really not a hemp fiber, being a leaf fiber, while the true hemp is a stem fiber.

JUTE

41. **Jute yarns** are made from the bast of the jute plant, sometimes called the Jews' mallow, the scientific name of which is *Corchorus capsularis*, and which is an annual belonging to the *Tiliaceæ* order.

As almost the entire supply of jute comes from the East Indies, being shipped principally from Calcutta, from which it derives the name sometimes given to it of Calcutta hemp, no special geographical division of jute yarns can be made. They are classified, as are linen and hemp yarns, according to whether they are line yarns or tow yarns, but are almost always dry-spun.

Like linen and hemp yarns, jute is found on bobbins, in skeins, and in warps. It is also found in cops, which, however, are not mule cops, but carpet cops made on a cop-winding machine.

RAMIE YARNS

42. **Ramie yarns** are produced from the fibers obtained from the bast of the stems of certain Asiatic members of the nettle family (*Urticaceæ*), which are now cultivated to some extent in other countries, including the United States. The botanical name for the species from which this fiber is derived is *Bœhmeria nivea*, sometimes called the Chinese nettle, or snow nettle, or, as given by some authorities, *Bœhmeria tenacissima*. The fiber is spoken of variously as *china grass*, *ramie*, or *rhea*. No definite geographical classification of ramie yarns, nor in fact a classification of the form in which they are put up, their appearance, or their method of production, can be satisfactorily given, as the ramie-yarn industry is not yet of much commercial importance, although considerable attention is being given to it, and there are a few ramie-yarn mills in England and Germany.

YARNS FROM LEAF FIBERS

43. Among the yarns made from fibers derived from the leaves of plants are those produced from **Manila hemp, sisal, New Zealand hemp,** and **pineapple fiber.**

As leaf fibers are usually coarser and less suitable for spinning into yarns and weaving into fabrics than either seed or stem fibers, they are more commonly used for rope making, as, for instance, for driving ropes, cordage for vessels, cables, etc., although in a few cases they are used for weaving into coarse mattings and carpets, and in the case of Manila hemp and sisal, for filling in upholstery fabrics. This is done to so small an extent that they are not of much commercial importance in the yarn industry.

FRUIT FIBERS

44. The only fruit fiber of much commercial importance is the **coconut fiber,** sometimes spoken of as *coir*, or *coconut bast*, which is obtained from the covering of the coconut, being used principally for mats, carpets, etc. The remarks that have been made regarding leaf fibers in general apply to the coir fiber.

YARNS

(PART 2)

YARNS FROM ANIMAL FIBERS

WOOLEN AND WORSTED YARNS

1. Wool, by which is understood the fleece of the sheep, is spun into two classes of yarns, namely, *woolen* and *worsted* yarns, the distinction between the two being in the disposition of the individual fibers in the thread. Strictly speaking, both are wool yarns, but it is the custom to divide them into these two main classifications for commercial purposes, because of the difference in their structure, appearance, method of manufacture, and uses.

A **woolen yarn** is a thread spun from sheep's wool in which the individual fibers are mixed and crossed in various directions so that the surface of the thread presents a rough, although uniform, appearance, but lacking in luster. A **worsted yarn** is also a thread composed of wool, but the individual fibers lie smoothly and in the direction of the thread and are parallel to one another. The surface of worsted yarn is comparatively smooth and generally has a well-defined luster.

No distinction is made between woolen and worsted yarns merely because of the length of the wool fiber used in their construction, although a somewhat longer fiber is generally used in the manufacture of worsted yarns, which are free from the very short fibers often found mixed with the longer ones in woolen yarns. Strictly speaking, the distinction between woolen and worsted yarns should be made under the head of yarns as classified according to the method of manufacture, since worsted yarn is produced by an entirely different system from that used in the manufacture of woolen yarn.

RAW MATERIAL FOR WOOLEN AND WORSTED YARNS

2. Of all animal fibers that are used in the production of yarn for textile purposes, the fleece of the domesticated sheep is by far the most important—so much so that the general interpretation of the word *wool*, unless otherwise qualified, is that of the wool of the sheep, although in its true sense the word wool is applicable to the fleece of some other animals. The sheep belongs to the scientific classification of *Ovis*, which is divided into a large number of species. Wool is produced in many parts of the world, chiefly in the United States, Australia, South America, and Europe.

Wools are often divided in a general way in America into two classes—domestic and foreign, or imported, wools. Foreign wools are sometimes divided according to the continent on which they are raised, as, for instance, South American wools, Asiatic wools, Australian wools, etc. They are also sometimes divided according to the country from which they come, as Russian wools, China wools, etc., and sometimes according to the ports from which they are shipped, as Buenos Ayres, Port Phillip, etc. Wool exported from Buenos Ayres is frequently called River Plata wool, from the fact that Buenos Ayres is situated at the mouth of the River Plata (Rio de la Plata). Another classification is that of the Cape wools from South Africa.

Domestic wools are usually designated by the state in which they are grown, as Ohio, Pennsylvania, West Virginia, Texas wools, etc. The wool from the large group of territories, or former territories, is known as territory wool, and includes North and South Dakota, Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Idaho, Washington, Oregon, and California wools.

Wools are often divided according to the use to which they are to be put, as, for instance, clothing wools for woolen yarns, combing wools for braid, luster, and carpet yarns; fine combing wools for the fine and medium worsted yarns, etc.; also according to the breed of the sheep, as Saxony, merino, cross-bred, etc. Sometimes two or more divisions are grouped, as, for instance, Australian merino, Ohio, Pennsylvania, or West Virginia cross-breds. The cross-breds are further subdivided according to the amount of merino blood in the cross-bred sheep, as, for instance, $\frac{3}{8}$-blood, $\frac{1}{4}$-blood, $\frac{1}{2}$-blood, etc.; also as XXX, which means a first cross of a merino with a Saxony, XX, which is the full-blooded merino, and X, which is the quality of a $\frac{3}{4}$-blood merino and $\frac{1}{4}$-blood common sheep. The term *delaine* is sometimes used in connection with wools, and while it is a term of somewhat loose application, its general significance is a wool of superior quality, from a sheep containing merino blood. Raw wools are also classified according to the condition or age of the sheep, whether washed or not, and in many other ways, but as this Section is intended to deal only with yarns and the extent to which the classes of wool affect the naming of yarns made from them, these will be ignored; in fact, many of the classifications of raw wools disappear when classifying the yarns.

3. Worsted Yarns Classified According to Raw Material.—The nomenclature depending on the country of origin or the shipping point of the raw wool is not extended to the yarns made from such wool, except in the case of Australian, which is a distinction given to certain kinds of worsted yarn, and American and Canadian when applied to braid yarns that are spun from long and coarse, or *braid*, wools, either of American or Canadian origin. Yarns, however, are classified to some extent according to the breed of the sheep from which the raw wool has been taken, and from these sources are derived such yarn classifications as yarns from $\frac{1}{4}$-blood, from $\frac{3}{8}$-blood, from $\frac{1}{2}$-blood, and merinos, in the worsted-yarn trade. There is a worsted merino yarn, however, that is made by blending a combed wool and a combed cotton in suitable proportions.

It is only worsted yarns that are classified according to the names of the wool from which they are made. Woolen yarns are spun to a large extent from wools that it is not necessary to classify according to their breed or origin, and commercial woolen yarns in many cases contain only a percentage of wool, so that such classifications are not applied to these yarns to any appreciable extent, except in certain cases; for instance, the term *merino yarn* is applied to certain so-called woolen yarns, which, however, should not be construed to mean that these yarns are made exclusively from the wool of the merino sheep.

All common and $\frac{1}{4}$-blood worsted yarns are spun into numbers below 20s; the $\frac{3}{8}$-blood and $\frac{1}{2}$-blood yarns range from 20s to 40s; the delaine worsted yarns, from 40s to 50s; while the Australian worsted yarns are the finest, ranging from 40s to 70s. The Canadian braid yarns are made from 20s to 40s.

The difference between yarns made from different wools is chiefly in the fineness of the thread. Yarns from the wool of sheep with a large proportion of merino blood are the finest numbers, with the exception of yarns from Saxony wools.

4. Woolen Yarns Classified According to Raw Material.—Woolen yarns spun on the straight woolen system may be roughly divided into three classes: (1) pure woolen yarns, (2) shoddy yarns, and (3) part-wool yarns.

1. *Pure woolen yarns* are composed of the wool of the sheep only, and in general are yarns of fine quality, and used in the highest-grade fabrics. They are not made to nearly so great an extent at present as formerly, and it may be stated that the bulk of the so-called woolen yarns now made are either shoddy or part-wool yarns.

2. *Shoddy yarns* are all wool but are made from a mixture, in the raw stock, of new wool and shoddy, new wool and mungo, new wool and extract, or new wool and some of the various hairs that are occasionally used for textile purposes. Shoddy, mungo, and extract are sometimes manufactured

into very coarse yarns, but are more frequently used with new wool as mixture yarns.

Shoddy is the wool fiber obtained from soft woolen rags, such as flannels, stockings, and knit goods, which have not been milled or felted. While shoddy is pure wool, it loses much of its characteristic wool nature in the manufacture and tearing apart again to regain the fiber. In the process of obtaining shoddy, the woolen rags are ground up or torn into a fibrous state, which necessarily breaks the fiber until it is only a fraction of its original length. The loss in length of the fiber and the destruction of the uniform and regular structure characteristic of new wool makes shoddy fit only for mixing with new wool in the production of the lower qualities of goods.

Mungo is the recovered fiber of hard-spun and felted woolen and worsted goods. Owing to the hard milling that these goods undergo, mungo is inferior to shoddy. There are two varieties of mungos, the better quality being obtained from the new rags that accumulate in tailor shops as clippings, and the poorer quality from worn broadcloths, suitings, etc.

Extract is the recovered wool fiber obtained from worn or waste cloth that contained cotton or other vegetable fibers as well as wool. The vegetable fibers are first removed by a chemical process known as carbonization, and the wool fibers afterwards worked up into a fibrous state in a similar manner to shoddy and mungo.

3. *Part-wool yarns* are made from a blend of wool and cotton, wool and silk noils, or wool and some other fiber, and while forming a very large class of yarns often called wool and sold as such, are really only part wool, such as are called in German half-wool (*halb wolle*) yarns. Merino yarns form one variety of such yarns; they are spun on the woolen principle from a blend of wool and cotton, and resemble woolen yarn. Different percentages of wool and cotton are used for merino yarns; for instance, 40 per cent. wool and 60 per cent. cotton, usually written 40–60; 50 per cent. wool and 50 per cent. cotton, written 50–50; 60 per cent. wool and

40 per cent. cotton, written 60–40; and 70 per cent. wool and 30 per cent. cotton, written 70–30.

Vigogne yarns is a name given to a class of yarn formerly made like merinos but with a very small proportion of wool, generally only from 3 to 10 per cent. The name was probably originally adopted in order to give the impression that the yarn was made from the wool of the vicugna goat, which makes a very desirable yarn, but vigogne yarns do not contain any vicugna wool; the small percentage of wool used is that of the sheep, cotton being the other constituent of the yarn.

5. A more convenient classification of woolen yarns than under the three foregoing headings would be to consider all woolen yarns other than those from pure, new wool—such as wool-and-shoddy and wool-and-cotton yarns—as **mixture yarns;** this is sometimes done, but it leads to complications, since the term mixture yarns, when used in connection with woolen yarn, also includes those of pure wool produced by mixing colored wools, and thus may refer to a yarn of any one of the three classes previously mentioned. For instance, yarns may be made from mixtures of different colors of wool, and also from mixtures of wool and cotton, wool and shoddy, wool and mungo, wool and extract, or wool and silk, either of one color or of different colors, all of which are sometimes spoken of under the general head of mixture yarns. Woolen mixes of this kind are very common, the mixing being made early in the process of manufacture, before the stock is carded. Gray-mixture yarns, for example, are obtained by mixing black and white wool together in such a proportion as to give a gray of the desired shade.

WOOLEN YARNS CLASSIFIED ACCORDING TO THE METHODS OF MANUFACTURE

6. Single yarns made from sheep's wool when divided according to the different methods of their production consist of: (1) woolen yarns made by the ordinary woolen process, (2) woolen yarns made on the Belgian system, and (3) woolen yarns made on the Saxon system.

7. Ordinary Woolen Process.—Most woolen yarns are of the first class, and are produced by spinning the yarn directly from the spool made at the card. The web of wool at the card is divided, by ring doffers, into ribbons, which are condensed into rovings by rub aprons or rub rolls. These rovings are then wound on the jack-spools from which they are spun at the mule.

The range of numbers of woolen yarns of this class is from $\frac{1}{2}$-run to 10-run for ordinary commercial purposes, which approximately corresponds to from $2\frac{1}{2}$-cut to 50-cut in the Philadelphia, or cut, system of numbering. In isolated cases, woolen yarns are spun finer than 10-run, but these yarns do not usually come on the market, being generally used by the mills producing them.

8. The Belgian System.—The only difference between common woolen yarns and woolen yarns made on the Belgian system is in the means of producing the roving at the card; in this system the Belgian condenser, or Bollette steel-tape condenser, is used to divide the web into the separate rovings required for spinning. The yarns are often sold under the name of Belgian-system woolen yarns, although they do not greatly differ from ordinary woolen yarns spun from the same stock and under the same general conditions.

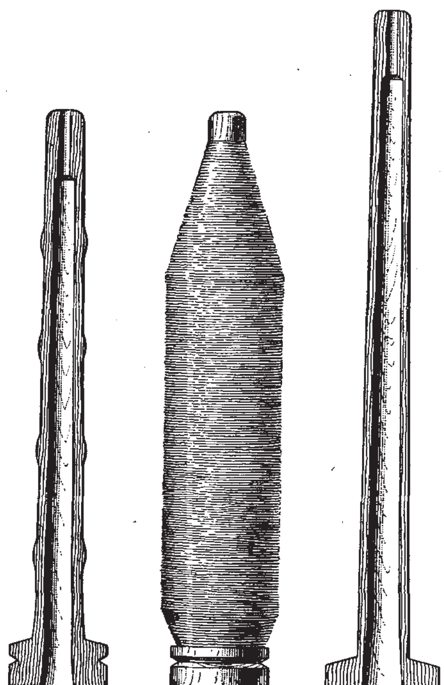
9. The Saxon System.—The difference between yarn spun on the Saxon system and other yarns is also in the method of making the rovings at the card. For yarns made on this system, the web is divided by narrow leather belts, the rovings being afterwards condensed by rub rolls or aprons, or both.

10. Woolen yarn can easily be distinguished from worsted yarn by the rough, oozy appearance of the former, the fibers projecting from its surface, and by the comparative weakness of its thread.

It is more difficult to determine, by an examination of the yarn, to which system a woolen yarn belongs—ordinary, Belgian, or Saxon—since all three classes of yarns have a general resemblance and each can be made from various grades of wool or various mixtures of wool and other materials. Woolen yarns belong to the condensed and spindle-drawn class of yarns as distinct from the roller-drawn yarns. All woolen yarns are carded and mule-spun. When examined in the condition in which they leave the spinning machine, they are generally on wooden bobbins, but may be on paper tubes.

WOOLEN YARNS CLASSIFIED ACCORDING TO FORMS IN WHICH PUT UP

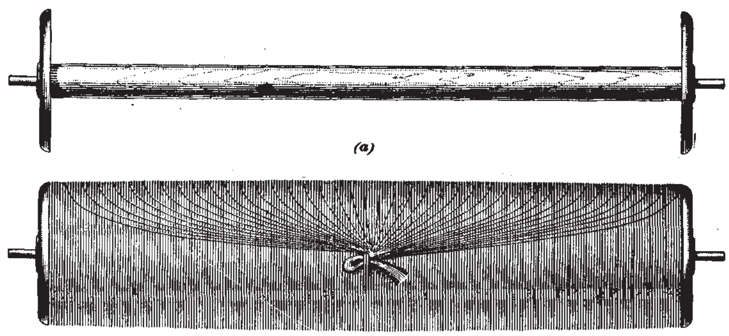
11. Among the forms in which woolen yarns are found are *bobbins*, *dresser spools*, *beam warps*, *conical* and *parallel tubes*, and *cops*.



(a) (b) (c)

Fig. 1

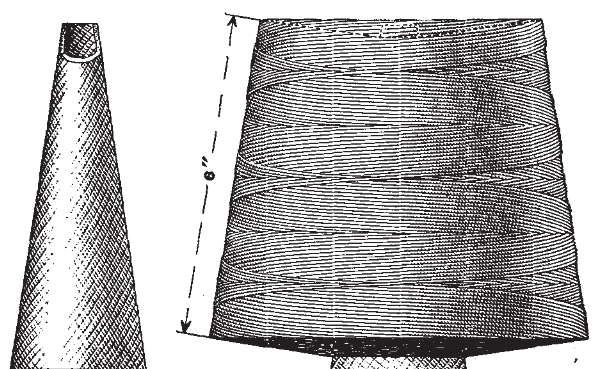
12. Bobbins.—The bobbin, by which is meant the spinning bobbin, is the form in which most single woolen yarns are put up as they leave the spinning mule. Two styles of bobbins are used, as shown in Fig. 1; (*a*) is a section through a regular woolen filling bobbin empty, and (*b*), a bobbin filled with yarn. The yarn is laid on the bobbin with a short traverse, commencing near the base, and extending to the nose, from which the yarn is unwound in the shuttle. The woolen warp spinning bobbins are of two styles, the more common type being similar to (*a*), but having a corrugated surface and no groove at the bottom. Another style, which has a smooth surface, is shown at (*c*); this bobbin is often used for knitting yarn as well as warp yarn. The warp yarn is built up on this bobbin with a short traverse gradually rising until the nose of the bobbin is reached, and the yarn is unwound from the nose at the spooler.



(b)

FIG. 2

13. Spools.—The spool on which woolen warp yarn is put up is shown in Fig. 2, (*a*) being an empty and (*b*) a full spool; it is a long double-headed bobbin about $2\frac{1}{8}$ inches in diameter at the barrel and with a distance of 40 or 48 inches



(a) (b)

FIG. 3

between the heads. A large number of ends are wound on this spool, usually 40 or 48, which are given only a slight traverse during the winding, so that the spool really consists of a number of ends wound side by side. Other names for this spool are *jack-spool* and *dresser spool*.

14. Beam warps are the form in which woolen yarn is finally put up for use at the loom in weaving, but as yarn is not often sold in this form, no description is necessary.

15. Cones and Tubes.—Woolen yarns are often supplied on conical tubes for knitting purposes and, less frequently, are put up on parallel tubes. The coned form is shown in Fig. 3 and the parallel tube in Fig. 4, (*a*) representing the empty tube, and (*b*) one filled with yarn, in each case.

16. Cops.—Woolen yarns are sold in the cop in either of two forms: (1) mule cops and (2) carpet cops. Merino yarns are often spun at the mule on a paper tube sufficiently long to project through the cop at each end. These cops are larger in diameter than the regular woolen spinning bobbin and are used for convenience in transporting yarns to knitting mills. A common style of merino cop is shown in Fig. 5 (*a*), while a smaller mule cop of filling yarn

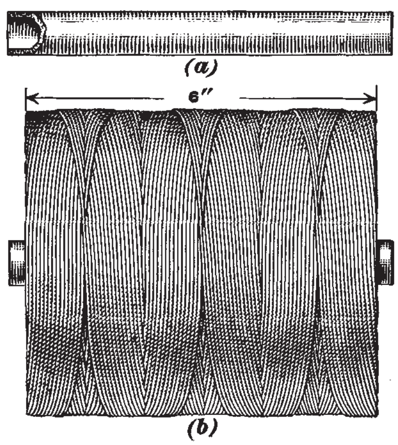


FIG. 4

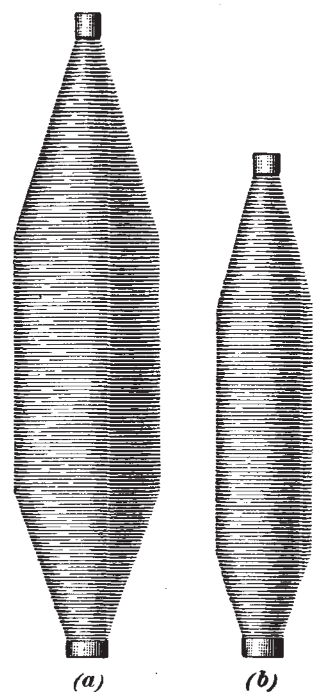


FIG. 5

produced in some branches of the so-called woolen industry, especially in the vigogne-yarn and imitation vigogne-yarn trade, is shown in Fig. 5 (*b*). This is also built on a paper tube. The carpet cop, which is wound on a special machine, is shown in Fig. 6, and is entirely different from the mule cop. It is held in the shuttle by means of an elastic strap and woven from the inside of the cop, commencing at the bottom.

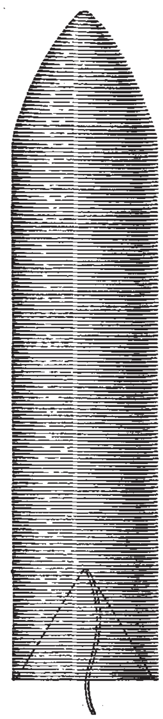


FIG. 6

WOOLEN YARNS CLASSIFIED ACCORDING TO THEIR USE

17. Woolen yarns, in common with most yarns, are spun mainly for weaving, in two varieties—warp and filling. A considerable quantity of woolen yarn is also spun for knitting purposes, chiefly in the merino yarns, which are supplied on cops or on cones. Woolen yarns are also used for filling in cheaper qualities of carpets, in which case they are usually supplied on cops. Woolen carpet yarns are sometimes sold in skeins, and are made from 40 yards per ounce to 200 yards per ounce, the most common weights being from 40 to 120 yards per ounce. The comparative lack of strength and the rough surface of woolen yarns render them unsuitable for many purposes for which cotton and worsted yarns are produced; in general, it may be stated that the use of woolen yarns is confined chiefly to weaving and knitting purposes.

WORSTED YARNS CLASSIFIED ACCORDING TO METHOD OF MANUFACTURE

18. The usual sequence of operations in the preparation of worsted yarn aims at the manufacture of a thread that shall be smooth and uniform in appearance, with the fibers arranged in parallel spirals and all short fibers eliminated. To obtain this result a combination of processes selected from the following is used: scouring, carding, doubling, back washing, combing, preparing, gilling, drawing, roving, and spinning. Thus a number of varieties of worsted yarns are produced, according to the processes selected and the style of machine adopted for each process. The same processes cannot be used for handling all kinds of wools, as they vary in length of staple and in other characteristics; nor can the effects desired in worsted yarns for special purposes always be obtained by one method only. The differences in the sequences of processes are chiefly as follows: (1) whether the carding process is used or not (in case it is not, preparing is substituted); (2) whether the comb is used or not, and if used, the style of comb; (3) the method of spinning, whether on the cap spinning frame, ring spinning frame, flyer spinning frame, or mule.

In a general way, worsted yarns may be divided according to the operations previous to spinning into four classes: (1) prepared yarns, (2) yarns made on the Bradford system, (3) yarns made on the French system, and (4) uncombed worsted yarns. They may also be divided according to the method of spinning without regard to the previous handling of the stock into: (1) cap-spun yarn, (2) flyer-spun yarn, (3) ring-spun yarn, and (4) mule-spun yarn.

19. Prepared Worsted Yarns.—In case yarns are to be made from wools that are too long to be put through the card, especially English wools, American or Canadian braid wools, and luster wools, they are prepared for combing by what is known as a preparing set of gill boxes, and are afterwards combed, drawn, and spun, without being subjected to a carding process, thus distinguishing them from other worsted yarns. Although they are here spoken of as prepared yarns, this name is not often used commercially; they are more generally described with reference to their appearance or their future use, such as luster yarns, braid yarns, or carpet yarns.

Prepared yarns are made from coarse, long-stapled, lustrous wool, and have a distinctive appearance on account of their luster. This quality is not especially given to the yarn by the preparing process, but is a natural feature of the long and coarse wools from which these yarns are made. Prepared yarns may vary from low to medium numbers, but are made largely in coarse, high-grade, carpet yarns and braid yarns; they may run as high as number 40s, and from that downwards as coarse as is desired.

20. Worsted Yarns Made on the Bradford System. The term **Bradford system** applies to the ordinary process of producing worsted yarns. It derives its name from the system widely used in the Bradford district of England, and for this reason is sometimes called the English system. The wool for yarns made on the Bradford system is both carded and combed; it then passes through the ordinary processes of drawing, and may be either cap-spun, flyer-spun, or ring-spun. The term Bradford system applies more to the series of drawing and spinning processes after the combing than to the methods of carding and combing.

Worsted yarn spun on the Bradford system is smooth and uniform in appearance, the fibers being laid parallel to each other in the direction of the thread; the yarn generally exhibits a well-defined luster and is strong and elastic. The luster is not so great as in the case of the prepared yarns, which affords one means of distinguishing the Bradford-system yarns from the prepared yarns.

Bradford-system worsted yarns may also be subdivided into several classes, depending on the method of spinning the thread—whether on a cap spinning frame, a flyer spinning frame, or a ring spinning frame. The bulk of the yarn spun on the Bradford system is spun on a cap spinning frame, since the production of this machine is greater than that of the flyer spinning frame. Cap-spun yarn, however, is much more apt to exhibit a *beard* than flyer-spun yarn, that is, have numerous projecting fibers. Flyer-spun yarn is smoother, softer, has less twist, and is more even than cap-spun yarn. Ring spinning is not yet on a commercial basis, although there is some ring-spun yarn made. The bulk of worsted yarn is spun on the Bradford system in numbers ranging from 12s to 60s.

21. Yarns Made on the French System.—The French system of manufacturing worsted yarns—generally called **French spinning**—differs from the Bradford, or English, system to a considerable extent in the drawing processes as well as in the spinning. It derives its name from the fact that it was largely developed in France, and the machinery for it made in one of the former French provinces (now a part of Germany); the yarns themselves are spoken of as **French-spun worsteds.** In this system, nearly every drawing process employs a peculiarly constructed roll, called a *porcupine*, filled with sharp needles for separating and straightening the individual fibers of the sliver, whereas in the Bradford system traveling bars, called *fallers*, set with needles are employed. French-spun yarns are spun on a mule in the form of a cop built up on a long, thin, paper tube. They can thus be distinguished from worsted yarns spun on other systems by the form of the tube on which they are spun, since the yarns made on other systems are either on wooden bobbins or paper tubes of large diameter. French-spun yarns are made to a considerable extent in America. Yarn spun on this system is softer, more bulky, and more elastic than worsted spun on other principles and generally has less twist per inch. The stock used for French spinning is either X, XX, delaine, or Australian, and the yarns are made in various numbers from 20s to 80s, according to the stock used. It is not necessary, however, to use only long-stapled wool in their production, since comparatively short fibers can be worked up in this way. This yarn is particularly suitable for the production of soft, fine, worsted goods, especially ladies' dress goods, and also makes excellent knitting yarn.

22. Uncombed Worsted Yarns.—Uncombed worsted yarns are prepared by a sequence of processes from which the combing is omitted; they are carded, drawn, and spun somewhat similar to the Bradford-system yarns. Owing to the omission of the combing process, they are more uneven

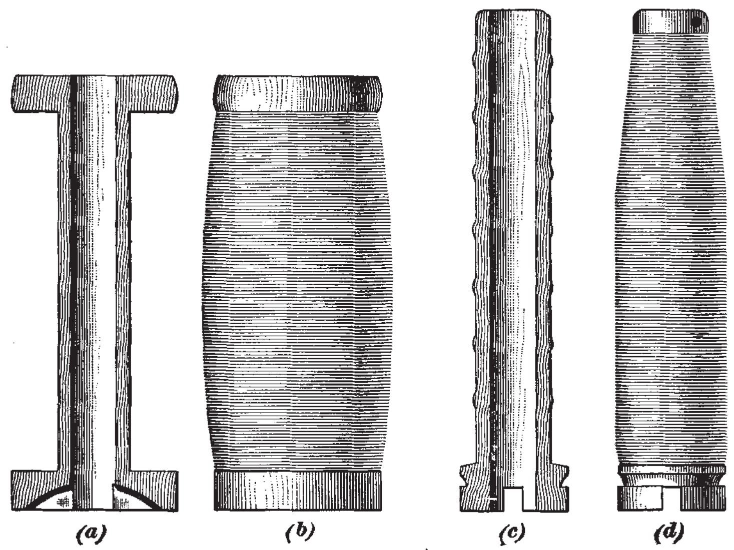


Fig. 7

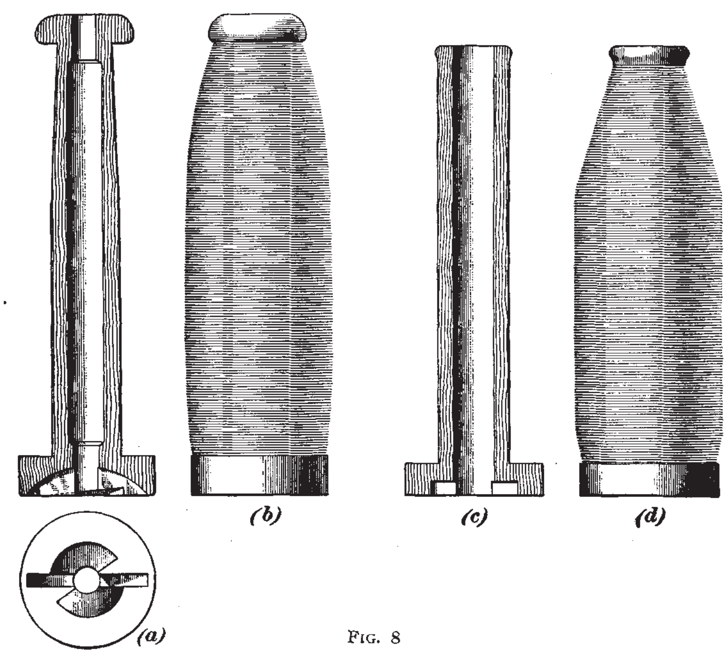


Fig. 8

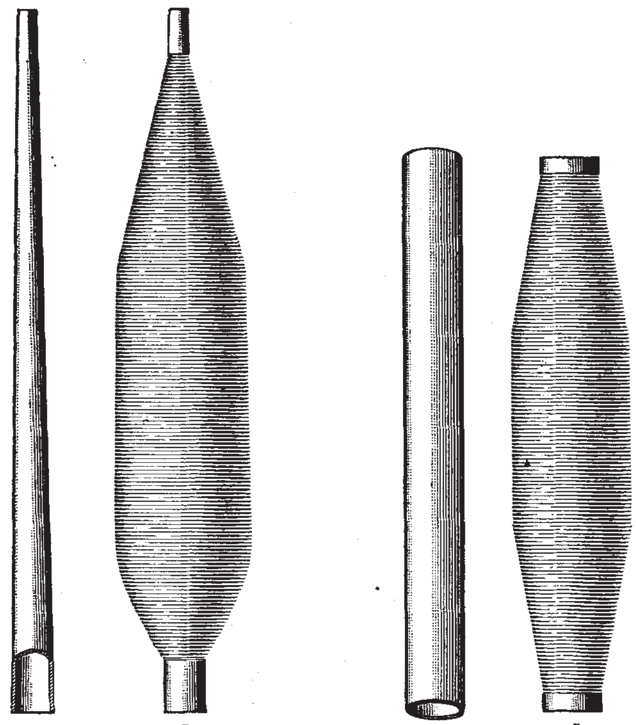
and irregular than the ordinary types of worsted yarns and bear more resemblance to a woolen yarn than does a true worsted. Uncombed worsted yarn contains short fibers, which in an ordinary worsted yarn would have been removed in the combing process. Strictly speaking, such a yarn ought not to be classified with either worsted or woolen yarns, since, in the usual acceptation of the definition, worsted yarn is always a combed yarn and woolen never a roller-drawn yarn; for convenience, however, these yarns are classed with the worsted yarns, although they are sometimes given the distinguishing name of *half-worsted* or *semi-worsted*. They are spun in coarse numbers and can be distinguished from other worsted yarns by their lack of luster and smoothness, and are generally used in the carpet trade.

23. Worsted Mixture Yarn.—Fancy mixtures of different-colored fibers are frequently made in worsted yarns, especially for knitting purposes. In making worsted mixtures, the blending takes place later in the series of processes than in the case of woolen mixtures, it generally being done after the combing. The word mixture in connection with worsted yarns has the same meaning as in connection with woolen yarns; namely, a blend of different colors, unless specially qualified as a worsted-and-cotton mixture; this latter, however, is seldom made.

WORSTED YARNS CLASSIFIED ACCORDING TO FORMS IN WHICH PUT UP

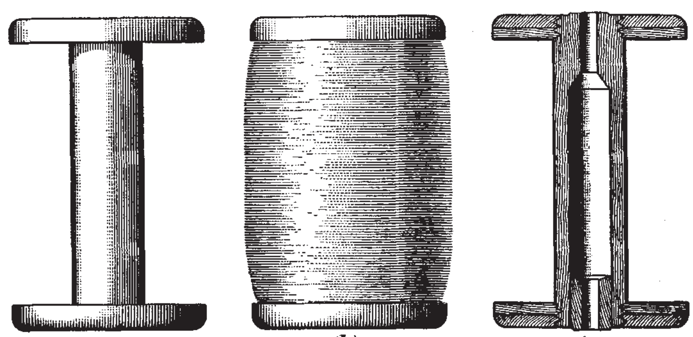
24. Worsted yarns are put up on *bobbins*, *cops*, *spools*, *cones*, *tubes*, *warp beams*, and in *skeins*.

25. Bobbins.—By a **worsted bobbin** is generally meant a *spinning bobbin* on which the yarn has been spun, or a *twister bobbin* on which the yarn has been wound after being doubled to make a two-, or more, ply yarn. The spinning bobbin may be either a double-headed bobbin, as shown in Fig. 7, in section at (*a*) and filled with yarn at (*b*); or a single-headed, as shown in Fig. 7, in section at (*c*) and filled with yarn at (*d*). The double-headed bobbin



(a) (b) (c) (d)

FIG. 9

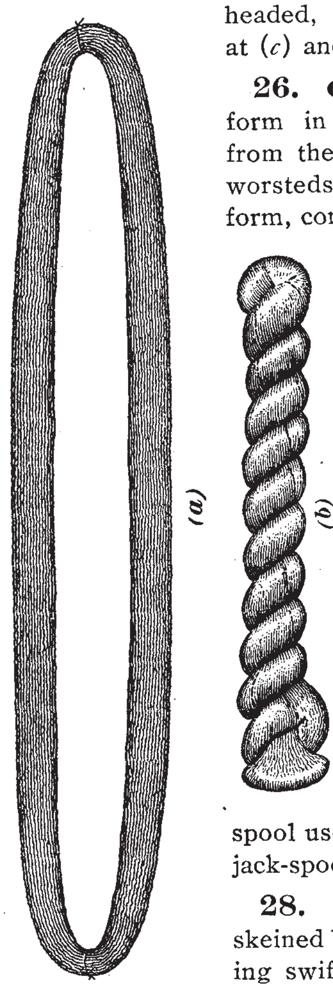


(a) (b) (c)

FIG. 10

is customarily used for warp, while the single-headed bobbin is filled with filling yarn and used in a shuttle.

Twister bobbins may be either double-headed, as shown in Fig. 8, in section at (*a*) and filled with yarn at (*b*); or single-headed, as shown in Fig. 8, in section at (*c*) and filled with yarn at (*d*).



(*a*) (*b*) FIG. 11

26. Cops.—A worsted cop is the form in which single yarn is delivered from the mule in the case of mule-spun worsteds. It is built up in a cylindrical form, coned at each end, on a long, thin, paper tube, shown empty in Fig. 9 (*a*) and filled in view (*b*). Shorter tubes of larger diameter used for frame spinning are shown empty in Fig. 9 (*c*) and filled in view (*d*). These are sometimes called *cannettes*.

27. Spools.—Worsted yarn is spooled in two forms; the spool, shown in Fig. 10, is similar to the regular cotton-warper spool and is used to form a convenient method of transporting worsted yarn for sale, since from this spool the yarn can be conveniently made into a warp; the other form of spool used for worsted yarn is the regular jack-spool or dresser spool, shown in Fig. 2.

28. Skeins.—Worsted yarns are skeined by being wound around the revolving swift of a reel; the skein when completed resembles the illustration in Fig. 11 (*a*). This is twisted several times and doubled upon itself, when the excess twist causes it to form into a firm roll, similar to Fig. 11 (*b*), suitable for packing and transportation. The circumference of a skein of worsted is generally 72 inches, although other dimensions can be arranged. The length, except when otherwise specified, should be understood as 1 hank, or 560 yards. Worsted yarns are generally put up into skeins for dyeing purposes, one form known as the Balmoral skein being intended for random dyeing, that is, dyeing several colors in one skein.

29. Parallel and **conical tubes** are used to a considerable extent in the worsted trade. Knitting yarns are often coned.

30. Beam Warps.—The information given regarding woolen beam warps is applicable to worsted.

WORSTED YARNS CLASSIFIED ACCORDING TO THEIR USE

31. Worsted yarns, as well as woolen yarns, are spun mainly for weaving, in two varieties—warp and filling. Considerable quantities of worsted yarns are also used for knitting purposes, including the so-called worsted merino yarn made of combed cotton and combed wool; knitting yarns are supplied in cop, cone, or skein. Worsted yarns are used very extensively for carpet making, especially for the higher-grade carpets; the worsted appears on the face of the various styles of carpets, both as cut and uncut pile, while the backing is often of cotton, linen, or some other vegetable fiber. Worsted carpet yarns are put up in skeins. They are generally made on the straight, prepared system and may be said to be coarse yarns, below, say, 16s. Rug and fringe yarns are usually made of worsted, in coarse numbers, and are often 3-ply skein yarns, although they are made 2-, 3-, or 4-ply as required. Worsted yarn is also made in limited quantities into harness thread, sewing thread, seaming thread, etc.

WOOLEN AND WORSTED PLY YARNS

32. The foregoing descriptions of woolen and worsted yarns apply to single yarns, but any woolen or worsted yarn can be made into ply yarn; in fact, it is very common to make worsted into ply yarns, more so than is the case with woolen yarns, except those for fancy double-and-twists. The term ply is not so frequently applied to woolen yarn as is the name double-and-twist, which indicates that two threads are doubled and twisted together at the same time. In worsted yarns, especially those made on the Bradford system, the process of doubling is fairly common also, as 2-ply yarn is generally used for worsted warps.

WOOLEN AND WORSTED YARNS CLASSIFIED ACCORDING TO SIZE

33. The expressions coarse, medium, and fine yarns are occasionally applied to both woolen and worsted yarns, but it must be understood that when these terms are used no definite size of yarn is referred to, since the terms are necessarily somewhat vague and indefinite; considerable leeway must therefore be allowed. For instance, a woolen yarn that a mill running on coarse cheviots and tweeds would consider fine would be thought a very coarse yarn in a mill running on fine dress goods or flannels; or in the case of worsted yarn, a yarn might be considered as fine in a carpet mill and as coarse in a fancy-dress-goods mill. Striking a general average, however, it may be stated that woolen yarns up to 4-run, or about 21-cut, are considered as coarse yarns, while those from 4- to 8-run, or from about 21- to about 43-cut, are considered as medium, although in many woolen mills an 8-run yarn is considered very fine. Woolen yarns above 8-run, or about 43-cut, are in almost every instance considered as fine yarns. Worsted yarns may be considered as coarse when spun into counts below 16s, while medium worsted yarns include those from 16s to 40s. Any worsted yarn above 40s will almost always be considered as a fine yarn.

YARNS PRODUCED FROM HAIR

34. Mohair yarns are produced from the fleece of the Angora goat, which is a fine, silky fiber closely resembling wool in its spinning properties. The source of supply formerly was Asia Minor, and considerable mohair is still obtained from there, but of late years the Angora goat has been introduced into the United States, France, and Spain, and Angora wool, or mohair, is now obtained from these countries. The principal characteristics of mohair are its luster and resistance to crushing, so that fabrics made from it cannot readily be creased. The fiber varies in length from 4 to 10 inches, the general length being about 5 or 6 inches; it is pure white, fine, curly, as well as lustrous. No classification of mohair yarns dependent on the source or origin of the material is customary, nor are they classified according to the method of their preparation or treatment after spinning, as in almost all cases they are made on the worsted principle. When delivered in the form in which it is spun, mohair yarn is on paper tubes or bobbins; it is also delivered on 6-inch warper spools or on dresser spools, and both in single and ply yarns. Its use is chiefly for weaving purposes, especially for dress goods, plushes, and part-silk goods. The luster and tendency to curl make it a suitable material from which to make certain novelty yarns, especially loop, or bouclé, yarn. Mohair yarns are produced in various numbers, up to as high as 36s.

35. Alpaca yarns are those produced from the fleece of the alpaca sheep, which from the fact of its resemblance both to a camel and a sheep is sometimes called the camel-sheep. The fleeces of the llama and guanaco, although not true alpaca, are often classed and used with alpaca. Alpaca is either white, red, brown, or black, is as long as 6 or 8 inches, somewhat fine, and generally spun alone into yarns intended for use in dress goods. The manufacture of this yarn is a small industry and is conducted on similar lines to the worsted- and mohair-yarn industry.

36. Vicugna yarns are now seldom manufactured; the true vicugna yarn is made from the fleece of an animal belonging to the camel-sheep variety, and is very lustrous, extremely fine and soft, and reddish brown in color, if undyed. This yarn should not be confused with vigogne and imitation vigogne.

37. Cashmere, or Tibet, Yarns.—Cashmere yarns are those spun from the hair of the Cashmere goat; this is an exceedingly soft, silky fiber, and when pure is of considerable value. The manufacture of these yarns is so small an industry as to be of no commercial importance.

38. Other animal fibers are camel hair, cow hair, and the fur of various animals, domesticated and otherwise. These are not generally used alone for spinning into yarn, but are used for adulterating woolen yarns.

39. Horsehair is not generally spun into yarn, but the mane and tail hairs are used alone as filling and sometimes as warp for such fabrics as coverings for the seats of chairs, for strainers, etc.

SILK YARNS

CLASSIFICATION BY RAW MATERIAL

40. The most valuable yarns known in the textile trade are **silk yarns**, the appearance of which is sufficiently familiar to render an extended description unnecessary. The features that give silk yarn its value are an intense luster, great strength in proportion to its size, as well as softness, elasticity, and durability to such an extent as cannot be found in any other material. Silk yarns are very suitable for dyeing, giving brilliant shades in all colors, and fabrics of silk have a rustling property, or *scroop*, not common to any other material.

41. Cultivated and Wild Silk.—All silks may be divided in two main classes: (1) cultivated silk, sometimes known as mulberry silk, and (2) wild silk, often called Tussah silk, although this is only one variety of wild silk. Silk yarns may therefore be classified according to the kind of silk used in their manufacture, as: (1) yarns from cultivated silks, and (2) yarns from wild silk. The cultivated silk is produced by the caterpillar of the *Bombyx mori*, the silk moth. Wild silk is produced principally by the caterpillar of the Tussah moth (*Antheræa mylitta*), although other varieties are produced from other moths, such as Eria silk, Fagara silk, Murga silk, Atlas silk, Yama Mai, and others.

Yarns produced from cultivated and wild silks, if undyed, are readily distinguished by the color. Cultivated silks in the natural state are a bright yellow, while by scouring, various shades from yellow to pure white are produced, according to the amount of coloring matter removed from the raw silk. The wild silks are always of a dark color, in some cases approaching a brown. The cultivated silks also are superior in luster, softness, and elasticity to the wild silks.

42. Classification of Silk Yarns According to the Country of Origin.—The countries from which the largest supplies of silk are obtained are China, Japan, Italy, France, Austria, Spain, and the United States. The production is greatest in China. In describing raw silk, the name of the country or district in which it is produced is used to a large extent, as is also the name of the port from which it was shipped; thus, there are Japanese silks, China silks, Italian silks, etc., with subdivisions such as Tsatlee and Canton silks, which are varieties of China silk. Owing to the fact that all cultivated silks bear a decided resemblance to one another and that after they are scoured and made into a thread the difference is not sufficiently great to retain the geographical name that was used to describe the raw material, such a classification of silk yarns is not made to any extent; they are classified rather according to the method of preparation or treatment of the yarn.

CLASSIFICATION ACCORDING TO METHOD OF PREPARATION

43. The essential differences in silk yarns, from both wild and cultivated silks, are due more to the differences in their manufacture than to anything else. This determines a primary classification depending on the treatment of the raw stock, one class, called *thrown silk*, consisting of yarns that are produced by the processes of reeling and throwing, and the other, called *spun silk*, consisting of yarns spun from waste raw silk. Thrown silk may be further divided according to the number of silk fibers combined to form one thread and the method of twisting adopted in producing this thread, or according to the extent of the scouring to which the silk has been subjected.

44. Thrown Silk.—A fiber taken from one silk cocoon consists of two single filaments held together by a gummy matter and is of great length, from 300 to 1,000 yards of good silk being obtained in a continuous thread from one cocoon. There is a much greater length than this on the cocoon, but it is not possible to obtain it in a continuous thread; the waste is used for spun silk. It is not customary, however, to take the individual fiber as a basis of preparation for making a silk thread, but to unwind several of these at one time, varying in number, from five to eighteen, to form one loose, even strand, termed a **single**. The process of obtaining these singles is known as *reeling;* this gives the name *reel* silk, often applied to thrown silk. The number of fibers composing the strand is not the same at all points, since, as the individual fiber varies in thickness, at some parts more filaments are used than at others, in order to produce a single that shall be even throughout its length. By the process known as *throwing* these singles are made into two classes of yarn: (1) **organzine** and (2) **tram.** These are used in largest quantities for weaving purposes, the organzine being used chiefly for warps and the tram for filling. The most perfect cocoons are selected for the manufacture of organzine, which is produced by first taking several singles, twisting each in the same direction, and then twisting these singles together in the opposite direction. Tram silk is made from less perfect cocoons with a smaller number of ends and less twist. In addition to tram and organzine, other yarns are also made from silk, such as embroidery, French, sewing, knitting, and machine twists, which differ chiefly in the number of strands used to make the final thread and the method of twisting them.

Neither trams nor organzines are all silk; about 30 or 40 per cent. is the gummy matter that holds together the two filaments forming the real silk. The amount of scouring, or boiling off, to remove this foreign matter determines four classifications: (1) hard silk, the term applied to silk after it has been reeled from the cocoon and before it has undergone any boiling-off process; (2) écru silk, which is silk that has been boiled sufficiently to remove about one-twentieth of the gum; (3) souple silk, which has been boiled sufficiently to remove about one-sixth of the gum; and (4) boiled-off silk, from which the gum has been completely removed. In both écru and souple silk, sufficient boiling is introduced to produce the luster characteristic of silk, although they differ in regard to the amount of gum removed. The first class is the darkest yellow and least pliable of silks, while the fourth class is the lightest in color and has the characteristic luster to the greatest degree. The other two classes are situated between these, both as to luster and color.

45. Spun Silk.—The thrown silks, such as the tram, organzine, and others, are often called *spun silks*, but this use of the term is erroneous; **spun silks** should be applied only to silks that are actually spun, and this is not the case with thrown silks, which are simply reeled and afterwards passed through a twisting process or processes. There are two grades of spun silk: *schappe* and *bourette*. **Schappe,** sometimes called chappe, florette, or filoselle silk, is made from silk waste from the fibrous portion of the cocoons that it is not possible or desirable to unwind in order to produce tram or organzine. The manufacture of these yarns includes the processes that break up the long silk fibers into short lengths, which are spun by a series of processes bearing some resemblance to those required in the manufacture of woolen and waste cotton yarns.

The waste made at schappe-spinning processes is again worked up into a still coarser yarn, which is known as **bourette** silk.

Tram and organzine silks bear considerable resemblance to each other in their appearance; the examination of either of these yarns shows continuous fibers that can readily be separated from the thread. Schappe silks show a more solid construction of thread, resembling a cotton or worsted yarn more than the tram and organzine silks; bourette yarns are coarse, lumpy, uneven threads.

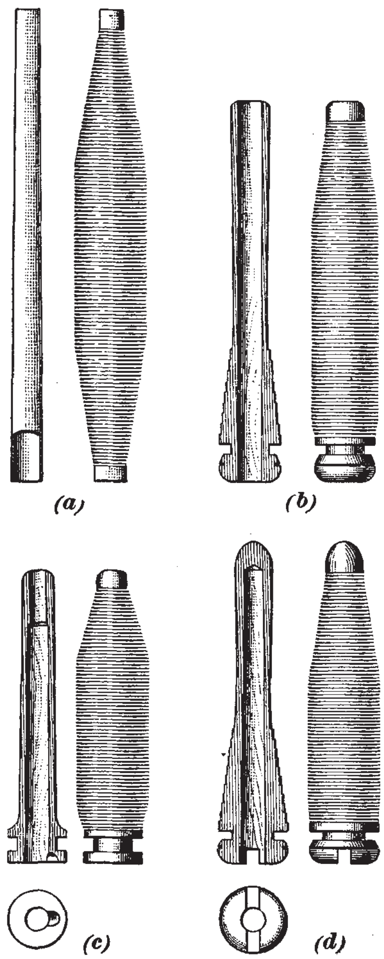


FIG. 12

SILK YARNS CLASSIFIED ACCORDING TO FORMS IN WHICH PUT UP

46. Silk yarns are found in *cops*, *spools*, *skeins*, *quills*, *cones*, *tubes*, and in *warps*.

47. Cops, usually known as **pin cops,** are wound on through paper tubes and are of a small size suitable for the shuttle, as shown in Fig. 12 (*a*).

48. Spools are the usual construction of double-headed bobbins and are used at various processes in the spinning, doubling, or winding of the yarn.

49. Silk **skeins** are formed in the ordinary way, so as to produce a continuous coil of thread.

50. The **quill,** or **filling, bobbin** for silk is small compared with that for other yarns; various kinds are shown in Fig. 12 (*b*), (*c*), and (*d*).

51. Parallel and Conical Tubes.—Silk yarn is sometimes put up in parallel and conical tubes.

52. Warps.—Silk yarn is, of course, made into warps for weaving purposes, but this form is not one in which silk is usually bought and sold, so that in this connection nothing need be said regarding them.

USES OF SILK

53. The uses of silk are chiefly: (1) for weaving, organzine being used as warp and tram as filling; (2) for the making of sewing, embroidery, and other threads that in the silk trade are generally known as twists; and (3) as knitting yarn for high-grade hosiery and underwear.

YARNS FROM MINERAL FIBERS

54. Asbestos yarns are the principal yarns produced from mineral fibers. Asbestos, which is a mineral found in the United States, Canada, Italy, and other countries, consists of a mass of short fibers that are separable into filaments of as great a length as 2 inches. These it is possible to spin into yarn that may be woven into cloth. Asbestos yarn is usually coarse and of a whitish or grayish appearance. It is incombustible, which is its chief value, and for this reason is used for making yarns and fabrics that must stand intense heat.

55. Wire Yarns.—Although hardly a suitable name, the term **wire yarns** is intended to cover very finely drawn wires and ply strands made from wires. The metals chiefly used for this purpose are gold, silver, gold- or silver-plated copper, iron, copper, and brass. The chief use of such metallic wires in the textile industries is in the very finely drawn and rolled gold and silver threads for ornamental purposes, which are usually put up on small spools and commonly called *tinsel;* iron, steel, brass, and copper wire is woven into screens and wire cloth for various purposes.

56. Glass Yarns.—Glass has occasionally been used for thread making. When softened by heat it can be drawn out into very fine threads from which it is possible to make yarns that under certain circumstances can be incorporated with yarns of vegetable or animal fibers. The production of glass yarns, however, is of no commercial importance.

YARNS WITH SPECIAL CHARACTERISTICS

CLASSIFICATION ACCORDING TO TREATMENT AFTER SPINNING AND TWISTING

CONVERTED YARNS

57. There are a number of processes through which single yarns may pass after the spinning: (1) several threads may be combined either as ordinary ply yarn or in some form of novelty yarn, the result of which is a complete change in construction; (2) the yarn, either single or ply, may be operated on so as to change the form in which it was originally put up to a form ready for the market or for some succeeding process, without, however, in any way changing its appearance or construction; (3) the yarn may be passed through one of the various converting processes, thus changing its appearance definitely and decidedly, but leaving its construction unaltered; to be so treated the yarn may be taken in the condition in which it leaves the spinning machine, but more frequently it is converted after having passed through some winding or form-changing process. It is entirely outside the scope of this Section to fully describe any of the various converting processes for yarn, as it is the purpose of this Section to describe only the differences in the threads as they are found to exist; therefore, only a brief definition will be given as to how to distinguish between yarns that have and have not been processed, or between yarns that have gone through different processes.

58. Dyed yarns are those that have passed through processes that impart color to them. They may have passed through only one process, for giving what is known as a one-bath or one-dip color, succeeded, of course, by drying, or they may have passed through several processes, for the purpose of first scouring, washing, or bleaching, then mordanting, and afterwards dyeing and drying. Dyeing is performed on practically every variety of yarn made from vegetable or animal fiber, whether cotton, wool, silk, flax, linen, or jute. Yarns made from mineral fibers are not dyed. The term dyed yarns is a general one that may be made more definite by classifying yarns as *skein-dyed*, *warp-dyed*, *cop-dyed*, *sliver-dyed*, *raw-stock-dyed*, *slub-dyed*, etc., according to the period in the process of manufacture at which the dyeing was done. **Skein-dyed** yarn, sometimes called *hank-dyed*, is yarn that has been skeined before being dyed. **Warp-dyed** yarn, sometimes called *ball-dyed*, or *chain-dyed*, is yarn that has been put up in the form of a warp before being dyed. **Cop-dyed** yarn is yarn that has been dyed in the same form in which it leaves the spinning mule by placing it on perforated tubes and forcing dye liquor through a number of these tubes. **Stock-dyed** yarn, spoken of as *raw-stock-dyed* yarn, or in the case of cotton as *raw-cotton-dyed* yarn, is yarn in which the fiber is dyed in the raw state—in the case of wool, immediately after scouring, and in the case of cotton, immediately after the opening process. **Sliver-dyed** yarn refers to cotton that has been dyed in the form of a card sliver. **Top-dyed,** or **slub-** or **slubbing-dyed,** refers to worsted that has been dyed in the form of a top, or slubbing.

59. Dyed and weighted yarns comprise those that have purposely had their weight increased during the dyeing process; they are usually silk yarns.

60. Bleached Yarns.—Bleaching yarns is a process or combination of processes necessary to give a white, or as nearly as possible a white, appearance to yarns. Bleaching is generally performed on cotton, linen, or other vegetable yarns, while wool, silk, and other animal fibers do not readily lend themselves to any process of producing an absolutely white thread, beyond that of washing or scouring off the foreign substances adhering to their surface, although processes of obtaining a yellowish white in the cloth are not unknown. This is sometimes done in the yarn, in which case it is bleached, usually with sulphurous acid either in a liquid or gaseous form, generally the latter. Woolen and worsted yarns are also bleached when delicate colors are to be dyed. The process is sometimes called *stoving* when woolens are bleached with the sulphurous-acid gas.

Cotton is subjected to various kinds of bleaching processes, known as *quarter bleach*, *half bleach*, *three-quarter bleach*, or *full bleach;* the last, which gives the whitest appearance, is especially applied to Egyptian cottons to remove the brown tint natural to that cotton fiber. In speaking of bleached cotton yarns it is advisable to use the word *bleached* and also state whether quarter, half, three-quarter, or full bleach is meant. The name *white* cotton yarns is not always sufficient to indicate bleached yarns, as white is sometimes applied to cotton to indicate yarns in the natural state spun from white cottons, such as American or sea-island, as distinguished from yarns in a natural state spun from brown cotton, such as Egyptian, Peruvian, and certain kinds of Indian and Central American cottons.

The flax fiber in the form of linen yarn lends itself to bleaching, although it is a more difficult process than that of bleaching cotton yarns. Bleached linen yarns are spoken of when only partially bleached as *half white*, or *cream color;* when bleached to a higher degree, as *three-quarter white;* and when completely bleached, as far as is commercially customary, as *full white.*

61. Scoured Yarns.—In the manufacture of woolen and worsted yarns, raw wool is always subjected to a preliminary scouring, or washing, process to remove the dirt and the natural grease, or yolk, with which the wool is impregnated, but this is separate and distinct from the scouring process as applied to yarns. During the manufacture of the yarns various oils and emulsions are applied to aid in the working of the stock and preserve the fiber from injury. In the case of woolen yarns this oil or emulsion is not removed when the yarns are put on the market for sale; that is, it may be stated that woolen yarns are practically always sold in a greasy condition, or *in the grease*. Worsted, however, is frequently subjected to a scouring, or, as it is called, a *back-washing*, process after carding or combing, for the purpose of removing any artificial impurities that may be in the stock and rendering it as nearly white as possible. This scouring, or back-washing, process is merely a treatment with warm water and soap or other detergents, and is in reality simply a washing process. Worsted yarns are also frequently sold without being back-washed, but in this case they are not nearly so white, and in fact at the best they possess only a yellowish shade.

Certain varieties of silk are scoured, or, as it is termed, *boiled off*, in order to remove the gum found on the raw silk, and in this process they lose from 15 to 30 per cent. of weight. They are spoken of as *stripped*, or *boiled-off*, silks. Milder processes that do not completely strip the fiber but rather tend to bleach both the fiber and the gum attached to it are known as *scouring*.

62. Mercerized Yarn.—Mercerizing is a process applied only to cotton yarns, and consists of a treatment, while under tension, with a solution of caustic soda that gives a silky luster to the thread. These yarns are usually either bleached, dyed, or bleached and then dyed. Unless otherwise stated, mercerized yarns are generally understood to be mercerized in the skein, although it is done in the warp form. This class of yarns is almost always 2-ply, as there is a risk of stretching a single yarn and making it uneven or damaging it in the process of mercerizing. As this process requires that the yarn shall stand considerable strain and yet the effect produced be that of a soft, pliable, elastic yarn resembling silk, it is necessary that the yarn should be strong and yet soft spun. For this purpose very good cottons are used, even for coarse and medium numbers of yarns, Peelers, Egyptian, and sea-island often being the stock selected; thus, although the turns per inch are few in proportion to the counts, a strong yarn is obtained.

63. Printed yarns are those that have been passed through a printing machine, and may be either warp-printed or skein-printed. The effect of the printing process is to impress short dabs or long blotches of color on the threads, the intervals being left white or the original color of the skein or warp. Either one, two, three, or four colors may be imprinted on the yarn, thus giving it a mottled appearance, which is accentuated when the yarn is interwoven with other yarns, and thus produces a speckled effect on the fabric.

It is cotton yarn that is usually used for printing purposes, although any yarns having a moderately smooth surface, such as linen, jute, silk, etc., may be used. Woolen and worsted yarns, owing to the nature of the thread, do not receive such a clear and satisfactory impression of the printing rolls as a comparatively smooth yarn like cotton. Before printing, yarns must be reeled into skeins or made into warps.

64. Glazed and Polished Yarns.—Polished yarns, or, as they are sometimes called, **glazed yarns,** or **glazed and polished yarns,** are those that have been passed through a process of applying a dressing material to the yarn and then brushing it until a high glossy polish is attained. Polishing is chiefly used in giving to sewing thread what is known as a *bright finish.* Polished yarns are often dyed yarns. The polishing process is a mechanical one, which distinguishes it from the method of obtaining a luster on cotton yarns by mercerizing—an entirely different process that depends on chemical action.

65. Gassed, or Genapped, Yarns.—All yarns have, to a greater or less extent, loose ends of fibers projecting from their surface. These are found to the least extent in yarns made by the multidrawing system and to the greatest extent in those that are made by the condensing, or woolen, principle of yarn preparation.

In yarns made from sheep's wool, it is found to the least extent in worsted yarns, and to the greatest extent in the ordinary woolen yarns. In woolen yarns, imitation vigogne yarns, and those of a similar character, the oozy construction and projection of loose ends of fibers is desirable and serves a definite object, but for certain purposes in the combed yarns it is undesirable and creates defects in the fabrics manufactured from them; for instance, in the making of certain kinds of laces and curtains from fine, combed-cotton yarns, the projecting fibers prevent that clear definition and sharp outline of the pattern that is desired. This oozy construction is also a disadvantage in such yarns as harness or heald yarns manufactured from worsted yarns. For this reason some cotton and worsted yarns are treated in a gassing machine, in which each thread is passed through a gas flame very rapidly, thus causing the projecting fibers to be singed off. The passage of the yarn is so rapid that the heat does not destroy or damage the thread. In the case of worsted and other yarns of animal origin, the process is called *genapping*, and gassed worsted yarns are called *genapped* yarns; for other yarns the terms *gassing* and *gassed yarns* are used.

Yarns that have been gassed or genapped are slightly brown, and the ends of the fibers are discolored. This is not detrimental if the yarns have previously been dyed a dark color, but otherwise it is desirable to pass them through some process that removes this defect; for instance, in making lace yarns it is better to gas them before the bleaching process, and in worsted yarns genapping is advantageously followed by a process of scouring or dyeing.

66. Prepared Yarns.—**Preparing** is the name usually applied to a process of coating yarns of vegetable origin with wax or grease, sometimes accompanied by a compressing process.

67. Processed yarns is a vague name given to yarns that have passed through some private or patented process for producing some special effect or change in the yarn. It is generally a modification of mercerizing or polishing.

68. This classification of converted yarns, while by no means complete, comprises the leading processes by which yarns may be changed after spinning or twisting. While these processes cannot be considered as a part of the regular yarn preparation in a textile mill, in many mills they are classed as such.

This list is not intended to include any processes that merely change the form in which the yarn is collected or arranged or that change the structure of the thread itself.

CONDITIONING YARNS

69. Conditioning, or **damping,** yarns is accomplished by various means and for different reasons. Fibrous materials, after being exposed in the various processes to the heated atmosphere of a textile mill, lose a certain percentage of the moisture that they contained in the raw state. Most yarns, if allowed to stand in the open air or in some storehouse where they can come in contact with the atmosphere, will regain a portion of this moisture and return to a normal condition.

For various reasons, however, it is sometimes considered desirable to cause the yarn to absorb an abnormal amount of moisture. If the yarn is produced for sale, this is frequently the result of a desire on the part of the seller to have the yarn weigh as much as possible within reasonable limits, although the precaution must be taken not to damp it to such an extent as would cause it to lose its excess moisture during transportation or would cause mildew, discoloration, or decay. Another reason for damping yarn is to cause the strands or twist put in the thread to become fixed, so that when the yarn is unwound it will not immediately run into snarls, as is sometimes the case with very dry yarns, especially in fine numbers or when excessively twisted in any counts.

Still another reason, if the yarn is for filling, is to enable the picks to be driven closer to one another in beating up in the loom in the case of fabrics that are very heavily picked and in which dry threads of filling would not lie sufficiently close together to enable the necessary number of picks per inch to be inserted; damping also prevents the filling from kinking.

70. This capacity for absorbing moisture, which is known as the *hygroscopic* property, is not so great in the case of cotton as in that of some other materials; cotton will, however, easily absorb 5 per cent. of moisture if removed from the hot spinning rooms of a mill and placed for sufficient time in a cool, moist atmosphere, and, under suitable conditions, can be caused to absorb still more moisture.

The hygroscopic property of woolen and worsted yarns is much greater than that of yarns spun from any other materials. If the yarn is stored in a dry atmosphere it will contain from 5 to 10 per cent. of moisture, but if stored for some time in a damp atmosphere will readily absorb from 10 to 25 per cent. additional moisture. This, of course, produces great variations in the weight of a given amount of yarn and should be an important factor in the purchase or sale of all yarns, although less attention is given to this matter in America than in England and on the continent of Europe, where conditioning houses are established for the express purpose of determining the exact percentage of moisture, not only in yarns but also in raw wools and stock in a partially manufactured condition.

Silk yarns also possess a marked hygroscopic property, but not to so great an extent as woolen and worsted yarns.

71. Conditioned yarn is either damped or steamed. A customary method of conditioning cotton yarn, especially in Europe, is to place it in a suitably constructed basement, the floor of which is absolutely level and made water-tight with clay or concrete. On this water-tight floor porous bricks are laid in rows, with slight spaces between the rows, so as to provide continuous channels along which water may flow. The basement is then flooded to about one-half of the depth of the bricks, fresh water being admitted at one end of the room and an overflow provided at the other. The yarn is placed in baskets and allowed to stand on the bricks for several days.

Another method is to pack the yarn in a frame between moist woolen cloths, a layer of yarn being placed on a cloth and covered with another cloth, and then a second layer of yarn, and so on. In this way, by being allowed to stand overnight, it will absorb almost as much moisture as it would in a week by the first method.

It is usually filling yarn that is steamed. This is accomplished by means of a steam chest, into which is carried a steam pipe having an outlet within. The chest is so constructed that it will contain a number of boxes, which are perforated with holes to admit the steam. The yarn is placed in these boxes and when a sufficient number of the boxes have been placed in the steam chest, the door is tightly closed and steam admitted for several minutes, after which the yarn is removed.

VARIETIES OF REGULAR YARN RESULTING FROM COLORING

SINGLE YARNS

72. Yarns, either single or ply, may be modified in appearance during the spinning or twisting process by the introduction of color, so that they cannot be described as natural yarns in the sense of indicating the natural color of the yarn, nor, in the case of cotton yarns, are the words gray or brown applicable to them, in the sense in which those terms are applied to yarn and cloth made from cotton in the natural color. In single yarns, the varieties generally found are *solids*, *mixes*, *intermittents*, *randoms*, and *mock twists*. In ply yarns, the varieties found are known as *twists*.

73. **Solids** are yarns spun from one color only of fibers that have been dyed in the raw stock or at some early process of yarn preparation; for instance, in the sliver, in the case of cotton, or in the top, in the case of worsted yarns. Another name for solids is *self-color*, or *selfs*, to indicate that they are made from one color. In dyeing the raw material in this way, it is almost impossible to have all fibers dyed exactly alike, but the later processes of yarn manufacture so blend the fibers as to eradicate any irregularity in shade. These yarns are made principally in cotton, and for filling, the object being to spin the yarn in a form ready for the shuttle of the loom, and thus avoid the reeling and back-winding processes that would be necessary if it were dyed in the skein or warp, and the quilling processes necessary if it were dyed in the long chain.

74. **Mixes** are those yarns made by blending fibers of a natural color with dyed fibers of the same material, or by blending two or more colors of dyed fibers. This is done at one of the earlier processes in the manufacture of the yarn, so that the fibers become thoroughly blended, and the effect is a delicately tinted or mottled appearance that cannot be obtained by dyeing the yarn after spinning. Innumerable combinations may be made: such as black and white; brown and white; blue, black, and white; brown and yellow. Light shades are made by using a large proportion of white or natural fibers with a slight proportion of colored, while darker shades are produced by increasing the proportion of the dyed fibers, or using fibers that have been dyed different shades. Various names are given to these yarns, such as *mixes*, or *fancy mixtures;* the English name is *mixture yarns*, and the French name *mélange*. The different shades producible are so numerous that very few of them are named, but they are generally indicated by a shade number. A few shades, however, are so commonly used that trade names have been given to them, although in this case the same name is sometimes found to have a different meaning in different districts, while two or more names are sometimes given to the same yarn.

In cotton yarns, one class of these fancy yarns are those known as *silvers*, which are combinations of black and white in light shades, making a silver gray, and blue and white in light shades, making a silver blue. These silvers are sometimes called *steels*. Another shade in common use is what is known as *Jaeger* in America and Germany, or *natural* in England. It is a light combination of brown and white, sometimes with a few black fibers in it, in imitation of the natural shade of some varieties of sheep wool commonly found in Jaeger garments. *Heather mixes* are other popular shades composed of browns, blacks, and other dark colors combined with purple fibers, sometimes three or four colors being used to make one mix. In woolen and worsted yarns, common mixes are known as *gray* mixes, which are combinations of black and white in various proportions, and *Oxfords*, which are dark grays made with a very small percentage of white, and so on.

Mixes are made in cotton, wool, worsted, mohair, schappe silk, and other materials, and are used principally for woven dress goods and for knitted fabrics, especially underwear. The information given as to the forms in which yarns are put up applies to the various mixture yarns.

75. Random yarns are those that have been skeined and one-half of the skein dyed by dipping it half way into dye liquor and after drying it dyeing the other half another color; or one-third of the skein may be dyed one color, another third of the skein a second color, and the remainder of the skein left a natural color. Many other random effects may be produced in a similar manner.

76. Intermittent yarns are those composed of two or more colors of fibers, usually of white yarn with a slight percentage of colored fiber, this fiber being placed in the yarn in streaks. Where the streaky color occurs, the yarn is very slightly thicker than the other portion of the thread;

but as it has been drawn out after the insertion of the colored streaks, this variation in size has been reduced so as to be hardly discernible. The streaks of color give a distinct mottled effect in the yarn, and also in the cloth or knit goods made therefrom.

The name intermittent yarn is commonly applied to these yarns in Europe, but in America they are sometimes called random yarns. Strictly speaking, they are not random yarns, for the true random yarn is one that is produced on an ordinary single or ply thread by an irregularity in dyeing. Intermittent yarns are found in cotton, woolen, worsted, or mohair. They are sometimes used as filling for weaving, but more frequently for knit goods, especially underwear.

77. Mock-Twist Yarns.—An imitation twist may be made at the spinning machine by putting up two ends of different colored roving and spinning them into one thread. Thus, for example, if a black end and a white end are run together, it will make a black-and-white mock twist. The English name for mock twist is *mock grandrelle.*

PLY YARNS

78. Twists.—In American textile manufacturing the word **twist** applies to a ply yarn composed of two or more differently colored yarns. For example, a single black yarn twisted with a single white yarn will make a black-and-white twist in 2-ply. A brown thread, black thread, and yellow thread will make a brown-black-and-yellow twist in 3-ply. In cases where a subdued tone is desired in a fabric or where a mottled effect is necessary, it is customary to use a twist yarn. For example, by twisting a brilliant color with a dark one, a softer color is produced than by using a solid thread of one bright color. Twists are made in cotton, woolen, worsted, mohair, silk, and other yarns, and sometimes each of the constituent threads of the twist is of a different material. The name *double-and-twist* is often applied to 2-ply twists made in woolen or worsted.

79. It will be noticed that in the manufacture of these solids, mixes, and twists the construction of the yarn itself is just the same as in the case of an ordinary yarn, the different appearance being obtained not by a change in the structure but by the introduction of color.

NOVELTY YARNS

80. A class of yarn that is made in very great variety but in relatively small quantity, even in the aggregate, as compared with ordinary yarns, is that classification known as *novelty yarns* or *fancy yarns*, the latter being the name usually given to them in England. These yarns are made in cotton, wool, worsted, mohair, and silk, but seldom, if ever, in other materials. In some cases, a certain variety of these yarns will be found in all of these materials; others, owing to their construction, can be made in only one or two of the materials that are suitable for use, while many are a combination of two or more fibrous substances.

A **novelty yarn** may be defined as one that differs in construction from an ordinary single or ply yarn. Novelty yarns do not include those that differ in appearance merely on account of their having been passed through a bleaching, dyeing, printing, scouring, mercerizing, polishing, or similar process, for such processes do not change the structure of the thread; yet dyed, bleached, mercerized, or printed yarns are often used as one or more of the constituent threads of a novelty yarn, although this is not sufficient to produce the novelty yarn. There must be some difference in the structure of the resultant thread from the regular type of single or ply yarn common in the material from which the novelty yarn is made. Thus it will be seen that a number of effects in single and ply yarns cannot be considered as novelty yarns, even though the appearance of a thread bears a marked difference from the ordinary yarn; for instance, a mock twist is a single yarn and has the appearance of two spirals forming a thread, and a cotton or woolen mix has a distinct mélange appearance, although the construction of the thread is that of the ordinary type; a twist made of two colored threads twisted together is still an ordinary type of ply yarn so far as its construction is concerned, so that neither ordinary solids, mixes, nor twist yarns can be considered as novelties.

81. The production of novelty yarns varies at different times, depending on current styles or fashions in goods. A certain type of yarn may be in vogue for one or two seasons and then not be much used for several years, another taking its place. Such yarns are principally used for woven goods, and occasionally for knit goods, to produce novel or extraordinary effects. When used for cloth they may form the body of the fabric or may be incorporated only in a very small proportion; for example, when one thread is inserted at intervals throughout the fabric. Novelty yarns are generally made in coarse numbers, owing to the fact that their construction, in most cases, prevents the formation of a fine yarn; for this reason, and also because the threads are in many cases uneven and often composed of two or more materials, the ordinary methods of indicating the counts of yarns are often discarded, and instead the size is indicated by the number of yards in a pound or other given weight.

As there is no uniformity in the naming of novelty yarns, it is not possible to give for each kind one name that is generally applied to it in all branches of the textile trade in America and Europe. Most novelty yarns are of domestic manufacture, although formerly imported, which again leads to confusion in naming them. For this and other reasons, most manufacturers of and dealers in novelty yarns sell them by number instead of by name. It is not intended to describe the manufacture of novelty yarns, as that is outside the scope of this Section; also, owing to the fact that they are made by only a few firms, and often by secret or patented processes, there is very little information available on the subject. It is intended, however, to describe the appearance of the yarns sufficiently for their identification so that the differences between them may be understood.

Novelty yarns may be divided into *single novelty yarns* and *ply novelty yarns*. Among the single novelty yarns are *flake yarns*, *knickerbocker yarns*, *mock knickerbocker twists*, and *crêpe*, or *extra-hard*, *yarns*.

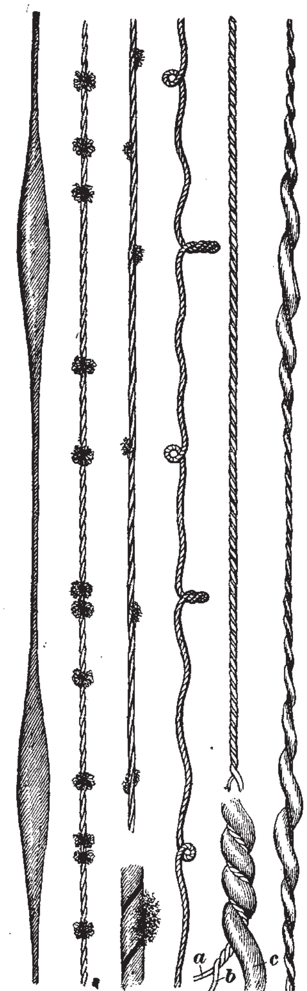


FIG. 13

SINGLE NOVELTY YARNS

82. Single flake yarns, as shown in Fig. 13 (*a*), are uniformly uneven single yarns, in which thick and thin places alternate regularly, the larger portions gradually tapering off to a thin thread, which enlarges again to a thick place. As the twist, given the yarn during the spinning process, has a tendency to affect the thinner places of the yarn more than the thicker ones, a great many more turns to the inch are found in the thin portion of a single flake yarn than in the thick portion.

Single flake yarns can only be made from fibers that are relatively short, of even length, and lend themselves to being drawn with accuracy; thus, the most common flake yarns are those made of cotton or wool, or sometimes a combination of wool and silk. In the true single flake yarn the flakes are evenly spaced throughout the length of the thread; the fibers are parallel to one another, lying in the direction of the length of the thread; and all fibers form a constituent part of the thread.

83. Knickerbocker yarns, or more briefly **knicker yarns,** Fig. 13 (*b*), are single yarns with which are intertwined relatively bulky pieces of the same material that, however, are not so large as to unduly weaken the yarn or prevent its being used for weaving purposes. These extra pieces are spoken of variously as *neps*, *motes*, *specks*, *nubs*, or *knickers*, and the yarn itself is sometimes called *speck yarn*, or *nub yarn*. The English name is *knicker yarn*. Sometimes this yarn is called flake yarn, but it is not a true flake thread, as the excrescences are not evenly spaced and are additions to the ground thread. They can be picked off from the thread and still leave a single yarn. They differ from true flake yarns also in the fact that the knickers are composed of balls of fibers crossed in all directions. Knickerbocker yarns may be made of materials in their natural state, that is, the yarn undyed and the ground thread and the knicker composed of the same material. They are sometimes made with the knicker of one color and the ground thread of another; sometimes they are bleached, dyed, or printed after being spun, so that a large number of styles are produced. The best grades are those that are so constructed as to show knickers at close intervals on as fine a ground thread as possible; these are the grades that more frequently are called nub yarns.

84. Knickerbocker mock twists are shown in Fig. 13 (*c*), the lower part showing a short piece of yarn enlarged. This yarn has the appearance of a twist yarn with the knicker effect showing on one portion of the twist. Each constituent part forms a spiral, with the nubs projecting from one of the spirals at more remote intervals than in the case of ordinary knickers. Knicker mock twists are always made in at least two colors, each spiral being a different color. Another variety of these yarns has knickers on both the spirals, thus giving an opportunity for the use of four colors if desired, that is, one spiral of a certain color carries knickers of another color, while the other spiral is of a third color with the knickers of a fourth color; yet the completed yarn is only a single yarn. Both knickerbocker yarns and knickerbocker mock twists are made in cotton, wool, and silk, or combinations of these materials.

85. Crêpe, or extra-hard, yarns, Fig. 13 (*d*), are single yarns in which an excessive amount of twist has been inserted, the yarn being allowed to contract during the twisting process; this forms numerous snarls, or kinks, thus giving to fabrics woven from it not only a rough appearance but a sharp, prickly sensation to the touch. Such yarns are chiefly made in cotton.

PLY NOVELTY YARNS

86. By using two or more threads in producing a novelty yarn there is a much wider range for the production of novel effects. An opportunity is given in ply yarns of introducing two or more threads of different colors, of different sizes, or of different materials, which in itself provides for endless combinations, more especially when one of the single yarns is not of the ordinary construction. The ordinary types of ply novelty yarns are *corkscrew yarns; bead yarns; gimp yarns; spiral yarns; ply flake yarns; 2-ply flake yarns; slub*, or *bunch, yarns; ply crêpe yarns;* and *twist corkscrew yarns.* The more complicated varieties are *knotted*, or *bourette, yarns; knotted*, or *bourette, twists; loop*, or *bouclé, yarns; diamond twists;* and *tinsel yarns*, as well as combinations of any two or more novelty yarns, or of novelty yarns with ordinary single or ply yarns, the combination being made by twisting them together.

87. Corkscrew Yarns.—The simplest way of making a **corkscrew yarn** is to double a thick and a thin single yarn together, each of the single yarns being twisted in the same direction, and the ply yarn, of course, twisted in the opposite direction. The tendency is for one yarn to be wound around the other yarn in such a way as to produce the corkscrew appearance that gives the name to the yarn. These yarns are made in cotton, worsted, mohair, or almost any material.

88. Bead Yarns.—A more pronounced corkscrew yarn, sometimes called the **bead yarn,** Fig. 13 (*e*), is produced by twisting together a fine 2-ply yarn and a coarse single yarn, usually of the same material. The lower part of (*e*) shows a portion of the yarn enlarged to show its construction more clearly. The two single yarns of the 2-ply yarn and the single coarse yarn are, originally, twisted in one direction, say to the right. The 2-ply yarn is twisted in the opposite direction, say to the left. Thus, the two threads that form the bead yarn are twisted in opposite directions. When these two are twisted together, the ply yarn becomes harder twisted and shortens, while the single yarn has the twist taken out of it and lengthens, thus becoming more open and oozy and giving a more pronounced corkscrew effect, sometimes spoken of as a *bead effect*, or *waved effect*. By a suitable number of twists per inch in the ordinary yarns and in the bead yarns, many different effects can be produced; the final twisting is sometimes carried to such an extent as to actually untwist the single yarn and commence twisting it again in the opposite direction to that of the original twist. This method of producing novelty yarns can be applied to either cotton, worsted, mohair, silk, or combinations of these, and lends itself to the application of color by the selection of different-colored threads.

These bead yarns should not be confused with yarns on which glass beads are threaded or imitation beads placed.

89. Spiral yarns are constructed in the same way as bead yarns, but consist of built-up threads made from several ends of ply yarns, being finally twisted from one fine end and one coarse end. One style of spiral yarn consists of two ends of coarse 2-ply and one end of thick single yarn twisted together; this makes a heavy ply thread, which is then twisted with a thin end of 2-ply yarn, thus producing a heavy, strong, spiral thread. By the use of color, considerable ornament can be applied to these threads. They are made in cotton, worsted, mohair, or combinations of these materials.

Bead and spiral yarns are made in many other combinations of single yarns and ply threads, or combinations of ply threads.

90. Gimp yarns is a name given to bead and spiral yarns.

91. Ply Flake Yarns.—Several varieties of ply flake yarn are made, either by combining: (1) a single flake yarn and an ordinary single, (2) a single flake yarn and an ordinary ply yarn, (3) two single flake yarns, or (4) a ply flake yarn and an ordinary 2-ply yarn. A combination of a single flake yarn and an ordinary ply yarn is shown in Fig. 13 (*f*). The thin thread is a common 2-ply yarn of regular construction throughout its length and is twisted in the opposite direction to the single flake yarn. When the two are twisted together, the ply yarn becomes harder and shorter, while the flake yarn becomes softer and longer, thus giving a pronounced bead effect near the flake. The ply flake yarn made from two single flake yarns is somewhat similar in appearance, but has not the strength of the ply flake yarn made from one single flake and the 2-ply thread. By making a flake yarn in this manner the flake is softer and more pronounced, as compared with the single flake yarn, while the ground thread gives the necessary strength to enable it to be woven. Flake yarns are more commonly made ply than single, and the customary interpretation of the term flake yarn is that of a ply flake yarn.

Ply flake yarns can be made in cotton, wool, silk, and other materials or any combinations of these materials, and of course lend themselves to the use of color in many ways.

92. Two-Ply Flakes.—Two ply flake yarns can be twisted together so that the thick part of one of the flake yarns comes against the thick part of the other flake yarn, thus making a thread with the flake part accentuated and composed of two distinct colors when each of the single flake yarns is of a different color. Such a yarn is shown in Fig. 14 (*a*). The name *cloud yarn* is applied to these various types of ply flake yarns.

93. Bunch Yarns.—Very effective novelty yarns can be made by inserting at regular intervals in the ground threads of ply yarn of one color, *slubs* of the same material but

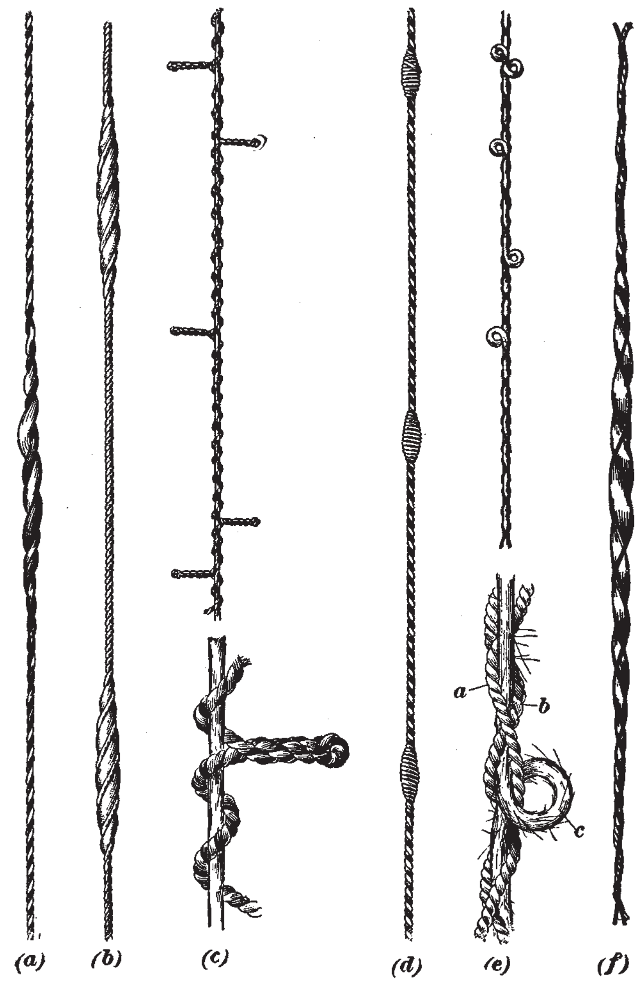


FIG. 14

of another color; **slubs** are small bunches of untwisted or loosely twisted yarn, as shown in Fig. 14 (*b*), which represents a small piece of **bunch, or slub, yarn.** This bears some resemblance to a flake yarn, but when closely examined it will be seen that each slub is absolutely separated from the next slub, being connected by the ply yarn only. More effective forms of slub yarns are produced by using two different colors alternating with each other, for instance, first a red slub, then a black one, next a red one, etc.; or each slub may be of two colors.

Bunch yarns are made with a cotton ground thread and cotton slubs, cotton ground thread and woolen slubs, worsted or mohair ground thread and woolen or silk slubs, and with other materials, while color is very largely introduced in their manufacture. In some branches of the trade and in various districts, bunch yarns are called *slub yarns* or *flake yarns*, while the name *cloud yarns* is also applied to them.

94. **Ply crêpe yarns,** Fig. 14 (*c*), are produced in various ways: (1) by doubling an ordinary single yarn with a single crêpe, or hard-twist yarn; (2) by doubling a ply yarn with a single crêpe yarn; or (3) by first making an extra-hard ply crêpe yarn and doubling this with an ordinary 2-ply yarn. All of these may be of the same or different colors.

95. **Twist Corkscrew Yarns.**—An effective corkscrew yarn is made by using either a mock twist or a real twist for the thick thread of the corkscrew and a one-color thread for the thin one.

96. **Knotted, or bourette, yarns,** Fig. 14 (*d*), comprise one of the most common types of novelty ply yarns and are produced by, and exhibit the effect of, one thread wound around a ground thread a large number of times until a pronounced knot, or button, of thread is formed; then for a certain distance the ordinary construction of a ply-yarn twist is maintained until the next button is reached. These yarns are generally called *knotted*, or *knop*, yarns, although the names *nub yarns* and *bug yarns* are sometimes given to them in America, while when made from worsted and silk or mohair and silk, they are generally called *bourette yarns*. The ground thread is a ply yarn of one color, the knotting thread usually a single yarn of another color, and the ground thread and knotting thread are twisted in opposite directions.

Knotted yarns can be made with the knops, knots, or nubs either closely or widely spaced, but the spacing is even throughout the length of the thread. The knots can be made in two colors, both differing from the color of the ground thread and the knots alternating in color; thus, a red and a white knot can be made to alternate on a black ground, in which case the ply yarn between the knots would be a red-white-and-black twist.

Knotted yarns are sometimes confused with knickerbocker yarns, but there is a considerable difference between them; knickerbocker yarns are always single yarns and knop yarns are always ply yarns. The term *nub yarn* is sometimes applied to a single yarn resembling a knickerbocker yarn but made more carefully and of better quality, so as to imitate a knotted yarn to some extent.

97. Knotted, or Bourette, Twists.—After a knotted yarn has been made, it is quite common to twist it with a yarn similar to the color of the ground thread in the knotted yarn, so as to make what is known as a **knotted twist**, or a **bourette twist**. This strengthens the thread and aids in passing the knot through the harness and reed of the loom in weaving. The word bourette in this connection should not be confused with bourette silk yarn, which is a different variety.

98. Loop yarns, sometimes called **curl yarns** or, when made in mohair or worsted, **bouclé yarns,** consist usually of three threads—two ground threads, which are the shortest, corresponding almost to the length of the completed yarn, and one loop thread, which forms a complete curl at intervals, the ground threads binding the loops. A loop yarn is shown in Fig. 14 (*e*), the ground threads being marked *a* and *b* and the loop thread *c*. The extra length of loop thread forming complete curls, or loops, on the surface of the yarn, makes it one of the most striking varieties of novelty yarns, especially when made of suitable combinations of color.

Loop yarns may be made: (1) with all three threads of one color, (2) with binding threads of one color and the loop of another color, and (3) with each thread of a different color. Loop yarns are most commonly made in mohair and worsted, and to some extent in cotton, but a cotton fiber does not lend itself to the formation of so distinct a loop as does mohair or worsted.

99. Diamond twists are made by using binding threads laid in opposite directions around a ground thread. A diamond twist on a flake ground is shown in Fig. 14 (*f*).

100. Tinsel yarns, sometimes spoken of as **brilliant yarns,** are combinations of an ordinary yarn and flattened metallic wire; the metals used for producing the extremely thin ribbon of metal are gold, silver, copper plated with gold, or copper plated with silver. Tinsel yarns are commonly made of a 2-ply worsted or silk ground thread, around which the tinsel or metallic wire is either closely or loosely twisted. Two of these threads are commonly doubled together. **Tinsel cords** are made on the corkscrew-yarn principle, using a metallic thread as the fine end.

101. Combinations of Novelty Yarns.—The combinations of novelty yarns are usually found in the form of twists, some of the varieties being as follows: (1) knotted twists, in which a knotted yarn is twisted with either an ordinary single or a ply yarn; (2) knot-and-loop twists, in which a knotted yarn is twisted with a loop yarn; and (3) knot-and-twist yarns, in which a knotted yarn is twisted with a common twist. Other combinations are produced by making a loop yarn in which the binding thread is a knickerbocker yarn, or in which the ground thread is a knot yarn. Many other combinations are also used.

102. When it is taken into consideration that any one of the varieties of novelty yarns made may be varied in size, that most of them may be varied in color or combinations of colors by the use of an unlimited number of shades, that in the case of those exhibiting a structure of thread that varies at intervals, the distance between these variations may be changed or the size of the thickened part may be extended in length or in thickness, that combinations may be made of two or more types of novelty yarns or of a plain yarn and a novelty yarn, and that in case of the simpler types they may be printed, dyed, or bleached after being spun, it will be realized that the possibility of producing novelties in yarns is unlimited.

It is said that 15,000 different designs, or styles, of novelty yarn have been made, any one of which is liable to come into use again at any time, according to the prevailing fashions in fabrics. These many different designs result chiefly from difference in coloring and combination of materials, since the number of distinct types of novelty yarns is comparatively small. Novelty yarns as a rule are made of relatively heavy weight—as low as 100 yards to the pound and from this upwards to as high as 3,000 or 4,000 yards to the pound. It is possible, however, to make certain types of novelty yarns in much finer numbers—up to as fine as 15,000 yards to the pound. Many kinds of novelty yarns are used in extremely small quantities, only one thread appearing at intervals in the fabric in some cases. This causes the trade in novelty yarns to be of a retail character, since a few pounds of a certain style is often sufficient for the buyers' requirements.

CLOTH ROOMS

(PART 1)

CLOTH-ROOM PROCESSES AND MACHINERY

INTRODUCTION

1. After cotton cloth has been woven and taken from the loom, it is removed to what is known as the **cloth room,** where it passes through certain processes that are necessary or desirable before it is ready to be shipped from the mill to the dry-goods merchant, converting establishment, exporter, clothing factory, or wherever it is intended to be delivered, according to the use to be made of it or the customary method of distribution to the ultimate purchaser. Such shipping of the cloth may take place through the dry-goods commission merchant or through his order; or it may be done directly by the mill, according to the system of selling the goods that is adopted. A complete list of operations that occur in American cotton-mill cloth rooms is somewhat as follows:

1. *Receiving and checking* the cloth from the weave room, for the purpose of verifying the amount received of each style and checking the weave-room report of cloth produced, is required in order to make certain that all the cloth that has been woven or for which the weavers are paid is received in the cloth room, also in order to keep the management informed as to the amount of cloth being received of each style, so

that progress on various orders can be ascertained and arrangements made for shipping.

2. *Inspecting* is for the purpose of examining the cloth received from the weaver, with a view to detecting faults in the fabric and taking suitable action thereon to prevent a repetition of them, and also for the purpose of sorting out the pieces of cloth into first grade, second grade, and in some cases third grade.

3. *Sewing* is the stitching together of the ends of each two consecutive pieces of cloth that are intended to form a continuous length, in order to facilitate some succeeding treatment and to conduct it with the greatest economy.

4. *Rolling* is the process of winding, in a large roll, the continuous sheet of cloth that has been produced by sewing the ends of separate pieces together.

5. *Brushing* is the process of treating the cloth, on one or both sides, with revolving brushes (usually bristle brushes, but sometimes wire brushes followed by bristle brushes), for the purpose of removing loose threads, loose fibers, dust, pieces of leaf, stalk, or other foreign matter, and also imparting a smooth clean surface to the fabric and laying the projecting fibers in one direction.

6. *Scraping and beating* is performed on coarse and heavy fabrics for the purpose of rubbing and striking from the cloth small projecting particles of a fibrous nature (such as knots, lumps, and nubs) that are produced in the processes of manufacture, or those of a foreign nature (such as motes, leaf, and stalk) that come with the raw cotton; these are difficult to remove by means of a mere brushing action.

7. *Shearing* is the operation of cutting from the face, or sometimes from both the face and the back of the fabric, projecting threads and fibers, the presence of which is undesirable in most fabrics.

8. *Calendering* is a compressing and smoothing action produced by passing the fabric between heavy hot or cold rolls to impart a smooth surface to the cloth.

9. *Folding* is the process of arranging the cloth in superimposed layers, each of the same length, so as to provide a

suitable form in which the fabric may be baled for shipment and offered for sale in dry-goods stores, as well as to give a ready means of ascertaining the length in each piece from the number of folds obtained.

10. *Stamping* is the operation of impressing on the outside of a folded piece of cloth such marks as may be required or desired, as for example, the name of the mill, the name of the fabric, the number of yards in the piece, and (especially for export) the trade mark of the manufacturer.

11. *Ticketing* is the operation of attaching to the folded piece of cloth some printed ticket, frequently highly colored or strikingly designed, which may contain the name of the mill, the name of the fabric, the trade mark, the length or width of the goods, and such other features of a like nature as are desirable. Sometimes this is done by means of paper bands passed around the piece of folded cloth and pasted in position; this may be adopted instead of, or in addition to, stamping and ticketing.

12. *Baling* is the packing of a number of pieces of cloth within a covering of burlap, or other material, suitably secured by ropes or iron or steel bands, to prevent the cloth becoming soiled or damaged in transit, and to facilitate transportation by reducing the bulk.

2. In this list only those processess that are usually found in the cloth rooms of American mills are defined. No mention is made of such processes as singeing, bleaching, tinting, starching, tentering, mordanting, dyeing, printing, filling, mercerizing, or associated processes that are necessary in the case of some fabrics to prepare them for the market. Though in a few cases one or more of these processes are conducted in the same establishment as that in which the goods are woven, yet this is the exception rather than the rule, and consequently all such processes are ignored here, since they more properly belong to the operation of a converting, or as it is sometimes called a finishing, establishment.

The expression *finishing* is sometimes applied to the processes that peculiarly belong to the cloth room of a mill, but it should not be used in this connection, since it is misleading, although there is a precedent for such a use of the term in connection with other industries, as for example in the knitting-goods industry, where finishing means the making up of the knitted fabrics in suitable form for the market, and in the woolen-and-worsted-cloth industry, where the finishing department includes some processes corresponding to those performed in a cotton-cloth room, together with such additional processes as are necessary to prepare the fabric for the market. However, in the cotton trade, it is becoming more and more common for all purely converting processes, which change the appearance of the fabric, to be conducted in a separate establishment, known separately as a bleachery, dye works, print works, or collectively as converting, or finishing, works.

The cloth-room processes listed here have as their object merely the changing of the form of the fabric from that in which it leaves the loom to a suitable one for shipment, and a slight or superficial cleaning of the cloth to make it presentable to the buyer, together with the necessary inspection and baling.

It is in comparatively few cloth rooms that all the processes listed are conducted, since but very few of them are absolutely necessary. The adoption of some or all of the processes depends on: (1) the fabrics that are to be treated; (2) the differences of opinion among millmen as to what is a suitable treatment even for the same fabric, and (3) the policy of the management either in the direction of avoiding all unnecessary processes, for the sake of economy, or of incurring additional expense in the equipment of the mill and in the operation of the cloth room, for the sake of producing the best quality.

3. The equipment and the operation of the cloth room cannot receive too much attention; in too many mills it is given but little consideration. In the designing or the equipment of the mill, very frequently any available space is utilized for the cloth room, while after the mill is in operation, so long as the goods are inspected and baled, and the room is operated at a minimum expense, it receives no further attention. As a matter of fact, the proper equipment and operation of the cloth room is of vital importance to the successful running of the mill. The construction and location of the cloth room should be of the best, its equipment the most suitable for the fabrics being manufactured, and the arrangement of the machinery such as will enable the cloth to be treated with the least amount of handling and the greatest economy. The machines used should be so selected, set, and operated as to effect an improvement in the cloth between its leaving the loom and being packed into bales, that will far more than compensate for the comparatively small expense per yard involved. This will increase the reputation of the mill for producing well-made, well-classified, and well-finished fabrics, and will result ultimately in increased prices or preference when orders are being placed. Careful and constant attention to this department cannot fail to result in creating in the mind of the wholesale or retail buyer, the commission agent or the converter, those favorable first impressions of the goods that are so desirable, and in preventing the unfavorable impressions that must be produced by badly finished, badly inspected fabrics, made up untidily or irregularly, either in the piece or the bale.

4. In case a mill is sufficiently large to justify the expense, a cloth room should be located independently of the main building, preferably immediately between the weave room and the storehouse for baled goods and on the same level as these. It should be connected both with the weave room and with the storehouse by passages and should be of fireproof construction.

Where the weave room, the cloth room, and the passage between are all on one level, or approximately so, the cloth may be conveyed directly from the former room to the latter by means of trucks running on rails. When the weave room is situated above the cloth room, the cloth may be dropped into the cloth room by means of inclined chutes, while in case the cloth room is at a higher elevation than the weave room, some mills adopt an endless belt, usually of rubber, that travels at a slow speed and has lags attached at short intervals, to carry the cuts of cloth up to the cloth room. In the case of the storehouse, it is important that the floor should be of such a height above the ground as to afford facilities for loading the bales of goods into railroad cars or on to trucks without raising them, and for this reason it is not always advisable to have the storeroom floor on the same level as the cloth room; but there should not be sufficient difference in the heights of the floors to prevent the bales being trucked from the cloth room to the storeroom on an incline.

One of the most important functions of a cloth room is the inspection of all the cloth manufactured by the mill, so as to ascertain imperfections that necessitate the classification of any pieces as *seconds*. In order that the persons inspecting the cloth may perform their work to the best advantage, the light should be of the best and should come from the best possible direction. It is desirable that this light should come from the roof; a good type is a saw-tooth roof taking the light from the north side, or if this is impracticable, a monitor roof is desirable. In case it is impossible to have either, the cloth room should be so located as to enable the light to be taken from the north side, where the inspection tables should be placed. The artificial light supplied should also be ample and suitable for use when daylight is not available.

The cloth room should be suitably constructed to reduce the risk of fire to a minimum, should be provided with fire-prevention apparatus, be well ventilated, and suitably heated. As many of the machines required are of heavy construction and others have intermittent motions that produce considerable vibration, the floor of the room should be of heavy construction. There should also be below it a well ventilated space, such as a low story or a basement, to provide against dampness in the floor. If this is impossible, the cloth room should be provided with a sufficient number of slatted platforms on which cloth can be stored above the level of the floor. These platforms are divided by vertical slatted partitions into bins for the storage of different styles of cloth, after they have been folded and examined, until a sufficient number of cuts is collected to form a bale.

The arrangement of the machinery in the cloth room should be such as to reduce to a minimum the distances between the points where the cloth must be handled, always bearing in mind the necessity for adequate light at those tables or machines where inspection takes place.

Cloth rooms should be kept as clean as possible. If the condition of the room, as regards cleanliness, is not carefully considered and if dust and dirt are allowed to collect, it is evident that the objects of a large part of the work will be defeated by a simple matter that could be easily remedied by a little extra care and attention to details. For the purpose of keeping the cloth free from dust and dirt, the dust should be removed from the machines by means of a system of ducts and strong blowers or fans connected to the different machines.

CLOTH CHECKING

5. During the process of weaving, the cloth is wound around a roll on the loom until a certain length has been obtained, when it is severed from selvage to selvage and the roll on which it is wound taken out, leaving the cloth in a compactly rolled condition, in which form it is taken to the cloth room. What is known as a **cut** of cotton cloth is that length into which the cloth is finally cut and delivered to the dry-goods store or other ultimate purchaser. The length of a cut is usually about 50 yards, and the completion of each cut is indicated by means of a cut mark placed on the warp. Although the cloth is sometimes removed from the loom when a cut has been completed, it is more common to continue weaving until two cuts have been made; this is known as a *double cut*. In some cases, three, four, or more cuts are woven before the cloth is removed from the loom. The rolls of cloth are usually collected by an operative detailed for that purpose, piled on a truck, and taken to the cloth room.

Cuts are also often spoken of as *pieces;* for example, it is occasionally found that the daily report of the weave room refers to so many pieces having been delivered to the cloth room. While the use of the word piece in this connection is to some extent justified by custom, it will not be used in this sense here; a piece will be considered as any continuous length of fabric without a seam, and the word *cut* will be used where the length of cloth between the cut marks is meant. The word *bolt* is also sometimes used to indicate a cut of cloth; for example, a bolt of gingham. The term *style* is used to describe a certain kind of cloth as determined by the weave, the weight per yard, the yarns, or any distinctive features in construction.

6. Different mills adopt different times for sending the cloth from the weave room to the cloth room, since this of course depends to a great extent on the size of the mill and the number of looms in operation; but it is always best to have a definite time set for this work, as by this means the operators in both rooms who have this in charge can arrange their other work to the best advantage. In the weave room, a record is kept of the number of cuts woven during each day, and if the room is running on more than one style of goods, the different styles are also designated, together with the number of pieces of each style woven. A duplicate of this report is sent to the cloth room, and the first duty of the overseer or second hand of this room when handling any newly arrived lot of cloth is to see that the weave-room report is carefully checked by means of the cloth received. This assures the discovery of any error that may have been made when booking the cloth in the weave room, and also makes it reasonably certain that no piece has been lost while the cloth has been passing from one room to the other. In some mills, it is customary for the list to be sent from the weave room in duplicate and one copy returned to the boss weaver by the overseer of the cloth room, either marked correct or with any discrepancy between the amount called for by the list and that received in the cloth room indicated. This gives the boss weaver an opportunity of having the error rectified immediately. As different styles of goods are handled differently in the cloth room, and as a favorable opportunity is given, when checking the cloth received, for placing all the pieces that are to be handled alike in a pile by themselves, this should be done then, after which they can readily be taken to the different machines through which they are to pass. It is important that these piles of cloth from the weave room should not be allowed to accumulate, but should be opened, handled, and examined within a reasonable time after they arrive in the cloth room, for they may contain faults that should be discovered and reported to the boss weaver as soon as possible, especially in cases where the faults are those caused by defects in the loom, which should be remedied promptly to prevent the weaving of more cloth that will contain the same fault.

SEWING AND ROLLING

SEWING-AND-ROLLING MACHINES

7. It is more convenient and economical at some of the machines used in a cloth room to handle the cloth in a long continuous sheet, rather than in separate pieces. In some of these machines the cloth follows a path over and under certain brushes, rolls, shears, etc., through which it is difficult to thread the piece of cloth, and if this threading had to take place each time that a cut was run through, much time would be wasted and the production of the machine greatly reduced. Even in machines where the threading of the new piece through the machine would not occupy much time, the frequent stoppages at the ends of the cuts would reduce the production and increase the labor cost. If cuts of cloth 50 yards in length were passed through any of these machines one at a time, the greater part of the attendant's time would be devoted to stopping the machine after one cut had run through and getting it ready to run another one. It is to avoid this loss of time that it has become customary to stitch the ends of consecutive pieces together and wind a number of them into one large roll, since by this means a much larger number of yards can be run at one time, without having to stop in order to start a new piece. As many of the later machines employed in a cloth room have a capacity of between 25,000 and 35,000 yards of cloth per day, if operated continuously, and as these machines are somewhat expensive to install, it is desirable to have as great a length as possible pass through each machine per day. It is also desirable to avoid any imperfect method of connecting the ends of cloth at the machine in question, which might result in damage to the machine or cloth or both. The sewing machine, therefore, has been introduced, and is widely used in cloth rooms for the purpose of neatly connecting the ends of pieces of cloth by means of a straight row of stitches extending from one side to the other, usually of the style known as a *continuous chain stitch*, and so arranged that the thread may be easily removed after it has served its purpose.

As the ends of the pieces are sewed together, some means must be provided for disposing of the cuts after they are attached to one another; this is generally done by winding them on a roll until a continuous length of as much as 1,000 yards or even more is obtained. The roll is then removed to the next machine through which the cloth is to pass, or in some cases is shipped in the roll to the bleachery or other converting establishment.

8. The two processes of sewing and rolling are generally performed in one machine, which is therefore called a **sewing-and-rolling machine.** Sometimes it is called the *opening-winding-and-sewing machine*, from the fact of its opening the small rolls of cloth that are taken from the loom and rewinding them into larger rolls, as well as sewing the ends together. The construction of the machine is such that after a piece of cloth is wound on the roll, the winding arrangement is stopped until the end of a second piece is sewed to the end of the first piece, after which the sewing mechanism is stopped and the winding arrangement started

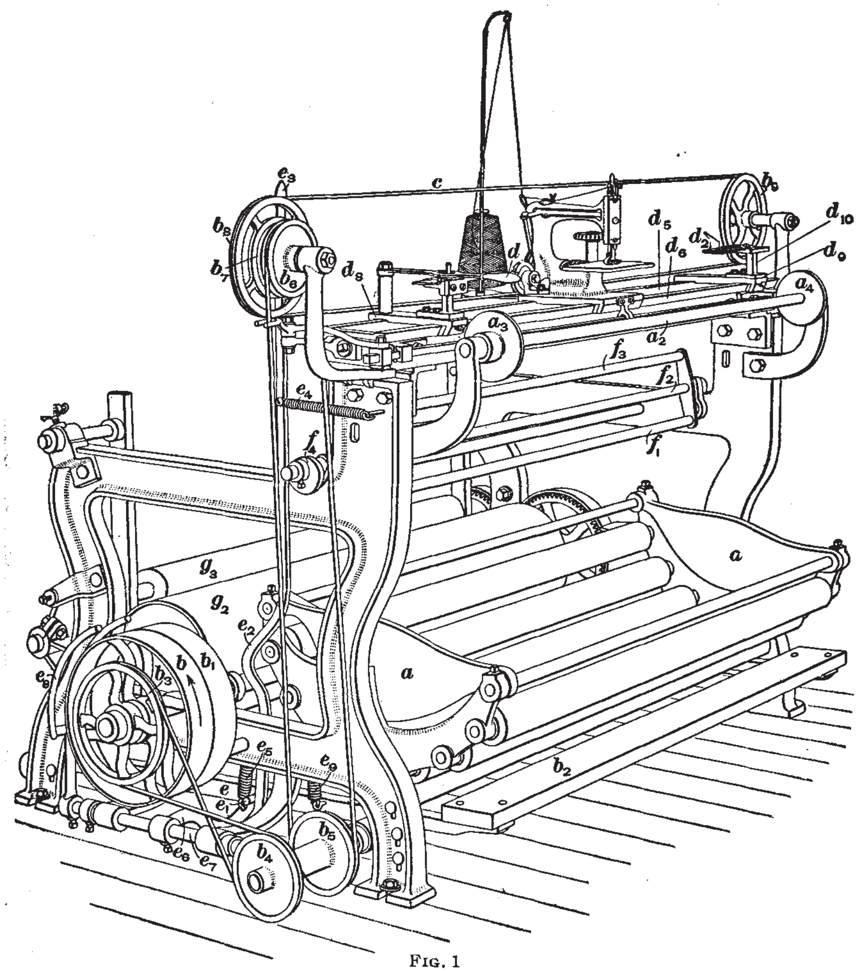


FIG. 1

and continued in action until the second piece is wound on the roll; winding is then discontinued and stitching repeated so as to attach a third piece of cloth to the end of the second, and so on. From the fact that the cloth is held stationary during stitching, the ends being attached to and distended between steel pins, while the sewing machine travels along a track and inserts the thread that forms the chain stitch, this style of sewing machine is spoken of as the *railway sewing machine*. The seam should occur as near the edge of the piece of cloth as is possible, in order to reduce to a minimum the amount of waste cloth and the extra thickness where the joining occurs; this is desirable so as to offer as little obstruction as possible in passing through succeeding machines. The seam should not be so near the edge, however, that there will be danger of the cloth raveling. From 1 to 2 inches is usually left between the edge of the cloth and the seam, although this distance may be increased.

The sewing-and-rolling machine is almost always used in a cotton cloth room where the cloth has to be brushed, sheared, or calendered afterwards. The cloth passes to the sewing-and-rolling machine immediately after being checked, while still in the roll in which it left the loom, consisting of one, two, or more cuts, all in one piece.

9. Rolling Mechanism.—A view of a sewing-and-rolling machine is shown in Fig. 1, while a cross-section through the machine is shown in Fig. 2. The cuts of cloth are placed, one at a time, in the cradle a at the front of the machine and the end passed through until it reaches the back of the machine, where it is wound on a wooden roll g_3. The bottom of the cradle consists of wooden rolls, which revolve easily and facilitate the unrolling of the cloth. A cut of cloth is shown at a_1, Fig. 2, and the path that it follows indicated by the full lines. From the cradle, the cloth passes upwards and over the rod a_2, thence over f_1, under f_2, over f_3, under the cylinder g_2, and thence to the roll g_3. In addition to the cylinder g_2, another cylinder g_4 is in contact with the cloth that is being wound on the roll g_3. Both these cylinders are covered with sandpaper so as to provide them with a rough surface and enable them to grip the cloth sufficiently to draw it from the cradle a through the machine. The rods a_2, f_1, f_2, f_3 not only guide the cloth, but assist in straightening it out and producing a certain amount of drag to keep it tightly stretched.

The rods f_1, f_2, f_3 also form part of an automatic stop-motion to stop the machine when each piece of cloth has been run through and a new stitching operation is necessary. The cam f_4, Fig. 1, is on the end of shaft f_2, on which the

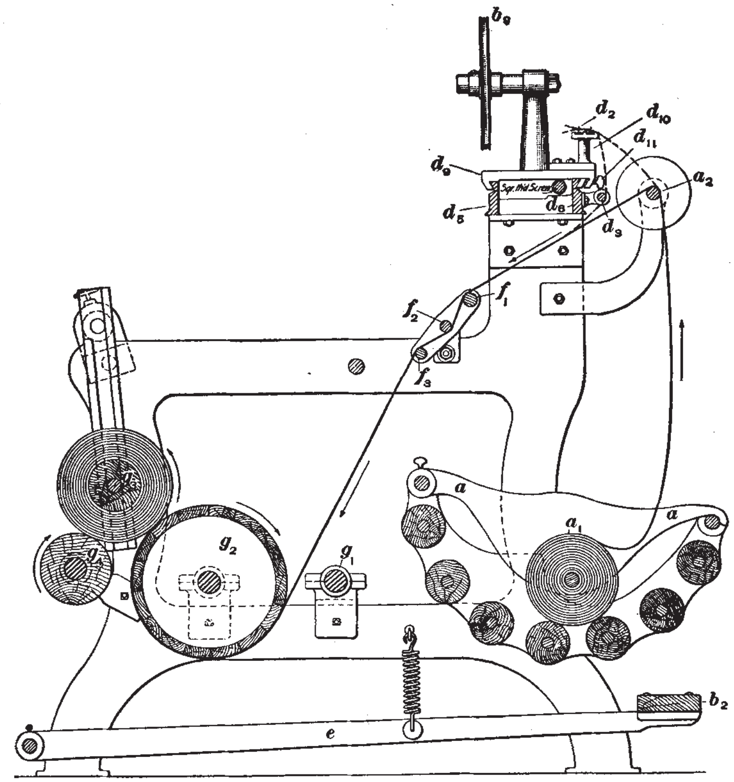


Fig. 2

tension bars f_1, f_3 are held by arms. This shaft rotates freely in its bearings. The tension rods are weighted on one side so that f_1 is heavier than f_3. Their natural position, which is assumed when there is no tension on the cloth passing through the machine and the last end of the piece is slack, is shown in Fig. 1, where f_1 is at the bottom. The position of the rods when the cloth is passing through the machine and is subject to tension is shown in Fig. 2, where f_1 has been moved upwards to the right and f_3 depressed to the left. This position is maintained until the *tail-end* of the piece approaches and the tension on the cloth slackens, which allows the rod f_1 to return, thus throwing the cam f_4 on the shaft f_2 against the stop-lever e_2 and, as the latter is moved by the cam, shipping the driving belt from the tight pulley b_1 to the loose pulley b. At the same time a brake is applied to a brake pulley, on the shaft g_1, Fig. 2, and the winding mechanism is stopped. The brake and brake pulley are not shown in the views given, but are situated behind the pulley b_1, Fig. 1. In practice, this device is frequently disconnected, since the operator is generally in constant attendance on the machine and stops the rolling mechanism by means of the stop-lever or the foot-lever b_2 at the bottom.

During the time that the cloth is being wound on the roll g_3 at the back of the machine, the cylinders g_2, g_4 receive their motion from a gear on the end of the shaft that carries the tight and loose pulleys b_1, b, Fig. 1, the belt being on the tight pulley during this operation. The belt is shifted from the loose pulley b to the tight pulley b_1 by the shipper fork e_8, which is controlled by a shaft e_7 to which is setscrewed an arm e_6, the other end of which is under an arm e controlled by the foot-lever b_2. The inner end of e_6 is drawn up against the arm e by means of a spring e_5. When it is desired to ship the belt from the loose pulley b to the tight pulley b_1, the operator presses down the foot-lever b_2, which lowers the arm e together with the inner end of the arm e_6, turns the shaft e_7, and throws the shipper fork e_8 in toward the machine, thus moving the belt from the loose pulley b to the tight pulley b_1. The arm e carries a projecting pin e_1 that, when the foot-lever b_2 is pressed down, engages with a notch in the lever e_2 and thus holds the belt on the tight pulley.

In case it is desired to ship the belt from the tight to the loose pulley other than by the automatic device described, the handle e_3 on the lever e_2 is pushed toward the back of the machine, which withdraws the lower end of the lever e_2 from above the pin e_1 and allows the spring e_9 to draw up the arm e, thus raising the foot-lever b_2. This allows the arm e_6 to be drawn up at the same time by the spring e_5 that tends to keep the inner end of e_6 pressed up against e. The lifting of the arm e_6 gives sufficient movement to the shaft e_7 to throw the belt from the tight to the loose pulley. The grooved pulley b_3 is attached to the loose pulley b and connected by a band to the pulley b_4, which is on the same sleeve as b_5, which is connected by a band to the grooved pulley b_6. Thus, when the driving belt is on the loose pulley b, the pulley b_5 imparts motion to the pulley b_6.

10. Stitching Mechanism.—When the cut of cloth that is placed in the cradle a has been entirely unwound, the end is attached to the pins d_1, Fig. 3, d_2, Fig. 1, at the ends of the machine; a new cut is then placed in the cradle a and the end of this cut also fastened to the pins d_1, d_2. The position of the two ends that are to be stitched together is shown by the dotted lines in Fig. 2.

Preparatory to stitching the two ends of cloth together, the cloth is stretched by means of the handle d, Figs. 1 and 3. A pin passes through the rod to which this handle is attached and is connected to the slide on which the pins d_1 are secured. After the cloth has been attached to the pins, the handle d is moved to the left until the arm rests in the notch shown, where it is secured until the stitching operation is completed, when it is raised out of the notch and moved to the right, in order thus to release the cloth. This stretches the cloth while it is being stitched, so that no wrinkles will be formed and also so that when released the cloth will not be narrower at the seam than elsewhere.

11. The action of the sewing mechanism is shown in Fig. 3. Just before the stitching action takes place, the driving belt is on the loose pulley and is imparting motion to the pulley b_6 by means of the pulleys b_3, b_4, b_5, as shown in Fig. 1. When the ends of the cuts have been placed on the pins and are in a suitable position to be stitched, the rod d_3, Fig. 3, is moved to the left, which throws the leather band from the

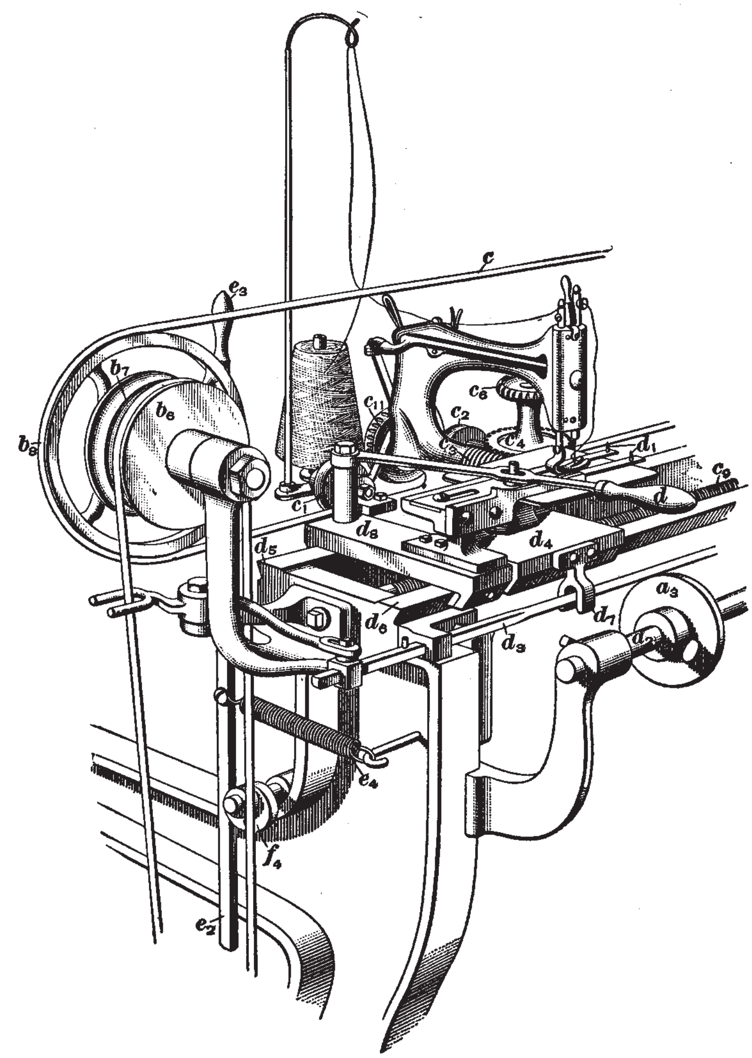


FIG. 3

loose pulley b_6 to the tight pulley b_7 and imparts motion to the pulley b_8 and the band c. This band passes around the two binder pulleys c_1, c_2 and a pulley c_{11} on the sewing-machine head, and by this means starts the stitching mechanism in operation.

At the same time, the sewing-machine head travels from one side of the machine to the other. The mechanism that accomplishes this part of the operation is as follows: The

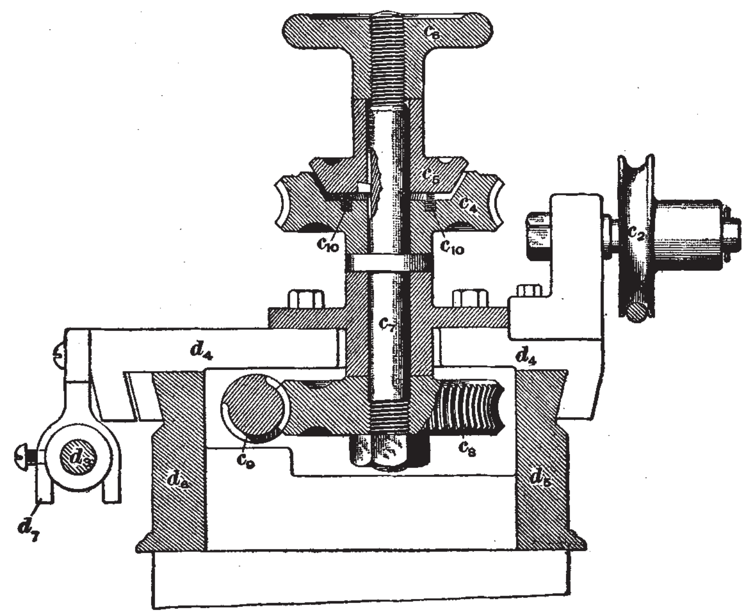


FIG. 4

pulley c_{11}, Fig. 3, that is attached to the sewing-machine head imparts motion to the worm c_3, which drives the worm-gear c_4. The worm-gear c_4, Fig. 4, forms a friction clutch with the casting c_5, which carries a key projecting into a keyway in the shaft c_7. At the upper end of this shaft is a thread on which is a hand wheel c_6, while at its lower end is a gear c_8, the teeth of which work in a stationary screw c_9. Before starting the stitching mechanism the hand wheel c_6 is screwed down, which forces the casting c_5 into contact with the worm-gear c_4; consequently, as the worm c_3, Fig. 3, imparts motion to the worm-gear c_4, Fig. 4, the shaft c_7 is rotated, thus giving motion to the gear c_8. Since the screw c_9 is stationary, the gear c_8, as it revolves, must necessarily receive a horizontal motion. It is by this means that the sewing-machine head is moved automatically from one side of the machine to the other during the stitching operation.

The plate d_4 on which the sewing-machine head rests, slides on the supports d_5, d_6 and carries a projection d_7, shown in Figs. 3 and 4, which, when the head has traveled the full width of the cloth, comes in contact with a casting setscrewed to the rod d_3; this moves the rod d_3 to the right and shifts the band from the tight pulley b_7 to the loose pulley b_6, thus stopping automatically the stitching mechanism when the seam has been completed. To move the stitching mechanism back to its original position the hand wheel c_6, Fig. 4, is unscrewed, which allows the springs c_{10} to force the casting c_5 out of contact with the worm-gear c_4 and breaks the connection between this gear and the shaft c_7. When the parts are in this position, the plate d_4, Fig. 3, together with the different parts of its supports, may be moved by hand to any desired position.

12. After the two ends have been stitched, they are removed from the pins d_1, d_2 and are allowed to fall between the rods a_2, d_3, Fig. 2. The rolling mechanism is then set in operation by pressing down the foot-lever b_2, when the second cut of cloth is unrolled and rewound on the roll at the back of the machine. This operation is repeated with a sufficient number of cuts to form one large roll, which should be made large enough to facilitate the operation at the future machines, but not so large that it cannot be readily handled. Rolls are ordinarily made from 28 inches to 32 inches in diameter and contain from 800 yards to 1,200 yards of cloth.

13. The plate d_8, Fig. 3, to which the supports for the handle d, and the pins d_1 are attached, is setscrewed to the supports d_5, d_6, and does not move during the stitching operation.

The plate d_8 is not attached to the plate d_4, although in Fig. 3 the latter is shown close to the former, as the sewing machine is there represented in its initial, or starting, position with the presser foot ready to pass between the pins d_1 as the plate d_4 and sewing machine start on their movement to the right. On the other side of the machine is a corresponding plate d_9, Figs. 1 and 2, carrying a pillar d_{10} supporting the pins d_2. The plate d_9 is capable of sliding on the supports d_5, d_6, but does not move during the stitching operation, being secured to the supports by means of a thumbscrew d_{11}, Fig. 2.

The guide plates a_3, a_4 shown attached to the rod a_2 in Fig. 1, are secured to the rod by thumbscrews in such a position that they serve to guide the cloth correctly while it is being wound on the roll at the back of the machine, and also in suitable relative position to the pins d_1, d_2. It is not customary to change the positions of the plate d_8, the pins d_1, and plate a_3 except in extreme cases. When it is desired to make adjustments for different widths of cloth, the thumbscrew d_{11}, Fig. 2, is loosened and the plate d_9 moved inwards or outwards to bring the pins d_2 into the desired position, after which the thumbscrew is again secured. At the same time the guide plate a_4 attached to the rod a_2, Fig. 1, is adjusted.

14. The sewing-and-rolling machine that has been described occupies a floor space of about 7 feet by 4 feet. The driving pulleys are 12 inches by $2\frac{1}{2}$ inches, and are usually operated at a speed of 320 revolutions per minute. When operated at its full capacity, it can sew and wind in a day from 500 to 600 cuts, averaging 50 yards in length.

15. In some cloth rooms, the sewing machine is independent of the rolling attachment. In case a stationary machine is desired, that portion of the machine shown in the upper part of Fig. 1 is mounted on high stands resting on the floor and is driven by hand or by power as desired. Another arrangement when the sewing attachment is required to be used in connection with some machine, other than a rolling machine, is to secure the upper portion of the mechanism shown in Fig. 1 to short stands suitable for attachment to any machine desired.

PORTABLE SEWING MACHINES

16. In many cases, it is necessary to stitch the ends of two pieces of cloth together in some part of the cloth room where it is more convenient to take the sewing machine to the cloth than to bring the cloth to the machine. This is the case when the stitches that bind the ends of two pieces together in a large roll have been broken or cut, through some cause, and a part at least of the two ends separated. It would be undesirable to run the entire roll of cloth through the sewing-and-rolling machine simply for the purpose of putting in these few stitches, and, in fact, in many cases it would not be possible, as the defective stitches are often not discovered until the cloth is being run through another machine.

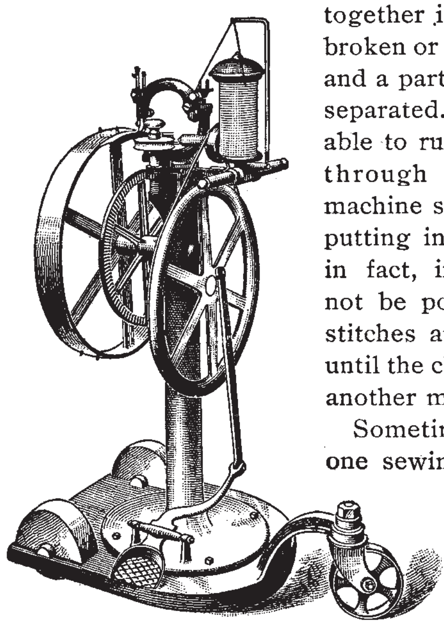


Fig. 5

Sometimes it is desirable to have one sewing machine available for use with several other machines; for example, when the cloth from a large roll has been run through a later machine and it is desired to attach the end of a new roll to the tail-end of the one that has been run through. In such cases, a portable foot-power sewing machine, shown in Fig. 5, is used. This machine rests on wheels and consequently can be moved readily from one part of the room to another, as may be desired. In operation the ends of the two pieces of cloth that are to be sewn together are attached by pins to a slowly rotating wheel. As the machine is operated by means of the treadle, this wheel feeds the cloth under the presser foot of the sewing attachment where the stitching is inserted. In other cases where the amount of available floor space is limited, the sewing machine is suspended from the ceiling of the room, and in still other cases where one sewing machine is required at various points in the room, the sewing mechanism is suspended from a track attached to the ceiling, so that it may be moved to different points in the room where it is required. In such cases, of course, the sewing is performed by hand power.

ROLLING MACHINES AND HAND SEWING

17. Many times, especially in the older cotton mills, machines are used for the same purpose as the sewing-and-rolling machine described, but constructed and operated without the sewing attachment. In general construction, they are similar to the machine shown in Fig. 1, although for special fabrics, such as those exceptionally wide and heavy, different styles of construction are adopted. The mechanism of the machine requires no description beyond that already given. With these machines, the ends of consecutive pieces of cloth are sewed together by hand, the operator using for this purpose a long, heavy needle with thin twine knotted at one end and longer than the width of the fabric. The tail-end of each piece is placed against the new end from another piece and the needle passed alternately through the cloth from one side to the other at intervals of about 2 inches. The knotted end of the twine remains at one edge of the cloth, while the operator ties another knot at the other edge after the thread has been passed through the cloth, so as to prevent its being drawn out in passing on to the roll or through a succeeding machine. This system is largely used in cloth rooms where consecutive pieces of cloth are sewed together temporarily, since it occupies less time and the thread can be easily drawn out later, but is not as satisfactory as machine sewing.

BRUSHING AND SHEARING

SHEARING-AND-BRUSHING MACHINES

18. Cotton cloth as it leaves the loom has loose threads lying on its surfaces, both face and back, and carries more or less dust and particles of foreign matter that have dropped on it during the process of weaving, or have been introduced with the yarn of which it is composed. It is desirable that these be brushed off. Ends of yarn also project from the cloth in places, and there is a fibrous cover to the fabric that is not uniformly even nor laid in one direction. In the case of certain cloths, it is desirable that these projecting fibers or threads be sheared off close to the surface of the fabric, after which a final brushing is given to improve the surface and lay the fibers in one direction. The shearing is especially desirable in those cloths where the pattern should show up prominently, and in ginghams and such fabrics, where it is desired to have the colors appear bright and lustrous. The operations of brushing and shearing are performed in a **shearing-and-brushing machine,** such as is shown in Fig. 6; Fig. 7 is a sectional view of the same machine.

In operation, the roll of cloth g, as it comes from the sewing-and-rolling machine, is placed in stands g_1 at the back of the machine. The cloth is then threaded through a slotted bar g_2 in an iron guide frame and partly around a number of rods g_3 before being passed under the roll g_4 on the machine. The object of passing the cloth around the rods g_3 is to remove wrinkles and straighten out turned selvages; also, to secure a uniform tension; it may be passed around these rods in any desired manner, according to the amount of tension desired. After being passed under the roll g_4 on the machine, the cloth passes partly around two additional tension rods g_5, g_6 that are adjustable, then over the bar g_7 and into the machine. The bar g_7 is constructed, as shown in Fig. 8 (d), in such a manner that the cloth, in passing over

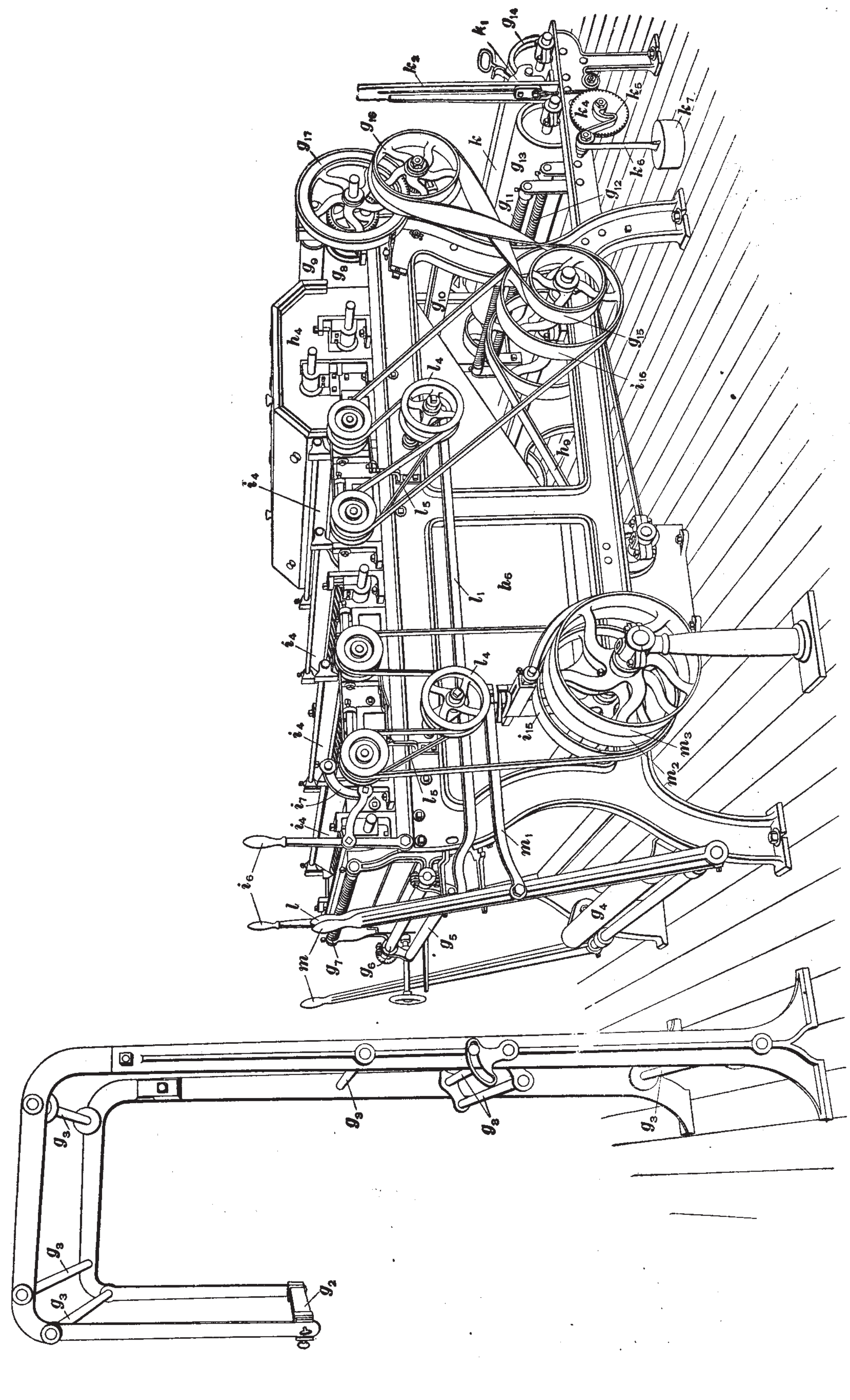


Fig. 6

Rotated 90° to fit on page.

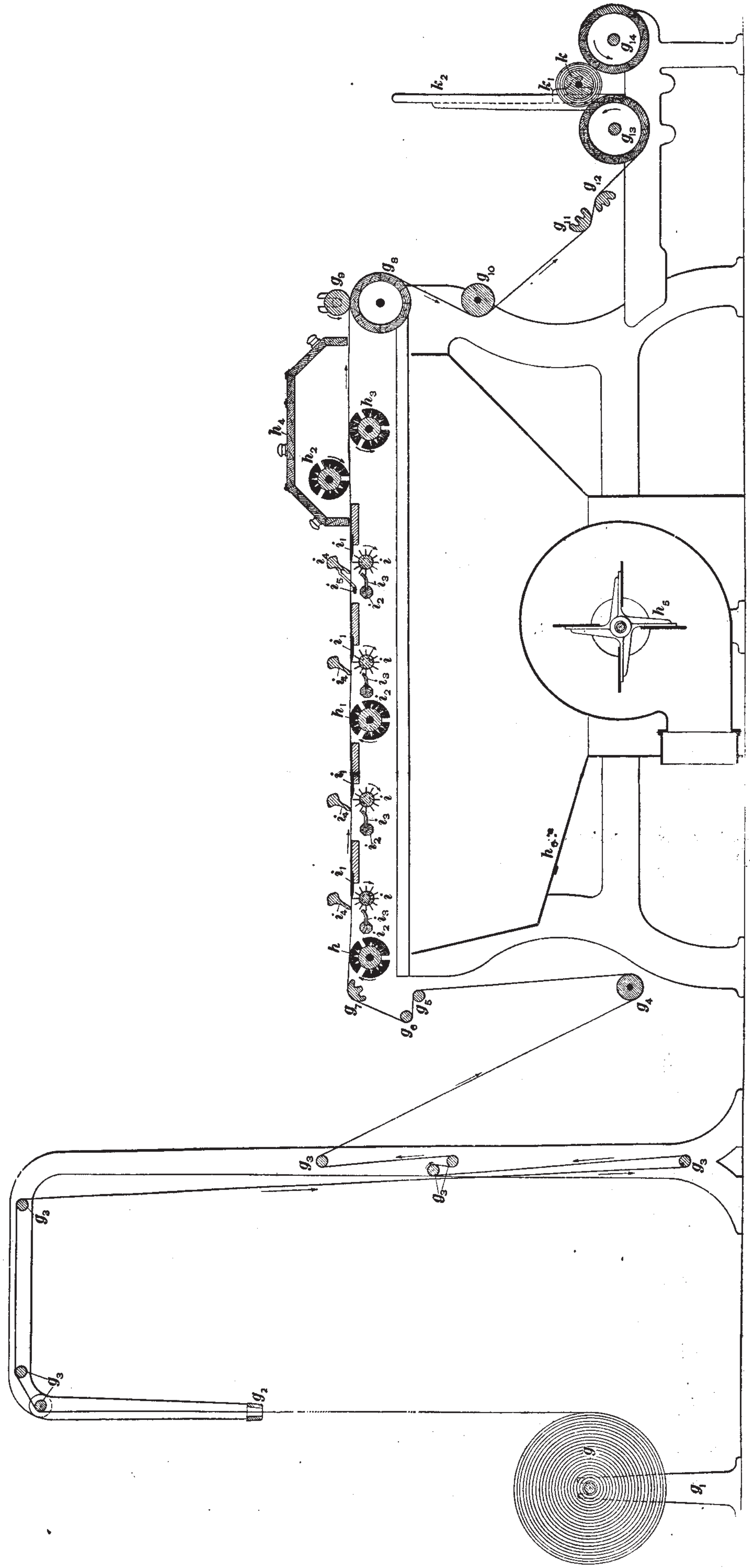


FIG. 7

Rotated 90° to fit on page.

it, is spread out to its full width and passes into the machine perfectly free from wrinkles. This is accomplished by means of two series of flutes, one series slanting toward one end, and the other toward the other end of the bar, as shown in the illustration, with the result that as the cloth passes over the bar the tendency is to stretch it in its width.

In passing through the machine, the cloth is acted on by four brushes h, h_1, h_2, h_3, Fig. 7, three of which h, h_1, h_3 operate on the face of the cloth, which is the under side in passing through the machine, and one h_2 on the back of the cloth. Four *revolvers* i, i, i, i, in conjunction with their respective ledger blades i_1, i_1, i_1, i_1, shear the projecting fibers from the surface of the cloth. It is customary to have each revolver or each two revolvers preceded by a brush running in the same direction as the cloth, but at a greater speed; the brush thus serves to raise the fiber so that it can be readily cut from the surface of the cloth by the revolver and ledger blade. The brush h_2 that comes in contact with the back of the cloth is simply for the purpose of removing loose threads, dust, bits of leaf, etc. from this side of the fabric. It is enclosed in a hood h_4, so as to prevent the flyings that it makes from passing into the air of the room in which the machine is placed. The brush h_3 gives a final brushing to the face of the cloth, removing loose ends of yarn and fiber left by shearing and laying down smooth and in one direction those fibers forming a part of the cloth. The brushes h_2, h_3, which finally brush the fabric, run in the opposite direction to the cloth where they are in contact with it.

The fan, or blower, h_5, which is enclosed in a casing h_6 so arranged as to enclose all the working parts of the machine, draws away all the flyings, fiber, and foreign matter removed from the cloth and discharges them, through a system of ducts, or flues, outside the mill. The amount of such matter removed in this way is considerable.

After passing through the machine, the cloth emerges between two rolls g_8, g_9, passes around a guide roll g_{10}, under the bar g_{11}, over the bar g_{12}, both of which are constructed similar to the bar g_7, then under the roll g_{13} which is covered with sandpaper, and finally is wound around the roll k by the roll g_{13} and an additional sandpaper-covered roll g_{14} that form what is known as the *rolling head*. The rolls g_8, g_9 are positively driven and are the means by which the cloth is drawn through the machine, while the rolls g_{13} and g_{14}, also positively driven, take the cloth as fast as it is delivered and wind it into a roll.

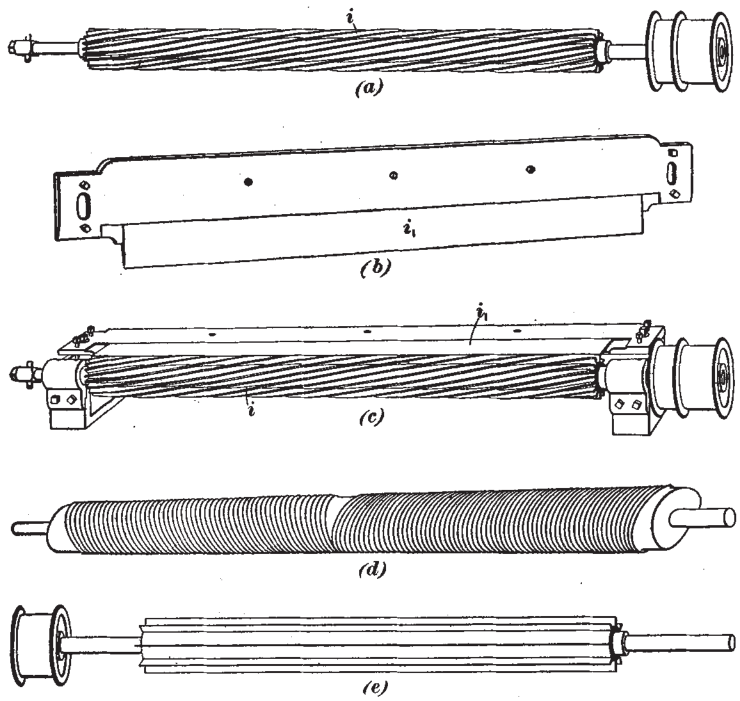


FIG. 8

19. The **brushes** of this machine are of ordinary construction and consist of a wooden barrel into which short, stiff bristles are inserted. Their only object is to clean the cloth of impurities and raise the fibers so that they may be readily cut by the revolvers and ledger blades.

20. Fig. 8 (a) shows the construction of a **revolver,** while Fig. 8 (b) shows the construction of a **ledger blade.**

The revolver has cutting blades arranged spirally on its surface so that as it revolves the projecting fibers of the cloth will be cut between them and the ledger blade, with which the cloth is in contact, in a manner similar to the action of a pair of scissors. Fig. 8 (*c*) shows a revolver and a ledger blade as mounted in the machine, with the ledger blade set lightly in contact with the blades of the revolver and its edge directly over the center of the revolver shaft. These parts together are known as a *set of blades*, or sometimes as a *shear*.

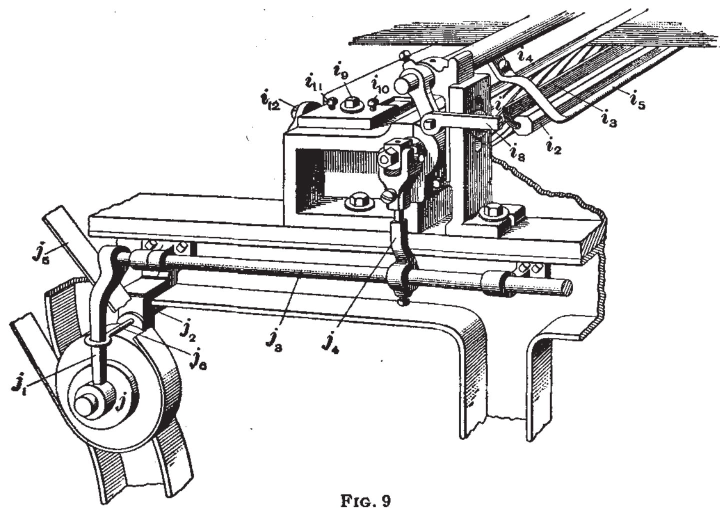


FIG. 9

The revolvers, in addition to having a rotary motion, also have a slight traversing motion, which not only aids them in shearing the cloth, but prevents uneven wear of the revolver or ledger blade. The method of imparting this traverse motion to a revolver is shown in Fig. 9. The revolver is supported at each end by stationary bearings, which hold it in the proper position with relation to the ledger blade, but still allow it to be moved laterally for a certain distance. This lateral, or traversing, movement of the revolver is obtained in the following manner: A rod j_3 that is supported by brackets attached to the framework carries at one end an arm j_1 that is operated by a cam j, being held in contact with the cam by a spring j_2 acting through a rod j_6. As the cam revolves, the lower end of the arm j_1 is caused to move in and out and consequently imparts a rocking motion to the rod j_3. Attached to the rod is an arm j_4 that carries a forked casting, each arm of which contains a slot. Between the arms of this fork is a small casting that carries two pins, one on each side, that project into the slots in the fork. This latter casting is carried by the shaft of the revolver, and although when moved laterally it imparts the desired traversing motion to the revolver, it does not interfere with the rotation of the latter. Since the rod j_3 receives a rocking motion it imparts a swinging motion to the forked casting, which in turn imparts the traversing motion to the revolver.

As each revolver is connected to the rod j_3 in the same manner, as shown in Fig. 14, a traversing motion is consequently imparted to each revolver.

In order to maintain the necessary contact between the cloth and the ledger blades, cloth rests, or guides, i_4, Fig. 7, are placed in front of each revolver on the upper side of the cloth. Their function is simply to press down the cloth so that as it passes the shearing point it will be in perfect contact with the ledger blade and thus the fibers will be evenly trimmed. Slotted bars i_2 having a wick, or oil swab, i_3 inserted in them are so placed in front of each revolver that the swab rests on the cutting blades. These swabs should be well soaked in oil so that they will lubricate the cutting blades and prevent their *screaming*, which will occur if they are allowed to run dry against the ledger blades.

21. When the seams formed by stitching the ends of two cuts of cloth together are passed through the shearing-and-brushing machine it is necessary, in order to prevent cutting the cloth, to raise the cloth guides i_4 so that the brushes h, h_1 will lift the cloth away from the revolvers and ledger blades. Since there is no brush immediately in front of the last revolver, a lifter rod i_5 is attached to the last cloth rest i_4 so as to pass underneath the cloth at this point and thus serve the same purpose. These guides are raised by means of two handles i_6, Fig. 6, either of which when operated raises a lever i_7 attached to the first cloth guide; and as all the other cloth guides are connected by a bar i_8, as shown in Fig. 14, this raises them all. This is done while the machine is in operation, the handle i_6 being pulled forwards for a short time while the seam is passing through the machine.

The ledger blades may be set to the revolvers as shown in Fig. 10. The blade is bolted to the frame by a bolt i_9 and may be raised or lowered from the revolver by two adjusting

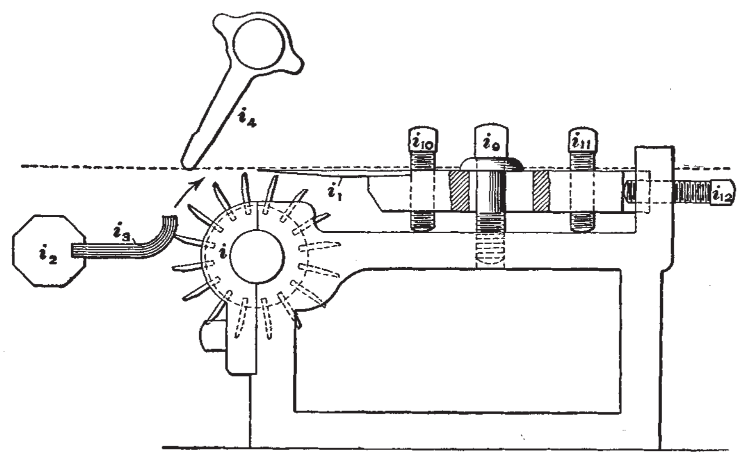


FIG. 10

screws i_{10}, i_{11}; a screw i_{12} enables it to be set forwards after it has been ground sufficiently to be shortened slightly. Fig. 10 shows only one end of a ledger blade, but the arrangement is the same for the other end and for all the blades.

Occasionally shears are arranged for the upper side of the cloth; when this is the case the arrangement is as shown in Fig. 11. The ledger blade in this case is adjusted by means of the screws i_{10}, i_{11}, i_{12}, and the oil swab i_3 is placed over the revolver. A guard i_{13} is provided to press the cloth down and away from the revolver and ledger blade when seams are to be passed through the machine. This is accomplished by the same handle i_6, Fig. 6, which when operated throws the guard i_{13} down under the revolver, as shown by the dotted lines in Fig. 11, and at the same time, by means of the connecting-rod i_{14}, lowers the cloth guide i_4, which in this case is placed underneath instead of over the cloth; the position of the cloth guide when it is lowered is also shown by dotted lines, while the corresponding positions of the cloth are shown by the two horizontal dot-and-dash lines.

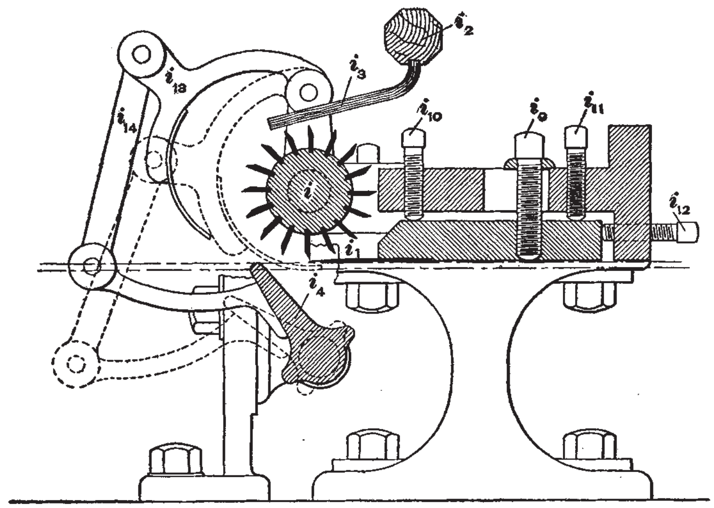


FIG. 11

22. In order to be sure that the cloth will not be cut when the seams are being passed through the machine, the driving belts of the revolvers are slackened and a friction is applied to them to check their rotary motion when this takes place. This is accomplished in the following manner: The belts that drive the revolvers pass around binder pulleys l_4, Fig. 12, that revolve on studs fastened in the castings l_2, which are pivoted at l_3. These castings are connected by a rod l_1, which is connected to a lever l, and also to friction bands l_5 that pass around brake, or friction, pulleys on the shafts of the revolvers and are attached to brackets l_6. When the

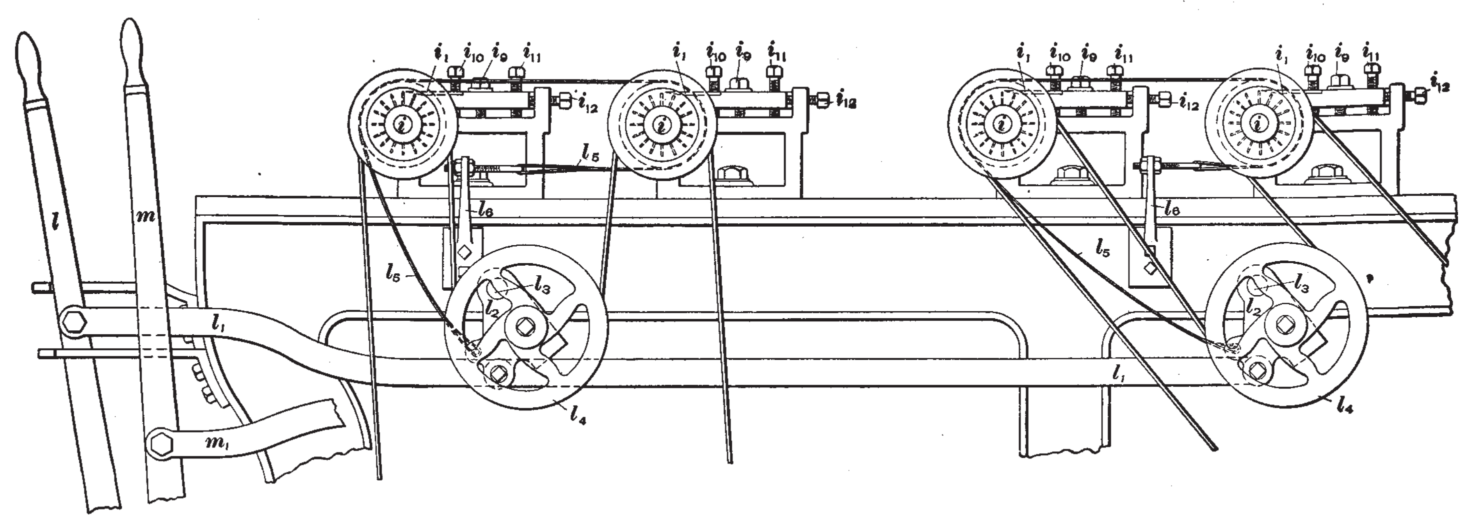


Fig. 12

handle l is forced forwards, the binder pulleys, in swinging about the center l_3, slacken the belts, and at the same time the steel friction bands l_6 are tightened and the motion of the revolvers checked.

23. The construction of the **rolling head** is shown in Fig. 13. The cloth in being wound is wrapped about a roll k, the journals of which are in contact with castings k_1 that slide in slotted stands k_2. Motion is imparted to the cloth

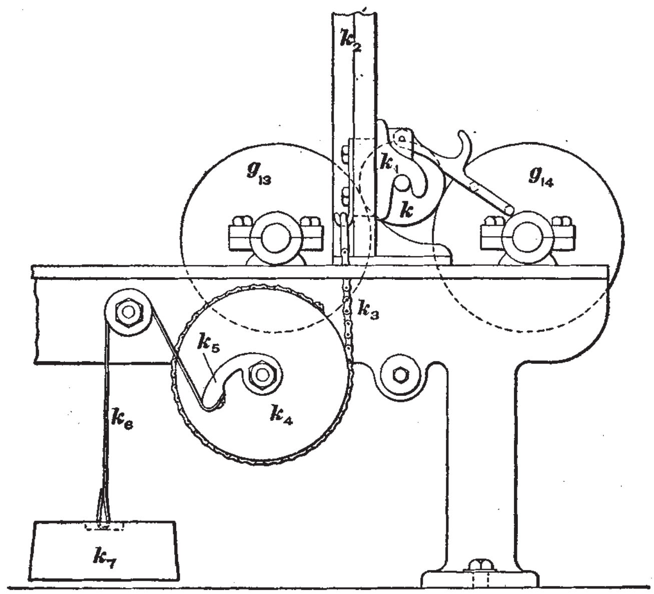


Fig. 13

by two sandpaper-covered rolls g_{13}, g_{14}. The chain k_3 attached to the casting k_1 is wrapped around a disk k_4, to which its other end is attached. Attached to a projecting wing k_5 cast in one piece with this disk is a strap k_6 that supports a weight k_7. As the roll of cloth increases in diameter, the castings k_1 are raised and the chain k_3 imparts motion to the disk, which raises the weight k_7. As this proceeds, the strap k_6 becomes wrapped around the smaller diameter on the wing k_5, so that the pressure on the journals of the roll k

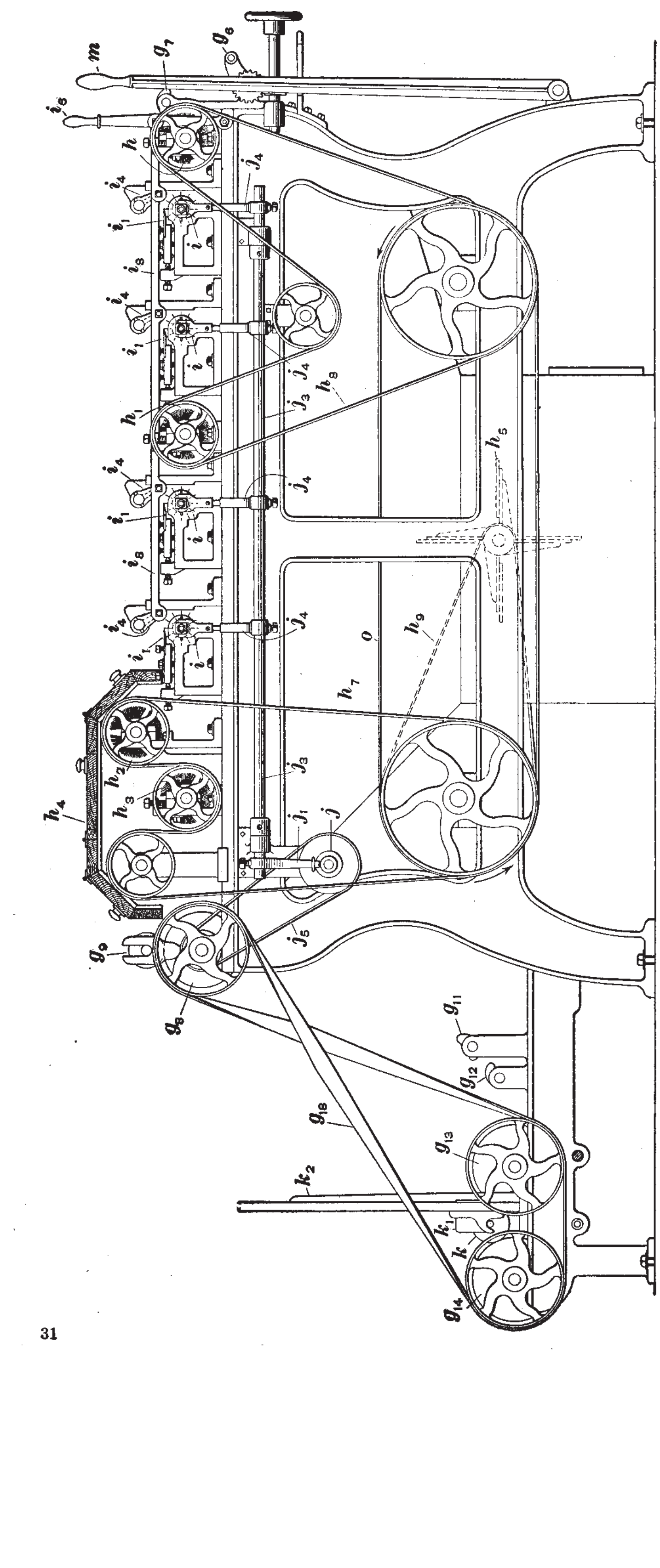

m
g7
g6
i8
h
i4
i1
i
i3
j4
h1
j3
h8
h5
o
h9
h7
h4
h2
h3
j1
j
j5
g9
g8
g11
g12
g18
g13
k2
k1
k
g14

FIG. 14

on which the cloth is wrapped is decreased correspondingly as the diameter, and consequently the weight, of the roll of cloth increases.

24. The **driving** of the shearing-and-brushing machine is as follows, the references being to Figs. 6 and 14, the former of which shows the belts on one side, and the latter the belts on the other side of the machine: The motion of the machine is primarily controlled by two shipper levers m, either of which, through the rod m_1, controls the shipping of the driving belt on the tight and loose pulleys m_2, m_3. The first two revolvers, as shown in Fig. 6, are driven by a belt from the pulley i_{15} on the main shaft of the machine. The last two revolvers are driven by a belt from the pulley i_{16} on a cross-shaft, to which motion is imparted by a belt o, Fig. 14. On the same shaft is a pulley that by means of a belt h_9 drives the fan, or blower. A pulley g_{15}, Fig. 6, on this shaft drives, with a cross-belt, a pulley g_{16}, while a gear compounded with g_{16} drives a gear g_{17} that is attached to the shaft of the roll g_8. The roll g_9 is driven by gears from the shaft of the roll g_8. On the opposite side of the machine the brushes are driven by belts h_7, h_8, as shown in Fig. 14. The rolls g_{13}, g_{14} are driven by a belt g_{18} from a pulley on the shaft of the roll g_8. The cam j is also driven by a belt j_1 from a pulley on this same shaft.

25. The machine represented in Fig. 6 is one of a large number of types of shearing-and-brushing machines. These machines differ very largely in construction:

1. They are made with from one to six sets of shears and from one to three brushes on one side of the cloth, usually the face side, in addition to the two finishing brushes —one on each side of the cloth. The number of shears and brushes on a machine depends on the finish required by a cloth, its condition, the material of which it is made, and the speed at which it is drawn through. Generally speaking, the coarser the cloth, the greater is the number of shears, etc. required, but some kinds of the finest cloth require a large number of shears and brushes. Where there is only

one shearing arrangement on one side of the cloth, there is usually one brush preceding it in addition to the two finishing brushes. Where there are two or more sets of shears on one side of the cloth, one brush precedes each set, or each two sets, of shears.

2. They may be constructed to shear and brush both sides of the cloth at the same time, with one or more sets of shears and brushes operating on the back of the cloth at the same time that others are operating on the face of the cloth, thus shearing and brushing both sides of the fabric by once running it through.

3. Card rolls may be added; these are wooden rolls covered with fillet card clothing, the teeth in which are somewhat straighter than those in ordinary card clothing; the rolls are run with the point of the teeth pointing backwards, in order to prevent forming any nap on the goods. They also are arranged on either one or both sides of the cloth and vary in number. A fuller description of them will be given in connection with the cotton brushing-and-calendering machine.

4. Emery rolls and beaters may be added; these are attached to the feed-end of the machine and are described in connection with the cotton brushing-and-calendering machine.

5. The rolling head may be replaced with a calender-rolling machine, by which the cloth is smoothed and pressed before being wound in a roll. This may be arranged for either cold rolling or hot calendering, with or without a steam moistening arrangement. This mechanism will be described later.

It will thus be seen that the differences in construction, caused by the variable number and arrangement of shears, brushes, and card rolls, and by the use or non-use of emery rolls, beaters, and hot or cold calender rolls, give an almost endless combination of mechanisms, resulting in hundreds of different arrangements of shearing-and-brushing machines; about fifty types are in regular use. The general principles, however, are here described, so that there should be no difficulty in thoroughly understanding the construction and operation of any of these machines that may be met with in practice. The variable constructions prevent any definite information being given as to the dimensions of shearing-and-brushing machines, but for general guidance it may be stated that these machines vary in length from 8 feet to 12 feet; the width is generally about 7 feet in all machines. About 500 cuts per day is a good average production for a shearing-and-brushing machine.

SHEAR GRINDER

26. When the revolvers or ledger blades of shearing machines become dull, they are sharpened on a **shear grinder.** This is a machine of substantial construction carrying an iron cylinder that has a traverse of about 4 inches, and against which the revolvers or ledger blades are held. The cylinder is kept supplied with fine emery and oil for grinding purposes. When the grinder is used for sharpening the revolvers, they are held in a suitably adjusted stand and driven by chains and sprockets, so as continuously to bring their different parts against the grinding cylinder. When the ledger blades are being ground, a different arrangement of stand is applied to hold the blades in a suitable position, and they are pressed against the grinding roll by levers and weights.

COTTON BRUSHERS

27. The **cotton brusher** performs work similar to that of the shearing-and-brushing machine described, except that it has no shearing operation. It, too, is constructed in many different ways, with a varying number of brushes on each side of the goods, and in combination with other mechanisms for producing various results. Fig. 15 shows a section of one type of this machine that not only comprises a complete brushing machine proper, but also includes emery rolls, beaters, and card rolls, as well as a calender-rolling attachment. The framework *a* of the main machine rests on the floor of the room and is arranged with a level horizontal

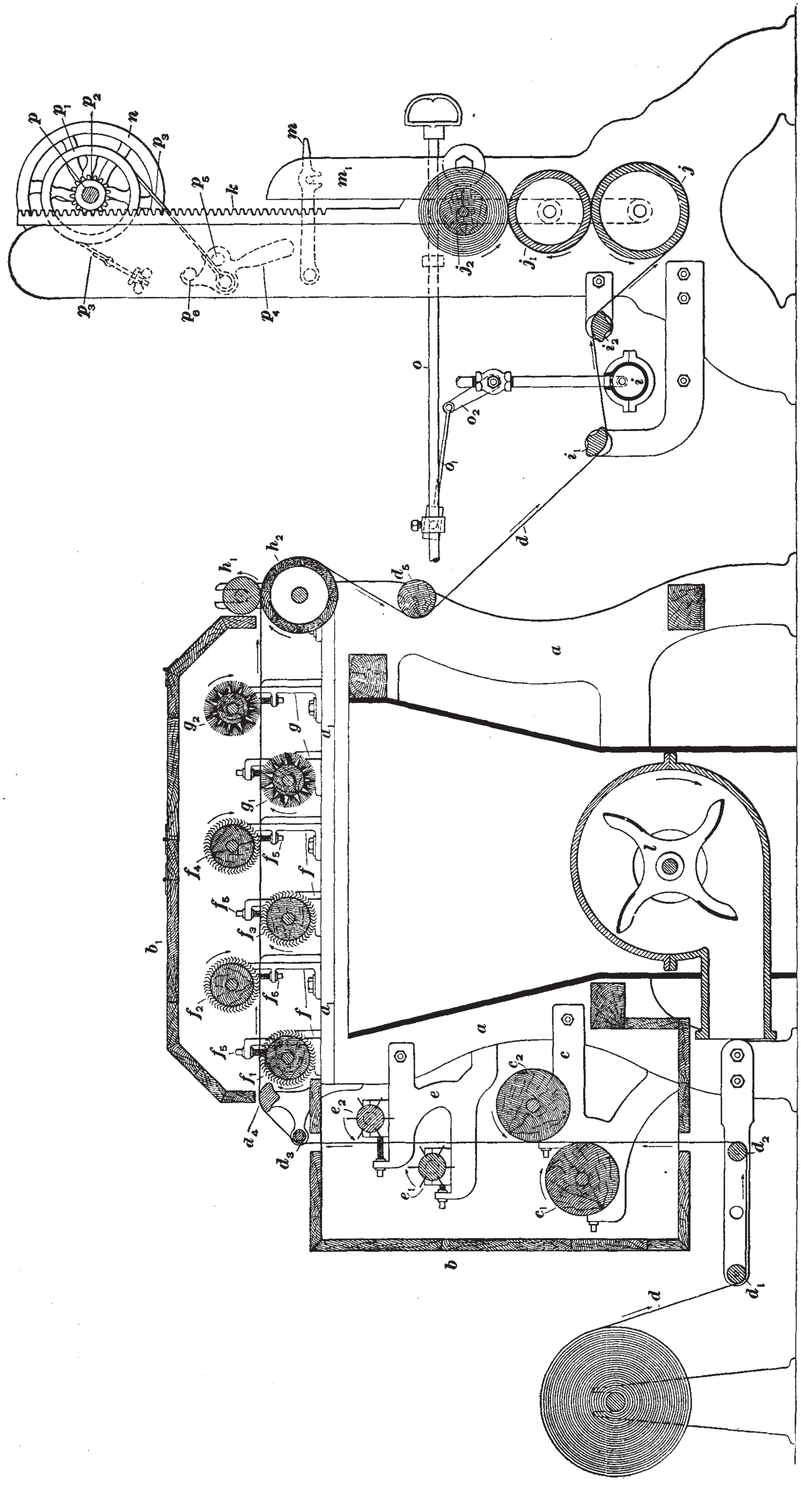


FIG. 15

Rotated 90° to fit on page.

surface at the upper part a_1, on which rest brackets carrying the brushes, card rolls, and the rolls that draw the cloth through the machine. At the feed-end of the machine is attached a bracket c carrying in suitable adjustable bearings the emery rolls c_1, c_2, so arranged that one operates on the face of the cloth and the other on the back. Each emery roll consists of a wooden barrel covered spirally with a fillet of emery cloth secured at each end, or in some cases with a coating of coarse emery glued on to the surface of the roll.

28. The cloth d passes through the machine in the direction shown by the arrows, first under the guide rolls d_1, d_2, thence upwards and between the two emery rolls. These rolls revolve in the opposite direction to that in which the cloth is passing, and have a scraping action, which for the most part removes motes, leaf, and rough places projecting on each side of the fabric, those that are not removed being sufficiently loosened to facilitate their removal by the beaters, card rolls, or brushes of the machine. The beaters e_1, e_2 are supported in adjustable bearings on a bracket e so that one operates on the face of the fabric and the other on the back. Fig. 8 (e) represents one of these beaters removed from the machine. It has steel blades radiating from the barrel and set equal distances apart, each side of the edge of the blade forming a sharp corner. These beaters run in the opposite direction to that in which the cloth passes, and knock off the knots and nubs that in many cases cannot be removed by any other means, as well as loosen the dust and dirt so that it may be brushed off by the card rolls and bristle brushes.

The cloth continues its passage over a guide roll d_3 and guide bar d_4 and next comes under the action of four card rolls f_1, f_2, f_3, f_4 supported from the framework by brackets f and adjustable by means of the setscrews f_5. The card rolls f_1, f_3 operate on the under side of the cloth and f_2, f_4 on the upper side. These rolls are covered with card fillet and run in the opposite direction to that in which the teeth point, thus avoiding the formation of a nap on the cloth, but serving to remove motes, specks, etc. After passing between these rolls, the cloth is subjected to the action of two bristle brushes g_1, g_2 mounted in adjustable bearings on brackets g that are set on the horizontal surfaces of the framework of the machine. These brushes are set with stiff bristles and correspond in their construction and operation to h_2, h_3, Fig. 7. The cloth then passes between the rolls h_1, h_2, which draw it through the machine. These rolls, in construction and operation, correspond to those shown at g_8, g_9, in Fig. 7, and are described in connection with the machine there illustrated.

29. The emery rolls and beaters are incased by the removable cover b, while the brushes and card rolls are covered by the upper cover b_1. Both of these covers are so constructed as to admit of their being partly removed, thus affording facilities for inspecting and cleaning the machine. An exhaust fan l is provided, which removes from the incased portion most of the lint, dust, and smaller particles of fibrous or foreign matter, delivering them into a flue or chamber arranged to receive them. The threads in many cases remain on the surface of the brushes or slightly embedded between the bristles and have to be removed at intervals—several times each day.

CALENDER-ROLLING MACHINE

30. The machine shown in Fig. 15 also differs from that shown in Fig. 6 in the treatment of the cloth after it leaves the machine proper. In the machine shown in Figs. 6 and 7, the cloth was simply rolled at a rolling head, but in the case of the machine shown in Fig. 15, an entirely separate mechanism is placed in front of the machine, known as a **calender-rolling machine,** the object of which is not only to form the cloth into a roll, but before doing so to pass it between heavy rolls for the purpose of smoothing out the goods. The cloth passes from the brusher under and partly around a guide roll d_5, thence under a guide bar i_1 and over a second guide bar i_2, beneath which is placed a hollow steam vapor cylinder *i*. This is connected to a steam pipe, and by means of perforations on its upper side allows a light vapor of steam to impinge on the cloth as it passes between the two guides i_1, i_2; the flow of steam is very small and can be regulated as desired. The fabrics only require to be moistened sufficiently to aid the heavy calender rolls in smoothing out the cloth and to give it a softer finish and feel. The steam is admitted to the vapor cylinder through a cut-off valve so arranged that it shuts off the supply of steam entirely when the machine is stopped, thus preventing any excessively damp places in the fabrics. This is accomplished by connecting the lever o_2 that operates the valve to the shipper rod *o* by a rod o_1; thus, as the shipper rod is operated to stop the machine, the steam is automatically cut off from the vapor cylinder *i*; when the machine is started again the steam is admitted to it without further attention on the part of the operator.

31. After leaving the guide i_2, the cloth passes under and partly around the lower calender roll *j* and upwards and partly around the upper calender roll j_1, thence to the cloth roll j_2, around which it is wound. In passing between the rolls *j*, j_1, the cloth is subjected to a certain amount of pressure, since both rolls are of considerable weight, thus calendering or compressing the fabric and producing a smooth surface. These rolls may be driven at the same surface speed, in which case they have merely a compressive action; or, by the use of unequally sized gears, the upper roll may be driven slightly faster than the lower one, thus producing an ironing effect on the fabric and increasing the smoothing action of the rolls. The rolls *j*, j_1 are hollow and fitted with stuffing-boxes, piping, and valves, so that steam may be admitted to the inside of both rolls in order to have them hot while the cloth is passing through; or in case it is desired that the fabric be cold rolled, the steam may be shut off and the fabric calendered without heat. In some cases where it is never desired to use the machine with hot rolls, smaller calender rolls are used without any arrangement for heating them.

32. At each side of the calender-rolling arrangement is a long rack, similar to k, Fig. 15, that rests on one of the journals of the wooden roll on which the cloth is wound. A gear p_2 on a cross-shaft p extending across the calender-rolling arrangement engages with the rack k, a similar gear engaging with the rack on the opposite side, which is not shown in Fig. 15. Attached to this shaft is a friction pulley p_1, around which passes a friction strap p_3 that is connected to a lever p_4. This lever is pivoted at p_5 and so arranged that by raising it the friction can be immediately released, or by lowering it, as shown in Fig. 15, the friction can be applied to the friction pulley. When in the position shown, the lever p_4 is held securely in place by means of a pin p_6 that engages its hooked upper part. By means of this friction arrangement the racks place a considerable amount of pressure on the cloth as it is wound, so that a smooth, hard, and even roll of goods is produced. This pressure may be easily regulated by increasing or decreasing the amount of friction that the strap p_3 places on the friction pulley p_1.

When a sufficient length of cloth has been wound around the cloth roll, it is removed by unhooking the latches m and swinging out the standards m_1, which are on each side of the calender-rolling head and pivoted on a pin at the lower part. These standards are lowered and the lever p_4 raised, while by means of the hand wheel n, the racks are raised so as to relieve the pressure on the cloth roll, which is then removed from the machine and a new one inserted.

It is found, in practice, that by calendering the cloth in this way, especially in the case of hot calendering and where the upper roll is run faster than the lower one, there is a gain in length. This varies from $1\frac{1}{2}$ to 5 per cent. and can be arranged to be still greater than this; but it is not desirable to stretch the goods too much, nor is there any ultimate advantage in doing so, since a certain length of the cloth has to be of a given weight, and the goods have to be made correspondingly heavier at the loom to offset the stretch.

33. After the roll of cloth has been formed and removed from the machine, it is customary to allow it to stand several hours or over night, after which the result of the steaming, calendering, and remaining under pressure for a considerable period is found to have imparted a very smooth appearance and feel to the fabric.

34. A cotton brushing machine with the attachments described occupies a floor space of about 10 feet by 7 feet and carries $14'' \times 3\frac{1}{2}''$ tight and loose pulleys on a shaft revolving at a speed of about 400 revolutions per minute. Most of the belts connecting the various parts of the machine are 2 inches in width.

CLOTH ROOMS

(PART 2)

TRIMMING-AND-INSPECTING MACHINES

1. In many mills where the cloth manufactured does not require shearing, heavy brushing, or calendering, or is not of sufficient strength or suitable construction to withstand the strain of such processes, the shearing-and-brushing machines of the types previously described are not used; this also renders the use of sewing-and-rolling machines unnecessary. In place of these machines one known as the **trimming-and-inspecting machine,** sometimes called a *cloth trimmer*, or a *brushing-and-inspecting machine*, is adopted. The object of this machine is to give a slight brushing to one or both sides of the fabric, thus removing loose threads, lint, dust, etc., and at the same time to afford a ready and rapid means of inspecting the cloth, if so desired. The machine is usually constructed to take the cloth in short pieces just as they are taken from the loom, although in some few cases it is made to take a roll from the sewing-and-rolling machine. It is also sometimes built without a brushing arrangement, in which case it becomes merely an inspecting machine.

A view of a common type of cloth trimmer is given in Fig. 1, while a section through the machine is shown in Fig. 2. This machine is built for both brushing and inspecting and is constructed to receive only one piece, usually either a single or a double cut, so that the cloth is not passed through the sewing-and-rolling machine before coming to this machine. The piece of cloth n, Fig. 2, is placed in the cradle n_1 and the end passed over the roll n_2, partly around the roll n_3, and then to the roll n_4, from which it passes into the machine. The cloth then passes partly around the roll n_5, after which it comes in contact with the brushes n_6, n_7, which may be arranged according to several methods. In some cases only one brush is used, which brushes the face of the cloth, while in other cases two brushes are used, both coming

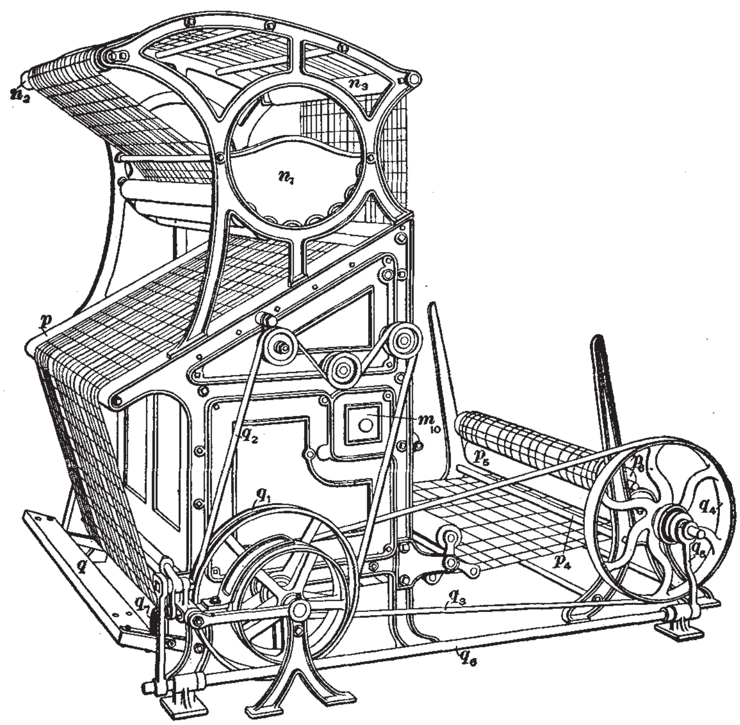


FIG. 1

in contact with one side of the goods; in still other cases the brushes are arranged as shown in Fig. 2. The brushes revolve in the opposite direction to that in which the cloth passes. From them, the cloth passes partly around the roll n_8 and is then lightly brushed by the brush n_9, after which it passes on to the inspecting table p, which is painted black. As the cloth passes over this table the attendant closely inspects it. In case any defect is noticed, the machine is stopped and the defect marked either by passing a short piece of colored thread through the selvage of the cloth, so as to call attention to it later, or, if possible, remedied at this point. From the table p, the cloth passes around the roll p_1, under the machine, then over and under the spreader

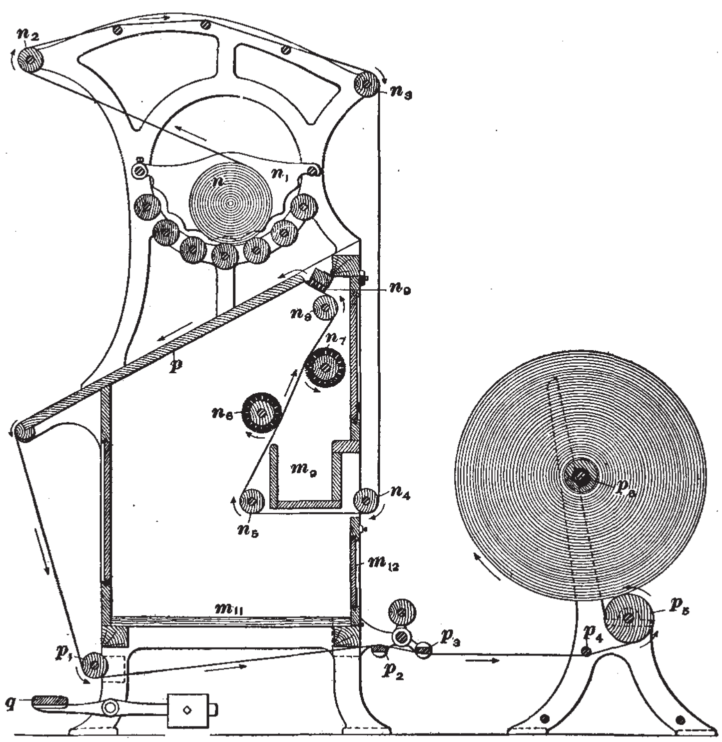


FIG. 2

bars p_2, p_3, respectively; these spread out the cloth so as to remove wrinkles, after which the cloth passes to the rolling head—under the rod p_4 and partly around the roll p_5—and is finally wound on the roll p_6. The outer surface of the roll p_5 is rough, thus enabling it to grip the cloth and draw it through the machine.

A flock box m_9 is provided with a door m_{10} (Fig. 1), by which the lint that falls from one side of the cloth may be removed. The lint from the other side falls into the space m_{11} and is removed through the door m_{12}. There are other doors in the casing by which the brushes may be reached. Threads should be picked off the brushes and lint removed from the box and enclosed space twice a day.

2. The **driving arrangement** of this machine is shown in Fig. 1. The driving belt is shipped from the loose to the tight pulley by means of the foot-board, or treadle, q. It is necessary, in order to keep the machine in operation, for the attendant to continually press down on this board, since a spring q_7 together with a weight at the inner end of the arm supporting the foot-board tend to bring it up and throw the belt from the tight to the loose pulley, thus stopping the machine. On the shaft with the tight and loose pulleys is a pulley q_1 that drives, by means of the belt q_2, the brushes n_6, n_7, Fig. 2. On this same shaft is another pulley that drives, by means of the belt q_3, a pulley q_4 loose on the shaft with the roll p_5. As the pulley q_4 is loose on the shaft, no motion will be imparted to the roll p_5 unless some other mechanism is brought into operation. This mechanism is as follows: The hub of the pulley q_4 forms one-half of a friction clutch, while the other half, which slides on a key on the shaft carrying the roll p_5, is controlled by an arm q_5 setscrewed to a rod q_6. When the belt is shipped from the loose to the tight pulley, by pressing down the foot-board q, the rod q_6 is turned in such a direction by the arm at its outer end and the mechanism connecting it to the foot-board as to throw the upper end of the arm q_5 toward the machine, thus connecting the two halves of the friction clutch and causing the pulley q_4 to revolve the roll p_5. If some such arrangement as this were not adopted, the momentum of the machine would cause the roll p_5 to continue to revolve for a certain length of time after the belt was shipped from the tight to the loose pulley. Since, however, in case a defect is noticed in the cloth as it is passing over the inspecting board p, it is desired to stop the cloth instantly, the friction arrangement is adopted, which allows the pulley q_4 to revolve without affecting the roll p_5 in case the two halves of the friction clutch are not connected.

When the operator desires to reexamine any of the cloth that has passed forwards or to return the cloth so as to rectify some fault that has been noticed, the foot-board is allowed to rise, which disconnects the rolling head from the driving power and allows the cloth to be easily pulled back. Some trimming machines are constructed with a reversing motion by which the operator allows the main foot-board to rise and then, by pressing down a foot-board at the side, causes the cloth to pass through the machine in the opposite direction to that in which it usually travels. The brushes do not revolve while the cloth is running in the reverse direction.

3. As it is usually desired to remove the cloth from the trimmer in a large roll, it is necessary to connect the tail-end of each piece of cloth that is passed through the machine with the end of the new piece in the cradle. This is done by sewing the ends of the pieces together by hand.

4. A machine of the type described, when constructed to take 40-inch cloth, occupies a space of 5 feet 6 inches in width and 6 feet 6 inches in depth from front to back. The driving pulleys are 12 inches in diameter with a 2-inch face and when operated continuously at 300 revolutions per minute cause about 50 yards of cloth to pass over the inspecting table per minute. This is a somewhat excessive speed for inspecting, hence these machines are more commonly operated at speeds of from 200 to 240 revolutions per minute. These latter speeds cause from 33 to 40 yards of cloth to pass over the inspecting table per minute.

The trimming machine, although provided with an inspecting arrangement, is not used for the inspection of every style of cloth made in a mill, since some styles require a more careful inspection; in such cases the trimming machine is used merely for the purpose of lightly brushing the fabric, and the cloth is inspected after it has passed the cloth folder.

In still other cases, the trimming-and-inspecting machine is used for inspection only, the brushes being dispensed with. This is especially the case with certain fancy fabrics, where the brushing would disarrange the floating ends on the face of the cloth and destroy the fancy effect desired.

FOLDING AND MEASURING

CLOTH FOLDER

5. After the cloth has been treated either by the shearing-and-brushing machine or by the brushing-and-inspecting machine, it is usually folded on a machine known as a **cloth folder.** A view of this machine is shown in Fig. 3, while a section through the machine is shown in Fig. 4. The roll of cloth r, Fig. 4, is placed in the stands r_1 and the end passed between the rolls r_2, r_3, from which it falls into a curved zinc apron r_4. The rolls r_2, r_3 draw the fabric from the roll of cloth r at a speed substantially equal to that at which the cloth is folded. Since, however, the folding operation must necessarily be intermittent in its action, a surplus of cloth is drawn from the roll r and deposited in the apron r_4 before the machine is started in actual operation. This accumulation is used to compensate for the irregularity between the rotary motion of the rolls r_2, r_3 and the intermittent action of the folding mechanism. The zinc apron r_4 also serves to keep the cloth from coming in contact with the floor. From the apron r_4, the cloth passes in front of the guide roll r_5 and over the guide rod r_6, from which it passes between a board r_7 and a friction bag r_8. The cloth then passes forwards and under a friction board r_9 and over a friction board s, between the guides s_1, Figs. 3 and 4, and thence around a roll s_2 to the folding blades s_3, by means of which it is folded on a table t. The folding blades consist of a frame made of two blades held in end pieces s_{10}, each of which has a projecting stud that is supported by a rod s_4 on each side of the machine. These folding blades are operated, as will be explained later, by a rod s_6 on each side of

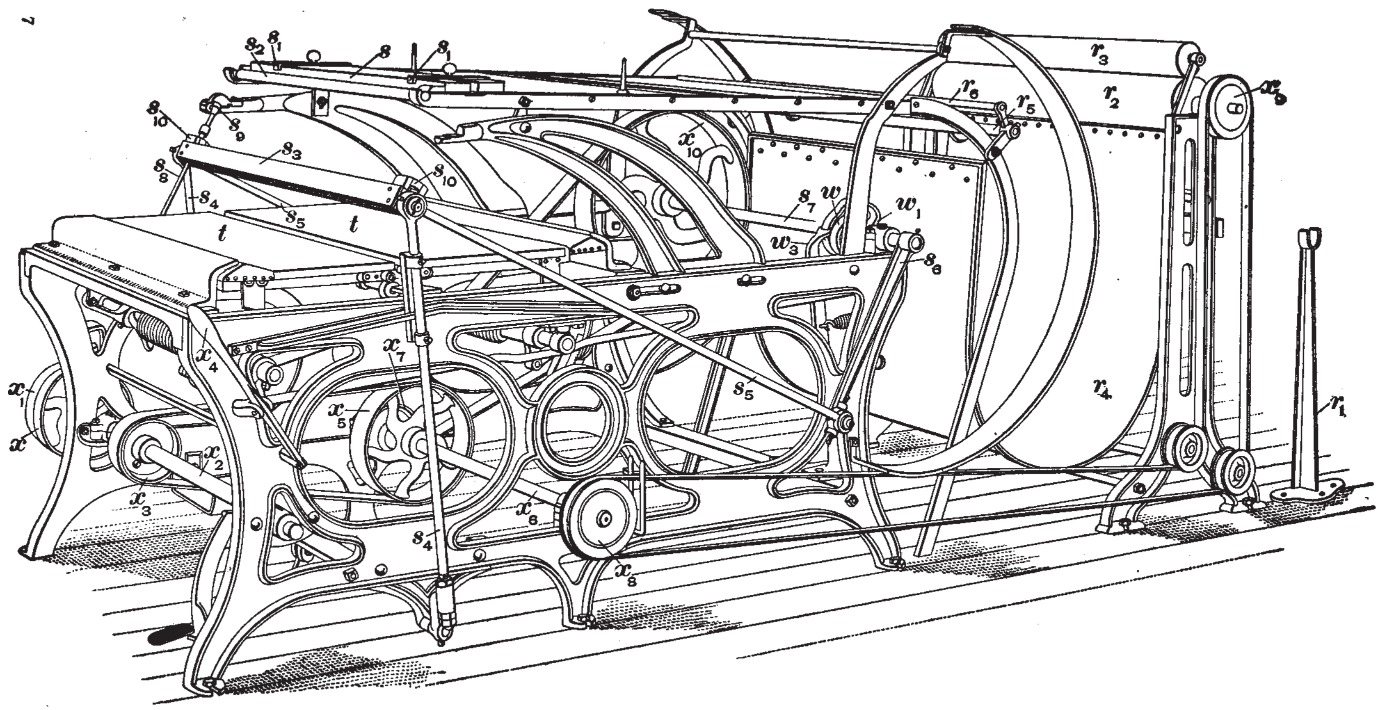

s
s1
s1
s2
s3
s4
s4
s5
s5
s6
s7
s8
s9
s10
s10
t
t
w
w1
w3
x
x1
x2
x3
x4
x5
x6
x7
x8
x9
x10
r1
r2
r3
r4
r5
r6

Fig. 3

the machine connected to a crank-arm s_6 that is fast to a shaft s_7. The position of the folding blades relative to the gripping jaws t_1, t_2 is controlled by a rod s_8, the upper end of which is held in a swivel-joint s_9, while its lower end projects and slides through a self-oiling bearing that is on the end of one of the end pieces s_{10} of the folding blades. As the folding blades are moved back and forth over the table t, they consequently assume the position shown by the full lines in Fig. 4 when at the back of the table and the position shown by the dotted lines when approaching the front of the table, the faces of the two blades being always at right angles to the swivel rod s_8. Fig. 5 shows the blades occupying the extreme backward position and placing the cloth under the jaw t_2.

6. In order to hold the cloth firmly in position as it is folded, the table t (see Fig. 5) is pressed against the jaws t_1, t_2; but in order to allow the folding blades to place each fold of cloth between the jaws and the table, an arrangement is provided to drop, alternately, the latter slightly at each end as the folding blades are placing the cloth between that end and its respective jaw. This table consists of two separate leaves hinged at the center, each leaf acting independently of the other as regards its holding the cloth against its respective jaw. In Fig. 4, the leaves of the table t are shown lowered so as not to be in contact with the jaws t_1, t_2, as will be explained later. The forward end of the table is supported by an arm t_3, Fig. 5, that is connected to a casting t_6 setscrewed to a shaft y. Forming a part of the casting t_6 is a ratchet t_7 that is protected, with the exception of a few teeth at its lower edge, by means of a shield t_8. Pressed against the shield by means of a spring not shown in the illustration is a pawl u attached to an elbow lever formed by the arms u_1, u_2. This lever is loose on the shaft y and is controlled by a rod u_3 attached to a lever w_2 that is in contact with the face of the cam w. A spring v that is on the shaft y has one end attached to a casting v_1 loose on the shaft, while its other end is attached to a casting v_2 setscrewed to the

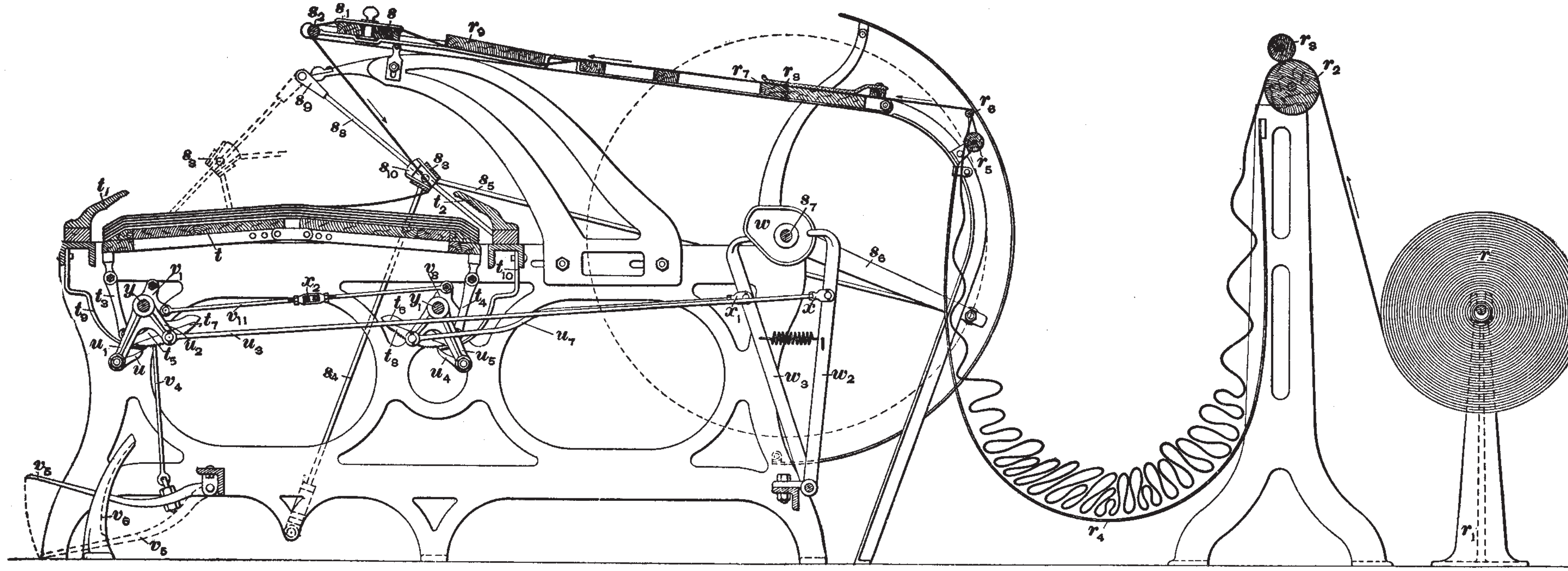


Fig. 4

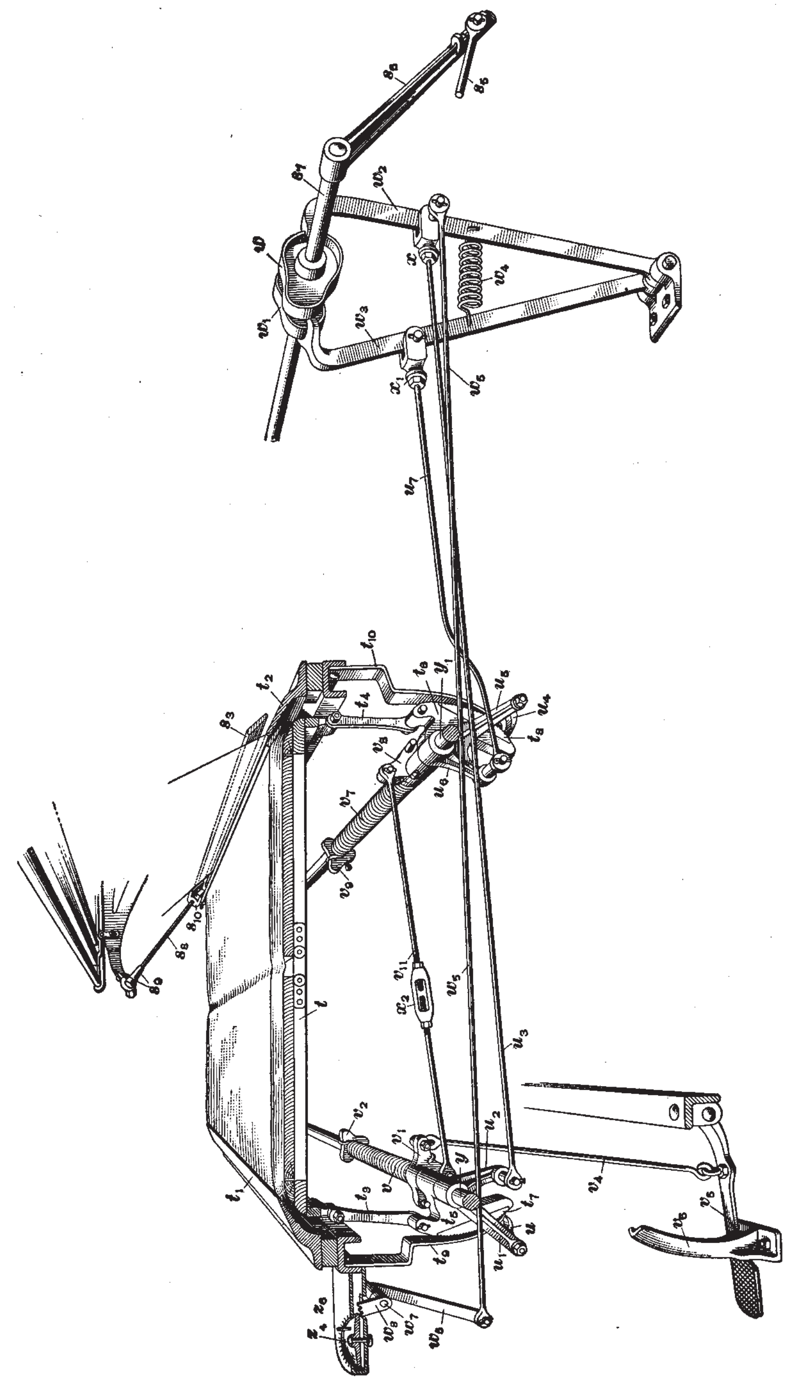


FIG. 5

shaft. These parts are duplicated at the rear end of the table. The casting v_1 is controlled by a rod v_4 attached to a foot-lever v_5.

The operation of these parts is as follows: In order to place the table t in position for operating the machine, the folding blades s_3 are first brought over the center of the table and the foot-lever v_5 pressed down until it is held by a catch in the casting v_6. Pressing down on the lever v_5 draws down the rod v_4, together with one end of the casting v_1, which compresses the spring v and turns the casting v_2. Since the casting v_2 is setscrewed to the shaft y, any motion of the former will be imparted to the latter and, in turn, to the casting t_5, which is also setscrewed to the shaft; consequently, as the foot-lever v_5 is pressed down, the casting t_5 will be moved up, which will push the forward end of the table t against the jaw t_1. A similar arrangement operates the rear of the table, the motion of the casting v_1 being imparted to a similar casting v_8 through the rod v_{11}, which results in the casting t_6 being moved up and pushing the rear end of the table against the jaw t_2. When the folding blades are in the center of the table both the pawls u, u_4 are up on their shields, thus permitting the table to be raised; if the pawls were in contact with their ratchets, the castings t_5, t_6 and, consequently, the table could not be raised. The shields t_9, t_{10} are so adjusted as to allow their respective pawls u, u_4 to engage just the required number of teeth in the ratchets t_7, t_8 as will operate the leaves of the table so that they will lower sufficiently to allow the cloth to be passed under the jaws t_1, t_2.

The cam w is so set on the shaft s_7 that when the folding blades s_3 are at the forward end of the table, that part of the cam farthest from its center will be in contact with the lever w_2, thus forcing it to the rear. This action draws the rod u_3 to the rear, together with the pawl u, which will engage with the ratchet t_7 and force down the casting t_5, thus dropping the forward end of the table t away from the jaw t_1 and allowing the folding blades s_3 to insert the cloth between these two parts. When the folding blades are removed from the opening formed between the front of the table t and the jaw t_1, the cam w on the shaft s_7 revolves sufficiently so that the lever w_2, together with the rod u_3, return to their normal positions. This action allows the spring v, which has been placed under additional tension by the downward motion of the casting t_5, to be released slightly, thus turning the shaft y and raising the forward end of the table t into contact with the jaw t_1 so as to hold the cloth firmly in position. As the rod u_3 is moved to the front, the pawl u slides up on the shield t_9, thus leaving the ratchet t_7 and casting t_5 under the control of the spring v. The pawl is thus in position to operate the ratchet t_7 as the cam w continues to revolve and the folding blades move forwards again to place the cloth under the jaw t_1.

A similar connection is made to the rear end of the table by means of the arm t_4 that is connected to the casting t_6; this casting is setscrewed to the shaft y_1, which carries a spring v_7. The elbow lever u_5, u_6 that controls the pawl u_4 is operated by a rod u_7 attached to the lever w_3 that is in contact with the cam w_1 on the shaft s_7. The springs v, v_7 through their respective connnecting-rods tend to keep the levers w_2, w_3 in contact with their respective cams, but in addition a supplementary spring w_4 is provided. When sufficient cloth has been folded and it is desired to remove it from the table t, the foot-lever v_5 is raised to the position shown by the full lines in Fig. 4. This allows the springs v, v_7, Fig. 5, to turn the pieces v_1, v_8 in such a direction that the pins shown in these pieces hold down the castings t_5, t_6, thus holding both ends of the table away from the jaws t_1, t_2 and allowing the folded cut to be readily removed.

7. The **driving** of this machine is shown in Fig. 3. The shaft x_2 carries tight and loose pulleys x, x_1 that are driven by a belt controlled by the shipper handle x_4. The shaft x_2 also carries a pulley x_3 that drives, by means of a belt, a pulley x_5 on the shaft x_6, which also carries a pulley x_8. The pulley x_8 drives the pulley x_9 on the end of the roll r_2, which drives the roll r_3 by friction. Another pulley x_7

is setscrewed to the shaft x_6, behind the pulley x_6; by means of a belt, the pulley x_7 drives the pulley x_{10} on the shaft s_7 that carries the cams w, w_1.

8. In some cases, other types of tables are used that differ somewhat from the one previously described. One of these types is known as the *automatic drop-center table*, while another is known as the *solid*, or *one-piece*, *table*. The automatic drop-center table resembles very closely in general construction the table described in connection with Figs. 3, 4, and 5, but the table is so arranged that its center lowers proportionately with the ends as the pile of cloth gradually increases. This type of table is used for a large variety of fabrics and is especially adapted for extra-heavy or coarse goods; it produces folds of even length, an object that is difficult of attainment in the case of heavy goods or when long lengths of cloth are folded.

The solid, or one-piece, table, although not hinged in the center, is operated in a manner similar to the others as regards the lowering of its ends for the insertion of the cloth under the gripping jaws, and is used principally for silks or extra-fine goods.

9. The folder described is equipped with a low back frame and apron, while another type, which is similar as far as the actual machine is concerned, is equipped with a high front frame. The first type is used principally for unfinished goods, although in some cases it is used for finished goods. The second type is used largely for bleached, filled, or starched goods, prints, ginghams, and other finished goods.

The high front frame does not require the use of the zinc apron and the stands at the back of the folder, thus differing from the machine previously described. In this case, a frame supporting rolls similar to r_2, r_3, Fig. 3, is placed in front of the folder so that sufficient space is left for the operator. The cloth passes from the cloth roll, which is supported by small stands, between rolls similar to r_2, r_3, and then down around a drop roll, up over another roll, over suitable guides to a roll similar to s_2 and thence to the folding blades of the machine. The drop-roll arrangement takes the place of the apron of the first type.

10. Measuring Motion.—In many mills, it is the custom for the operator of the cloth folder to count the folds laid on the table, when the machine does not run too fast for this to be done. He thus ascertains the length of each cut. In other mills, measuring motions are used, which indicate on a dial the number of folds or yards of cloth in each cut. A common type of measuring motion is shown at the front of the machine in Fig. 5 and in detail in Fig. 6.

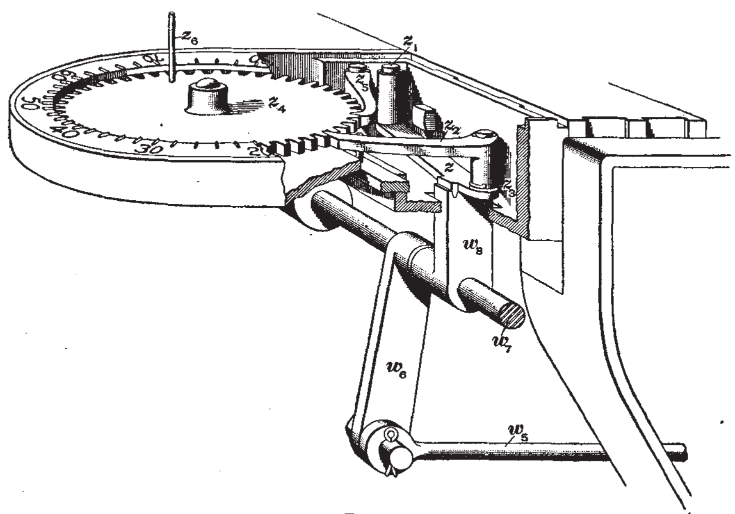


FIG. 6

Attached to the lever w_2, which is actuated by the cam w, is a rod w_5 that is connected at the front end to the bottom of an arm w_6 attached to the shaft w_7. The cam w is so set that each time the folding blades approach the front of the machine, this cam presses the upper part of the lever w_2 backwards, thus drawing the lower end of the arm w_6 backwards. As the shaft s_7 continues to revolve, the lever w_2 is drawn forwards by the spring w_4, and the lower end of the arm w_6 pushed forwards. Thus, the arm w_6 makes a forward or backward movement each time that one layer of cloth is placed on the table, and imparts a reciprocating motion to the vertical arm w_8, which is attached to the shaft w_7. A horizontal arm z mounted on a stud z_1 carries at its opposite end a pawl z_2 also mounted on a stud. The upper end of the arm w_8 is connected to the under side of the arm z by means of teeth and gives an oscillating motion to the end of z that carries the pawl z_2. A spiral spring z_3 serves to keep the pawl constantly pressed against the teeth of a ratchet gear z_4, the various parts being so proportioned as to cause the movement of one tooth to be imparted to this ratchet each time that the folder blades make their forward movement. While the folder blades are moving backwards, the pawl z_2 is being drawn backwards to mesh with the next tooth on the ratchet, a second pawl z_5 holding the ratchet in place until z_2 assumes the new position.

The cover of the measuring motion is so constructed as to form a circular plate, or dial, which is divided into fifty spaces to correspond with the number of teeth on the ratchet. These spaces, each of which counts two, are numbered from 10 to 100, and as the ratchet carries a pin z_6, the number of folds is thereby indicated. For example, if the ratchet is set so that the pin stands against 100, which is really *0*, on the cover and the folding blades make twenty-five backward and twenty-five forward movements, the ratchet will have revolved a distance equal to twenty-five teeth, while the pin will have been carried opposite the point marked *50* on the cover, indicating that fifty folds have been made. In case the folding machine is so constructed and set that each fold consists of 1 yard, the length of cloth folded will be 50 yards.

11. The usual length of each fold of cloth is 1 yard, but folders may be constructed to make folds of $1\frac{1}{4}$ yards, of $1\frac{1}{2}$ yards, or of 1 meter. This generally requires a different machine, although some machines are so constructed that they may be adjusted to give different lengths; for example, from 1 yard to $1\frac{1}{4}$ yards or from $1\frac{1}{4}$ yards to $1\frac{1}{2}$ yards.

In the case of a 1-yard fold the exact length given by the mill varies from $35\frac{1}{2}$ to $36\frac{1}{2}$ inches, according to the policy of the management. In cloth rooms where the fabric is under tension during almost its entire treatment, as, for instance, where it is sewed and rolled, sheared, brushed, and rolled again, it is slightly stretched, and after being folded in loose cuts tends to contract. In such cases, it is often folded slightly more than 36 inches for each so-called yard, and thus controversies with purchasers are avoided.

12. Little need be said concerning the operation and care of a cloth folder, since all parts are readily accessible and easily set. The stands at the back of the machine in which the roll of cloth rests should be so placed as to bring the roll in the center of, and perfectly parallel with, the machine, so as to prevent the cloth passing to the rolls at an angle. Care should be taken to have sufficient cloth in the apron r_4, Fig. 4, so that the folding blades will take the cloth from it and not from the rolls r_2, r_3. If the cloth slips between the rolls r_2, r_3 and they do not therefore deliver the cloth fast enough to keep sufficient cloth in the apron, a weight can be attached to each end of the roll r_3, which increases the friction between the two rolls and prevents this slippage. If the two rolls take in too much cloth for the folder to take care of, the speed of r_2 should be reduced by changing the drive.

The friction placed on the cloth by the bag r_8 and friction board r_9 should also be carefully watched, in order to prevent the cloth being too tight between the roll s_2 and folding blades s_3. If the friction on the cloth is too great, it will be drawn very tight between the folding blades and the roll s_2, Fig. 4, which will sometimes cause the folding blades to pull the cloth out from under the jaws t_1 or t_2 when folding; or perhaps the fold may not be pulled completely out of the jaw, but may be started sufficiently to make the length of the folds uneven. If, on the other hand, there is too little friction on the cloth, it will be very loose and will flap considerably in being folded. This will often result in the cloth sliding ahead of the blades when they stop under the jaws t_1 or t_2, which will also have the effect of making the length of the folds uneven. The friction can be adjusted by increasing or decreasing the pressure of the friction bag on the cloth. The friction can be increased by folding a piece of cloth of the required weight so that it can be inserted in the friction bag, which is practically a flattened tube of cloth so supported that its under surface comes in contact with the cloth as it passes over the board r_7, Fig. 4. The lower edges of the folding blades should always be kept perfectly clean, especially when heavily sized goods are being folded, in which case the folding blades are very liable to become dirty and sticky, and the cloth clinging to them will result in the folds being dragged back.

The length of the fold that is being made by the folding blades should be measured frequently, in order to make sure that it is correct. If the cranks that impart motion to the folding blades need adjusting, this may be done by means of nuts and setscrews on the crankpins. Care, however, should always be taken that the cranks on both sides of the machine are set exactly the same length.

13. Care should also be taken to see that the bushings at the ends of the folder blades are not too loose, and if it is found that this is the case, the play can be taken up by means of setscrews provided for that purpose. Sometimes it will be found that the pawls u, u_4, Figs. 4 and 5, have become so worn by use that they will not properly engage the teeth of the ratchets t_7, t_8. In this case the points of the pawls may be sharpened so that they will properly engage with the teeth of the ratchets, or if the pawls are greatly worn, new ones may be put on. When the teeth of the ratchets become worn or broken, it is usually inadvisable to attempt to repair them by filing or other means; it is far better to put in new ratchets. The folder blades should be so adjusted that there is the same distance between the bottom folder blade and the under side of the jaws t_1, t_2 when the folder blades are in their forward and in their backward positions. When the folder blades are at the limit of their movements in either direction, the edge of the jaw t_1 or t_2, as the case may be, should be in line with, or perhaps a little back of, the top edge of the folder blades.

The rods u_3, u_7, Fig. 5, should be so adjusted that the fron and rear ends of the table are lowered at the proper time. This is accomplished by the adjustments at x, x_1 provided for this purpose. These rods, together with the cams w, w_1, should be so adjusted that the table closes immediately on the withdrawal of the blades from under the jaws. The casting v_1 is connected to the casting v_8 by the connecting-rod v_{11}, which is provided with a turnbuckle x_2, so that both ends of the table can be made to act in harmony by turning the turnbuckle to the proper position.

In case the cloth is pulled out from beneath the jaws t_1, t_2 when the machine is in operation, if there is not too much friction on the cloth it is probable that the springs v, v_7, Fig. 5, need tightening. These springs, however, should not be tightened so that the pressure of the table on the jaws t_1, t_2 is any greater than is absolutely necessary. Usually the pressure of these springs can be tested by pushing down on the cloth table, and it will generally be found that a fairly strong pressure with the hands is necessary to force the table down against their tension. If lint collects on the ends of the table after the machine has been operated for some time, the table should be carefully cleaned; and it may be that the duck covering at the ends of the table is worn smooth and thin, in which case a new covering of duck or other heavy cloth should be placed on them. The slipping or improper gripping of the cloth at the jaws is also caused by the beveled portions of the ends of the table being warped or worn excessively. This can be tested by inserting a piece of paper at intervals throughout the entire length of the jaws; the paper should be gripped between the jaws and the ends of the table. These last two faults are the most common.

The speed of a cloth folder is spoken of as so many yards per minute; that is, while the machine is actually running it is folding that number of yards per minute. The total number of working minutes per day, however, could not be multiplied by the yards per minute in order to obtain the production of the machine, since a large portion of the operator's time is consumed in separating and removing the cuts as they are folded.

14. Cloth folders that fold the cloth in folds 1 yard long are constructed with the tight and loose pulleys x, x_1, Fig. 3, 10 inches in diameter, and when running 250 revolutions per minute will fold 75 yards of cloth a minute, which is a fair average speed for folding ordinary fabrics. A machine of this description occupies a floor space of about $5\frac{1}{2}$ feet by 10 feet. Cloth folders that are so constructed as to fold the cloth in folds $1\frac{1}{4}$ yards in length also have driving pulleys 10 inches in diameter that, when running 200 revolutions per minute, will cause the machine to fold 75 yards of cloth per minute. On some fabrics a cloth folder, if operated by a skilled operator, may be run at a faster speed than that given above, but on the other hand it will be found that where goods are very wide or are very light and delicate, the speed of the machine should be correspondingly reduced. In setting up a cloth folder it is very important that the machine should be set perfectly level. This may be ascertained by placing a level on the front girt of the machine and also on the cam-shaft s_7, Fig. 3.

The cloth, as it comes from the shearing-and-brushing machines and is carried to the folder, is in the form of a large roll, containing a number of cuts stitched together. However, as the cloth is folded at the front of this last machine, the operator watches closely as it passes through, and as each cut is folded, detaches it from the rest of the cloth. Thus, there will be only a cut of about 50 yards in each separate piece of cloth that is taken from the folder. In some mills it is the custom to leave the cloth in double cuts, each separate piece in this case being about 100 yards in length.

MEASURING ATTACHMENTS

15. Cotton cloth when intended for shipment in bales of either single or double cuts is usually measured at the cloth folder, as already described; but when it is to be shipped in a roll, it is usually measured at the rolling head of the last machine through which it passes before being ready for shipment, or at the calender-rolling attachment, if it passes through this process. It is possible, however, to apply measuring rolls and dials to almost any machine through which the cloth passes, as these are constructed in various sizes and styles, with suitable brackets for attaching them, either to the sides or tops of machine frames or to horizontal rails or upright posts.

The usual arrangement consists of a worm on the end of the measuring roll, driving a dial gear, the length run being indicated by a pointer, or finger. When cloth is handled in short lengths, a single dial is used, to register up to 60, 75, or 100 yards. For large rolls, double dials are used to register a maximum of either 2,600 or 5,100 yards, while for recording very much greater lengths, such as the total amount of cloth passed through a machine in a week, counters that will register up to 100,000 yards are applied. The gearing between the measuring roll and the finger on the dial is selected so that as a point on the circumference of the measuring roll travels 36 inches, the finger moves over a space indicating 1 yard on the dial.

STAMPING

16. **Stamping** is the operation of impressing on the outside of a cut of cloth a combination of marks to give information as to the name of the mill where the goods was woven, the name of the cloth, the weight and length of the cut, and frequently a trade mark, etc. The imprint is usually arranged so as to be long and narrow—not more than 15 inches in width and from 20 inches upwards in length, according to the style of the design and the information to be given. It is usually stamped on one-half of the outside fold of the cut; that is, the cut of cloth after leaving the folding machine in 36-inch folds is doubled once so as to reduce the width to 18 inches, and the imprint stamped on one of these halves. In some cases, more particularly where a 45-inch fold is used, one-third of the width is turned inwards on each side, thus reducing the width of the fold to 15 inches, and the impression is then made on the central portion, at the back of the cut. Usually blue ink is used to make the impression, but black, red, and other colors are sometimes used.

The stamps by which the impressions are made consist, in some cases, of wooden blocks with the design or letters that are to be imprinted cut in relief. More commonly, however, they consist of smooth blocks of hardwood into which have been driven the letters or portions of the design previously formed out of strips of copper, the edge of the strip forming the outline of the design desired. The portion of the stamp that indicates the number of yards is usually separate from the remainder, as the length of the cuts is not always the same, thus necessitating a separate series of stamps, the proper ones being selected for each piece. The remainder of the imprint may be in one or more pieces, preferably in two or three; for instance, the name of the mill on one, the trade mark on another, and the weight per yard on a third.

Stamping is performed either by hand, in the case of a small mill, or by machine, in the case of a large mill. A stamping machine operated by power will stamp the product of three thousand looms and is somewhat expensive; consequently, it is not usually introduced in mills with less than five hundred looms running on goods that have to be stamped.

17. The **inking arrangement** is somewhat similar whether for hand or power; it consists of a copper box either filled with water and having a rubber covering or containing a rubber pad filled with water. This is for the purpose of providing a surface that yields to the slight inequalities in the surface of the stamp and affords a means of equalizing the supply of ink. The surface of the rubber is covered with soft cloth or flannel in the case of hand stamping, to which the ink is applied by means of a brush. In the case of machine stamping, the pad is covered by an endless apron, which travels over the surface of the pad and conveys the supply of ink. When goods are stamped by hand, the impression is made just as with an ordinary rubber stamp for making an impression on paper, namely, by first pressing the stamp on the inked surface and then on the cloth, this being continued with different stamps until the design desired is impressed.

18. Stamping Machines.—The machine for stamping consists of a substantial framework to support the various mechanisms required. Vertical rods that slide in suitable guides carry a cross-bar to which are attached as many stamps as are required to complete the design, the arrangement being such that the cross-bar may be adjusted at either end to give a uniform impression. The rods supporting this arrangement are actuated by cams, which raise and lower the cross-bar, and when the latter is dropped into position, another cam produces the desired pressure to make the imprint. A sliding table moves forwards to receive the piece of cloth to be stamped, which is laid on the table in any desired position, determined by adjustable sides; the table then travels backwards until it is in position under the stamps and remains there a sufficient length of time to allow the impression to be made and the stamps to be returned. The table then moves forwards again to admit of the removal of this piece of cloth and the insertion of another piece, during which interval the stamps have again moved downwards, but this time into contact with the stamp pad, so as to receive another supply of ink in readiness for stamping the next piece of cloth.

Stamping machines carry tight and loose driving pulleys 18 inches in diameter and $2\frac{3}{4}$ inches wide, revolving at a speed of about 40 revolutions per minute. The space occupied by such a machine is about 6 feet × 5 feet.

If all the cuts are exactly equal in length, which seldom occurs, the mark to indicate the number of yards in the cut can be impressed at the same time as the other parts of the design; but it is more common to stamp these afterwards by hand, since there is usually a slight variation in the length of the different cuts, so that it may be necessary to stamp one length as 49 yards, the next as $49\frac{1}{2}$, a third as 48, a fourth as 50, etc.

PREPARATION FOR SHIPMENT

BALING

19. To prepare cloth for shipment it is either baled or cased, usually the former. Baling differs according to whether the goods are intended for domestic or foreign shipment, being much more carefully performed in the latter case. When cloth is to be shipped from the mill to the bleacher, converter, or the domestic consumer, a number of cuts (varying according to their length and weight and the size of bale desired) are taken from the compartment in which they are stored in the cloth room, the number of yards and weight of each cut being entered in a book or on a sheet of paper. Each cut is folded one or more times, to reduce its width to the desired size, when it is ready for baling.

20. Baling Presses.—Three types of baling presses are used for cloth intended for domestic shipment—the **togglejoint press,** the **screw press,** and the **hydraulic press.** Screw presses are not now usually adopted, owing to their slow action, and hydraulic presses are expensive and usually too powerful for domestic baling; the togglejoint press is therefore most commonly installed in cotton cloth rooms for this purpose. Fig. 7 is a perspective view of a togglejoint press. The framework of the press is composed of the bed *b*, on the upper surface *a* of which the bale is formed, and the head *c*, both of which may be made of either cast iron or wood. The upright rods, or columns, *d* are usually made of steel and serve to connect the bed *b* with the head *c*. Running horizontally across the machine below the head and between the columns is the screw *e*, which imparts motion to the working arms f, f_1, f_2, f_3. This screw has a right- and left-hand thread and carries two

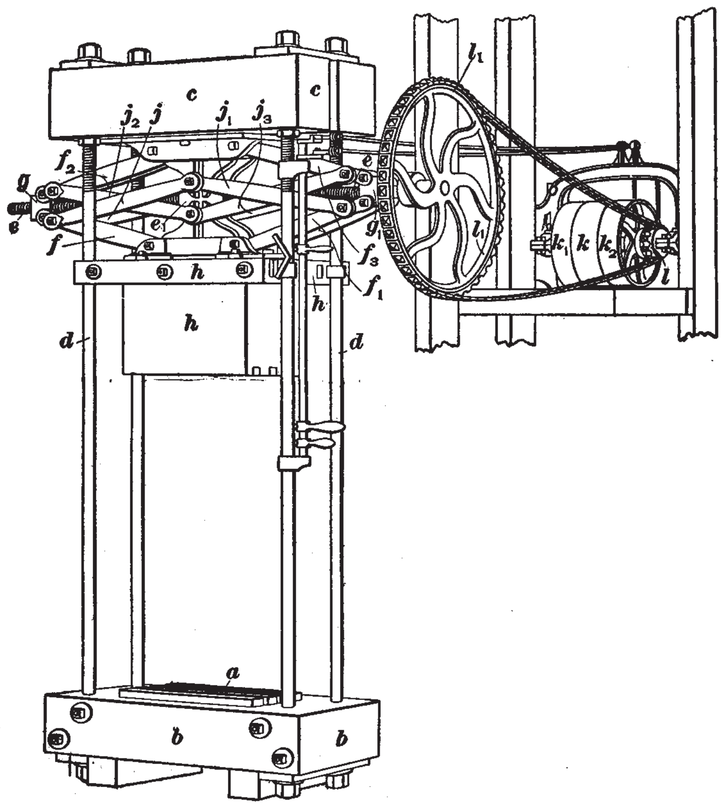


Fig. 7

nuts g, g_1. The arms f, f_2 are pivoted at one end to the nut *g*, while their other ends are connected, respectively, to the follower *h* and to a bracket attached to the head. The arms f_1, f_3 are similarly connected on the other side of the head. By this means, when the screw *e* is turned in one direction, it will draw the nuts toward the center of the screw, straighten out the working arms, and force down the follower *h*. When the screw is turned in the opposite direction, it will draw the nuts out, cause the arms to fold up, and thus raise the follower. The arms j, j_1, j_2, j_3 serve merely to steady the working parts. The bed and follower are constructed with recesses through which cords may be passed while the cloth is under pressure, and secured before the pressure is released.

An automatic power attachment is used in connection with the press and consists of a bracket and short shaft containing three pulleys—*k*, which is attached to the shaft, and k_1, k_2, which are loose on the shaft. The bracket also carries two rods, with belt shippers, springs, and lever attachments for shipping the belts from one pulley to another. One loose pulley is driven by a crossed belt, while the other is driven by an open one and consequently revolves in the opposite direction. On the shaft with the pulleys is a small sprocket gear *l*, which drives, by means of a chain, a large sprocket gear l_1 on the same shaft as the screw *e*. In operation, one belt is first shipped to the tight pulley, which turns the screw in such a direction that the follower is forced downwards until the cloth has been compressed sufficiently, when the belt is automatically shipped to its loose pulley. After the bale has been secured with ropes or bands the other belt is shipped from its loose pulley to the tight pulley, which reverses the screw and raises the follower.

21. Before forming the bale of cloth, the required number of pieces of rope (if rope is to be used) of sufficient length to pass around the entire bale are placed in position in the grooves in the bed; it is becoming the practice now to use, instead of rope, steel bands cut to suitable lengths and secured by buckles. The method of passing these around the bale, however, is much the same in either case. After the ropes or bands have been properly placed in the grooves, a piece of burlap of sufficient size to cover the lower side of the bale and half of the surrounding four sides is placed in position on the top of the bed. The required number of cuts of cloth are then placed on this burlap and covered with another piece of burlap similar to the first, after which the follower is allowed to descend and subject the cloth to the necessary pressure to produce a bale of the required size. The burlap is then drawn up from the bottom and down from the top so as to overlap and the edges are sewed together. The ropes or bands are next secured around the bale and the follower allowed to rise, after which the bale is removed and marked with the necessary shipping instructions and description of its contents, such as style, number, length, or other particulars. This marking is generally done by means of a stencil. If the bales are usually shipped to the same destination and they are usually marked with certain standard markings, it is customary to have these stencils made of brass plate, the letters being cut out. In those mills where the addresses to which shipments are to be made are constantly changing, stencil machines are being introduced which prepare paper stencils in a very short time. After the bales are completed they are trucked to the storehouse and held for shipment.

22. It is not customary to completely enclose the bale of goods in burlap, especially if it is to be transported a short distance, in which case it is common to use only a small strip of burlap for the bottom and another for the top, leaving the sides partly exposed. This is not a good practice, since bales of cloth are carelessly handled in transportation, and the exposed cloth may come in contact with the bottom of a car that is dirty or that has been used for oil, acids, or some other substance that has a detrimental effect on the fabric, or at any rate soils the edges of the folds. Similarly, bales become marked with grime and dirt when laid on wharves. As a result, when the cuts are opened, streaks of grime or dirt will frequently be found running across the cloth where it has been folded or along the selvages. These marks are known to the converters as *bale marks* and are very objectionable, as it is impossible in many cases to remove them in bleaching.

It is customary at the same time that the cuts are piled up in the press to make a record of the contents of the bale; that is, the style of the cloth, the number of cuts in the bale, the number of yards in each piece, the weight of each piece, the total number of yards, the total weight of cloth, and the average weight per yard, thus affording a means of ascertaining whether the cloth is being manufactured according to the weight per yard ordered.

23. Foreign Shipment.—When goods are to be shipped abroad, especially for long distances by ocean transit, the style of baling is somewhat different and much more completely and carefully performed. Bales for ocean shipment are pressed more closely than for domestic shipment, since ocean rates depend on the space occupied. The covering of the bales must be more elaborate, in order to resist moisture. Hydraulic presses are almost always used for baling cloth for ocean shipment, on account of the greater pressure that can be obtained. The bales are also much heavier than domestic ones, from 100 to 200 cuts being sometimes baled together; but this depends on the instructions of the foreign buyer, since in some cases small bales are made, to facilitate transportation to the interior of foreign countries.

The methods of covering foreign bales vary according to requirements, but one example will serve to illustrate all. On the bottom platform of the press a piece of burlap or coarse linen canvas is laid, and on the top of this, tarred cloth, which is canvas covered with pitch to make it waterproof. Above this, one or more layers of heavy gray or brown absorbent paper are laid, so as to prevent the pitch striking through to the cloth, and on this, thick white paper is placed. The cloth is then piled up to the required height and on the top paper and cloth are laid in reverse order, namely, white paper next to the fabric, then gray or brown absorbent paper, then the waterproof tarred cloth, and above it the outside covering of burlap. Sometimes additional sheets of oiled linen cloth are placed next the outer layer of paper, with still another layer of absorbent paper next the white paper. The lower platform of the press is raised by hydraulic power and the ends of all the layers folded so that they will overlap and yet remain in their respective relative positions to the cloth. The outer coverings are sewed up at the sides and ends, after which four or more steel bands, usually painted to prevent corrosion, are secured around the bale and fastened by rivets, after which the pressure is released, the bale removed, and the necessary shipping marks placed on with stencils, together with the customary injunction, "Use no hooks."

SHIPMENT IN ROLLS OR CASES

24. It is becoming more and more customary to ship ordinary cotton cloth from the mill to the converter in rolls, just as it leaves the shearing-and-brushing machine, or, where it is not required to be sheared and brushed, as it leaves the sewing-and-rolling machine; that is, after the wooden roll on which the cloth is wound at these machines is removed. In this case a piece of burlap is placed around the roll and sewed where the ends overlap. The roll is then placed on its end and a small piece of burlap tucked in the upper end and sewed around the end of the roll along the edge of the selvage of the piece of burlap previously placed around the roll of cloth. The roll is then stood on this end and the opposite end covered in the same way, thus completely enclosing the cloth.

25. Another method of shipment is to pack the cuts of cloth in cases. This is common for ginghams and those fabrics that leave the mill in the condition in which they are forwarded to the dry-goods commission houses, ready for the dry-goods store. The cases are constructed to hold the required number of bolts of cloth and are lined with paper. After the cuts have been packed in the case, they are pressed down and the cover nailed on; the cases are then stenciled with the required shipping instructions, after which they are removed to the storehouse to await shipment.

CLOTH INSPECTION

26. The proper inspection of cotton cloth is one of the most important matters in connection with the operation of a cloth room. It is important to have every piece examined in order to detect faults and trace them to the weaver who has caused them or allowed them to pass. It is also a means of detecting faults in the cloth that cannot be attributed to the weaver, but to some other operative in the weaving department or in some other department; as, for example, wrong drafts in the drawing-in room, or unsuitably mixed cotton, or defective yarn produced in the spinning room. By the inspection of cloth the different cuts are also graded for shipment. Almost every mill divides the cuts into two grades—firsts and seconds—and some into three or more grades, depending on the strictness of the buyer's requirements or the reputation that the mill desires to maintain. In addition to the regular grades, the inspection also results in producing a certain number of remnants, or *mill ends.*

27. Among the principal faults to be watched for is that known as *ends out*, where the weaver has failed to replace a broken end or ends as soon as the breakage occurs. *Mispicks* result when the loom, after having been stopped by the filling breaking or running out, has run for a pick or two before being entirely stopped and then the weaver in starting with fresh filling has allowed the first pick of the new filling to lie in the same shed as the last, thus giving two consecutive picks in the same shed; this trouble is accentuated in fancy or colored goods, where the additional defect of making a break in the pattern results. *Broken picks* result when a pick of filling breaks part way across the shed and is not removed so as to be replaced by a complete new pick. *Bad selvages* are due to various causes. *Smashes* are produced by the shuttle remaining in the shed and breaking out a portion of the warp yarn; these can be remedied, if not of serious proportions, by the weaver piecing up the warp and making a new start in such a way as to avoid evidence of there having been a smash, although this is not always done. *Thin places* in the cloth may result from starting the loom improperly after a breakage in filling, or may be caused when the loom is running; *thick places* are also caused in a similar manner, there being too much filling in a given space in comparison with the remainder of the fabric. *Floats* occur where there has been an entanglement in the warp resulting in imperfect interweaving for a short distance filling-way and warp-way, thus producing a hole in the cloth or a thin place where it has been scratched over. Most of these defects are the fault of the weaver.

Slubs, or *slugs*, and *thick places* in the filling are due to defective yarn preparation, attributable to departments previous to the weaving department. An *insufficient* or an *excessive number of picks* per inch results when the wrong take-up gears are placed on the loom by the fixer or second hand; and many other defects of a similar nature occur that are not the fault of the weaver. The duty of the weave-room overseer, in a small mill where he is also the cloth inspector, is to call the attention of the proper officials to these faults, that they may deal with them in such a manner as will prevent or reduce the frequency of their occurrence and may also decide whether the cloth shall be considered as first quality or as seconds.

In case a defective length of cloth must be entirely cut out, it is customary in most mills merely to lay the two remaining pieces together and mark the cloth with the combined length of the two pieces, thus, $25 + 20 = 45$. This forms a *blind end*, and if shipped to the converter in this condition, this defect will not be discovered until the cloth is being run through some machine at a rapid rate, which will cause much loss of time in threading the cloth through the machine again and frequently the spoiling of a number of yards by the defective treatment of that portion of the cloth. The converter prefers that the two cut ends should be sewed together so as to make one continuous cut. Whenever it is necessary to sew two ends of cloth together for this or any other reason, it should always be done by machine and not by hand, since hand-sewed seams in the gray cloth almost always break when they are subjected to the strain that is applied in certain converting machinery, thus causing entanglement and spoiling a considerable length of the fabric. Similarly, when in a piece of cloth a place that has been allowed to pass through the loom without having filling inserted is discovered, the two woven portions merely being connected by warp ends, this should be cut out and the ends sewed together. Since the warp alone is not sufficient to stand the strain of the converting processes the cloth would be broken or, in case of singeing, the ends would be burnt away, thus causing a break.

28. The cloth-room inspector should be trained to consider the requirements of the converter as far as possible, in order to obtain for the mill a good reputation for delivering cloth that causes little trouble in bleaching, dyeing, or printing. For example, the inside end of a piece of cloth should be left flat when the folds are doubled over for shipment and not allowed to crumple, as is often customary, since this causes wrinkles for $\frac{1}{2}$ yard or more, which cannot easily be removed. The converters also appreciate a good selvage to a fabric, since defective selvages, by breaking, cause as much trouble as any other fault in cotton cloth, if not more. Many of the faults produced in weaving show up much worse after the cloth has been dyed or bleached.

The practice of placing pins or leaving needles in cloth should not be permitted; they should be looked for by the inspector and removed, as well as broken teeth of combs that have been used for scratching up defective places. Any such metallic substances damage the rolls of the converting machinery or adhere to their surfaces, thus producing a series of damaged places for a considerable distance.

No black lead (graphite) marks should be permitted, nor marks made by any material containing wax or grease, since such marks will not bleach out. Pure chalk crayons only should be used in any department for marking cotton goods, especially cloth that is to go to the converter.

29. The standard of quality for grading the cuts depends on the policy adopted by the mill and the requirements of the buyer, so that it is difficult to give any hard and fast rule for this. In general, it may be stated that where the requirements are fairly stringent and where cuts that contain any serious imperfections or any excessive number of minor imperfections are not classed as first quality, the number of seconds should not exceed 2 per cent. in a well-managed mill; it should be less than this for ordinary plain goods and not greatly in excess for fancy or colored goods. Some mills making both plain and fancy goods keep their seconds at less than $1\frac{1}{2}$ per cent. the year around.

30. Cloths may be inspected in the cloth room in three ways: (1) at the brushing-and-inspecting machine shown in Fig. 1; (2) by means of an inspecting machine of simpler construction, consisting of little more than a black slanting table over which the cloth is drawn by hand or by means of revolving rolls which can be readily stopped in case a defect is noticed; (3) fold by fold, after it has been removed from the cloth folder and laid on a flat table.

The most common and perhaps the most satisfactory system of inspection is the one last named. The piece of cloth as it is taken from the folder is doubled over on itself once and each fold turned over by hand, and any defects noted. After one side has been inspected, the piece is turned over end for end and the other half of each fold examined in the same way. This is a more expensive system than the first and second, but results in a more careful examination, and as the piece of cloth is stationary the minor defects can not only be observed but in some cases remedied. For a more careful inspection, the cloth is laid flat as it comes from the folder and an entire fold turned over each time. In the larger cloth rooms the inspection is usually performed by girls, who refer especially defective pieces to the superintendent of the cloth room for final inspection and action.

31. The appliances required in a cloth room are scissors, cloth nippers, weaver's combs, a block of wood, a cloth rubber, water, soap, and oxalic acid. The scissors are for the purpose of cutting out defective lengths of cloth, separating the pieces of cloth into single cuts, and clipping off loose ends of yarn. The nippers, shown in Fig. 8 (*b*), are for the purpose of grasping slubs and lumps in the cloth that have not been otherwise removed, and drawing them out. The comb, Fig. 8 (*a*), consisting of a number of sharp teeth leaded into a brass back, is for the purpose of scratching adjoining ends of warp or picks of filling over a thin place

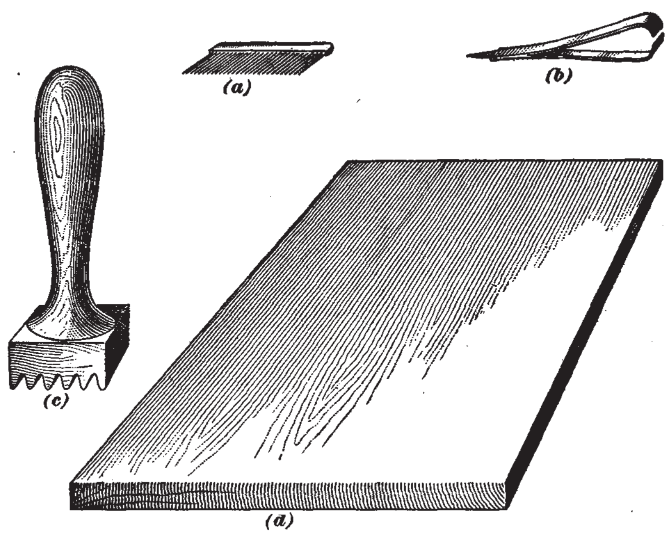


Fig. 8

or hole; as, for example, after a slub has been removed, the comb is used to draw over the open space preceding or succeeding picks of filling and remove any evidence of a flaw in the cloth. Small floats are scratched over in the same way. Spots or streaks of black oil are often found in cotton cloth, and if caused by a spot of oily lint, can sometimes be picked out with the nippers, but more frequently after doing so, or in case it is impossible to remove it with the nippers, the black place must be soaked in oxalic acid and rubbed until the black spot disappears, after which that portion of the cloth must be carefully and thoroughly rinsed out with clear, cold water, so as to prevent the action of the acid continuing and *tendering* the fabric.

In some mills the use of oxalic acid for this purpose is prohibited, and oil stains are removed by means of soap and water. A good plan is to have a piece of whitewood board about 9 inches wide, 18 inches long, and $\frac{5}{8}$ inch thick, Fig. 8 (*d*), which is used bare or covered with several thicknesses of cloth and placed under the oily mark. A little water is then poured on the fabric and the spot rubbed with white soap of good quality. When it has become thoroughly saturated with soap and water, it is rubbed with a wooden cloth rubber, such as is shown in Fig. 8 (*c*), which is an implement having the upper part fashioned into a handle and the lower part corrugated, until the marks are effaced, after which the cloth is rinsed with clean water and wiped as dry as possible with a clean cloth.

SUMMARY

32. A summary of the combinations of machines and processes used in the cloth room is now appropriate. The treatment of fabrics in the cloth room and the number of processes used depends on: (1) the class of goods made by the mill; (2) the differences of opinion among mill men as to what is suitable treatment even for the same fabric; (3) the policy of the management, whether tending toward economy in cost at the expense of quality or the desire to produce the best quality irrespective of cost.

Inspection and folding or rolling are the only absolutely essential processes in the cotton cloth room. Some mills making standard goods, such as print cloths, where little advantage is to be gained by making a high quality and where the only thing to be noted in the cloth room is to prevent too low a quality, are content with passing the cloth directly from the loom through a folder, inspecting it afterwards by hand, and then baling the cloth for shipment. Where such fabrics are shipped in a roll, they are passed through a sewing-and-rolling machine, inspected at the same time, and shipped in the roll; or sometimes after being sewed and rolled they are passed through an inspecting machine, rolled, and shipped.

The later processes of brushing, shearing, and calendering depend on the conditions named. Shearing is adopted only when it is desired to bring out the pattern strongly or produce a comparatively bright face on the fabric, and where shearing is adopted it is always combined with brushing. Shearing-and-brushing machines may be used for coarse, medium, or fine fabrics, the differences being in the adjustment of the shears and brushes, since a delicate fabric will, of course, not stand the same amount of shearing and brushing as a coarse or medium fabric. The number of shears and brushes, generally speaking, is determined by the cloth to be operated on; the larger numbers being used for heavy and coarse fabrics. In some cases a large number are used for fine fabrics, each being set to operate lightly.

Emery rolls, beaters, and card rolls are usually applied only to those machines intended for dealing with coarse or medium fabrics, especially such as duck, ticking, sheetings, twills, etc. Such heavy fabrics will withstand the pressure and strain brought on them by the emery rolls, the beaters, and the card rolls, being finally treated by stiff brushes and either calendered or not, according to the requirements of the mill or of the buyer. For such fabrics it is not common to use shears, since sheetings and similar goods are enhanced in value if they have a full, soft appearance and feel.

The removal of dust, dirt, and small particles of foreign matter is desirable for all fabrics, and consequently brushing combined with a strong exhaust fan for removing the dirt brushed off is common to the treatment of almost all fabrics. In general, therefore, it may be stated that coarse, heavy goods, where a bare surface is not desired, are treated by emery rolls, beaters, card brushes, stiff brushes, and are sometimes calendered. Coarse goods, where a full, soft face is not desired, are treated by shearing also. Medium and fine goods, where a bare face is desired, are sheared and brushed, but not usually calendered, the extent of the shearing and brushing being determined by the number of shears and brushes in the machine and by the closeness or openness of the setting. Fine goods, of course, will not stand as close a setting as medium and coarse goods. Sewing machines are only used where the fabric is to be shipped in a roll, or where a number of cuts are to be sewed together to facilitate the passage of the cloth through the shearing, brushing, or calendering machines. Otherwise, the sewing-and-rolling machine has no part whatever in changing or improving the appearance of the fabric.

The absolutely necessary processes in a cloth room are merely those that change the form from that in which the cloth leaves the loom to that in which it is to be shipped, namely, the folding or baling, or in some cases rolling, and, where required, stamping or ticketing. All other processes are optional. In fine-goods mills, especially those making fancy goods, and where the cloth is to be immediately forwarded to the converter, it is not usual to adopt any machines except the folding and inspecting machines and baling presses. The pieces are not even sewed together, but each piece is inspected on a machine of simple construction, then folded, inspected, and afterwards baled.

MILL ENGINEERING

(PART 1)

MILL CONSTRUCTION

SELECTION OF A MILL SITE

1. Introduction.—The immediate reasons for the erection of textile mills may be classed under three heads: (1) capitalists seeking a new location of investment; (2) established mills making extensions; (3) local individuals promoting the erection of a mill. Under the first condition a company or corporation is first formed and the necessary capital invested. A location for the plant is then chosen, in which connection there are many points to be considered, all of which depend on the natural and artificial advantages of the locality. From the mill engineer's point of view, the natural advantages of a location, such as the character of the soil on which the foundation is to rest, the reliability of the water supply, if water-power is to be used, and many other like considerations are the more important, while from the manufacturer's standpoint, the artificial advantages, such as proximity to the market and to the raw-stock supply, and the class of help that can be utilized, are the more important. It is the function of the mill engineer to adapt a site, often chosen without particular regard to engineering considerations, to the needs of the manufacturer.

Under the second and third conditions, the choice of the site for a mill structure is generally more limited, and both the manufacturer and the engineer must adapt themselves to the conditions that are met with, especially when additions are to be made to established plants.

2. Class of Goods to Be Manufactured.—In entering into a discussion of the natural and artificial advantages of various locations, the first consideration should be the class of goods that is to be manufactured. For instance, if the mill is to manufacture cotton yarns or fabrics and a fine quality of goods is to be made, it is advisable to locate the mill in a district where there are other fine-goods mills; that is, in a fine-goods center. For the medium and coarser grades of cotton manufacturing the South is now offering excellent locations, while the fine-goods mills are still largely confined to the North. The same conditions apply to silk mills, which are usually concentrated in some locality that is especially adapted to their needs, owing to its proximity to a supply of labor, or other considerations. If the mill is to engage in the manufacture of woolens or worsteds, the field is larger, since these industries are not so concentrated, but more scattered throughout the country, each mill being erected where the best and most advantageous conditions are found; worsted mills, however, are more concentrated than woolen mills.

3. Help to Be Employed.—One of the main considerations entering into the choice of a locality for the plant is the class of people from which operatives can be obtained. It is preferable to locate the mill where skilled and trained help can be obtained at a minimum expense; but if this is impossible the mill should be located in a district where large numbers of intelligent people can be utilized as operatives even if they are totally untrained. With the aid of a skilful superintendent and overseers, together with a few skilled workmen, this class of help can, in a short time, be trained to meet the requirements of the mill. Formerly the native help was depended on entirely in American mills, but of late years a large number of French-Canadians, Portuguese, etc. have been utilized, so that a well-located mill is often situated in close proximity to a large resident population of foreign help. In the South, many mills are located in the upland, or mountainous, districts and the mountain population is drawn on for the necessary help. In the North and Middle States, the question of a good supply of native help is not so important, because of the large resident colonies of foreign help in all large manufacturing centers.

4. **Market and Transportation Facilities.**—The proximity to the raw-stock supply is also an item of the utmost importance to the manufacturer, and in the South many mills are advantageously located near, and in some cases actually in, the cotton fields. The Northern and Middle States, which are essentially manufacturing districts, do not offer these advantages, and the mills should be located preferably with reference to large markets and shipping points. This is true of cotton, woolen, worsted, and silk mills, since by this means the raw stock can be more readily and cheaply transported to the mill, while the buyer for the mill is also able to keep in closer touch with the fluctuations of the market, thus enabling the mill to purchase to advantage, and likewise keep in closer communication with the selling houses.

Railroad and other transportation facilities should in all cases be carefully considered, and if possible the mill should be situated in close proximity to two or more railroads or other methods of transportation under separate control, thus securing the advantage of competitive freight rates. It is always an advantage to have the plant situated on the direct, or main, line of a railroad, but in some cases where this is impossible the railroad company, especially in the South or West, can be induced to run a spur, or branch, track to the mill, provided that the amount of traffic will warrant the expense; the railroad companies will not always do this in the Middle or Eastern States, however. Railroad facilities are indispensable and the distance from the market is not so important an element as the freight rates, for it often happens that one location, while more remote from the market than another, offers greater facilities for transportation.

5. Fuel and Mill Supplies.—Another consideration that should enter into the choice of a location is its proximity to the machine shops where the equipments of the mill were purchased, and which also are frequently sources of mill supplies; since if the locations are near, parts of broken machines, supplies, and other materials can be obtained at short notice, thus preventing portions of the mill from lying idle while awaiting repairs. This is an especially important consideration with mills that are not equipped with complete machine shops, including facilities for producing parts of the machinery most liable to become worn or broken.

A mill should be located near large coal fields, if possible, thus insuring a plentiful supply of fuel at low rates; but, as in the case of New England, this is often impossible. In many instances the best location is on tide water, since the rates of transportation of coal by water are much lower than by rail.

6. Water Supply.—If the mill is to be located on a stream and water-power is to be used, several points in regard to the character of the stream should be noted. The abundance of the water supply for a number of successive years should be determined, in order that the maximum and minimum amount of flow can be ascertained. It should be determined whether the minimum supply will be sufficient to operate the mill; in this connection the extent of the watershed, or area drained, should be considered, since some very small streams are never known to run dry, while many larger ones run extremely low during certain portions of the year. The water supply should be as uniform as possible and the river free from freshets as well as from dry periods. A river that is free from ice is also to be preferred to one that is periodically blocked, although the Merrimac River, on which Manchester, New Hampshire, and Lowell and Lawrence, Massachusetts, are situated, and which is the largest manufacturing river in the world, is subject to both ice and freshets. The natural conditions that govern the construction of the dams, canals, sluices, etc. should also be considered before finally deciding on a mill site, as these will enter largely into the cost of construction, unless there is an existing water-right from which water-power can be purchased. As water-power is the most easily developed power and can be had for a very small expense, many small mills are located largely with reference to the water-power facilities.

Care must be taken also to have a suitable water supply for general mill purposes, such as for the boilers, drinking water, dyeing purposes, and in the case of woolen and worsted mills for scouring and finishing. The mill should also be located with regard to the drainage and sanitary conditions and should preferably be situated on a gentle slope.

7. Formerly the climatic conditions were a very important consideration in the location of a mill, because of the greater facility with which some fibers could be manipulated under certain atmospheric conditions; but at present this is of little importance, since the temperature of the mill is easily regulated, and with the improved types of humidifiers now on the market the percentage of moisture in the air is easily governed.

In many cases, especially in newly developed territory, local authorities will remit the taxes of a proposed plant for a term of 5, or sometimes 10, years as an inducement to attract worthy enterprises to their locality. Offers of this kind should always be solicited and accepted, provided that no serious conflict with other advantages is thereby created.

EXCAVATIONS

CHARACTER OF SOIL

8. After the general locality of the mill has been decided on with due regard to the natural and artificial advantages, it is necessary to choose the actual site of the structure. In this connection the character of the soil on which the foundation is to rest should receive the most careful consideration. It is well to have expert engineering advice on this point, since the services of a mill engineer are invaluable in the erection of large and important mill structures. A good mill engineer, especially one who is independent of machine shops, will save the cost of his fees many times over, not only in the reduced cost and increased stability of the structure and its equipment, but also in the reduced cost of operating the mill, by so arranging the equipment that the transit of material and the number of employes necessary are reduced to a minimum.

A perfect foundation is one of the most difficult problems of engineering as well as one of the most important, for on it depends the stability of the whole superstructure. If after completion and the installation of the machinery the structure settles to any great extent, the results are disastrous; even a small settlement, especially if not uniform, will cause great annoyance by throwing the shafting out of line. When this happens the wear and tear on the shafting and hangers is greatly increased, as well as the power required to drive the mill. Besides the annoyance resulting from having the floors out of level, if the foundations are weak or insufficiently supported, all the subsequent stonework and brickwork are likely to crack and greatly spoil the appearance, and lessen the strength, of the structure.

Before building the foundations for the mill the ground must be excavated, either for the basement or for trenches, so as to place the masonry below the frost line; but before the excavation is begun the nature of the soil that is to support the foundation should be determined. If this cannot be determined from existing structures or wells, borings should be made. For this purpose, an auger about 2 inches in diameter and of suitable length is used—similar to an auger for wood boring—and tests made, from 5 to 10 feet apart, over the entire area of the foundation. As the auger brings up samples of the soil, the character of the substrata is determined. When the importance of the proposed structure requires it, trial pits are sometimes dug from 10 to 20 feet apart, especially where a shelving bed of rock or gravel exists at a comparatively short distance below the surface.

It is not always safe to rely on the character of the soil in close proximity to the proposed mill site, since conditions varying from a bog to a solid granite ledge are often found in the space of a few yards. The soil or strata usually met with in building operations may be classed under three divisions—*rock*, *virgin soil*, and *made ground*.

9. Rock, in its original geological formation, is spoken of as bed rock, or solid ledge. It forms the finest foundation for heavy structures, provided that it is of sufficient area for the entire mill to rest on. But it is undesirable to have a portion of the foundation rest on a ledge while another portion rests on a softer material, since the mill will not settle uniformly and the walls will often crack open at the junction of the ledge and softer material. It often happens that the surface of the rock is uneven and requires considerable blasting and concrete work to secure a good foundation, which adds considerably to the cost. The sandstones and limestones are often found in strata, beds, or layers, one on another; if these layers are not separated by clay, and the beds are even, they make good foundations. The strata, or beds, of rock may shelve, or dip, at varying angles, especially in hilly sections. A ledge is not always reliable, and in many cases will be found to be shaly in structure, partly decomposed, or faulty in other respects.

10. Virgin soil is either gravel, clay, loam, sand, or marshy ground in its natural condition.

1. *Gravel*, when compact and united with sharp sand into a firm, unyielding stratum, is known as *hard pan*. It makes the best foundation (except bed rock) and, on account of its being more easily leveled, is much less expensive to build on. Usually a 6- or 8-foot stratum of gravel will support any mill structure although there may be softer material underneath.

2. *Clay* is the most uncertain of soils, owing to its elasticity, due to being mixed with marl, etc.; to its tendency to absorb moisture; and, in many cases, to the position of its bed or strata. In dry seasons it is very firm, while in wet

seasons it is elastic and unreliable. When the layers of clay are inclined, the foundation has a tendency to slide, producing results threatening the stability of the superstructure.

3. *Loam*, or clay mixed with sand and other earthy substances, when compact and of considerable depth, is a good material to build on, provided that the structure is not an extremely lofty or heavy one.

4. *Sand* is formed from the decomposition of the older rocks, either by the effects of the weather, the action of heavy rains, the wearing away by running water, or the spontaneous decomposition of the rocks themselves. The particles are carried to the rivers and either deposited in their beds or borne out to the ocean. The sand usually found in excavations has its origin either as the formations in the beds of ancient rivers that have long ceased to flow, and is therefore called *river sand*, or by the attrition, or grinding, of the rocks themselves during the geological upheavals in past ages. The latter is called *virgin*, or *pit*, *sand*, and has never known the action of water.

5. *Quicksand* is a very fine sand, often mixed with clay or loamy material in such proportion that it will retain water until it is perfectly saturated. But by confining quicksand and keeping it as nearly dry as possible, it may be excavated or built on with little more difficulty than common sand. In many cases, quicksands are mixed with a bluish or leaden-colored silt, or soapstone slime. Often in excavating quicksand, beds of this blue marl are found; when wet it is tough and hard, but when dry, it crumbles to a powder and is utterly unfit for foundations. An attempt to excavate in quicksand without previously getting rid of the water contained therein, is almost as useless as to dig in water itself, for the saturated sand will flow into the excavation as fast as it can be removed.

6. *Marshy soils* are formed by the decay of plants, weeds, and other vegetable matter in sluggish water, which, having no current, allows the plants, etc. to take root in the bed. When these plants die, others take their place each year. These successive beds of decayed matter are formed under

slight pressure and have innumerable cavities between them, as would a heap of decayed hay. Sometimes these deposits reach such a depth that their bottoms have not been reached. Large areas of marshy lands are formed in this way, by the periodical overflowing of rivers, and the rise and fall of the tides along the coast. The terms *swamp* and *bog* are often used and may be considered here as having the same meaning as marshy soil.

During freshets, rivers bring down large quantities of soil held in suspension, which is deposited when the waters subside. This formation is called alluvial, from the Latin word *alluvius*, meaning a washing upon. The term alluvial is often used to designate deposits that are of yearly recurrence, as the Nile and the Mississippi deltas, although the river bottoms of many streams are of this origin. The value of alluvial soil for foundation purposes varies considerably. In many cases, it consists of a clay formation that is hard on top, especially during dry weather, but soft and unreliable underneath. Heavy buildings should not be erected on alluvial ground without a careful investigation of the subsoil by means of borings or trial pits.

11. Made, or **artificial, ground** may consist of various kinds of materials; such as the refuse of cities, earth and other materials removed from cellars and other excavations, the cinders, ashes, etc. from manufactories and furnaces. It should not be built on, if the structure is of importance, until the nature of its subsoil has been investigated, though for minor edifices a suitable foundation may often be obtained on it.

12. From this description of the soil and materials met with in foundation beds the following deductions may be made:

It is generally safe to build on bed rock any structure that may be required, provided that the foundation beds are kept level.

Gravel, even when mixed with small boulders, can be considered perfectly reliable for any ordinary structure, under usual conditions.

Sand will carry very heavy loads, if it is confined; but great precautions must be taken to properly confine it, and also to keep water, especially if running, from it, as the action of water will soon wash it away.

Clay, when compact and dry, will carry large loads, but water should be kept from it, both under and around the structure, the foundations of which might otherwise give way, due to the difficulty of retaining the pasty or semiliquid mass formed.

A thick, hard, or compact stratum, overlying a much softer one, even silt or quicksand, will often carry a considerable load, the hard stratum floating on the soft as a raft floats on the water. It is usually better not to break through this hard stratum, as it serves to spread the base and distribute the pressure over a large area.

The silt, slush, and decayed vegetation contained in the marshy lands, especially in the Southern States, are not fit to build on without piling.

BEARING VALUE OF FOUNDATION SOILS

13. There is some difference of opinion regarding the safe bearing value of foundation soils, due probably to the difficulty of arriving at any experimental results that will have a general application. Conservative engineering practice dictates that the greatest unit pressure on the different foundation soils shall not exceed the values given in Table I.

FOUNDATIONS

FOOTINGS

14. It is important that the area of the footings, or supports, for the foundation wall be increased beyond that of the latter in order to decrease the weight per square foot. By spreading the weight of the structure over a larger area, it is more evenly distributed, and the likelihood of a vertical

TABLE I

SAFE BEARING VALUES OF DIFFERENT FOUNDATION SOILS

Material	Tons per Square Foot
Granite formation	30
Limestone, compact beds	25
Sandstone, compact beds	20
Shale formation, or soft, friable rock	8 to 10
Gravel and sand, compact	6 to 10
Gravel, dried and coarse, packed and confined	6
Gravel and sand, mixed with dry clay	4 to 6
Clay, absolutely dry and in thick beds	4
Clay, moderately dry and in thick beds	3
Clay, soft and semifluid	1 to $1\frac{1}{2}$
Sand, compact, well-cemented, and confined	4
Sand, clean and dry, in natural beds, and confined	2
Earth, solid, dry, and in natural bed	4

settlement, due to the compression of the ground, is greatly diminished. For this reason, the higher and heavier the building is to be, the wider and deeper must be the supports, or footings, for the foundation; and if extremely soft or yielding ground is encountered, piling should be resorted to in order to carry the weight of the building to a more solid base.

15. Footings may be of iron; timber; large, flat, building stones, laid directly on the ground or on a bed of concrete; or they may be of concrete alone, or concrete and stepped-up brickwork. Where piling is used, heavy capping timbers are often placed on the heads of the piles, with either stone or concrete footings; or large footing stones may be laid directly on the piles.

16. **Timber Footings.**—Timber is often used for footing courses where a large bearing surface can be obtained and is necessary; provided, always, that the timber can be kept from rotting. In some cases the timber is charred on the outside; in others, it is coated with asphalt. If the ground is continually wet, there is little to fear, as timber will not decay when continually saturated with water; but when alternately wet and dry, unprepared timber cannot be depended on.

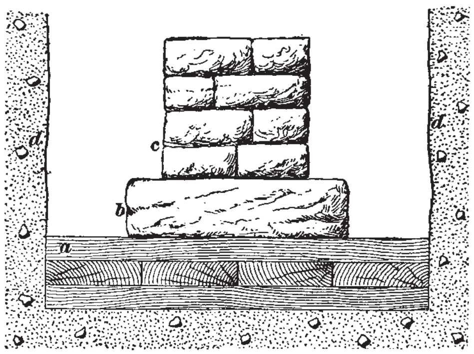


FIG. 1

The best method of placing plank under walls for footings is to use 3″ × 12″ plank cut in short lengths and laid crosswise in the trench. A layer of plank of the same size is then laid lengthwise, and the third layer is placed transversely. As

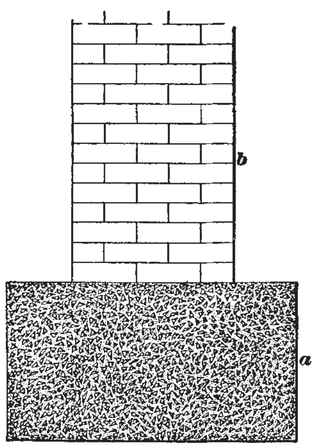


FIG. 2

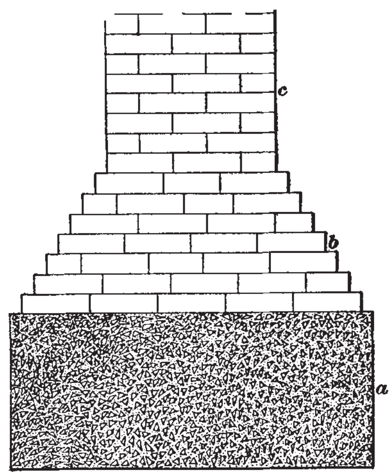


FIG. 3

shown in Fig. 1, *b* is the stone footing resting on the planks *a* and carrying the stone foundation wall *c* between the walls *d*, *d* of the trench.

17. Concrete and Stone Footings.—Fig. 2 shows a 20-inch brick foundation wall *b* on a concrete footing *a* 20 inches thick and 3 feet wide.

Figs. 3 and 4 show the concrete base *a* and stepped-up brick footing courses *b*. In Fig. 3, each course of brickwork sets back $1\frac{1}{2}$ inches for each course; in Fig. 4, the courses are set back 3 inches for each two courses. At *c* is shown a 20-inch brick foundation wall resting on the stepped-up brick footing.

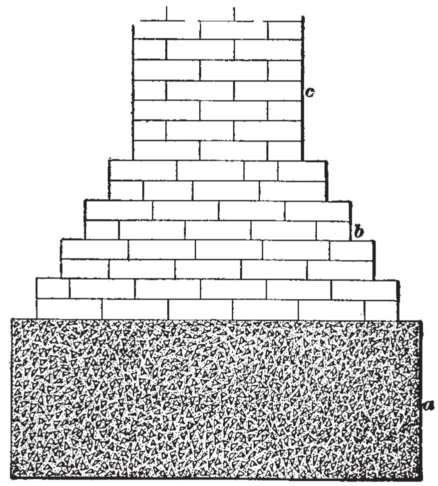


Fig. 4

Fig. 5 illustrates a stone footing composed of three courses *a* of flat stone, each course being 8 inches thick. The top course has a projection of 6 inches on each side of the 20-inch brick foundation wall *b*, while the middle and bottom courses project 3 inches each, making the width of the bottom stone 3 feet 8 inches.

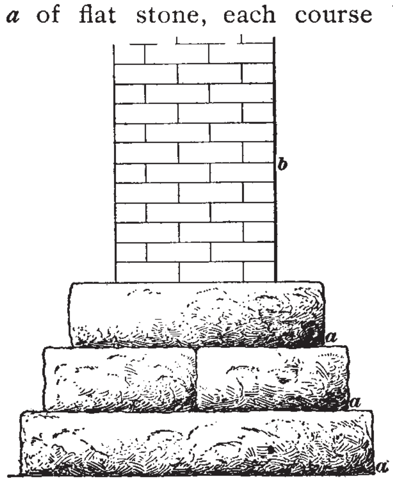


Fig. 5

Fig. 6 shows a stepped stone footing *a*, similar to that shown in Fig. 5, but supporting a 24-inch stone foundation wall *b*. Each base course advances in stages of 3 inches.

Fig. 7 shows a footing consisting of a single course of stone *a*, 8 inches thick and 2 feet 4 inches wide, carrying a stone wall *b* 20 inches thick.

18. As a general rule, concrete, when of sufficient depth and width and properly made and laid, makes the best of footing courses. It should be made of one part good cement, three parts clean, sharp sand, and five parts sharp, broken stone. In very important work, such as the footings of very high buildings, chimneys, etc., a proportion of one part cement, two parts sand, and four parts broken stone is generally used. The New York building laws call for the first proportion.

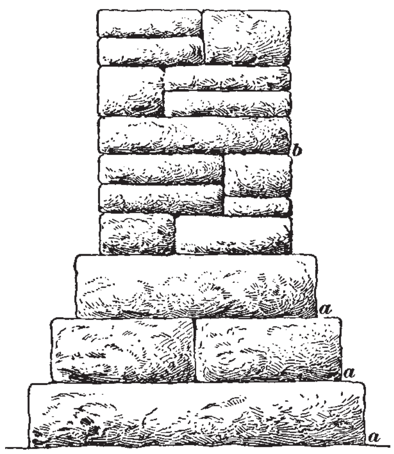


FIG. 6

None of the stone used in making concrete should be larger than will go through a 2-inch ring. In localities where stone cannot readily be obtained, broken brick or terra cotta may be used in the same proportion as stone, taking care to use good hard-burned material. Well-broken foundry slag and scoriæ, steam-boiler ashes from anthracite coal, and clean-washed gravel, mixed in the proportion given, make good concrete, though gravel, being round and smooth stone, does not adhere to the cement as well as broken stone, slag, brick, or scoriæ.

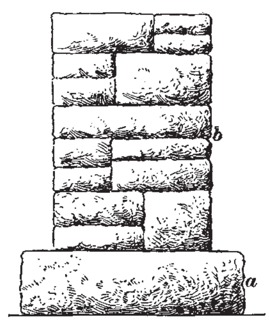


FIG. 7

In preparing concrete, the material should be worked on a platform of boards, with sides about 10 inches high, battened on the back and laid on the ground near the work. The platform is used in order that no loam or clay may contaminate the concrete, the effect of which would be a loss of strength in the concrete, as the clay adheres to the stone and prevents close contact with the cement. The sand and cement should first be thoroughly mixed by being shoveled together while dry, at least twice, so that there will not be an unequal proportion of sand to cement in different parts of the heap. The broken stone, or whatever material is used for the *aggregate* (as the stone, slag, or other coarse material is called), should then be added, the mixture being kept wet all the time and thoroughly shoveled together, so that every portion of the stone or other material may be perfectly coated with the cement. No concrete should be made unless it is to be used at once, because the cement, forming its most essential part, sets or hardens quickly, and if it sets before being placed in the footing trenches, it is valueless.

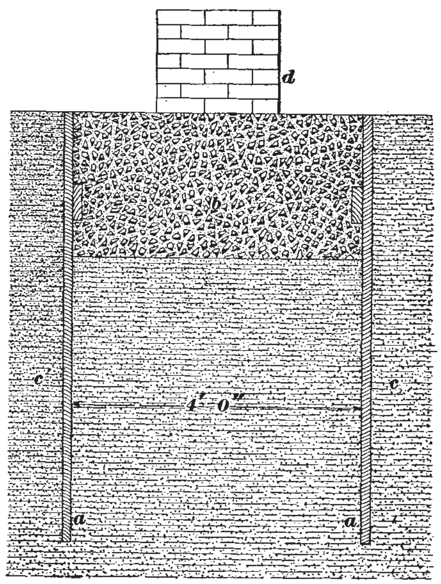


FIG. 8

19. Fig. 8 shows a method of confining quicksand by using sheet piling, between which the concrete is placed. The sheet piling *a* is placed, in this case, 4 feet apart; the concrete *b* is 2 feet thick and extends the full width of the piling; the quicksand, through which the sheet piling is driven, is shown at *c*, and the 20-inch brick foundation wall at *d*.

Fig. 9 gives an example of a footing, composed partly of timber, that was placed near the water-line of a marsh, in New York state, to carry a mill 50 feet by 80 feet and 40 feet high. The soil is a stiff, black muck, and at a depth of about 5 feet, water-soaked sand was found. A concrete bedding *a* 12 inches thick was laid in the trenches; on it 2-inch spruce planks *b* were placed crosswise, and then 8″ × 8″ timber laid parallel with the trench and filled in with concrete. On these were laid the base, or bed, stones *d*, on which was built a 20-inch foundation wall *e*. The trenches on each side of the wall were filled in with sand, rammed down, as shown at *f*. No settlement has occurred, though the mill has been built several years.

20. Stone footing courses should be laid with large, flat stones not less than 8 inches thick. If more than one course is laid, as shown in Figs. 5 and 6, the joints should never come over each other as this would defeat the object of bonding, which is to tie firmly together the parts of the wall. All stone footings should lie on their natural, or quarry, beds, and all the joints and spaces between the stones must be well filled with mortar, which acts as a bedding between the stones and prevents the uneven pressure of one stone on another, which might cause a fracture of the lower one and produce settlement. All footing courses, as indeed all mason work below ground level, should be laid in cement mortar, although in dry, well-drained soil lime-and-cement mortar may be used.

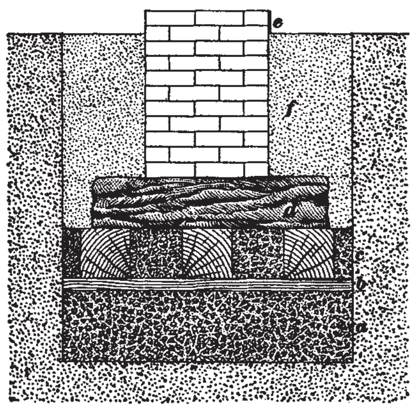
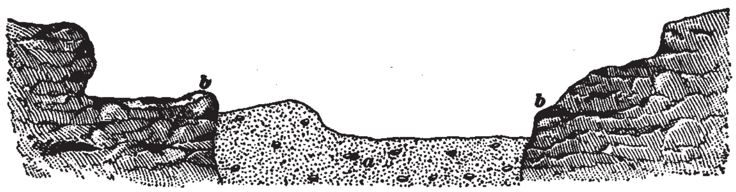


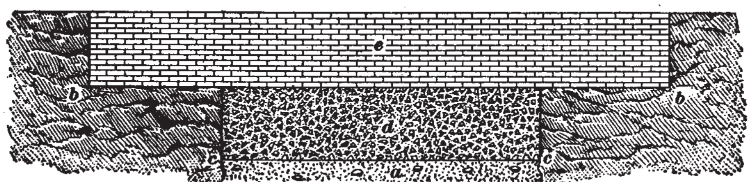
FIG. 9

21. Stepped-up brick footings having concrete bases, as shown in Figs. 3 and 4, are often used. The pyramidal form of stepped-up brickwork carries the load of the superstructure more evenly to the footings and reduces the risk of settlement or fracture; it is used very extensively for piers supporting iron columns. Nothing but good, hard, well-burned bricks should be used, and they should be laid in cement mortar and should break joints; that is, no two joints in successive courses should come directly over each other.

22. Footings on Rock and Gravel.—In placing foundation footings on rock, it is sometimes found that some portions of the footings will rest on the rock, and others, owing to the diversified character of the surface, will rest on clay, sand, or gravel. The settlement of the foundation walls—and as a necessary sequence, that of the whole building—will then be uneven, as the walls resting on the rock will not settle, while those resting on the sand, gravel, or



(a)



(b)

FIG. 10

clay will, by compressing the material on which they are carried.

Fig. 10 shows the method used to obtain equal settlement in this case. At (*a*) is shown the rock and gravel before leveling or excavating, *a* indicating the clay or sand, and *b*, the rock. It is customary to remove the rock to a certain level, as shown in (*b*). The softer soil *a* is then removed and leveled off, as at *c c*, and a bed of concrete about 3 feet thick, as shown at *d*, is then put down; the concrete is brought to the level of the rock and the brick or stone foundation wall *e* is built on it.

23. Footings for Piers.—The brick or stone piers or iron or wooden columns that support the timbers of the first floor should be set on concrete and stone or stepped-brick footings of sufficient area to support, without appreciable settlement, the weight that they will carry. Even more attention should be paid to these footings than to those of the foundation walls, since the piers carry the weight of the whole interior of the structure, including the floors, machinery, stock in process of manufacture, and live load, while the footings for the foundation walls support practically but little more than the actual weight of the mill walls. The piers are also subjected to a greater amount of vibration from the machinery than the foundation walls—an element that is peculiarly liable to produce excessive settlements. Vibration becomes an important factor where a large amount of weaving machinery is to be supported.

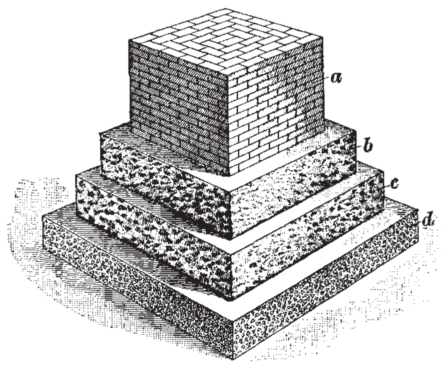


FIG. 11

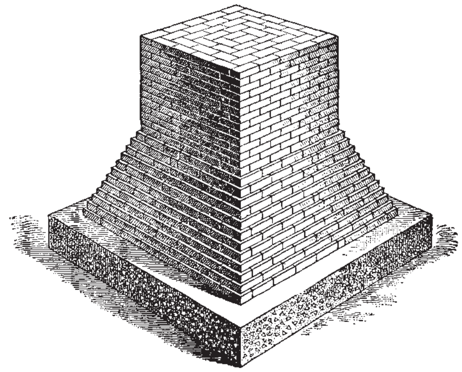


FIG. 12

Fig. 11 shows a brick pier *a* resting on a base stone *b*, which in turn is supported by a bed-stone *c* resting on a thick bed of concrete *d* of sufficient area to carry the required load. In many cases only one stone is used between the pier and the concrete. When wooden or iron columns are supported in this manner, an iron plate should be let into the upper surface of the base stone *b* to give a true bearing for the column, as the load that can be safely carried will thereby be greatly increased.

Fig. 12 shows a brick pier resting on stepped brickwork and supported on a concrete base. Sometimes the concrete footing for piers is made to run the entire length of the mill, to insure sufficient bearing surface and thus do away with any settlement and prevent the soil squeezing up between the piers, as it sometimes does when heavy structures are supported on isolated piers.

PILING

24. Piling is an important branch of foundation work that, although not masonry work in itself, is yet, as a supporting structure, considered as pertaining to masonry construction. A *pile* may be considered as a column with a base more or less rigid, according to the nature of the soil into which it is driven. It is held in place by the pressure against its end and sides, just as a stick driven into damp sand will stand upright and support a load, even though it may not have reached firm bottom, the friction of the sand—or the pressure of its particles against the sides of the stick or pile—holding it in place. It is usual to excavate to a point below where the heads of the piles are to be cut off, in order that they may be leveled before the concrete is put in or the foundation begun.

Piles are usually driven by successive blows of a heavy block of wood or iron falling from a height. This block weighs from 1,200 to 2,000 pounds, and is called a *hammer*, *monkey*, or *ram*. It is raised by means of a rope or chain that passes over a pulley fixed on top of an upright frame, and falls between parallel guides directly on the head of the pile placed under it. The chain or rope is wound over a drum, which is driven by a small engine. After the hammer or ram is drawn up to the required height on the frame, it is released, and falls on the head of the pile, forcing it into the ground.

Piles are generally round and from 9 to 18 inches in diameter at the head, and should be straight and clear from bark and projecting limbs; but where piles are exposed to the rise and fall of tides, it is considered best to drive them with the bark on, since they are then not so easily affected by the action of sea-water, and are not likely to be attacked by the *teredo navalis* and other boring sea worms.

Oak, spruce, hard pine, cypress, and elm are the principal woods used for piling. Oak has the advantage of being hard and tough, and stands hammering well, but cannot be obtained in as large, straight, or long pieces as other woods.

Piles are prepared for driving by cutting or sawing the large end square and bringing the small end to a blunt point with an ax, the length of bevel being about $1\frac{1}{2}$ or 2 feet. In very soft and silty material, however, they can be driven in better line if left blunt. A pointed pile on striking an obstruction, invariably glances off and is thrown out of line; the blunt pile, on the contrary, cuts or breaks through the obstruction.

The large end of the pile should be cut or chamfered for a few inches from the end, so that a wrought-iron ring about 1 inch thick and approximately 3 inches wide will fit over it tightly when struck one or two light taps by the hammer, or ram. Sometimes a ring from 1 to $1\frac{1}{2}$ inches less in diameter than the pile is placed on the top of the pile, and driven into it by light blows; this, however, is not as desirable as the other method, as the ring is apt to split long pieces from the sides of the piles, and usually is not put on until the pile is more or less battered on the end, so that it is carelessly placed and is not concentric with the head of the pile. The rings lessen the tendency of the pile to split or *broom* from the repeated blows of the ram. This splintering of the fibers is known as *brooming*.

25. Shoeing Piles.—Piles driven through soft material have a tendency to split on reaching rock or hard gravel, thus greatly impairing their bearing capacity; to prevent this, their ends are often protected with wrought- or cast-iron shoes.

Fig. 13 illustrates three methods of doing this. At (*a*) is shown a $\frac{1}{2}'' \times 2\frac{1}{2}''$ wrought-iron strap *a* bolted to the pile *b*, forming a shoe that is the same on both sides of the pile. At (*b*) is shown a cast-iron conical shoe fitted over the end of the pile *b*; the head *c* protects the end of the pile and the straps *a* hold the shoe in place. Fig. 13, (*c*) shows one of the best forms of cast-iron shoes. The pile has a blunt end from 4 to 6 inches in diameter, shown at *b*, which the top of the solid conical point of the shoe *c* fits; the straps *a* extend up the sides of the pile, and are bolted or spiked to it, as shown. The straps and bolts hold the shoe in place, while the flat end of the pile receives the effect of the blow.

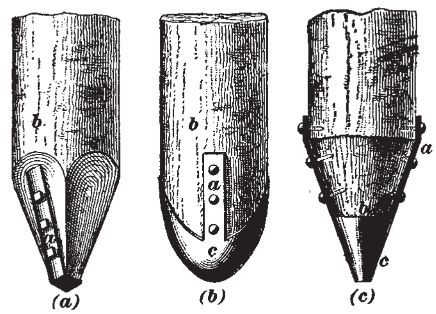


FIG. 13

26. Timber Footings on Piles.—For footing courses on pile foundations several methods are practiced. Fig. 14 shows a timber footing course, or capping, laid below the water level to prevent rotting. Heavy timbers *b* are spiked longitudinally to the tops of the piles *a*, which are cut off at an even height, and the timbers *c* laid transversely on and secured to these. By this method the load is distributed evenly over the tops of the piles.

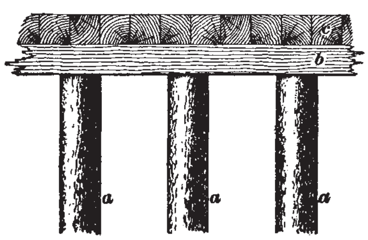


FIG. 14

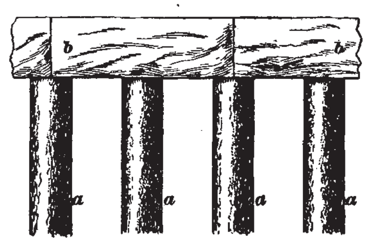


FIG. 15

27. Stone Footings on Piles.—Fig. 15 illustrates footings made of large-sized building stone with level beds, *a* being the piles and *b* the building-stone footings. These stones must in every case rest directly on the piles. Great care must also be taken that one pile comes under each corner of the stone, to keep it from tipping, and that the stone has a full bearing on each pile head. To insure this, the piles must be sawed off perfectly level and all the same height, as no pieces of wood or small bits of stone should be placed under the stones to give them bearing on the piles; wooden chips crush under a load, and pieces of stone are likely to be broken or dislodged, leaving the block in a state of dangerous instability.

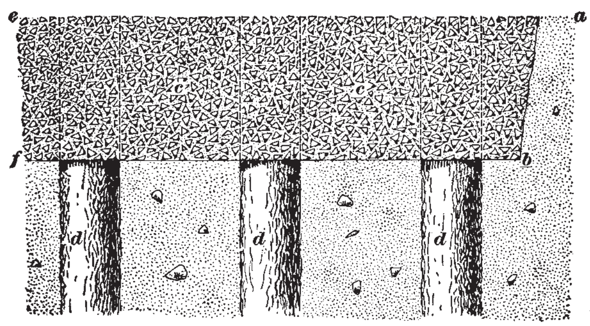


FIG. 16

In many cases concrete filling is used between the piles, as shown in Fig. 16. After the piles are cut off at the water level, which is shown at *a e*, the earth is excavated to *b f*, usually about 2 feet, and the space thus obtained is filled in with the concrete *c*, well rammed around the sides of the piles *d*, and leveled off at the top to carry the foundation walls. This method is best adapted to situations where the soil is constantly wet, as then the piles will not become dry and rot.

In some instances the piles are covered with 3-inch planking laid transversely on top of the concrete and the foundation walls built on this.

FOUNDATION WALLS

28. The **foundation walls** above the footing courses are usually of stone or brick. The method of building brick foundations is the same as for all brick walls; therefore it will not be described here, but will be taken up under Brickwork.

29. Thickness of Walls.—A very good rule for fixing the thickness of stone foundation walls is, that they shall be at least 8 inches thicker than the wall next above them, for a depth of 12 feet below the surface; and for every additional 10 feet or part thereof in depth, they should be increased 4 inches in thickness. Thus, if the first-story walls are 12 inches thick, the stone foundation walls should be 20 inches

TABLE II

THICKNESS OF FOUNDATION WALLS

Height of Mill	Brick Inches	Stone Inches
Two stories . . .	20	24
Three stories . . .	24	28
Four stories . . .	28	32
Five stories . . .	28	32
Six stories	32	36

thick for 12 feet in depth, and 24 inches thick if the depth is greater. The thickness of foundation walls in all large cities is controlled by building laws; where there are no existing laws, Table II will serve as a guide.

30. Stone-Rubble Foundation Walls.—Stone foundation walls below ground, when concealed from outside view, are usually constructed of rough rubble, as shown in Fig. 17, which represents an elevation (*a*) and section (*b*) of a 20-inch rubble stone wall, shown at *a*, 10 feet high, with footing stones *b*, 8 inches thick, and 2 feet 8 inches wide. These walls should be bonded together as shown in Fig. 18, where *a* shows a *bond stone*, or *header*, of the stone foundation wall *b*. All stone walls 24 inches or less in thickness should have a header extending through the wall at least every 3 feet in height and 4 feet in length; if the wall is over 24 inches in

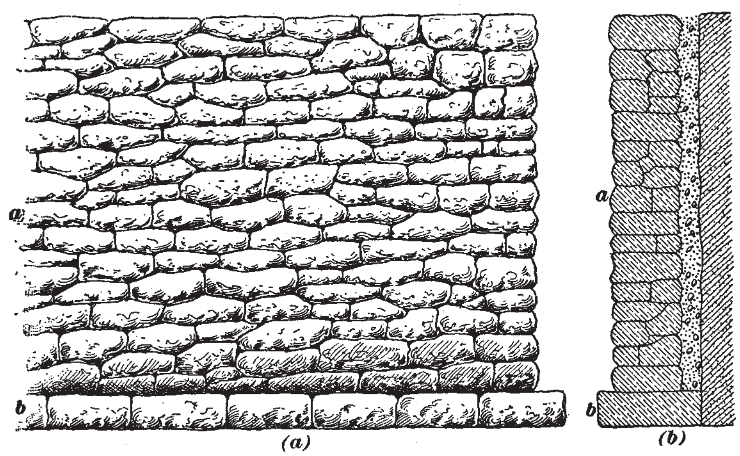


Fig. 17

width, one header should run into the wall at least 2 feet for every 6 superficial feet of wall space. These headers serve to bind the stones of the walls together and keep the foundation from splitting apart crosswise when weight is placed on it. They should not be less than 18 inches in width and 8 inches in thickness, and should be good, flat stones.

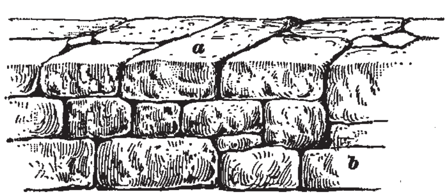


Fig. 18

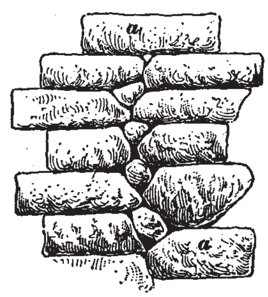


Fig. 19

Fig. 19, at *a*, *a*, shows vertical joints coming one above another through several successive outside courses; this should never be allowed, but the joints should be broken, as shown in Fig. 17. Where a long vertical joint occurs, the weight above may cause the wall to settle more on one side of the joint than on the other and produce serious rupture.

All wall angles should be well tied by long stones laid alternately, as shown at *a*, Fig. 20. By this means the weight on the corners of the wall is more equally distributed and the wall can be kept plumb and true.

Foundation stones should always be laid on their natural, or quarry, beds. The tendency to splitting, or cleavage, in a stone is with the grain or bed; so that when the stone is laid on the original bed, the weight of the material placed above it comes against its grain. No stone should have more face than bed, and one side, at least, should be reasonably flat. When laid, every stone should be well bedded in mortar.

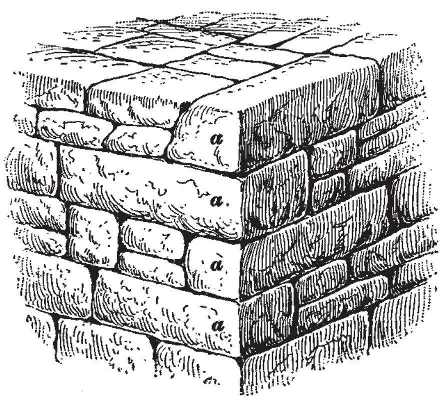


Fig. 20

31. The usual practice with masons in rough walling is, after setting the larger stones, to fill the interstices with spalls or chips of stone, or even pebbles, more or less carefully fitted, and put in dry; then to dash in mortar, trusting that it will work its way into the crevices. It does so to some extent, but the method is not a good one. A good, conscientious workman will place no stone, even the smallest chip, except in a bed of mortar prepared to receive it, rubbing it in well, and settling it with blows of the trowel and hammer; again driving smaller fragments into the mortar, which is squeezed up around it, so that all the stones have a layer of mortar between them.

It is a good plan to *grout* the walls; that is, fill all the joints with mortar made so thin that it will flow into the interstices, or spaces, between the stones.

For good work, the outside of the wall (even when concealed by the bank of the excavation) should be carried up with a good face, as shown in Figs. 17 and 20, and the joints well filled with either cement, or lime-and-cement mortar. If this is properly done, any moisture that runs out from the bank or descends from above, so as to flow down over the outer face of the wall, will drip off instead of running into the joints.

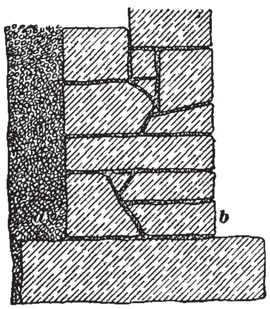


FIG. 21

The space between the outside of the foundation and the bank of the excavation should be filled in with gravel or sand (preferably the former) well packed down. Thus, in Fig. 21, *a* is the filling in the space between the foundation wall and the bank while *b* is the stone wall. This method makes the basement dry and warm, and keeps much of the moisture away from the foundation walls. Before filling the trench on the outside some engineers give the outside of the foundation wall two coats of hot tar to make it impervious to water.

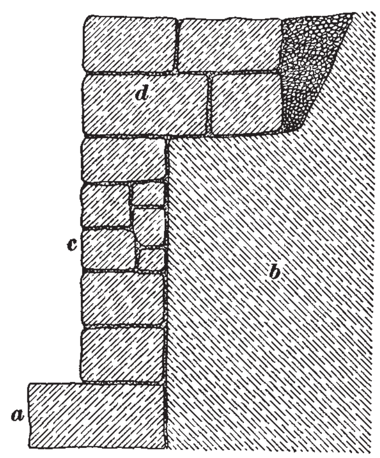


FIG. 22

32. Foundation Walls Partly on Rock.—A very faulty construction that is sometimes met with is that in which a portion of a ledge of rock projects into the foundation wall, so that the foundation is built partly on the rock and partly on the footing course. This is shown in Fig. 22, *a* being the footing course; *b*, the rock projecting into the foundation wall; *c*, the thin wall in front of the rock to bring the foundation to the thickness figured on the plans; and *d*, the wall of the building carried up to its full height and thickness, and resting partly on the thin wall *c*, and partly on the ledge of rock *b*.

In a wall so built, the water will find its way either through the imperceptible seams of the ledge of rock *b*, or over its top into the body of the masonry, keeping it constantly damp. Besides, there is a serious risk that under the heavy weight of the upper wall, the thin wall built against the ledge—but in no way bonded to it—will separate from it and fall away, leaving the superincumbent masonry most insecurely supported; moreover, a foundation wall, built partly on unyielding rock and partly on softer soil, will settle unequally and crack, perhaps injuring the masonry above, and, at least, opening an inlet for moisture. The ledge should be cut away so as to leave ample space for the whole thickness of the foundation walls down to the footings, with sufficient space between the wall and the ledge of rock for packing gravel, as shown at *a*, Fig. 21. This will intercept the water and carry it away from the wall.

MILL-BASEMENT CONSTRUCTION

33. A very good mill construction in cases where it is desired to obtain room for storage of stock or for mill processes in the basement, consists of excavating the cellar so that the basement floor will be about 5 feet below and the first floor about 7 feet above the surface of the ground. This construction admits of windows in the basement walls and makes a basement that can be utilized for the heavier types of machinery or for dyeing or other wet processes and also for those machines that require a solid foundation on account of vibration. The floor should be cemented; sometimes small, crushed stones or rubble are first laid down and the cement laid on top. The small stones or rubble are often filled with grout.

The pillars in the basement may be of wood if there is a good air circulation, and of iron or brick if the cellar is damp; in any case, care should be taken to have a solid foundation, since these pillars or piers support the entire weight of the floors, machinery, etc. that is above.

Fig. 23 shows a mill foundation of this construction; *a* is a thick bed, or footing, of concrete; *b*, a footing course of broad building stones; *c*, a stone foundation wall rising to the surface of the ground, and *d*, the brick wall of the mill; a_1 is a concrete footing for the brick pier c_1 that rests on a footing stone b_1 supported by the concrete footing. The basement floor is laid with a grouted layer of rubble *e* over which a cement floor *f* is laid. Where heavy machinery that

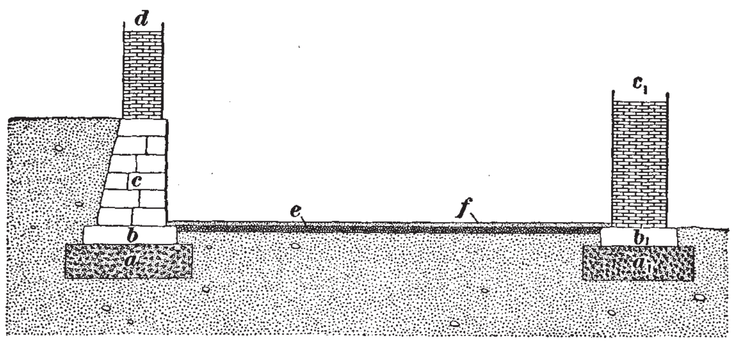


FIG. 23

must be lagged down is to be used in basements, the best practice is to place 8-inch timbers, to which the machinery may be fastened, on a solid foundation, and fill between them with well-rammed stones covered with coal-tar concrete to the level of the top of the timbers. In some cases a board or plank flooring is placed over the whole. It has been found that timbers set too closely confined in cement concrete will rot; therefore, the coal-tar concrete is recommended.

MORTAR

34. All foundation work, whether stone or brick, should be laid in **cement** or **cement-and-lime mortar.** If the soil is wet or damp, cement mortar should be used, but for ordinary purposes cement-and-lime mortar fulfils the requirements. For foundation walls above the ground and for the general wall construction of the mill good lime mortar may be used.

35. Cement Mortar.—Cement mortar, if made of Rosendale or any of the ordinary quick-setting, light cements, should be made in the proportion of three parts sand to one part cement; but if made of the heavy, slow-setting cements called Portland cements, may be made with four parts of sand to one part of cement. When mixing cement mortar, it is advisable that these parts should be actually measured in barrels. (It is a common practice with many builders to have one laborer shovel cement or lime, while three or four others are shoveling sand; this is a very unreliable method of measuring.) After the sand and cement are thrown on the platform, they must be thoroughly mixed by being shoveled together, at least twice, so that the cement may be thoroughly incorporated with the sand. (A little lime may be added in winter to prevent freezing.) Sufficient water is then added to make a stiff paste; the mortar must be immediately conveyed to the work and used, as the cement *sets*, or hardens, very rapidly, and when once hardened cannot be used again.

36. Lime Mortar.—Lime mortar is prepared in much the same way as pure cement mortar. A bed of sand is first made in a mortar box, and the lime is distributed as evenly as possible over it, both the lime and sand being first measured in order that the proportion specified may be obtained. The lime should then be slaked, by pouring on water, and covered with a layer of sand, or, preferably, a tarpaulin, to retain the vapor given off while the lime is being converted into hydrates of lime by action of the water; sand is then added, if necessary, until the mortar contains the proper proportions. The proportion of sand to lime usually specified and called for by the New York and Boston building laws, is three parts of sand to one part of lime. If, however, both the materials are of good quality; that is, if the lime slakes freely, becomes a fine, impalpable powder, resembling flour in texture, and perfectly free from foreign matter, and the sand is clean and sharp—one part of lime to four parts of sand is sufficient, but more sand than this is injurious. It is considered good practice to make lime mortar in large quantities, and then leave it in piles for use as it may be needed, after stirring and tempering.

37. Cement-and-Lime Mortar.—For this mortar, the cement, lime, and sand should be well mixed together, before water is added, as described for cement mortar. Cement-and-lime mortar should be used shortly after it has been mixed, before the cement sets.

BRICKWORK ABOVE THE FOUNDATION

BRICKS AND BRICKMAKING

38. The present American practice is to build the walls of the mill above the foundation of bricks laid in lime mortar, although in certain localities where large amounts of suitable stone may be obtained cheaply mills have been constructed of this material.

Bricks may be said to be artificial stones manufactured from a peculiar clay containing protoxide of iron, in regular and uniform shapes for convenience in laying. Other substances that form part of ordinary clay either do no good or are absolutely harmful; carbonate of lime, in any large quantity, renders the clay absolutely unfit for making brick. Sand or silica should not exist in any excessive quantity, as an excess of sand renders the brick too brittle and destroys cohesion; 25 per cent. of sand is considered a good proportion. The protoxide of iron in the clay causes the red color in the brick after burning, the color varying with the proportion of iron.

39. Hand-Made Brick.—Many of the common bricks, especially in the smaller towns and cities, are made by hand. The clay is thrown into a circular pit, where it is mixed with water and tempered with sand or ashes by means of a tempering wheel attached to a long lever and worked by horsepower. When soft and plastic, it is taken to the molding table and pressed into the molds by hand. The molds are dipped either in water (called *slop molding*) or in sand (called *dry molding*) to prevent the clay from adhering to the mold. The sand-molding process gives cleaner and sharper brick than the slop molding. After the bricks are shaped in the mold, they are laid in the sun or in a drying house for three or four days, after which they are stacked in kilns and *fired*.

40. Machine-made bricks, as their name implies, are made by machinery, the object of which is to facilitate the process of preparing the unburned bricks. There are several systems of preparing machine-made brick, but in general the results obtained by these processes are similar to those obtained by hand.

41. Burning the Brick.—When either the hand- or machine-made processes are used, the bricks, after drying, are built into a large mass, or kiln, containing from 100,000 to 300,000 bricks. *Eyes*, or flues, are left at the bottom as receptacles for fuel. The bricks are laid loosely together in order to allow the heat to pass in and around them. When ready, the fire is started, slowly at first, but afterwards increased to an intense heat; and after burning for a period, determined partly by the fuel used but mainly by experience, the fires are allowed to die out gradually.

The quality of the brick contained in a kiln that has been fired may be divided into four classes: First, the extreme outside brick, which are burnt so little that they are almost worthless. Second, a layer inside the above, in which the brick are underburnt and soft; these are called *pale*, or *salmon, brick*, and are unfit for foundation or face work, but are used for filling in between stud partitions, and sometimes between harder brick in the inside of walls, although their use for this purpose is not recommended. Third, a layer consisting of brick well-burned, hard, well shaped, and of a good red color; this brick is good for any purpose. Fourth, the brick in the inner layer and those just above the flues are overburnt, very hard, very brittle, and usually distorted, cracked, and even vitrified; they should not be used in any structure subject to shock, but are often used for paving brick.

42. Size of Bricks.—In the United States the size of bricks is not regulated by law, consequently the dimensions vary not only with the maker, but also with the locality. In the New England states, the average size of common brick is about $7\frac{3}{4}$ in. × $3\frac{3}{4}$ in. × $2\frac{1}{4}$ in.; New York and New Jersey bricks will run about 8 in. × 4 in. × $2\frac{1}{2}$ in., and the walls laid in them will run 8, 12, 16, and 20 inches in thickness for 1, $1\frac{1}{2}$, 2, and $2\frac{1}{2}$ bricks. Most of the Western common bricks measure $8\frac{1}{2}$ in. × $4\frac{1}{8}$ in. × $2\frac{1}{2}$ in., and the thickness of the walls measures about 9, 13, 18, and 22 inches for thicknesses of 1, $1\frac{1}{2}$, 2, and $2\frac{1}{2}$ bricks. On the seacoast of some of the Southern States, the bricks are made with a large percentage of sand, and will average 9 in. × $4\frac{1}{2}$ in. × 3 in.

43. Strength and Quality of Brick.—Whenever possible, the mill engineer should see that the bricks to be used meet the following requirements:

1. They should be sound, free from cracks or flaws, and from stones and lumps of any kind, especially pieces of lime.
2. They should be uniform in size, with sharp angles and edges, and the surfaces true and square to each other; this insures neat work.
3. Good building brick should be quite hard and well burned. A simple, and generally satisfactory test for common brick is to strike two of them together, or to strike one with the edge of a mason's trowel; if the brick gives a ringing sound it is generally sufficiently strong for any ordinary work. A dull sound shows it to be soft or shaky.
4. A good brick should not absorb more than one-tenth its weight in water. Weigh the brick, immerse it in water for 24 hours, and then weigh it again; from the increase in weight the percentage of water it has absorbed may be found. Very soft, underburned bricks often absorb from 25 to 35 per cent. of water; weak, light-red bricks, often used in filling the interior of walls, will absorb about 20 to 25 per cent.; while the very best brick may absorb not more than 5 per cent., and should, if possible, be used for outside walls and foundation walls and piers.

5. Bricks that are to be used for piers and the foundations of heavy buildings should not break under a crushing load of less than 4,000 pounds per square inch.

6. A good brick, 8 inches long, 4 inches wide, and $2\frac{1}{2}$ inches thick, should not break under a center load of less than 1,600 pounds, the brick lying flat, supported at each end only, and having a clear span of 6 inches, and a bearing at each end of 1 inch. A first-class brick will carry 2,250 pounds in the center and not break. Tests have been made with brick that carried 9,700 pounds before breaking.

THICKNESS OF BRICK WALLS

44. Before considering the actual construction of the brick walls of the mill, some attention should be paid to the thickness of walls for mill structures required by law. For this purpose, an extract is given from the building law of New York, relating to the thickness of brick walls in proportion to their height; as the laws of other cities do not vary materially from this, it can safely be taken as a standard.

"The walls of all warehouses, stores, factories, and stables 25 feet or less in width between walls shall not be less than 12 inches thick to the height of 40 feet (see Fig. 24).

"If over 40 feet in height and not over 60 feet, the walls shall not be less than 16 inches thick to the height of 40 feet or to the nearest tier of beams to that height; and thence not less than 12 inches to the top (see Fig. 25).

"If over 60 feet in height and not over 75 feet in height, the walls shall not be less than 20 inches to the height of 25 feet or to the nearest tier of beams to that height; and thence not less than 16 inches thick to the top (see Fig. 26).

"If over 75 feet in height and not over 85 feet in height, the walls shall not be less than 24 inches thick to the height of 20 feet, or to the nearest tier of beams to that height; thence not less than 20 inches thick to the height of 60 feet, or to the nearest tier of beams to that height; and thence not less than 16 inches thick to the top (see Fig. 27).

"If over 85 feet in height and not over 100 feet in height, the walls shall not be less than 28 inches thick to the height of 25 feet, or to the nearest tier of beams to that height; thence not less than 24 inches thick to the height of 50 feet, or to the nearest tier of beams to that height; thence not less than 20 inches thick to the height of 75 feet, or to the nearest tier of beams to that height; and thence not less than 16 inches to the top (see Fig. 28).

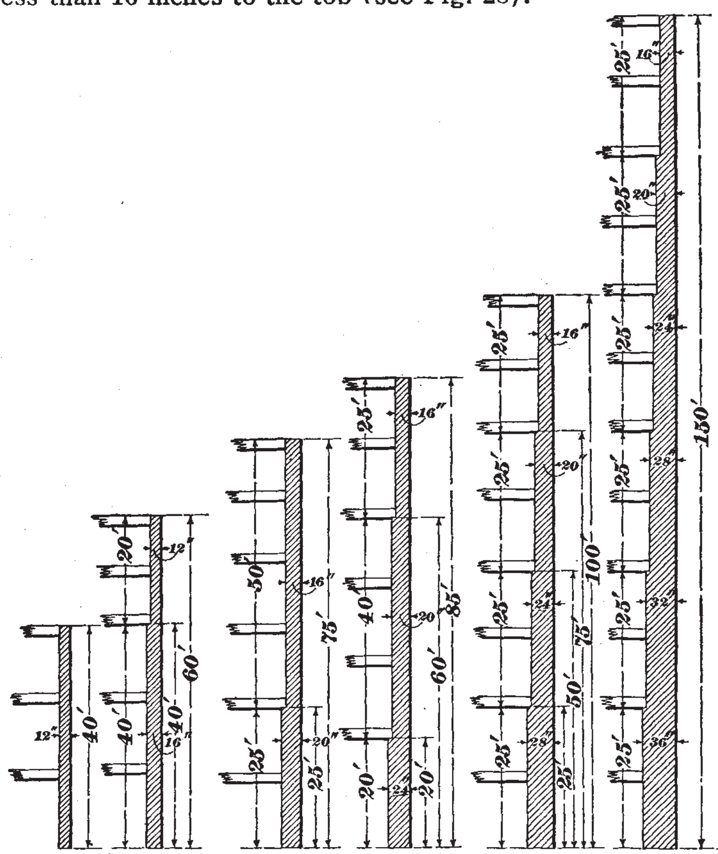


Fig 24 Fig. 25 Fig. 26 Fig. 27 Fig. 28 Fig. 29

"If over 100 feet in height, each additional 25 feet in height, or part thereof, next above the curb, shall be increased 4 inches in thickness, the upper 100 feet of wall remaining the same as specified for a wall of that height (see Fig. 29).

"If there is to be a clear span of over 25 feet between walls, the bearing walls shall be 4 inches more in thickness than is

TABLE III

THICKNESS OF MILL WALLS IN INCHES

Height of Building	City	Stories				
		First	Second	Third	Fourth	Fifth
Two stories	Boston . .	16	12			
	New York .	12	12			
	Chicago . .	12	12			
	Minneapolis	12	12			
	Memphis .	18	13			
	Denver . .	13	13			
Three stories	Boston . .	20	16	16		
	New York .	16	16	12		
	Chicago . .	16	12	12		
	Minneapolis	16	12	12		
	Memphis .	$22\frac{1}{2}$	18	13		
	Denver . .	17	13	13		
Four stories	Boston .	20	16	16	16	
	New York .	16	16	16	12	
	Chicago . .	20	16	16	12	
	Minneapolis	16	16	12	12	
	Memphis .	27	$22\frac{1}{2}$	18	13	
	Denver . .	21	17	13	13	
Five stories	Boston . .	20	20	20	20	16
	New York .	20	16	16	16	16
	Chicago . .	20	20	16	16	16
	Minneapolis	20	16	16	12	12
	Memphis .	$31\frac{1}{2}$	27	$22\frac{1}{2}$	18	13
	Denver . .	21	21	17	17	13

heretofore specified, for every $12\frac{1}{2}$ feet, or fraction thereof, that said walls are more than 25 feet apart."

Table III gives the thickness of walls, in inches, required by law for mills, in the six cities mentioned.

The tops of the second-floor beams are taken as 19 feet above the surface of the ground, and the heights of the other stories are 13 feet 4 inches, including thickness of floors, as the New York and Boston laws give the height of the wall in feet and not in stories. The Chicago ordinances provide that the maximum heights of stories, in accordance with the thicknesses given in Table III, are 18 feet in the first, 15 feet in the second, 13 feet 6 inches in the third, and 12 feet above.

As the weight of textile machinery and the high speeds at which it is run has a tendency to produce an excessive vibration, the walls of textile mills are frequently made thicker than is required by the building laws. At times also large amounts of raw stock and finished goods are carried, so that the weight supported, per square foot of floor area, is probably greatly in excess of that in many other industries. Thus, a four-story textile mill intended to carry a large amount of machinery and stock might have walls 28, 24, 20, and 16 inches thick at each respective story. If the mill is to be extremely wide, the walls should be made 4 inches thicker at each story.

BRICKLAYING

45. To build any kind of a brick structure, so as to make a strong and durable piece of work, it is necessary to have a bed of mortar between the bricks; brickwork consists, therefore, of both bricks and mortar. The strength and durability of any piece of work will depend on the quality of the brick, the strength and quality of the mortar, the way in which the bricks are laid and bonded, and whether or not the bricks are wet or dry when laid.

The function of the mortar in brickwork is threefold: (1) To keep out moisture and, by filling all crevices, to prevent as far as possible excessive changes in temperature; (2) to unite the bricks into one mass; (3) to form a cushion to fill up any irregularities in the brick, and distribute the pressure evenly. The first object is best attained by grouting, or thoroughly flushing, the work; the second depends largely on the strength of the mortar; and the third is effected chiefly by the thickness of the joints.

Common brick should be laid in a bed of mortar at least $\frac{3}{16}$, and not more than $\frac{3}{8}$, inch thick. Every joint and space in the walls not occupied by other material should be filled with mortar. The best way to allow for the thickness of the mortar joint is to measure the height of eight courses of brick in the wall; this should not be more than 2 inches greater than eight tiers of the same brick laid dry, that is, without mortar. A *course* is a horizontal row of bricks plus the thickness of the mortar joint. As common brick is usually quite rough and uneven, it is not always easy to determine the thickness of a single joint, but the variations from the above rule, in any eight courses that may be selected, should be very slight.

46. The best method of building a brick wall in which each course consists of two outside courses and one inside, is as follows: The two outside courses are laid in mortar, spread with a trowel so as to form a bed for the brick to lie on. The bricks in each outside course are laid up against the last ones previously laid in that course after some mortar has been scraped against their adjoining sides. The brick to be laid is pressed into its place with a sliding motion, which forces the mortar to completely fill the joint. Having continued the outside courses of brick to an angle or opening, the space between the bricks should be filled with a bed of soft mortar, and the bricks of the inside course pressed into this mortar with a downward slanting motion, so as to press the mortar up into the joints; this method of laying is called *shoving*. If the mortar is not too stiff, and is thrown into the space between the inner and outer courses of brick with some force, it will completely fill the upper part of the joints in the inner course, previously laid, which were not filled by the shoving process. A brick wall laid in this way will be very strong and difficult to break down.

Another method of laying in the brick between the inside and outside courses in a wall is to spread a bed of mortar, and on this lay the dry brick. If the bricks are laid with open joints and thoroughly slushed up with mortar, it makes good work; but unless the workmen are carefully watched, the joints do not get filled with mortar, and the wall will not be as strong as when the bricks are *shoved*.

Some bricklayers lay the inside courses dry on a bed of mortar, as described in a previous paragraph, and then fill all the joints with very thin mortar; this is called *grouting*. No more mortar should be used than will fill all the joints. This method is not as good as the others because the thin mortar lacks cohesion, and does not bind the brick together as well as does stiffer and more tenacious mortar. Grouting should never be done in freezing weather; the mortar contains so much water that it freezes very readily and is then useless as a bond.

Bricks should be laid as clean as possible, and for well-appearing work the most nearly perfect and best-colored bricks should be reserved for the outside work. For the inside of the walls the color is not so important, but all unburnt, unsound, or badly misshaped bricks should be rejected.

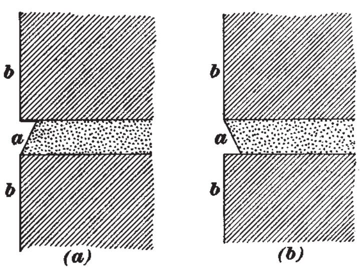


FIG. 30

47. Joints in Brickwork.—For inside walls that are to be plastered, the mortar projecting from the joints is merely cut off flush with the trowel. All outside and inside walls, where the bricks are left exposed, should have the joints *struck*, as shown in Fig. 30 (*a*), where *a* shows the mortar joint, and *b* the bricks in the wall. This *striking* the joint is done with the point of the trowel, which is held obliquely. This method makes the best job for outside work, as the water will not lodge in the joint and soak into the mortar, as it will when the joint is struck as shown in Fig. 30 (*b*). The second form, however, is easier to make.

For particular outside work where it is desired to give the walls a more finished appearance the joints instead of being struck are *jointed*. This is done as fast as a few courses are laid, with a blunt instrument known as a jointer, which is drawn along the joints, smoothing and slightly concaving the mortar.

48. Bricklaying in Extremely Hot or Cold Weather. Mortar, unless very thin, will not adhere to a dry, porous brick, because the brick robs the mortar of its moisture and therefore prevents the proper setting. On this account, bricks should never be laid dry, and in very hot, dry weather should be as wet as possible. When porous bricks are used this is of great importance in obtaining a strong wall. However, when the weather is not extremely hot, care should be taken not to make the bricks too wet, or they will keep the mortar soft and the increasing weight of the wall, as it is built, will be apt to throw it out of true. During long, wet periods the piles of bricks should be covered with boards or canvas in order to keep them from being soaked with water.

Brickwork should never be laid in lime mortar when the thermometer is below 32°, as freezing lime mortar unfits it for useful purposes, and work can never be done as economically in cold weather as at other times. Lime mortar is damaged when it alternately freezes and thaws. The sun shining on one side of the wall may cause the mortar to soften, while that on the other side will be frozen; this may cause serious damage by causing the wall to buckle. In constructing large buildings in winter, if one-fifth cement is added to the lime mortar, it will not be damaged by freezing. The surface of the bricks must be clean and free from frost, snow, and ice, when they are laid, or the mortar will not adhere to them.

Sometimes salt is mixed with the mortar to prevent it from freezing, but it is undesirable, as it usually causes *efflorescence*, or the white deposit often seen spread over a wall.

Portland cement mortar and Portland cement-and-lime mortars are not affected by changes in temperature.

BOND IN BRICKWORK

49. The proper construction of a brick wall involves many things besides the mere laying of one brick on top of another, with a bed of mortar between.

All corners and joints should be carefully plumbed, the courses of brickwork kept perfectly horizontal, which necessitates uniform mortar joints; the wall surfaces, both exterior and interior, must be kept in perfect alinement; and all walls must be carried up approximately together. All these conditions may be complied with, and yet the work may be imperfect; the merit of the brickwork must be judged by the thoroughness of its bond, both lengthwise and crosswise. This bond must be maintained by having every course perfectly horizontal, both longitudinally and transversely, as well as perfectly plumb. Aside from the quality and character of the material, the *bonding* of a wall contributes most of its strength.

50. Bond, in brickwork, is the arrangement of the bricks in such a way as to tie together all parts of the wall by means of the weight resting on the bricks, as well as by the adhesion of the mortar; and also for distributing the effects of the weight over an increased area. When the bricks are placed lengthwise on the face of the wall, as at *a*, Fig. 31, they are termed *stretchers;* when placed crosswise and their ends only exposed to view in the face of the wall, as at *b*, they are called *headers*. Bricks laid with their long axes in the direction of the length of the wall, or stretcher bricks, give the wall strength in the direction of its length, while header bricks, or those with their long axes laid across the wall, give it strength in a transverse direction.

To obtain the best results in bonding throughout the mass of the wall, strict attention must be given to the location of every joint in the brickwork. On the face of the wall, the vertical joints in each course throughout the height should be kept perpendicular, or directly over those in the second course below; this is called *keeping the perpends*. Unless the closest attention is paid, the lap is ultimately lost through irregularity of the brick and mortar joints, and extra *bats*, or *closers*, are necessary. The joints across the top of the wall should be kept in line, so that if the *perpends* are observed on one face of the wall, the other face will also work up correctly. Even when the wall is exposed only on one face, it is just as essential to have the joints on top of the wall kept in line, as otherwise its effective longitudinal bond will soon be lost, since at best the heading bond furnishes a lap of only 2 inches.

The importance of having the bond preserved in the whole wall can be understood by reference to Fig. 31, which repre-

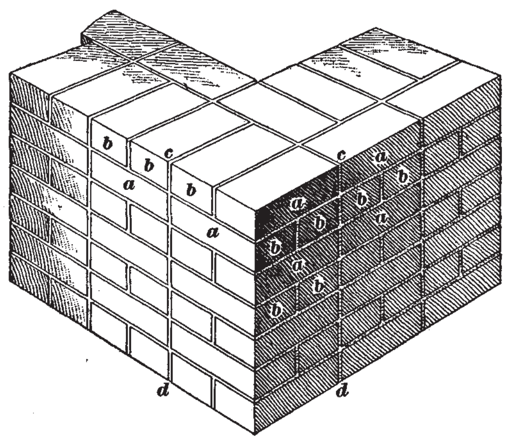


FIG. 31

sents a section of a wall consisting of alternate courses of stretchers and headers. By placing the brick as shown, no longitudinal bond exists and the wall is simply a series of isolated piers that join each other at the vertical lines *c d* and have no bond or union between them other than that obtained by the adhesion of the mortar. This method manifestly lacks strength and efficiency. In order to overcome this difficulty, and to secure a continuous bond in the length of the wall, recourse is had to a different arrangement of the bricks and to the use of blocks that vary in size from the ordinary brick. These blocks are called *closers*, the term meaning that they perfectly finish or close the length of the courses that have been adjusted to obtain the bond. The vertical joint that is shown at *c d*, Fig. 31, is avoided and no two adjacent courses have joints that are immediately over each other. The closers are made by cutting the bricks with a smart blow with the edge of the steel trowel into such blocks as the situation requires; these are called *bats* and are designated according to the proportion they bear to the whole brick.

51. The different bats, or closers, used in brickwork are shown in Fig. 32; (*a*) represents a whole brick of the usual size. When the brick is cut longitudinally on line *a b*, as

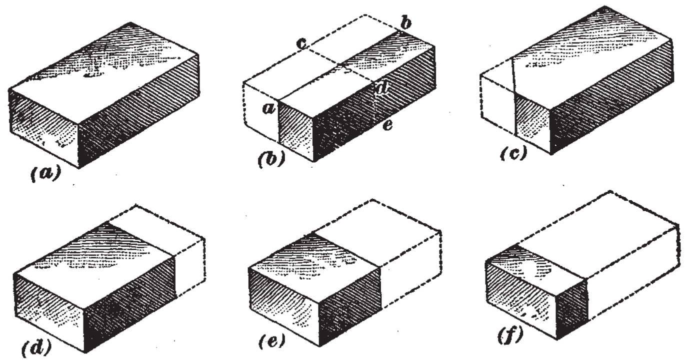


FIG. 32

at (*b*), each half is called a *queen closer;* but as it is difficult to cut the full length in this manner, the usual mode is first to cut the brick on the line *c d*, and then to cut each half on the line *a b*. When the brick is cut as at (*c*), it is called a *king closer*, and is a form well adapted for closers at door and window jambs, etc. When one-fourth of the whole length of the brick is cut off, as at (*d*), the remainder is called a *three-quarter bat;* and in like manner the portion remaining, as in (*e*), is called a *half bat;* and at (*f*), a *quarter bat.*

There are several methods of placing the bricks in the wall when closers are used to properly secure the lap, each method having its own name to indicate the kind of bond used. Assuming the wall to have the properties of a column, its bearing capacity will necessarily depend on the strength of its least dimension, which is its thickness, so that the bond that secures a thorough union of the constituent parts in this direction will always be the most desirable.

52. Heading Bond.—When all the courses present the ends of the bricks in the face of the wall, the wall will then be composed entirely of headers; this method, however, is only adapted for use in sharp-curved walls, as it possesses little longitudinal bond.

53. Stretching Bond.—When all the courses consist of stretchers, the wall formed should only be used for partitions that are but 4 inches in thickness; where the wall is thicker

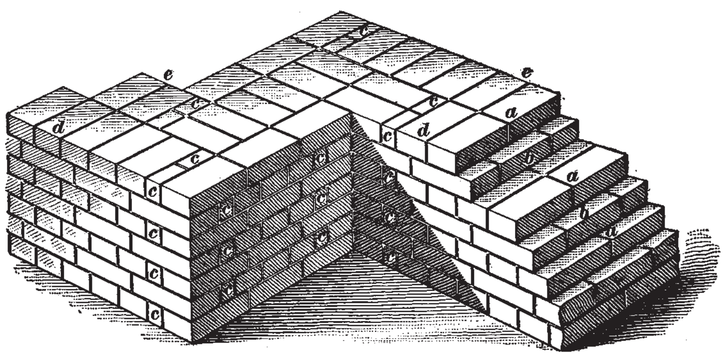


FIG. 33

than this, the method cannot be followed, as there will be no transverse bond whatever.

54. English Bond.—Though not much used in this country, this is probably the best and strongest method of bricklaying. A wall bonded by this system shows header and stretcher courses alternately, as shown in Fig. 33. The longitudinal bond is obtained by the use of quarter-bat closers *c* placed in alternate courses, as shown. This is without doubt the best and simplest method to follow in all work where strength is required, as by its use a complete and thorough transverse bond is procured. The heart of the wall consists entirely of heading bond, and the joints of the heading course, as at *a*, are well bonded by the headers of the stretching course as at *b*. The English bond can also be accomplished by the use of the three-quarter bats, and many authorities prefer them to quarter-bat closers, as by using three-quarter bats only one mortar joint is required in place of two.

An objection frequently urged against the appearance of the English bond on the face of the wall, is the recurrence of so many headers, which give the work the appearance of being constructed of so many tile-like blocks. The use of diminutive blocks of either brick or stone, in heavy walls, always tends to reduce the apparent strength of the structure, and it loses much of the effect of permanence, a very effective factor in good design.

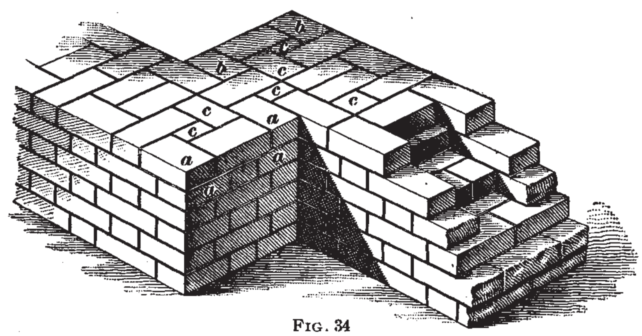


FIG. 34

55. The **Flemish bond** is used to overcome this belittling effect, as only two-thirds of the number of headers that occur in English bond are exposed, and each course is composed of a header and stretcher alternately. The method of laying brick in Flemish bond is shown in Fig. 34. The lap is obtained by the use of three-quarter bats, both at the external and internal angles of the wall, as shown at *a* on the external, and at *b* on the internal angles. The closers occur in the heart of the wall and are quarter, half, and three-quarter bats, as shown at *c*.

Owing to the headers and stretchers being placed on the inner side of the wall immediately opposite those on the outer face, both faces will appear exactly alike when thus arranged; the wall is then said to be built in *double Flemish bond*. Fig. 34 shows that only one-half of the body of the 4-inch thickness is bonded to the adjacent thickness; in other words, the upper bed of each face stretcher is only bound to the inner thickness by means of the width of one header; in this respect, the strength of wall is sacrificed for the sake of appearance. A vertical strip 2 inches wide occurs on each side of the face headers, that has no bond other than that of the adhesion of the mortar. To obviate this defect, the outer face is sometimes built in Flemish bond and the inner face in English bond.

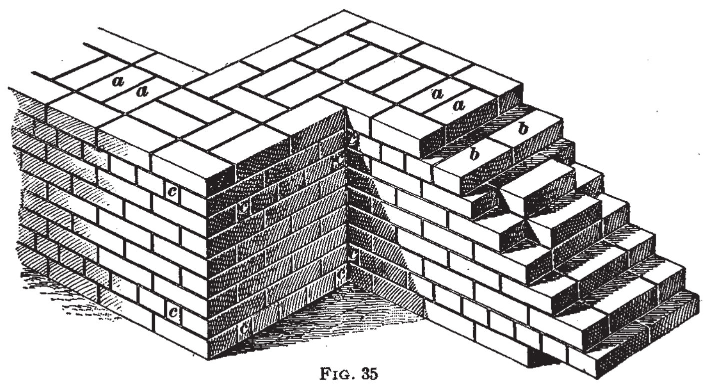


FIG. 35

56. Garden, or Running, Bond.—The bond most generally used in the United States is shown in Fig. 35. It enables the bricklayer to build a larger amount of wall in a given time than can be accomplished by the use of either the English or Flemish bond and is sometimes called *American bond*. It consists in laying from five to seven courses in height as stretchers, bonding with a row of headers at regular intervals. The longitudinal lap is secured by closers *c*, *c*; the heading course in the heart of the wall is shown at *a*, *a*, and bonds the heading course *b*, *b* exposed on the face. This is known as **garden, or running, bond.** Its principal defect is that the wall is practically composed of a series of 4-inch slices from $12\frac{1}{2}$ to $17\frac{1}{2}$ inches in height, that ordinarily have no transverse bond other than the mortar. It fulfils the requirements, however, if every joint throughout the body of the wall is well filled with good mortar, the vertical joints being well rammed with the edge of the trowel.

In mill structures it is customary to make every fifth or seventh course a header, or bonding, course, the former method making the stronger wall and the latter the quicker to build.

CARRYING UP THE WALLS

57. It is very important that the walls of a building should be carried up as evenly as possible, no wall being built more than 3 feet above the rest unless separated by an opening. If one part of a wall is built up ahead of another, unequal settlement is produced. The joints in the brickwork of the higher part will have set before the remainder has been added, consequently the work laid last is very likely to settle away from the other. This not only weakens the wall, but also mars its appearance. If it is absolutely necessary to carry one part of a wall higher than the rest, the end of the high part should be stepped, or *racked back*, and not run up vertically, with only toothings left to connect it with the rest of the work.

JOINING NEW WALLS TO OLD

58. In joining a new wall to an old, when the walls come at right angles, the new work should not be toothed or bonded into the old work, unless the new work is laid in cement mortar. All masonwork built with lime mortar will settle somewhat, owing to a slight compression of the mortar joints, and this settlement is apt to cause a crack where old and new work are bonded together. In place of toothing, or bonding, a groove should be cut perpendicularly in the old wall, usually the width of a brick, to make what is called a *slip joint*. This method of bonding is shown in Fig. 36; *a* is the groove, or chase cut, where the new wall is to enter in the old wall; *c* is the new wall, and *d* the old wall. The new wall has a series of bricks *b* that fit into the slot *a*.

In cheap construction, where new work is bonded into old, the method most commonly used is to nail a piece of $2'' \times 4''$ timber against the wall, as shown in Fig. 37, where *a* shows the $2'' \times 4''$ timber spiked to the old wall, and entering the center of the new wall; at *b* is shown the old, and at *c* the new wall.

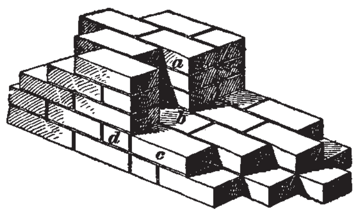


FIG. 36

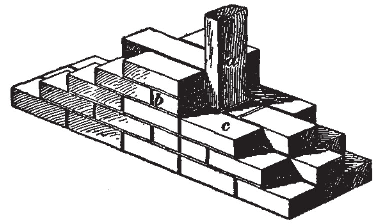


FIG. 37

The average settlement of brick walls where the foundation is stable and the mortar good is 1 inch in from 40 to 60 feet, or as some engineers reckon $\frac{1}{4}$ inch to the story. If a wall is built rapidly the settlement will be found to be much greater than if it is built slowly, since the weight is then put on the mortar before it has time to set.

OPENINGS IN BRICK WALLS

59. Openings for windows and doorways should be built into the walls where required. For their corners round-cornered bricks, or those molded with one corner rounded off, are appropriate, since they are not so easily defaced as square-cornered bricks. Segmental arches should be turned over the window frames and generally over doorways, although occasionally semicircular arches are used for doorways and other large openings. The two forms of arches used over the windows of mill structures are the *rowlock* and the *bonded arch*. In the **rowlock arch,** shown in Fig. 38, each course of bricks is turned independently, while in the **bonded arch,** shown in Fig. 39, the two courses are bonded together. The bonded arch is considered the stronger, but the rowlock arch is generally used as it is sufficiently strong for mill purposes and has the additional advantage of being easier to lay.

Arches should be laid with close joints, or the shrinkage of the mortar will cause the arch to crack and perhaps in extreme cases to drop out. They should not be laid too flat, or they will crack, especially if laid with thick joints.

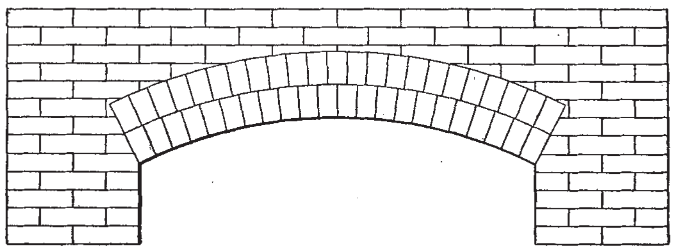


FIG. 38

The rise of any large arch should be at least one-sixth of the length of the span. It is laid with a center, or framework, that supports it while being laid, and which should not be removed, or *struck*, until the weight of the masonry above has been added.

A large arch with light abutment walls, that is, walls at each side, is liable to spread and crack. This may be pre-

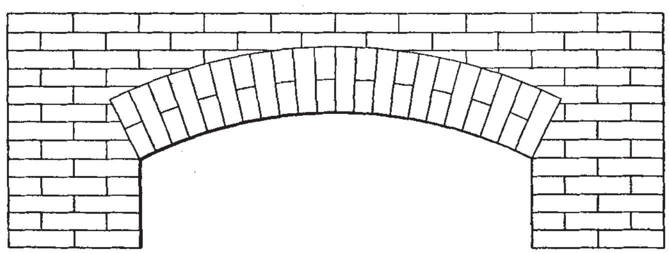


FIG. 39

vented by embedding an iron rod, with a plate attached to each end, in the brickwork just above the arch. The use of iron in brickwork should be limited, however, not only because of the danger of its rusting, but also because the expansion of the iron pieces, when heated, is liable to crack the walls.

BRICK PIERS

60. Brick piers are built in the same manner as brick walls. When less than 3 feet square and supporting a beam, girder, arch, column, or lintel carrying a wall, they should contain bond stones at least 4 inches thick, or cast-iron plates of sufficient strength and the full size of the piers, at least every 30 inches in height. In height, isolated brick piers should not exceed twelve times their least square dimension. The

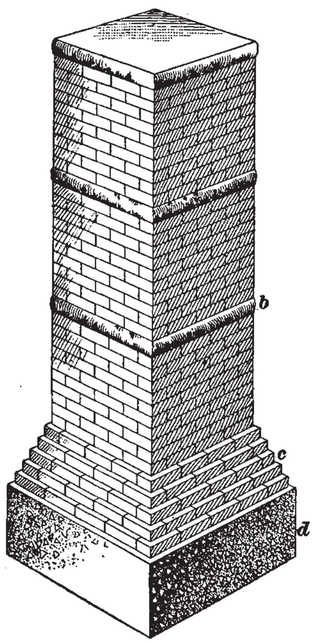


FIG. 40

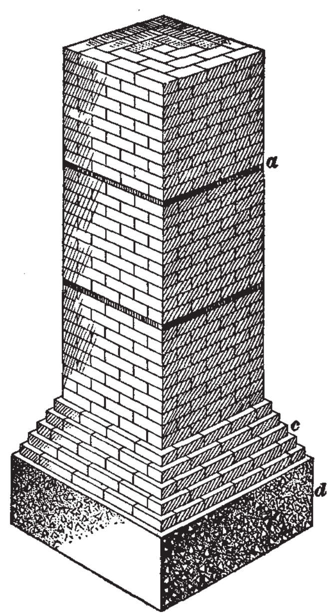


FIG. 41

object of bonding a pier carrying a heavy weight is to distribute the load over the whole area, thereby causing it to bear equally on each brick used in the construction. The bond stones should be either granite, bluestone, or one of the durable limestones. The blue Vermont marble is also used, but the softer sandstones and freestones should be avoided.

Fig. 40 shows a pier bonded with 4-inch bond stones *b*, a stepped-up brick foundation at *c*, and a concrete footing at *d*. Fig. 41 shows a brick pier with 1-inch iron bonding plates at *a*, and stepped up brick foundation and concrete footing at *c* and *d*.

FIRE-WALLS

61. Fire-walls are brick interior walls arranged to separate portions of the mill in which processes involving a greater risk of fire are carried on, from other portions of the mill. They should be carried down to secure foundations like the other walls of the mill and carried up through the roof, so as absolutely to intercept the progress of a fire and prevent its spreading and destroying the entire plant. They should contain as few openings as possible, and these should be thoroughly protected with automatic fire-doors, the construction of which will be explained later.

CHIMNEYS

62. If the boiler plant of the mill is to be equipped with forced- or induced-draft appliances, a comparatively short stack will suffice to carry off the smoke and gases incidental to the combustion of fuel beneath the boilers. If, however, natural draft is to be relied on, a **chimney** of sufficient height to insure the combustion of the fuel will be required. Iron stacks are occasionally used, but brick chimneys are to be preferred, since they are more stable and retain the heat of the gases to a greater extent, thereby increasing the draft of the flue. The footing for a brick chimney should consist of a bed of well-rammed concrete, at least 3 feet thick, of sufficient area to safely support the structure; this area will vary according to the size of the chimney and the character of the soil on which it rests. The foundation of the chimney may be either stone or stepped brickwork laid in cement mortar and resting on the concrete footing. The chimney should be built tapering and the top provided with an iron cap to prevent moisture from working into the brickwork and to prevent the topmost bricks from becoming loose and being blown off. A round chimney is to be preferred as it has only 55 per cent. of the wind pressure that a square chimney is subjected to and costs but little more to build. Fig. 42 (*a*) shows an elevation of a 106-foot chimney, while Fig. 42 (*b*) is a section showing the proportions of the brickwork and the diameter of the flue: *a* is a bed of concrete on which the foundation *b* is built; *c* is the outside wall of the chimney; *d*, the flue; *e*, an iron cap; and *f*, the opening at the bottom, which is connected with the boiler by an iron pipe.

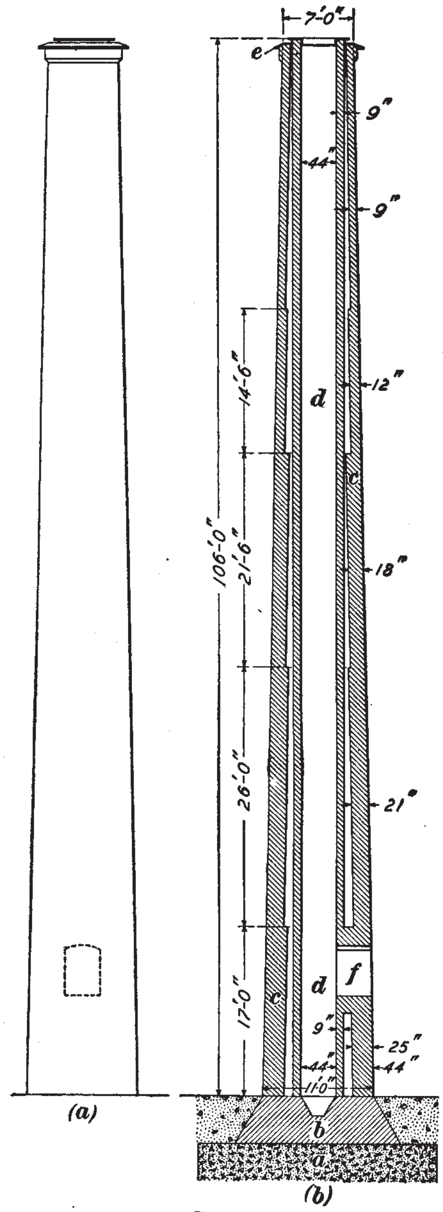


FIG. 42

MEASURING BRICKWORK

63. The method of measuring brickwork usually followed is by the thousand bricks as laid in the wall. Most mason contractors, in estimating on the cost of brickwork, take the entire superficial area of the wall in square feet, measuring it on the outside of the wall, so that the angles are taken twice. This is done to allow for the extra labor in laying up the angles. The bricks are then computed as laying $7\frac{1}{2}$ bricks to the square foot for a 4- or $4\frac{1}{2}$-inch wall, 15 for an 8- or 9-inch wall, $22\frac{1}{2}$ for a 12-inch wall, 30 for a 16-inch wall, and so on, adding $7\frac{1}{2}$ bricks per square foot for every additional thickness of 4-inch wall.

These figures apply to the Eastern and New England states. In the West and South, the bricks are larger, and give from one-quarter to one-third less bricks per square foot in the wall than in the East, and the price is regulated accordingly. In some parts of the West and South two measurements are used; the first, or *kiln count*, represents the actual number of bricks purchased and used, while the second, or *wall measure*, designates the number of brick in the wall, estimating $22\frac{1}{2}$ bricks to every superficial foot of 12-inch wall.

Among some builders the custom prevails to reduce all brickwork to cubic feet and estimate in that way; as for example, a wall 24 feet long, 12 feet high, and 20 inches thick will contain 24 feet $\times$ 12 feet $\times$ 1 foot 8 inches = 480 cubic feet, at $22\frac{1}{2}$ bricks per cubic foot equals 10,800 bricks.

When estimating the amount of brick required for a mill, from 2 to 3 per cent. should be added for outside walls; on inside work, or other work where many bricks must be broken, from 4 to 5 per cent. should be added, in order that no shortage will be occasioned by bricks that should be rejected.

A first-class mason well tended, that is, well supplied with brick and mortar, should easily lay from 1,000 to 1,200 bricks per day on outside work, and on inside work, or as it is sometimes known *backing-up* or *filling-in*, from 1,500 to 2,000 bricks. On less particular work, such as the massive work necessary for engine beds, etc., a good mason will often lay 3,000 and even 4,000 bricks per day of 8 hours. The weight of brickwork laid as explained is about 125 pounds to the cubic foot.

Where the size of the structure being built is sufficient to warrant it, a brickwork inspector, preferably a practical mason, should be employed to inspect all brickwork and see that it is properly laid. Of course on small buildings this is not practical and the engineer must keep an eye on this himself.

STONE TRIMMINGS

64. In all structures, a certain amount of stone is laid in connection with the brickwork. In mills this stonework is ordinarily confined to door and window sills, steps, and other minor parts, and is known as **stone trimmings.** Window sills, especially, should be a single stone let into the wall 3 or 4 inches on each side and extending under the window frame far enough to prevent water from working into the wall. If the window sill is made of brick, the rain water will soak into the wall and weaken it. If of cut stone, window sills should have a bevel, or wash, to throw the water from the wall; if a window sill is simply quarry-faced, it should be set so as to utilize whatever natural bevel there is to the stone. All stone should be laid in cement mortar.

Granite is the best stone to use in mill work, and as economy and an appearance of solidity are desired, it should not be too smoothly finished. For steps and door sills six-cut work is often used, while window sills are appropriate if simply quarry-faced. Occasionally a date stone or keystone for a large arch must have a smooth surface, in which case a ten-cut stone should be used.

The terms *quarry-faced*, *four-cut*, *six-cut*, etc. when applied to stone work refer to the method of cutting and finishing the stone. A **quarry-faced stone** is one that is left rough, just as it comes from the quarry. Sometimes the edges of the stone are pitched off to a line. Quarry-faced stones are also called *rock-faced* and *pitch-faced* work. The terms **four-cut, six-cut, eight-cut,** etc. indicate the degrees of smoothness of the face of a stone obtained by hammering and other finishing processes. A six-cut stone is smoother than a four-cut stone, and an eight-cut stone has a finer surface than a six-cut stone, etc.