"*TEXTILE MANUFACTURER*" *MANUALS*

THEORY OF SIZING

STARCH GRANULES

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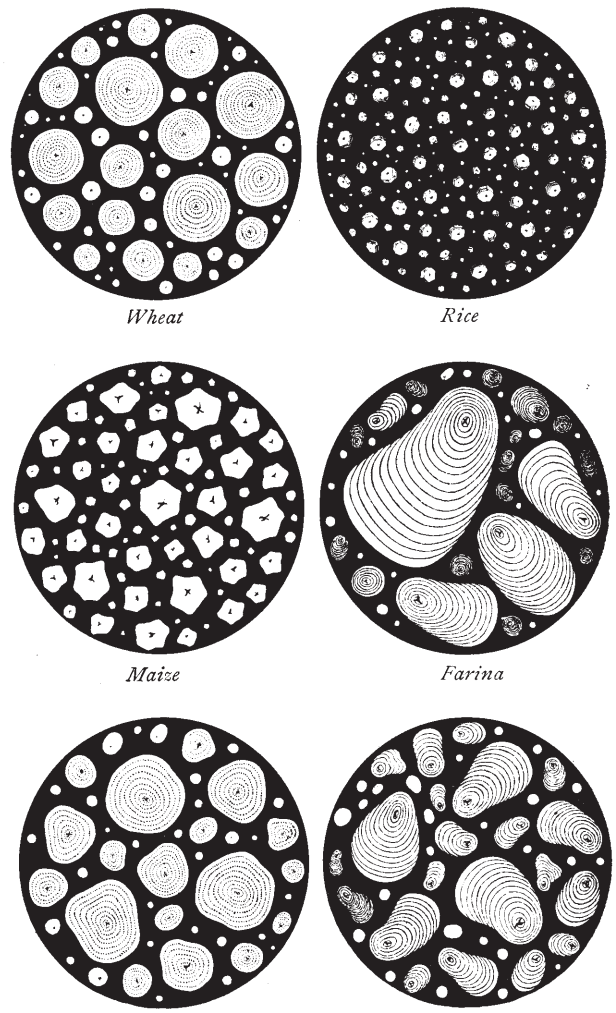

Wheat — *Rice*

Maize — *Farina*

Tapioca — *Sago*

Theory of Sizing

BY

HARRY NISBET

Weaving and Designing Master, Municipal Technical School, Bolton

AUTHOR OF
"GRAMMAR OF TEXTILE DESIGN"

MEMBER OF THE TEXTILE INSTITUTE

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TO

HIS WORSHIP THE MAYOR

OF

THE COUNTY BOROUGH OF BOLTON

ALDERMAN DR JAMES YOUNG, J.P.

THIS BOOK

IS

DEDICATED

AS AN

EXPRESSION OF GRATITUDE

FOR, AND

APPRECIATION

OF,

PROFESSIONAL SERVICES RENDERED

TO

THE AUTHOR

PREFACE

THE *Theory of Sizing* treats of the essential constituents and properties of sizing ingredients, and of the chief factors determining the selecting, blending and mixing of those ingredients suitably to the requirements of manufacturers and merchants of textile fabrics.

The descriptions of the physical characteristics; the dimensions and illustrations of the six chief varieties of starch which, either separately or else blended with two or more varieties in combination, constitute the fundamental basis of most size-mixtures and size preparations; and also the methods of distinguishing the different species of starch granules, both by microscopical examination and chemical reaction, are derived from personal observation and experiment, and will serve as guides in identifying different kinds of starch.

Also, the formula stated in §96, p. 66, is a deduction, by the author, from calculations based on the R.D. of several soluble materials, and subsequently verified by actual tests. This formula will have a wide application of usefulness and practical value in estimating the variation which it is necessary to make in either the relative density or the volume of solutions, in order to ensure corresponding weights of solid matter dissolved in them.

The contents of this book were written as part of a series of articles, entitled *Preliminary Operations of Weaving*, and contributed, by the author, to the TEXTILE MANU-

FACTURER, in which excellent journal that series of articles are continued. The matter treating of the theory of sizing, however, has been revised, enlarged, re-arranged and adapted in its present convenient form more suitably to the purpose of a standard text-book for students of weaving in particular, and also as a book of reference generally, for those requiring information on the important subject of sizing, sizing ingredients and size mixing.

HARRY NISBET.

BOLTON, *January* 1912.

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THEORY OF SIZING

CHAPTER I

Introduction

THE COMMERCIAL AND TECHNICAL POLICY OF SIZING YARN

§1. The operation of sizing constitutes one of the most important stages in the preparation of warps which, if not previously sized, would be unable to withstand the tensile strain and excessive chafing action of the shedding harness, reed, and shuttle race-board during the operation of weaving.

This is true in respect of warps for most varieties of textile fabrics produced from warps composed of "single twist-yarn"; and especially of those employed in the manufacture of "grey" cotton goods that are woven and sold in the grey state, or natural colour of the cotton staple, and of which the market value is often very largely, and sometimes chiefly, determined by the results obtained in the sizing-room.

§2. It is not surprising, therefore, that the important problems relating to the theory and practice of sizing have received a considerable amount of attention from industrial and analytical chemists, sizing-specialists, textile manufacturers and machinists, and many technical writers. Indeed, probably no other departments of the textile industry have proved such prolific sources of discussion, contention and even litigation, or have provided so much material for literary composition, as those concerned with the sizing of yarn and the finishing of cloth, which two operations are sometimes very closely and intimately associated. And whether these subjects are studied from a purely theoretical and chemical standpoint, or as mechanical operations, they abound with matter of considerable interest to students and experts, and with questions of vital importance to manufacturers, merchants and salesmen of most varieties of textile fabrics in the manufacture of which the processes of either sizing or finishing have been involved.

§3. As regards the commercial morality or justification of sizing yarn, for weaving purposes only, that process is both a commercial and also a technical contingency in the economy of textile manufacturing, and one of which the policy could be questioned only by those whose knowledge of the textile industry in general, and of the weaving branch of that industry in particular, is of a limited character. The structure of most textile threads, and especially those produced from such comparatively short filaments as those of the cotton fibre, necessitates some kind of treatment by which they are made better able to resist the tensile strain and abrasive action of the moving parts of a loom to which they are subjected during the operation of weaving.

§4. This improvement in the weaving qualities of yarn is effected by a process of sizing which consists of impregnating the yarn with an adhesive compound of various ingredients, chiefly with the object of laying down the exposed ends of fibres that protrude from the threads and constitute what is variously described as "oozy," "fluffy," and "hairy" yarn. The immediate effect of sizing yarn, therefore, is that the threads become both smoother and also slightly stronger, because the fibres composing them are consolidated and lie together more compactly. This not only reduces the frictional resistance between the warp-ends as they pass each other in the act of shedding during weaving, and between those threads and the parts of the loom named in the first paragraph of §1, but it also increases their resistance to tensile strain, and thus reduces the risk of threads breaking during weaving, thereby improving the quality, and also increasing the production, of cloth.

§5. Hence the impregnation of warp yarn with a glutinous size paste, with the sole object of improving its weaving capabilities, is as essential to the manufacture of certain classes of textile fabrics as is the legitimate use of an alloy of silver, copper or other baser metal, as a binding and strengthening material, in the manufacture of articles of gold.

§6. It is well known, however, that the modern practice of sizing is abused, and frequently exceeds the legitimate bounds of its primary object of facilitating the operation of weaving. It is also sometimes seized as a favourable opportunity for accomplishing many other purposes, some of which are of a questionable character.

§7. The sizing of warp yarn, presumably, was conceived with the sole object of facilitating the operation of weaving, and of enabling textile fabrics to be produced from strands of yarn so fine and delicate that they could not, unless reinforced with some suitable medium, withstand the severe ordeal of weaving.

§8. With the introduction of the power-loom, however, the art of sizing acquired much greater importance in the preparation of warps; and it is now frequently made to serve other objects than that of assisting the weaver. For example, the process of sizing is sometimes utilised as a means of imparting to the finished cloth certain desired tones of colour, peculiarities of texture, and a soft mellow " tone " or other feeling when handled; linen finishes, and other subtle artificial effects with the object of improving the appearance of the cloths, and thereby conveying the impression that they are composed of yarn of superior quality. In the manufacture of inferior qualities of certain varieties of grey cotton fabrics, the process of sizing also presents a favourable opportunity for adding to the yarn excessive quantities of weighting material in the form of china-clay and other mineral substances which have no direct beneficial effect whatever, either on the yarn during weaving, nor on the wearing qualities of the finished cloth, although as much as 250 per cent. of size is sometimes added to the net weight of yarn.

§9. It is in order to meet the varied requirements and prejudices of manufacturers and merchants, according to the particular classes of fabrics in which they trade, that there exists such a great variety of ingredients employed for the purpose of sizing yarn. There are also innumerable patented recipes for size-mixings, in addition to numerous proprietary " secret " concoctions, many of which are known, from analyses, to contain ingredients of common quality and sometimes of an injurious character. Therefore, if these substances are not used with discretion, they may prove a source of risk and danger by acting with detrimental effect on both the yarn and the copper immersion and sizing rollers; and also on other metal parts of the sizing machine with which they come into contact. Hence, unless the ingredients of these special sizing preparations are known, and their use properly understood, they are better entirely avoided.

CHAPTER II

CLASSIFICATION OF SIZING INGREDIENTS: THEIR ESSENTIAL CONSTITUENTS, PROPERTIES, AND SPECIFIC PURPOSE. MILDEW: ITS CAUSE, EFFECT AND PREVENTION. ALSO THE PHYSICAL STRUCTURE AND MICROSCOPICAL APPEARANCE OF DIFFERENT VARIETIES OF STARCH GRANULES, AND METHODS OF DISTINGUISHING THEM.

CLASSIFICATION OF INGREDIENTS

§10. Although the list of ingredients generally described as "sizing" materials comprises a great variety of substances, the number essentially composing a size mixture for ordinary purposes, and exclusive of water, does not usually exceed two for pure and light sizing up to 20 per cent.; and five for both medium and heavy sizing from 20 to 50 per cent. and upward. The recognized standard ingredients for general use may be conveniently classified into five distinctive groups of different materials, according to their chief characteristic properties, namely:—

Group 1: *Adhesive Substances* possessing glutinous properties to consolidate the fibres and give smoothness, body, and stability to the yarn; and also to serve as a medium for fixing other ingredients upon it.

Group 2: *Softening Substances* possessing emollient properties to prevent the adhesive and weighting materials from becoming hard or powdered; and also to preserve the soft and supple qualities of yarn.

Group 3: *Antiseptic Substances* to prevent or check the origin or development of mildew and other forms of decomposition so liable to occur in the nitrogenous and other organic matter of vegetable and animal products.

Group 4: *Deliquescent or Moistening Substances* to keep yarn in a humid condition, and prevent it from becoming too dry and hard.

Group 5: *Weighting Substances* to increase the weight and bulk of cloth.

§11. The chief varieties of materials constituting the respective groups of sizing ingredients are specified below; and a description is given, in §§14-79, of their essential constituents, and of the chief properties which specially adapt those materials more or less suitably for the purpose of sizing yarn:—

GROUP 1: Materials yielding adhesive properties may be divided into three chief classes—namely: (1.) Farinaceous or starch-bearing grain and seed products, comprising wheat flour and starch, rice starch, and Indian corn or maize starch; also starch or "*fecula*" obtained from the roots and other parts of plants and trees, as for example, farina or potato starch obtained from the tuberous roots of the potato plant, tapioca starch obtained from certain South American and West Indian tree roots of the genus *manihot* or *manioc*, and sago starch obtained from the pith of a certain species of East Indian palm trees. In addition to the pure starch products just named, and several others, there are also numerous starch preparations, as soluble starch, octopus gloy, apparatine, and many other varieties of starch paste or mucilage which only require to be heated before applying them to the yarn, and which are sold under different trade-names. (2.) Gum and similar glutinous natural products, as gum-tragacanth and gum-arabic; also manufactured gum preparations comprising dextrine or British gum, gum-tragasol, gelatose, and other gum substitutes. (3.) Mucilage material termed "pectin," consisting of a gelatinous substance extracted from seaweed, known as Irish moss, Carrageen moss, and pearl moss; also Iceland moss and other varieties of seaweed.

GROUP 2: Emollient substances employed to make yarn soft and supple may be divided into four chief classes—namely: (1.) Animal fat or grease and wax products, comprising beef and mutton tallow, bone fat, lanoline, wool grease (also known as Yorkshire and recovered grease), beeswax, and spermaceti (sperm whale) wax. (2.) Vegetable oil and wax products, comprising bleached palm oil, olive oil, castor oil, coco-nut oil, cotton-seed oil, carnaüba or Brazilian palm wax, Chinese or "insect-wax," and Japan palm wax. (3.) Mineral wax, as paraffin wax. (4.) Commercial products, comprising glycerine and glycerine substitutes, glucose, dextrose or grape sugar, stearine, several varieties of specially prepared sizing soap; also velvet or tallow pulp, and many other tallow substitutes.

GROUP 3: Antiseptics employed to prevent fermentive and other decomposition of organic matter may be divided into three chief classes—namely: (1.) Chloride of zinc. (2.) Acids, comprising carbolic acid, salicylic acid, cresylic acid, formaldehyde or formalin, arsenious acid and perchloride of mercury. (3.) Thymol and glycerine.

GROUP 4: Deliquescents employed to retain yarn in a moist and flexibly soft condition may be divided into two classes—namely: (1.) Chloride of magnesium and chloride of calcium or lime. (2.) Glycerine.

GROUP 5: The weighting material employed with that specific object is almost invariably kaolin or china-clay, a natural mineral product which is found in abundance in Devon and Cornwall, and used extensively in cloth finishing, and also in the manufacture of china porcelain and other varieties of earthenware.

§12. In addition to the foregoing chief classes of sizing ingredients, which are more or less essential to meet the numerous requirements of manufacturers, according to the different classes of fabrics which they produce, there are also employed, in some size-mixings, many other substances that are not essential either to the preparation of size, nor beneficial to the yarn, for weaving purposes, nor to the finished cloth; but which are intended to produce certain pleasing effects, as specified in §8, p. 3.

These minor substances comprise, amongst others, colouring material of various tints, to impart to the finished cloth certain tones of colour for the purpose of improving the appearance of the fabric, and also, in some instances, with the express object of simulating the peculiar rich brown tone which is natural to certain varieties of both Egyptian and Sea Islands cotton staple. In other instances, however, the contrary effect is sought by the addition, to size prepared from wheat flour, of a little blue colouring material for the purpose of neutralising the brown tone of the flour, and thereby imparting to the yarn a whiter tone.

Other materials are employed to impart to the finished cloth certain soft and mellow "tones" and subtle peculiarities of "feel" and texture, when handled; as well as many other desired artificial effects. Also, a little common soda is sometimes employed in size, with the object of reducing the risk of the yarn and cloth developing the stains of ironmould from the use of zinc chloride, as explained in §66, p. 42.

§13. Also, it is found by experience, that for the purpose of sizing yarn, better results are obtained by employing as the ingredient with which to endow the size with its adhesive and glutinous properties, some substance which is derived from the same natural kingdom as that from which the textile material to be sized has been obtained. Hence, if the yarn to be sized is produced from fibres of vegetable origin, as cotton, flax, jute, hemp, china-grass and other kindred species of vegetable fibres, the substance employed to give the size paste its adhesive properties should also be of vegetable origin, as flour or starch obtained from the cereal grains, or other vegetable product. Likewise, if the yarn to be sized is produced from fibres of animal origin, as wool and silk, in that case, the adhesive properties of the size employed should also be of animal matter, as glue, and similar preparations.

Essential Constituents, Properties and Specific Purpose of Sizing Ingredients

Group 1: ADHESIVE SUBSTANCES

§14. The following brief description of the essential constituents and properties of the principal ingredients employed for sizing yarn explains why they are more or less suitably adapted for that purpose:—

Wheat Flour.—Wheat flour is used most extensively as a material for endowing a size mixture with its most essential property of adhesiveness. This is accountable from the fact that the principal constituents of wheat flour are starch and gluten, which exist in varying proportions, according to the quality of flour, and range approximately from 60 to 70 per cent. of starch, and from 3 to 15 per cent. of gluten. It is to these two chief constituents, starch and gluten, that flour produced from wheat and other cereal grains owes its value as a sizing commodity. If flour and water are combined in suitable proportions, and the mixture heated to about 180° F. (82° C.), the starch and gluten combine to produce an adhesive paste of great binding and fixing power.

It is because of the powerful adhesiveness of gluten that some sizers prefer whole flour instead of starch, especially for the purpose of heavy sizing, when the gluten serves to fix a large amount of china-clay and other weighting material upon the yarn. Being a nitrogenous compound of several organic elements, however, the presence of gluten in flour used for sizing is condemned by some authorities because of its marked tendency to develop quickly a state of septic or putrefactive decomposition, during which it emits a peculiarly sour and offensive odour.

§15. Under certain favourable conditions of exposure to a warm, moist, and ill-ventilated atmosphere, flour is liable to foster the germination and development of several species of both animal and vegetable microbes, some of which are inherent to the flour itself, whilst others are deposited from the atmosphere, and find in flour a favourable fertilising medium. For these reasons. therefore, whole flour, containing the nitrogenous substances as gluten and albuminoids, is said by some authorities to be unsuitable for sizing purposes owing to the subsequent danger of mildew and other decomposition. It is also said that the use of flour for sizing is declining in favour of starch and its numerous preparations, because the elimination of the nitrogenous substances containing the fermentive and putrefactive principles makes pure starch much less liable to mildew or other organic decomposition.

Another advantage which starch possesses over whole flour of any kind is that it may be mixed with water and boiled immediately, ready for use; whereas flour is usually steeped in cold water for a period varying from two or three days to as many weeks, and sometimes months. The chief object of steeping flour is to promote the action of fermentation with a view to neutralising the septic principles inherent to the nitrogenous constituents of flour, and thereby reducing the tendency of the gluten to develop a state of decomposition, as mildew. Fermented flour is said to impart to the yarn and cloth both a soft and mellow feel, when handled, and also a better tone of colour.

MILDEW: *Its Cause, Effect and Prevention*

§16. MILDEW is one of numerous manifestations of the putrefactive or fermentive principle of decomposition which attacks substances of an organic structure, and results chiefly from the exposure of such material to the influence of a warm and humid atmosphere. Organic matter in general affords a favourable fertilising medium for the active germination and prolific growth and development of all varieties of moulds, or mildew. These growths assume a great variety of distinctive forms chiefly according to their origin and the particular organic nature of the material which is affected, and also the character of the atmospheric conditions to which the substance is exposed. Thus, the moulds may manifest themselves only in the form of stains or slight discolorations on yarn or in cloth; or they may occur in the more vigorously active and destructive vegetable forms of different species of fungus, of which there is an immense variety. In either case, the presence of mildew acts with rapid and very destructive effect on whatever material is affected by it; but its further progress may be checked by adopting certain remedies and precautions, provided the necessary steps are taken at an early stage of its development.

§17. If the presence of mildew spores or germs, on yarn or in cloth, are detected in their initial stage of growth, their development may be easily arrested, and the growth even destroyed, either by vigorous washing and steaming, or by treatment with dilute solutions of chlorine or other bleaching agents. The stains and discoloration caused by mildew in the second stage of development are, however, very difficult or impossible to remove, even though the germs may have been destroyed in the manner just indicated. But if decomposition is allowed to reach the third stage, the fibres are attacked to such a degree that they lose their strength entirely, and the destruction of the yarn or cloth thus affected is complete.

§18. The difficulties arising from mildew in cloth are encountered more frequently in bleachworks and dyeworks than elsewhere. Also, fabrics that have been soaped tend more readily than before soaping to develop mildew if they are allowed to remain in that condition for a prolonged period.

The risk of mildew developing on yarn or in cloth may, however, be prevented, or at least minimised by a judicious use of a suitable antiseptic substance introduced into the size paste with which the warps are sized. But the greatest precaution against this evil is to entirely avoid the exposing of sized yarn, or cloth produced from it, to such climatic and other favourable conditions as may tend to foster the germination of mildew spores, and which encourage their growth and development.

§19. Textile fibres of vegetable origin, as cotton, linen, jute, hemp, china-grass, rhea, ramie and others, are more readily attacked by mildew than are the fibres of animal origin, as the numerous varieties of wool and kindred fibres, silk and others. Also, cotton is much more susceptible than other species of vegetable fibres to the fertilization and development of mould or mildew germs, especially if the material is dyed with indigo dye, which is a blue pigment colour also of vegetable origin, and obtained from the indigo plant of the genus *Indigofera*.

§20. Wheat Starch.—Starch is extracted from wheat flour by the simple process of washing the whole flour with water to remove the gluten and other nitrogenous substances, which remain in suspension in the water, whilst the heavier starch granules settle down by gravitation to the bottom of the vessel. Wheat starch is employed for both sizing warps, and also for cloth-finishing, especially for soft, mellow and light sizing and finishing, as it does not impart to yarn or cloth the same degree of firmness as that produced by farina (potato starch) or maize (Indian corn) starch. Nor is the paste produced from wheat starch so clear and transparent as that produced from either farina or maize starch.

§ 21. Rice Flour and Starch.—Rice flour is prepared from the husked seeds or grains of the rice plant, and the starch obtained by submitting the flour to a process of fermentation, or preferably to the chemical action of either caustic alkali or dilute acid to separate the starch granules from the gluten and other nitrogenous elements of the flour. Rice starch alone is only suitable for pure and very light sizing; for although it yields a relatively thicker paste than that of wheat flour or maize starch, it is less adhesive, and not so conducive to good weaving. The hard and gritty character of rice granules imparts to the yarn a harsh, rough, and crisp surface which acts with injurious effect on the shedding harness during weaving. For these reasons it is advisable to blend rice starch with wheat flour or other binding material, which should be mixed and boiled separately before being combined, as the harder and tougher granules of rice starch require to be boiled for a longer period to burst them thoroughly.

Or, instead of this method, a superior size mixing is produced if a blending of about 10 per cent. of rice flour or starch, and 90 per cent. of wheat flour, is steeped and fermented before boiling. Also, if it is required to combine china-clay with rice flour, the latter should first be well mixed in the boiling-pan, after which the china-clay is added and both boiled together to ensure their more thorough admixture before combining them with the wheat flour and other ingredients to be boiled all together. Another method of preparing starch is to mix it with water, and afterwards add either chloride of zinc or caustic-soda solution, which breaks up the rice granules and increases their solubility, as described in the last paragraph of §22, and also in §38, p. 29.

§22. Maize Flour and Starch.—Maize flour is produced from Indian-corn grains, and the starch obtained either by fermentation, or chemical treatment. Maize starch produces a relatively thicker paste than that of other varieties of starch, and, like rice starch, it requires to be well boiled to effect a thorough bursting of the hard and tough granules, which otherwise tend to impart to yarn a harsh, brittle, and wiry feel. For these reasons maize starch is rarely used alone, excepting for pure and light sizing, and is therefore usually blended with wheat flour or other binding agent to reduce the harshness of the granules, and thereby impart to the yarn a softer and mellower tone.

The importance of effecting a thorough disaggregation of the clusters of maize-starch granules, either by prolonged boiling or by treatment with chloride of zinc, caustic alkali, or an acid, is emphasised because of the greater tendency of maize, than of other varieties of starch, to develop, under similar atmospheric conditions, mildew and other forms of decomposition.

For light and pure sizing, maize starch and wheat flour may be boiled separately and afterwards combined; or they may be steeped, fermented, and boiled together. But for medium and heavy sizing, china-clay, chlorides of zinc and magnesium, may be combined with the starch, to be all boiled together in the boiling-pan, and afterwards mixed and boiled with the fermented wheat flour ready for use.

Instead of using chlorides of zinc and magnesium, a superior size mixing is obtained by steeping the starch in caustic-soda solution of 50° Tw. (R.D. 1·25) in the proportions approximately of 0·3 gal. (3·75 lb.) caustic solution to 100 lb. starch. The action of the caustic alkalies effects a more complete dissolution of the starch granules, which become more soluble, and therefore produce a paste of a more homogeneous character, uniform consistency, stronger adhesive power, and also one that imparts to the yarn a smoother, softer, and mellower tone and feel. Furthermore, starch treated in this manner is much less liable to develop mildew. But it is very important to remember, however, that caustic alkali and chlorides of any description should never be employed in conjunction with each other, as these agents react upon and decompose each other, with injurious effect. (*See* also §38, p. 29.)

§23. Farina or Potato Starch.—Farina is obtained by pulverising raw potatoes and washing the pulp to remove the cellular tissue from the pure starch granules, which, having a R.D. (relative density) of 1·5, are precipitated by gravitation. Farina swells and thickens into a gelatinous paste more quickly and at a lower temperature than any other starch of commerce; and in a pure state it is less liable than others to mildew. It also produces a relatively thicker paste than that of other varieties of starch, excepting maize; but it possesses less adhesive and strengthening properties.

If used alone, farina is said to impart smoothness to the yarn, which also retains its pliability; but it is only used in an uncombined state for sizing fine counts of yarn with a pure and very light size. For this purpose it may be boiled to a thinner paste by the addition of either chloride of calcium or magnesium to increase its penetrating power.

But in any case it is expedient to use farina size paste immediately after preparation, as it becomes thinner and weaker by continued boiling, and also separates and liquefies if allowed to remain in a cold state. This, however, may be prevented by mixing the starch in water containing caustic-soda solution, which not only makes the starch more soluble and increases the adhesiveness of the size, but it also negatives the tendency to develop mildew, as explained in the last paragraph of §22.

For medium and heavy sizing, farina is usually blended with some other variety of flour or starch, or other binding material possessing stronger adhesive power, as wheat flour, sago and maize starch, in which case it tends to make the yarn feel crisp.

§24. Tapioca Starch.—Tapioca, also known as West Indian *cassava*, and *Brazilian arrowroot*, is a starch substance obtained in a crude state from the roots of a certain species of South American and West Indian tree of the genus *manihot* or *manioc*. Whilst the crude material is in a soft and moist condition, it is submitted to a process of drying on hot plates, during which many of the starch granules swell and burst, and the whole mass breaks up into hard, crisp and irregular forms. Also, the heating process causes many of the starch granules to become torrefied and ruptured beyond recognition.

Tapioca for sizing purposes is obtained in the form of a powder which, on pressing it between the finger and thumb, feels harsh, crisp, and gritty, like rice starch. Tapioca starch, however, is inferior to other varieties of starch for sizing yarn, because it yields a paste of feeble adhesive properties, and its variable quality makes it very unreliable.

Size paste prepared from tapioca also loses its tenacity, and liquefies by continued boiling or if left in a cold state, in the same manner as that prepared from farina, both of which varieties of starch have their origin in the roots of plants. Also, being a cheaper commodity, tapioca is frequently used as an adulterant of sizing starch preparations, and is also largely manufactured into dextrine or British gum, which is used more extensively in cloth finishing.

§25. SAGO FLOUR and STARCH. — Sago is a starch substance reduced from the pith obtained from the stems of a species of palm tree, and is chiefly employed for sizing yarn of fine counts with a light and pure size, which imparts great strength to the yarn and leaves it pliable. Unlike that produced from farina and tapioca starch, both of which are obtained from roots, sago starch paste is greatly improved by prolonged boiling, which effects a more thorough dissolution of the starch granules.

Also a superior mixing for light and pure sizing of great adhesiveness is obtained by first mixing the starch in water containing caustic-soda solution (as described in the last paragraph of §22), and also by adding about 30 to 35 per cent. of farina to the net weight of sago flour after this has been previously well boiled.

Physical Structure and Microscopical Appearance of Different Varieties of Starch Granules, and Methods of Distinguishing them

§26. Starch is a compound granulose vegetable substance containing the same elements (but in a different chemical combination) as those which constitute sugar, cellulose, gum, and many other substances, constituting the group known as " carbohydrates," which are so-called because they are each composed of the simple elements, carbon, hydrogen, and oxygen, always in the constant atomic proportion of $C_6 H_{12} O_6$, with hydrogen and oxygen always in such relative proportions as to form water—namely, 2 to 1 (H_2O) respectively.

Starch is contained in abundance in a numerous variety of plants, and forms the principal organic constituent of all cereal or corn grain produce, potatoes, and the pith and roots of certain species of plants and trees. In a dry and pure state, starch granules form a fine white or greyish powder, having a somewhat harsh, crisp, and rough feel, according to its origin. They consist of minute opaque particles having distinctive and characteristic forms peculiar to the particular species to which they belong, and by which they may be identified if examined and measured miscroscopically. The granules are also of different sizes, not only according to their respective species, but even in a single specimen obtained from the same source.

§27. When viewed by the aid of a microscope, the physical characteristics of starch granules are revealed so distinctly as to enable one who is conversant with them readily to distinguish the different varieties, if their general appearance, as illustrated on the *Frontispiece,* is considered in conjunction with micro-measurements of the granules. This may be accomplished effectually by employing an $\frac{1}{8}$ in. objective, the No. 3 or "C" eyepiece, with the body of the microscope adjusted in length so that each division of the scale on the eyepiece micrometer indicates a value of $\frac{1}{10000}$th part of an inch (approx. $\frac{1}{400}$th mm.). This combination of lenses, with the draw-tube of the microscope extended about 3 in., gives an approximate magnification of 1000 diameters; but for a general observation of starch granules, sufficiently to distinguish the different species of the commercial varieties of starch, a $\frac{1}{4}$ in. objective may be employed to give a magnification of about 500 diameters, with each division on the micrometer scale indicating $\frac{1}{5000}$th of an inch (approx. $\frac{1}{200}$th mm.).

§28. Starch granules of normal and abnormal size usually have the appearance of a laminated or stratified structure built up of a succession of more or less circular and flat discs of varying thicknesses and diameter. The rims of these discs produce a series of faint concentric striæ or rings (analogous to the fine and delicate graining observed in a cross-section of an ivory tusk), encircling a distinctly visible central point, known as the "hilum," which apparently marks each extremity of an imaginary polar axis.

These characteristics are not perceptible if the starch granules are examined in a dry state; but they are resolved distinctly if the granules are previously combined with water and examined between a glass slip and a very thin cover glass. Their distinctive features are still more pronounced if, instead of water, the granules are mounted in such media as dilute alcohol, dilute glycerine, turpentine, Canada balsam, glycerine jelly, or if stained with very dilute solutions of either iodine or fuchsine tinctures, and other suitable stains; or if coloured rays of light are transmitted upward through the granules. Also, polarised light is especially valuable in resolving otherwise faint or obscure markings on starch granules, and in causing them to display four dark streaks radiating at different angles from the "hilum" in the form of a cross which varies in shape according to the different forms of the granules, and also the positions in which they are observed. Thus, on rotating either the polariser or analyser of the polariscope, the arms of the crosses radiate at different relative angles, thereby causing the dark crosses to change their character and assume such forms as the Greek cross, the Latin cross with the arms of the horizontal limb drooping, and also the form of a condensed black letter **X**.

§29. The peculiar phenomena of the dark crosses and their changing forms, in starch granules, when these are submitted to the influence of polarised rays of light, do not appear to have been explained. They may possibly be caused by either the obstruction or absorption of those particular rays of light by some element in the granules, or else by the diffraction of those rays by the striated surface of the granules as the rays of light fall upon them at varying angles of incidence; similarly to the familiar phenomenon of the divergent streaks of light and shade radiating from the axis of a metal shaft or disc, of which the end of the shaft and the surface of the disc has been highly polished whilst each rotated on its axis.

The General Forms, Physical Characteristics, Microscopical Appearance and Dimensions of Starch Granules

§30. A microscopical examination of the six principal varieties of starch used for sizing purposes, and described in §§20-25, pp. 13-18, revealed the following particulars, which will serve as a useful guide to their chief characteristic features for the purpose of distinguishing the different species illustrated on the *Frontispiece*, and described in the following table:—

Varieties of Starch.	General Forms and other Characteristic Features of the Granules.	Dimensions of the Granules, stated in $\frac{1}{10000}$ ths of an inch. (Approx. $\frac{1}{400}$th mm.)	
		Normal.	Maximum.
Wheat.	Spherical or globular, with a smooth even surface; also a hilum and concentric rings faintly visible. Of very variable sizes ranging from $\frac{1}{10000}$th to $\frac{18}{10000}$ths of an inch in diameter. With polarised light they display dark crosses. If the pure dry starch powder is pressed (but not rubbed) between the finger and thumb, it has but a slightly crisp feel. On being smoothed down to a level surface, the starch has a flat or dead white tone, and does not glisten.	9	18
Rice.	Angular polyhedral, resembling miniature blocks of the basaltic rock pillars seen at Giant's Causeway and Fingal's Cave. With hilum, but no other distinctive markings visible with either plain or polarised light. Of fairly uniform size ranging from $\frac{1}{20000}$th to $\frac{6}{20000}$ths of an inch. In a dry state the starch powder has a faintly brown flat tone of colour, and does not glisten when smoothed down to a level surface. If pressed between the finger and thumb, it produces a sharp crackling noise, and has a crisp and gritty feel like fine dry quicksand.	2	3

Maize or Indian Corn (Cornflour).	Irregular rounded polyhedral, like the seeds of a pomegranate. With hilum, but no visible striæ or other distinct markings. They are of very irregular size, ranging from $\frac{1}{10000}$th to $\frac{11}{10000}$ths of an inch, and display a black cross if viewed with polarised light. In a dry and pure state the starch powder has a flat tone of a purer white than that of wheat starch, and does not glisten when smoothed down to a level surface. It has a harsh and crisp feel, but is not gritty like rice starch; and if pressed between the finger and thumb, it produces a sharp crackling noise.	6	11
Farina (Potato).	Ovoid and elliptical, but appear round when viewed endwise, and bear a striking resemblance to new potatoes, and also to mussel and similar sea-shells. With hilum and very distinct rings or striæ, which appear either concentric or eccentric to the hilum, according to whether the granules are viewed endwise or lengthwise, respectively. They are very irregular in size, even when obtained from the same tuber, and range from $\frac{3}{20000}$ths to $\frac{104}{20000}$ths of an inch in length. With polarised light they display black crosses which assume different forms on rotating either of the two prisms of the polariscope. In a dry state the starch powder is almost of a pure white tone, and glistens with a scintillation resembling that of hoar-frost or fine dry snow. If pressed between the finger and thumb, it produces a very distinct crackling noise, and has a harsh and crisp feel. If a little farina is combined with either water or alcoholic spirit, and mounted either on a glass slip or in a live-box with the cover-glass adjusted lightly, so as to leave a little space for the free movement of the granules, it will be observed, if the object is held up to the light, that the granules descend with a rolling motion, and produce a glittering effect resembling that presented by particles of silver or gold-dust as these descend in spirituous media; or by the sparkling rays of light emitted by the scintillation of radium.	21 × 15	52 × 39

Tapioca.	The perfect granules are more or less spherical, with a hilum and concentric rings faintly visible. They are of very irregular size, ranging from $\frac{3}{20000}$ths to $\frac{40}{20000}$ths of an inch in diameter; and with polarised light they display a black cross. There are also numerous granules of imperfect and indefinite forms. These appear to be swollen, ruptured, and torrefied, without any visible markings. They also have a more gelatinous appearance, and are not influenced, like the perfect granules, by the action of polarised light, which is proof that they have undergone some physical and chemical transformation as explained previously.	10	20 × 17
Sago.	Generally ovoid and elliptical, with many pear-shaped granules. They bear a close general resemblance to those of farina, for which they might easily be mistaken, excepting for the fact that they are uniformly smaller than those of potato starch granules, and range in size from $\frac{3}{10000}$ths to $\frac{27}{10000}$ths of an inch. Sago and farina granules also display similar physical characteristics as regards the hilum and striæ, and also in respect of their behaviour under the influence of polarised light. Sago granules, however, usually present a more damaged appearance than those of farina, and are frequently seen with one end broken off and jagged. In a dry state the starch powder has a faintly dull brown tone, and glistens slightly on being smoothed down to a level surface. If pressed between the finger and thumb, it produces a slight crackling noise, and has a harsh, crisp, and dry feel.	16 × 12	27 × 20

§31. Starch substance in general may be proved by testing it with certain chemical reagents of which iodine solution is the one usually employed for that purpose. Iodine reacts upon all varieties of starch by staining the granules a rich blue colour of different tones varying from a delicate tint to the deepest hue, and even black, according to the strength of the solution. This reaction occurs only if starch is in a cold state either before or after it has been heated. The blue colour vanishes if the starch is heated, but partially reappears as the starch cools, and is neutralised by the reaction of such reducing reagents as alkaline solutions, sulphide of hydrogen, and sulphurous acid.

§32. A simple chemical test for the purpose of identifying the particular species of *pure* starch granules is effected by exposing, for a period of about 24 hours, a small sample of pure starch granulose to the influence of iodine vapour emanated from a few iodine crystals that are confined, along with the sample of starch to be tested, between two watch-glasses, with ground rims, held together by clips. After being thus exposed for about 24 hours, the starch powder assumes a distinctive colour according to the particular species of starch. Thus, wheat starch is tinged with a dark tone of dove-colour; maize or Indian corn starch assumes a dark violet hue; farina or potato starch becomes of a yellow-grey or light fawn tone; sago starch is tinged with a light brown tone; rice starch assumes a light chocolate colour; and tapioca starch is stained a dark fawn tone.

As, however, the varieties of starch employed for the purposes of sizing and finishing rarely, if ever, consist of the pure starch of the particular species for which they are sold, but are generally adulterated with several other varieties of starch, and sometimes also with substances of a foreign character, chemical testing is not sufficiently reliable for the purpose of discriminating between the different species of starch. This may only be accomplished with any degree of certainty by the aid of a microscope; and even by adopting this course it is frequently difficult, and sometimes quite impossible, to identify with absolute certainty the particular species of starch, especially if the granules have been previously subjected to a heating process or other influence by which they may have become torrefied, ruptured, or partially dissolved.

The identification of starch granules is greatly facilitated by comparison with authentic specimens of the various species of starch properly mounted for the microscope; and also with authentic samples of starch powder in bulk, for fingering.

§33. Cold water has no appreciable effect on starch, excepting that of tapioca, which, in consequence of being heated during the process of its manufacture into a commercial product, acquires a somewhat gummy or sugary nature, and therefore dissolves slightly and coagulates, even if steeped in cold water. If, however, starch is heated in water raised to a temperature ranging between 140° and 160° F. (60° and 71° C.), according to the species, the granules swell and burst, although they do not dissolve completely, and the mixture produces an adhesive paste which on cooling becomes a translucent gelatinous mass. In a normal state, starch is not perfectly soluble even in water raised to the boiling temperature of 212° F. (100° C.).

§34. Soluble Starch. — Soluble starch is prepared from ordinary varieties of starch, and may be obtained in the form of either a dry white powder, or else as a starch paste or size which only requires to be heated ready for use. During recent years soluble starch in one form or another has come more prominently under the notice of manufacturers as a substitute for ordinary starch, as a sizing material possessing powerful adhesive properties, and one, moreover, which is much less liable to develop mildew. It has, however, for many years been known and sold extensively under a variety of trade names, and used for both warp-sizing and cloth-finishing.

§35. Starch granules contain about 95 per cent. of pure starch substance termed "granulose," which is soluble in hot water, and about 5 per cent. of pure cellulose tissue forming a tough and insoluble outer covering of the granules. This outer covering or cuticle requires to be ruptured or destroyed in order to liberate the granulose and thereby ensure the complete dissolution of the granules. That object may be effected by various means, either by submitting the starch to chemical treatment, or else by subjecting it to heating at high temperatures.

By one method ordinary starch is boiled until it becomes a clear solution from which alcohol precipitates a white powder of soluble starch granules. But the destruction and removal of the cellulose tissue of starch granules are usually effected more expeditiously by submitting ordinary starch to the chemical action of such powerful agents as dilute alkaline solutions of caustic soda or potash, dilute sulphuric and other acid, and the fermentive principle of diastase, all of which have a rapidly decomposing effect on the cellulose tissue.

Diastase and dilute sulphuric acid, however, have little effect on starch granules, unless these are previously heated in water sufficiently to rupture them and cause gelatinisation. But if a solution containing diastase, such as a cold-water infusion of malt, is allowed to act upon gelatinised starch paste at a temperature ranging from 140° to 160° F. (60° to 71° C.), the starch liquefies, and on cooling yields a glistening white precipitate of soluble starch.

§36. Starch treated with solutions of either caustic soda or potash yields a paste of a consistency which increases in proportion to the concentration of those alkalies; and when the required consistency of the paste is obtained, further activity of the alkali may be neutralised by an acid. Size paste prepared in this manner is not only more tenacious, but it is less susceptible to the influences which tend to promote and foster putrefactive decomposition and the development of mildew, as described previously in the last paragraph of §22, p. 16. Being also of a more transparent character, it does not impair the lustre and purity of colour in dyed yarn, and it offers considerable resistance to boiling water.

§37. Two examples of different brands of soluble starch that were examined microscopically and also by other means, were apparently composed by blending pure starch of wheat, sago, and potatoes (farina) in the approximate proportions of one part wheat starch, two parts sago starch, and three parts farina, without any visible trace of adulteration. In both examples the granules generally, and those of the sago starch and farina in particular, were more or less ruptured and truncated, but not crushed or battered. They were, therefore, easily identified by their otherwise well-preserved distinctive forms. In their dry granular state they formed a glistening powder of a clear white tone, a harsh and crisp feel, and produced a sharp crackling noise when pressed between the finger and thumb.

In their general outward appearance, and feeling when handled, specimens of dry soluble starch are similar to ordinary varieties of starch in a normal state; and, excepting to the trained vision and sense of touch acquired by experience, there is nothing to distinguish soluble starch powder from that of other varieties of pure starch. Also, even when they are examined microscopically, the characteristic surface markings were, with rare exceptions, not discernible in the granules of soluble starch; although, when viewed by the aid of polarised light, the granules displayed the characteristic black crosses very distinctly. They also yielded the blue reaction with iodine solution in a very dilute form, and this staining intensified the hilum and striations on some of the granules, and enabled those markings to be resolved very distinctly by the microscope.

§38. APPARATINE and GLOY are two of the earliest of many similar examples of ready-made sizing and finishing starch pastes prepared from soluble starch and sold under a variety of trade-names. These, or similar preparations, may be produced by first mixing 100 lb. (16 per cent.) farina or other variety of starch with 50 gals. = 500 lb. (80 per cent.) water, and afterwards adding slowly 2 gals. caustic-soda solution at 50° Tw. (R.D. 1·25), which at that density is equal to 25 lb. (4 per cent.). There should be employed for this purpose a *wooden* mixing beck containing dashers, and without nuts, bolts, or other metal fittings being exposed inside the beck. Whilst adding the caustic solution, the dashers should be put into action, and continue to revolve until the mixture becomes a translucent gelatinous paste of the required consistency, when sufficient acid to neutralise the alkali and arrest its further activity in dissolving the starch, should be added. Also, if required, the paste may be made of a firmer consistency by heating. Starch paste thus prepared is practically immune from the usual consequences of bacterial infection, which conduces to a state of decomposition and mildew, even if exposed to the atmosphere. (*See* also the last paragraph of §22, p. 16.)

§39. GUM. — Natural gum exudes in the form of a juice or sap from certain shrubs and trees which yield gum of different varieties according to their species.

Gum-tragacanth, gum-arabic, and gum-senegal constitute the three principal varieties that are sometimes employed in combination with other ingredients for the purpose of sizing yarn, but more frequently for finishing cloth, as the two last-named varieties tend to impart to yarn a harsh and stiff feel. Gum-tragacanth, however, possesses good binding properties which impart to the yarn both body and stability without harshness, and it does not impair the purity of colour of dyed yarn, but tends readily to decompose and develop mildew. Gum-tragacanth may be obtained in the form of either leaf-gum having the appearance of strips of ribbon with crimped edges, or vermicelli gum in the shape of cylindrical sticks; and it varies from a dark to a light dull brown tone of colour, according to its purity.

The mode of preparation is to macerate the gum in cold water for about 24 hours, during which time it swells considerably, though it does not dissolve until it is afterwards boiled for several hours; or dissolution of the macerated gum may be accelerated by boiling it for a period of only 15 to 20 mins., under a pressure of 60 to 70 lb., in a boiler or kier. This course may also be adopted for boiling starch when preparing ordinary size paste. In a cold state the mucilage of gum-tragacanth gives a violet reaction with iodine solution; hence it is surmised that it contains a certain amount of starch substance.

§40. DEXTRINE, or BRITISH GUM, is manufactured from ordinary starch either by heating at a temperature of about 302° to 320° F. (150° to 160° C.), or else by submitting the starch to the chemical action of dilute acid (excepting acetic acid) or diastase, and heating at a temperature of about 212° F. (100° C.). Dextrine is a variety of soluble starch of greater solubility, and is obtained in the form of a fine dry powder varying from a white to a faint brown tone. It is used more extensively for cloth finishing than for sizing yarn, as it tends to make the yarn feel sticky, especially if exposed to a damp atmosphere. For this reason its use as a sizing ingredient is restricted to light sizing, when it requires to be used sparingly and in combination with starch.

§41. GUM-TRAGASOL is manufactured from the kernels of the locust bean of the edible variety familiar to most people. It forms a viscous mucilage of powerful binding properties, and may be used either alone for light sizing, or it may be combined with starch and china-clay for medium and heavy sizing. Gum-tragasol imparts to the yarn strength, smoothness, and suppleness, and dispenses with the necessity of employing as much tallow or other softening material. Also, being transparent, it does not impair the lustre or tone of dyed yarn, and is said to be practically immune from any tendency to mildew.

§42. SEAWEED MUCILAGE is sometimes employed in cloth finishing, but rarely as a sizing ingredient, because the presence of salt tends to impart to the yarn a harsh feel. This tendency, however, may be reduced by steeping the weed or moss in cold water previous to macerating it in either hot water or an alkaline solution. After boiling, the substance is strained to separate the "pectin" mucilage from the cellulose tissue, and the jelly thus obtained may then be combined with other sizing ingredients, as required.

GROUP 2: SOFTENING SUBSTANCES

§43. TALLOW which is obtained from the carcases of oxen and sheep is found to be superior to any other material for imparting to size paste those emollient properties necessary to preserve the suppleness of yarn; but its relatively high price has created a demand for cheaper substitutes. These latter comprise a great variety of substances that are employed either alone or in conjunction with tallow; but more frequently they are used as adulterants, and sold under various trade names.

Tallow is adulterated very extensively with inferior grades of fat, grease, and oil, including mineral oil; and also with different varieties of wax, including the mineral wax, paraffin; as well as with many other substances, some of which are positively harmful for sizing purposes.

It is advisable, therefore, that tallow and tallow substitutes should be carefully analysed before using them for sizing yarn. Russian tallow is said to be superior to other tallow for sizing; but whatever brand is employed, it should be quite fresh, pure, of a good white tone, a firm texture, and also have a high melting-point of about 110° to 122° F. (43° to 50° C.) for beef tallow, and about 116° F. (47° C.) for mutton tallow. It should be observed, however, that the melting-point of beef tallow falls to about 104° F. (40° C.), whereas that of mutton tallow rises, as the material becomes older.

§44. BONE FAT and MARROW FAT are sometimes employed either in conjunction, or, as adulterants, in combination, with tallow; but their dark colour, especially that of bone fat, and also their marked tendency to become rancid and malodorous, make their use for sizing purposes very undesirable.

§45. Yorkshire and "Recovered" Grease are trade terms for wool grease, of which "lanoline" is a more highly refined preparation. Wool grease is the foul refuse recovered from the soapy effluent containing the greasy waste products of wool washing and scouring, and is extracted from the wool by means of such powerful detergents as silicate of soda, carbonate of soda, or soda-ash, soap, and ammonia. In the less purified forms, wool grease is characterised by a disagreeable odour, and also contains fatty acid in a free or uncombined state, which makes it unsuitable for sizing yarn.

§46. Wax of many varieties is sometimes employed either in conjunction or in combination with tallow, fat, grease, and oil of some kind, as an emollient for size paste. Its use, however, is not generally advisable, and if used at all its application should be confined strictly to sizing warps for such fabrics as are to be sold in a grey state; that is, not bleached, dyed, or printed. Wax of any description should not be used in size paste for sizing warps for fabrics that are to be subsequently bleached, dyed, or printed, because of the difficulty of removing it effectually from the yarn, even by the process of bleaching.

Most varieties of wax of commerce, and more especially wax of mineral origin, as paraffin wax, do not readily dissolve or emulsify and combine freely with other ingredients of the size mixture; but they tend, during mixing and boiling, to rise to the surface of the liquid and collect in undissolved masses.

This tendency appears to be more pronounced with wax having a higher average melting-point, such as carnaüba or Brazilian palm wax, Chinese or "insect wax," beeswax, and paraffin mineral wax; and less pronounced with Japan palm wax or fat, and spermaceti whale wax, which have a lower average melting-point.

Wax also offers resistance, in a greater or lesser degree, even to such powerful detergents and bleaching agents as caustic alkali, chloride of lime or bleaching powder, and soda-ash; and it does not saponify completely under their influence, during the process of bleaching.

§47. For these reasons, therefore, wax of any kind, and in any form, is quite unsuitable as an emollient for size paste, especially for sizing warps for fabrics that are intended for bleaching, dyeing, or printing; for should any trace of undissolved wax remain on the yarn after the bleaching or washing process, it will repel and effectually resist the colouring principle of the dye or printing colour, and thereby incur the risk of causing white specks, spots, and other blemishes to appear in the finished fabric.

Apart from these objections to the use of wax as an emollient in sizing, however, it serves as an excellent lubricant for the warp threads, and also keeps down effectually the free extremities of the fibres composing the threads, which it leaves quite supple and smooth. The effect of wax on warp yarn, therefore, is to reduce the chafing action of the warp ends against each other, and also their abrasion by the shedding harness, reed and shuttle race-board of the loom during weaving; thereby reducing the number of breakages of the warp-ends, and also increasing the durability of the shedding harness.

§48. Beeswax in the commercial form is a hard and solid substance of a tone varying from dark brown to white, according to the degree of refinement. Its scarcity and high price, as well as its unsuitability, restrict its use for sizing, although many imitations of it are sold as beeswax and used for that purpose. It is also frequently adulterated with paraffin and other cheaper and inferior wax products that tend to reduce the melting-point of beeswax, which should not be lower than about 144° F. (62° C.).

§49. CHINESE WAX or "INSECT WAX" is one of the lesser-known varieties of wax, and, when refined, it forms a white crystalline substance resembling spermaceti wax, but possessing more of the constituents of beeswax, with a high melting-point, ranging from about 180° to 187° F. (82° to 86° C.).

§50. SPERMACETI WAX is a solid white crystalline fat reduced from oil obtained from the head cavities and blubber of the spermaceti whale, and it melts at a temperature ranging from about 115° to 122° F. (46° to 50° C.). Its high price, in comparison with that of other softening materials that are considered to be of equal and even superior merit, restricts its wider adoption as a sizing ingredient, although it is thought by some users to possess superior virtues as an emollient.

§51. CARNAÜBA WAX, also known as Brazilian palm wax, is a lesser-known variety of vegetable wax obtained from the leaves of the carnaüba palm tree, which flourishes in South America. It is used as a substitute for, as well as an adulterant of, beeswax. Carnaüba wax is of a greenish-yellow tone, which is not easily removed, and it melts at a temperature ranging from about 185° to 194° F. (85° to 90° C.), according to its age. The pure wax melts at about 185° F. when fresh, and at about 194° F. when it is older. If boiled with a caustic potash solution, the wax assumes a reddish tone; it also saponifies with difficulty if boiled with alcoholic potash solution, and even then it only partially dissolves.

§52. JAPAN WAX is another variety of vegetable wax, derived from the fruit of a certain species of palm tree. It consists of a hard solid substance having a light yellow tinge, and a rough crystalline structure that glistens like broken fragments of alabaster. Japan wax is not a true wax, but really a fat, although it bears a close resemblance to beeswax, for which it is frequently substituted and sold for sizing purposes. It melts at a temperature varying from about 122° to 129° F. (50° to 54° C.), according to its purity, and saponifies under the influence of caustic alkali and other powerful bleaching agents. It also emulsifies more readily than other varieties of wax, excepting spermaceti, and combines with other sizing ingredients more freely than other wax, during size-mixing.

The use of Japan and spermaceti wax as emollients for sizing, therefore, is not so objectionable as bees', Chinese, carnaüba, and paraffin wax, as the two former kinds are much less difficult than the latter to remove from the yarn by the process of bleaching.

§53. Paraffin Wax is a substance reduced from paraffin and petroleum mineral oil, and varies from a brown to a white tone, according to its purity. It melts at a temperature ranging between 100° and 140° F. (38° to 60° C.) according to quality; but that having a melting-point of about 120° to 125° F. (49° to 52° C.) will meet the requirements for sizing purposes.

The use of paraffin wax as a sizing emollient, however, unless it is confined strictly to yarns for fabrics which are not to be bleached, dyed, or printed, cannot be too strongly condemned, as it offers greater resistance than other varieties of wax to the bleaching agents, and does not saponify under their influence.

Therefore, any preparation of tallow, fat, grease, or other material containing paraffin wax, and intended as an emollient for size paste, should be strictly avoided.

§54. Oil of many kinds is used either alone or in conjunction with other softening material for size-mixing, but its use for that purpose is not recommended, as it tends to impart to the yarn a dull tone. Although oil possesses more powerful emollient properties than those of tallow and wax, and may therefore be employed in a smaller quantity, it has not the same binding or fixing power, and does not give body or fulness to the yarn. If oil is employed alone as a sizing ingredient, or as an adulterant of tallow or wax, it should be of vegetable origin, and not a mineral product.

Mineral oil of any description should not, on any account, be employed, either alone or in combination with any other emollient, for sizing purposes; since, like the mineral wax, paraffin, it resists the action of bleaching agents, does not saponify under their influence, and is difficult to remove. It is therefore liable to cause stains and other blemishes of a serious character in the finished cloth. Palm oil, olive oil, castor oil, coco-nut oil, and cotton-seed oil constitute the principal varieties of oil employed for sizing purposes. They are sometimes employed in conjunction with tallow and wax, but more frequently they are used as adulterants of those materials.

§55. PALM OIL, in a bleached and highly refined state, is used extensively as an emollient for size-mixing, both in a pure state and in conjunction or in combination with other softening materials.

§56. OLIVE OIL is used extensively in the manufacture of soap, and also for numerous domestic purposes; but its dark tone of colour makes its use objectionable for the purpose of sizing yarn.

§57. CASTOR OIL is of a thick and viscous character, for which reason it is quite unsuitable, if used alone, for size-mixing; but it is frequently used in combination or in conjunction with tallow, fat, and wax, in which case its use as an emollient for size paste is not objectionable.

§58. COCO-NUT OIL is usually supplied as a solid white fat, having a melting-point ranging from about 70° to 80° F. (21° to 27° C.); but because of its marked tendency to decompose rapidly, its use as an emollient for sizing is not advisable, and it is better avoided.

§59. COTTON-SEED OIL is used chiefly as an adulterant of tallow and wax.

§60. GLYCERINE is an essential constituent of most varieties of oil and solid fat, and it possesses certain properties common to those materials. It constitutes a very valuable sizing material, being a powerful emollient and softening substance which also possesses exceptionally good deliquescent and antiseptic properties that have no injurious effect upon yarn or cloth, such as chlorides have. Nor is it easily liable, as tallow, fat, and oil, to decomposition. In fact, as an ingredient of size for pure and light sizing, with the sole object of improving the weaving qualities of the yarn, and not of increasing its weight by the addition of china-clay or other weighting material, glycerine has no equal.

A sizing preparation consisting of starch-paste and glycerine embodies all the properties that are essential for pure sizing. But, although glycerine is possessed of such valuable properties as a sizing ingredient, its relatively high price prohibits its more extensive use for that purpose. Hence, there are numerous cheap and inferior glycerine substitutes that have little or no value for sizing, and are therefore better avoided.

§61. Pure glycerine of normal density has a R.D. (relative density) of 1·28 (56° Tw.). It does not evaporate or dry up, but, on the contrary, is very highly deliquescent or hygroscopic; and, if exposed to a moist atmosphere, it is capable of absorbing an amount of vapour equal to about 50 per cent. of its own weight. Even when exposed, in a room, during a period of two weeks, to a warm and relatively dry atmosphere, a given quantity of glycerine of 52° Tw. (R.D. 1·26) increased gradually to 8·5 per cent. more than its original net weight, when its power of absorbing moisture, under those conditions, ceased. Being such a powerful deliquescent, and of greater potentiality, as such, than chloride of magnesium, glycerine should not therefore be employed in an excessive amount for sizing yarn for cloth which is likely to be exposed to a damp climate. (*See* also §77, p. 46, CHLORIDE OF MAGNESIUM.)

§62. GLUCOSE is a term indicating a variety of kindred substances of a similar general character, and consisting chiefly of the essential constituents of sugar. It is, however, usually employed to signify that specific variety of glucose termed "dextrose," also "grape-sugar" and "starch-sugar." The glucose of commerce is manufactured extensively from different varieties of starch, and used in some trades as a substitute for pure cane-sugar, and also as a substitute for glycerine in size-mixing, for which purpose, however, it is quite useless. Glucose bears a close resemblance to glycerine, but is more viscous and of a much denser consistency than that substance.

§63. STEARIN is the principal constituent of hard fat, such as tallow and suet; and it also occurs in some varieties of vegetable fat and oil. It consists essentially of a base of glycerin, cholesterin, palmitin, or olein, in amalgamation with a fatty acid termed stearic acid. Thus, a glycerine base with stearic acid produces a glycerine stearate compound. Cholesterin is the chief constituent forming the base of wool-grease, of which the fatty acid is stearic acid forming cholesterine stearate. Likewise, olein constitutes the base united with oleic acid forming olive and similar kinds of oil. Oleic acid with any fatty base produces an oleate compound of that base. Also, palmitin is the basic principle united with palmitic acid constituting palm and similar oil of the palmitate series of compounds.

§64. SOLUBLE OIL is virtually soap-water produced by saponifying oil by the action of caustic soda, as in soap manufacture, and afterwards adding water, approximately in the following proportions, by volume:—25 per cent. oil; 5 per cent. caustic soda at 50° Tw. (R.D. 1·25), and 70 per cent. water. The oil and caustic alkali solution should first be combined and boiled together very thoroughly to ensure complete saponification of the oil; after which the water should be added at a high temperature to prevent the emulsified oil congealing into solid lumps of hard soap. For sizing purposes the oil selected should be of vegetable origin, as castor oil, olive oil, or palm oil. After being treated in the manner described, the material becomes soluble in water, and combines quite freely with it.

A variety of soluble oil sold as "oleine oil" is prepared from olive oil, and used for sizing purposes; but it is important to remember that soluble oil of any description should not be used as an ingredient of size paste containing chloride of calcium, magnesium, or zinc, and sulphate of magnesium, because of their antagonism to the caustic alkali which is present in the soluble oil.

§65. SIZING-SOAP of several varieties is prepared specially for use in size-mixing, and is employed with the object of assisting the tallow or other fat to dissolve and emulsify more thoroughly, and so enable it to combine more freely with the other ingredients to produce a size paste of a more homogeneous constitution. It also causes china-clay to boil down to a thinner consistency, and prevents it from spurting up and splashing in the pan during boiling.

The special object in view in the manufacture of sizing-soap is to produce soap in which the caustic alkali employed in its manufacture is properly fixed or neutralised, so that there is no trace of it left in a free or uncombined state. Soap of any description, however, should not be employed in conjunction with chlorides of magnesium, zinc, or calcium, nor with sulphate of magnesium.

These metallic salts decompose soap, and thereby destroy its power of emulsifying tallow or other fat, and oil. In like manner soap decomposes those salts, and thereby destroys the distinctive properties for which they are employed. Hence, in combination with each other they form hard and insoluble compounds that nullify the value of a size-mixture containing them, and also involve risks of injuring the yarn and cloth.

Group 3: ANTISEPTIC SUBSTANCES

§66. Chloride of Zinc is a deliquescent salt produced by dissolving a base of zinc metal by the action of hydrochloric acid. Zinc chloride constitutes the recognised standard antiseptic ingredient for sizing, and is employed chiefly with the object of preventing and checking the growth and development of mildew. It also increases considerably the weight of yarn and cloth; and by absorbing moisture from the atmosphere it prevents them from becoming too dry.

In its commercial form, chloride of zinc is liable to contain traces of iron, in solution as ferrous chloride, which constitutes one of the most objectionable impurities that can occur in zinc chloride intended for sizing purposes. Also, zinc chloride should never be allowed to come in contact with iron, as it readily attacks and rapidly begins to absorb and retain that metal in solution. Hence, if chloride of zinc which is contaminated with iron is employed as a sizing ingredient, the iron is liable to oxidise on the yarn and cloth if these are exposed either to a moist atmosphere, or water; thereby involving the risk of causing ironmould to occur in the form of dark buff-coloured stains distributed uniformly throughout the material affected by it, as previously indicated in §12, p. 8.

§67. A good test for the presence of iron, in zinc chloride solution, is to add to a small quantity of that substance, in a test-tube, a little solution of yellow prussiate of potash. If there is any trace of iron present in the zinc chloride, it will be deposited in the form of a blue precipitate which becomes darker if allowed to remain.

Chloride of zinc is also liable to adulteration with common salt; but if the amount does not exceed 2 to 3 per cent. of salt, it is disregarded, and not considered to be an intentional adulteration.

Ammonium chloride, if present in chloride of zinc, may be detected by adding to a small quantity of that solution, a strong solution of caustic soda, and boiling them in a test-tube, when the presence of ammonium chloride will be indicated by the characteristic fumes of ammonia that are emitted.

§68. When chloride of zinc is employed as an ingredient of size for heavy sizing, it is generally used in the form of a strong solution of about 100° Tw. (R.D. 1·5), containing about 37 per cent. solid crystal chloride and 63 per cent. water, by weight, and forming what is termed a 37 per cent. solution, weighing 15 lb. per gallon. At that density it may be employed in the proportion of about 22 per cent. of the net weight of flour; or 4 gals. to each sack or peck of 280 lb. flour. If, however, the yarn or cloth will be subjected to either a damp atmosphere, or to intense heat as in "slasher" sizing, calendering, and singeing, the amount of chloride used should be reduced, or preferably entirely avoided, for reasons to be stated presently.

§69. Chlorides of any description require to be used with great caution in size-mixing, especially for warps that are to be sized in a "slasher" or "cylinder-drying" type of sizing machine, and not one of the hot or warm air drying type. They should also be used very sparingly, or, better, not at all, in size for warps for fabrics that are to be submitted to a finishing operation of either calendering, or of singeing or "firing" to remove the nap or down from the surface of the cloth. Otherwise, if yarn contains chloride of zinc, magnesium, or calcium in excessive amounts, the heat of the drying-cylinders of the slasher sizing machine, or of the calender rollers or cylinders of the finishing machine, and also of the Bunsen gas-flames, or else the red-hot iron or copper firing-plates of the singeing machine, decomposes the chlorides and thus liberates the constituent acid of those salts, with the result that the free hydrochloric acid attacks and burns or decomposes the yarn, thus making the cloth tender and weak.

In consequence of frequent and serious damage to yarn and cloth arising from this cause, there is an urgent demand for other substances possessing antiseptic and deliquescent properties, and which may be employed as safe and efficient sizing ingredients.

§70. CARBOLIC ACID is a caustic and very poisonous coal-tar product possessing very powerful antiseptic properties, and is said to be the best and cheapest antiseptic that could be employed for sizing; but its use for that purpose is objectionable because of the very disagreeable and persistent odour which it imparts.

§71. CRESYLIC ACID is also a coal-tar product which is sometimes used as an antiseptic ingredient of size paste; but its use for this purpose is not extensive.

§72. SALICYLIC ACID is a coal-tar product employed as an antiseptic, and one that is found to be suitable for light sizing for the warps of fabrics intended for transportation in a grey state. It is a powerful antiseptic, and being of a non-poisonous character, its use as a sizing ingredient does not involve the grave risks that attend the use of poisonous substances. Its high price, however, is an obstacle to its wider adoption for sizing purposes. In an undissolved state it forms a fine white crystalline substance, and bears a close resemblance to the crystals of Epsom salts.

§73. FORMALDEHYDE or FORMALIN, from formic acid, is a formic aldehyde solution with a suffocating odour, and possessing antiseptic and disinfectant properties equal to those of carbolic acid. It is recommended as a valuable antiseptic ingredient for size, for which purpose it should be applied in a very dilute state.

§74. ARSENIOUS ACID is a powerful antiseptic, but its highly poisonous character debars its use as a sizing ingredient.

§75. PERCHLORIDE of MERCURY is probably the most powerful antiseptic substance known, and is also the most deadly of the mineral group of poisons, with the exception of the *cyanides*.

§76. THYMOL is derived from the essential oil of the common garden shrub, thyme. It occurs in the form of a white crystalline substance resembling alum, and is said to possess antiseptic properties of equal potency to those of carbolic acid.

GLYCERINE—described in §§60, 61, p. 38.

Group 4: DELIQUESCENT or MOISTENING SUBSTANCES

§77. Chloride of Magnesium is a deliquescent salt produced commercially by the action of hydrochloric acid on a base of magnesium metal. As a deliquescent, however, it is greatly inferior to glycerine, and far more dangerous as a sizing ingredient.

On exposing a given quantity of magnesium chloride solution of 60° Tw. (R.D. 1·3) simultaneously with a corresponding weight of glycerine of 52° Tw. (R.D. 1·26), as described previously, and under precisely the same atmospheric conditions, in a room of warm and dry air, the chloride solution actually lost, by evaporation, 15·5 per cent. of its net weight during an exposure extending over a period of two weeks, and it ultimately crystallised; whereas the glycerine gained, by absorption, 8½ per cent. of its own weight during the same period. (*See* also §§60, 61, p. 38, Glycerine.)

§78. Chloride of Calcium or Lime is also a deliquescent salt which results on submitting limestone, marble, and other calciferous rock to the action of hydrochloric acid; and it is sometimes employed either alone or else in addition to magnesium chloride for heavy sizing.

Glycerine—described in §§60, 61, p. 38.

Group 5: WEIGHTING SUBSTANCE

§79. China-clay or Kaolin is a mineral product which abounds in the counties of Devon and Cornwall, and is employed for heavy sizing, with the primary and sole object of filling and increasing the weight of yarn and cloth; although it has no beneficial effect whatever, either upon the warp-yarn, during weaving, or upon the wearing qualities of the finished fabric. Indeed, its effect upon yarn and cloth tends in quite the opposite direction; but the responsibility for its abuse in sizing is put upon the cloth salesmen and merchants.

China-clay is prepared for use in the form of a very fine white powder, resembling flour, and having an unctuous or greasy feel when handled. It also possesses a great affinity for water, and is found to be superior to any other material for increasing the weight of yarn and cloth during sizing.

CHAPTER III

Size Mixing. Size-Mixing Plant. Also Size Boiling and Automatic Feeding Devices

SIZE MIXING

§80. Size mixing permits of very considerable variation in both the choice of ingredients and the relative proportion in which they are combined, chiefly according to particular requirements and personal preference. These factors are of such a widely different character that it is quite impossible either to dogmatise on the subject of sizing or to give precise data relating to the selection and relative proportions of sizing ingredients to meet specific requirements.

The character of those materials, and the manner of blending them, are determined by such variable factors as the counts, quality, and other characteristics of the warp yarn, and the percentage of size to be added to it; the number of warp ends and picks per inch required in the cloth; the character of the finished texture as regards its weight, tone, and feel; the character of the finishing operation, if any, to which the cloth will be submitted after weaving, as bleaching, dyeing, printing, calendering, and singeing; the use of the fabric; also its ultimate destination as regards transport by land or sea, and climatic conditions of the country in respect of temperature and humidity; and many other considerations.

§81. It is obvious, therefore, that a judicious selection of suitable sizing materials to meet special requirements may only be made with a more or less intimate knowledge of their chief characteristics and essential properties; of their mutual chemical influence upon each other when they are blended together to produce a homogeneous size mixture; also of their effect upon yarn and cloth under the varying conditions of the manufacture, transport, and use of the cloth.

It is also very desirable that each delivery of sizing materials should be analysed and tested for quality and strength, so that any difference in these respects from the usual standards may be counterbalanced by varying the relative proportion in which those materials are combined.

The difference in volume, of any solution, necessary to compensate for any variation that may exist between the relative density of two different solutions of the same material, may be readily obtained by employing the formula given in §96, p. 66.

§82. When preparing a size mixture, solid substances should be weighed, and liquids measured, very carefully. Liquids should also be of uniform strength as regards the relative density or degrees by Twaddell's hydrometer; otherwise, any variation in this direction, especially of caustic alkali and chloride solutions, will require to be properly adjusted by varying the amount of those liquids, accordingly.

Uniform results are obtainable from size paste, prepared in accordance with a given recipe, only by employing ingredients of uniform quality and relative density; by combining them in the same relative proportion and order; by heating them at the same temperature, and for a corresponding period; and also by applying to the yarn the size mixture at the same temperature and density.

§83. It is safer for a competent person to supervise, throughout, the preparation of size paste from materials of known properties, quality, and strength, than to rely on proprietary and patented concoctions respecting the composition and properties of which he has no definite knowledge.

By adopting the former course he will be better qualified to vary the character and proportions of the respective ingredients necessary to produce any desired effect on the yarn and in cloth, without incurring the risk of danger and uncertainty of effect that may result from tampering with materials and secret size preparations composed of ingredients that are unknown to him.

SIZE-MIXING PLANT

§84. A size-mixing plant is of a very simple character, and usually consists of from two to four, and sometimes five, rectangular wooden vats or becks, and a metal boiling-pan or cauldron, as illustrated in Figs. 1 and 2, which represent a front and an end elevation of a size-mixing plant consisting of four becks and a boiling-pan. For mixing size for pure and very light sizing with size paste prepared from starch, only two becks are necessary, one for mixing the starch and water, and one for boiling the mixture, in combination with an emollient substance, ready for applying to the yarn in either a boiling state as in " slasher " sizing, or else in a cold state as in " dresser " sizing.

For medium and heavy sizing with size paste prepared partly or wholly from flour in combination with emollient, antiseptic, deliquescent, weighting, and other materials, the size-mixing plant should comprise from three to five becks and a boiling-pan. The becks should be in successive communication by means of service or feed pipes, and placed either at different elevations, or else provided with force pumps or rams to enable the contents of each vat to flow, either by gravitation, or else by pumping them into the next successive vat.

§85. The first beck (No. 1, Fig. 1) is the mixing vat, in which are combined the flour and water in an approximately equal proportion by weight—that is, about 10 lb. flour to each gallon of water. After mixing, the contents of the first vat are passed into the second vat (No. 2) for fermentation, after which the mixture is passed into the third vat (No. 3) to be diluted with water to the requisite density, and stored in reserve, ready to be passed into the fourth beck (No. 4) to be combined and boiled with

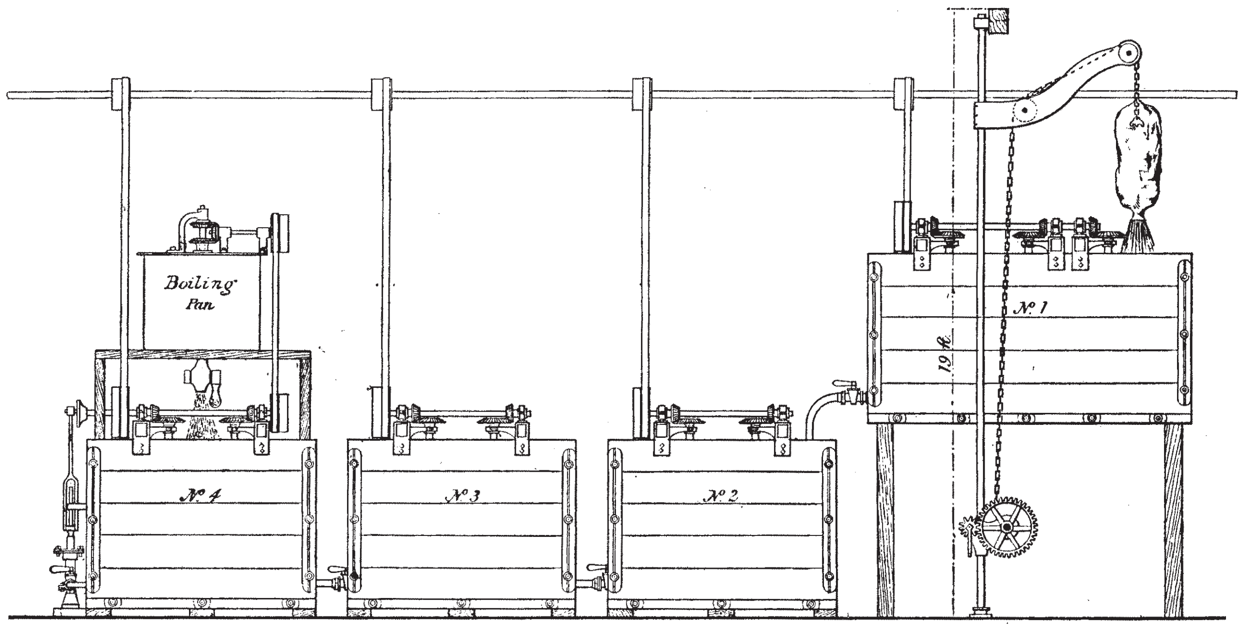

FIG. I.

all the other sizing ingredients, ready for applying to the yarn.

The boiling-pan is provided with a cock-tap or valve, and fixed immediately over the last vat to enable the contents of the pan to be emptied into that vat.

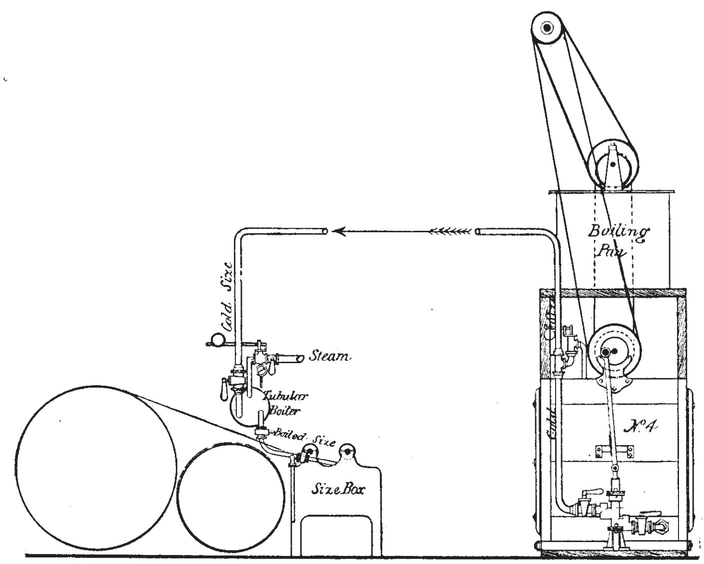

FIG 2.

§86. The boiling-pan is used for the purpose of boiling the china-clay tallow, and all other solid substances separately and thoroughly before passing them into the last vat to be combined with the flour and water and other ingredients, all of which are then boiled together to ensure their thorough admixture.

The object of boiling the china-clay is to break up the particles of clay into the finest division possible before combining and reboiling it with the flour or starch mixture. The preliminary boiling, however, is said to be quite useless and unnecessary, provided the china-clay is obtained in a finely pulverised or powdered form, instead of in the usual form of hard and compressed lumps.

The last mixing beck and the boiling-pan are each furnished with open steam-pipes to supply high-pressure steam for the purpose of boiling the contents of those vessels. Also, the mixing becks and boiling-pan are each provided with dashers that revolve slowly to ensure a thorough blending and combination of the respective sizing ingredients, and also to keep the contents of the becks in a state of constant motion, and thereby prevent the heavier substances from settling down to the bottom of the becks during mixing.

§87. Size-mixing becks vary in minor details of construction, dimensions, and also in the different forms of dashers or agitators with which they are equipped; but whatever special feature they may embody, it is important that they should be capable of being drained and cleansed thoroughly whenever that is necessary. This should take place, preferably, before mixing each fresh lot of size, in order to prevent its infection with the putrefactive germs of any old sizing material that may remain in the becks from the previous mixing. Also, the employment of a suitable form of beading to fill in the corners inside the becks, and thus make them more or less rounded, instead of square, will conduce to greater cleanliness by preventing the sizing materials from lodging in them.

§88. Size-mixing becks are constructed to any specified dimensions, according to requirements; and may be furnished with one, two, or three dashers, according to the size of the becks. The dimensions of a beck of any desired capacity may be calculated approximately on the following basis:—

When in combination, equal proportions, by weight,

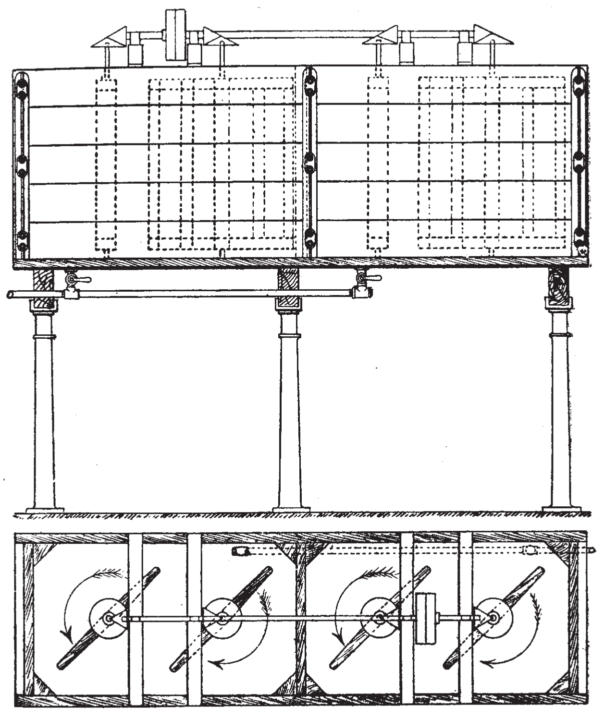

Fig. 3.

of cold water and flour, or starch, are in a volumetric ratio of 3 : 2 respectively. Thus, if 10 lb. flour or starch are added to 1 gal. (10 lb.) of water, it produces a volume of $1\frac{2}{3}$ gal. This is equal to an increase of $66\frac{2}{3}$ per cent. per gallon, or $6\frac{2}{3}$ per cent. per pound per gallon. Therefore, if a size-mixing beck were required for mixing four sacks ($280 \times 4 = 1120$ lb.) of flour with 1120 lb. $\div 10 =$ 112 gals. of water, plus a surplus margin of, say, 50 per cent. to allow for fermentation, it would require to have a capacity of 45 cub. ft.; thus—

$$112 + (66\tfrac{2}{3} \text{ per cent.}) = 187, \text{ and } 187 + (50 \text{ per cent.}) = 280 \text{ gals.},$$

then

$$280 \div 6{\cdot}232 = 45 \text{ cub. ft.}$$

This capacity would be obtained in a beck 5 ft. long $\times$ 3 ft. wide $\times$ 3 ft. deep, all inside measurements.

§89. The dashers applied to size-mixing becks comprise several modifications. They are also operated by various arrangements of bevel driving gear to revolve the wings continuously during mixing, fermenting, and boiling, for the purpose of churning the contents of the vats and keeping the sizing ingredients in a state of vigorous and constant agitation to ensure their thorough blending, and also to prevent the heavier substances from settling down by gravitation to the bottom of the vats.

The particular form of dasher usually employed is that illustrated in Fig. 3, which represents an elevation and a plan of two becks, each of which contains a pair of wings that extend for the full depth of the becks, and are driven by means of a simple arrangement of bevel-wheel gearing designed to revolve the wings in reverse directions, as indicated by arrows.

§90. Another modification of dashers is that by which two wings are arranged one above the other, as illustrated in Fig. 4. In this instance the axis of each wing is in the same vertical plane, with the lower wing keyed directly on to an upright shaft, whilst the upper wing is secured to a long sleeve bearing which is mounted quite freely on the shaft. Both the upright shaft and

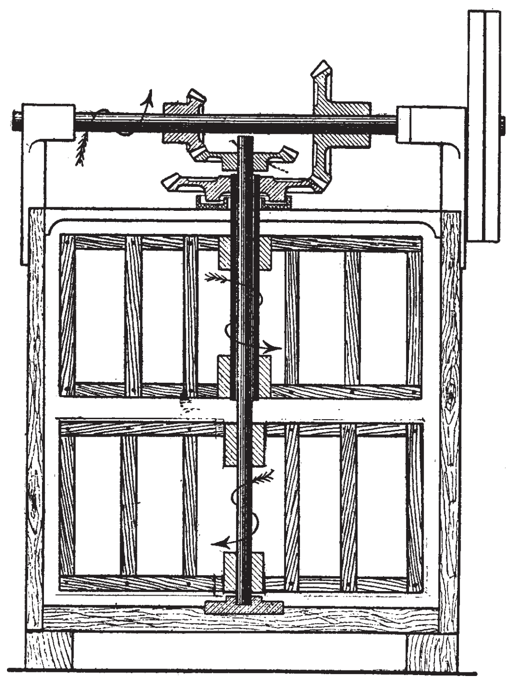

FIG. 4.

sleeve bearing containing the dashers are each surmounted by a separate bevel-wheel, keyed fast to them. These two wheels each gear respectively with, and are driven by, one of two driving pinions keyed to a horizontal shaft containing the loose and fast driving pulleys, whereby the wings are both revolved with a corresponding velocity, and in reverse directions, as indicated by arrows.

This arrangement of dashers is precisely similar to that adapted to the boiling-pan illustrated in Figs. 1 and 2. In that instance, however, a simpler form of driving gear is employed, whereby the dashers are operated by only three bevel-wheels, as illustrated by a detailed diagram in Fig. 5, instead of four bevel-wheels, as represented in Fig. 4.

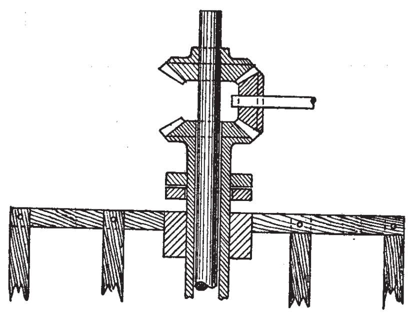

FIG. 5.

§91. A boiling-pan of a more modern and approved type than that represented in Figs. 1 and 2 is illustrated in Fig. 6. The special features of this pan are that it is constructed on the principle of a boiling-kier with a concave instead of the usual flat base; and also the peculiar form of dashers with which it is fitted. These consist of two forked wings that are in reversed positions, and mounted in such a manner that they revolve on a common axis, but in reverse directions, and with the ribs of one wing passing between those of the other wing.

This is effected by mounting the lower wing securely on to a vertical shaft, whilst the upper wing is secured to a sleeve bearing which is mounted freely on the same shaft to permit of their rotation in opposite directions as stated. The form of driving gear to operate the dashers is precisely similar to that described previously, and illustrated by a sectional diagram in Fig. 5.

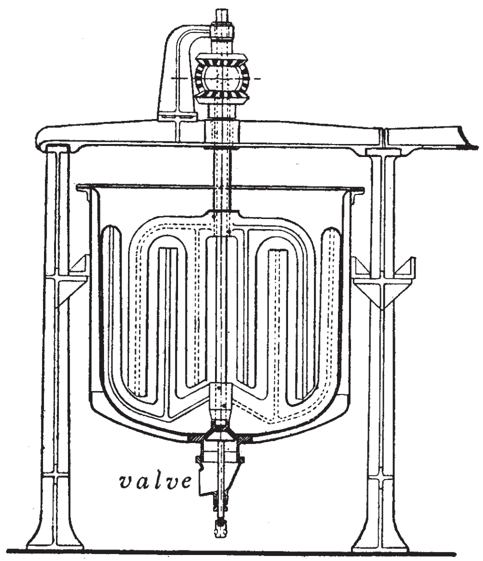

Fig. 6.

SIZE BOILING AND AUTOMATIC FEEDING DEVICES

§92. After all the sizing ingredients are boiled together in the last mixing beck, the size paste is ready for conveying to the size-box of the sizing machine, where it is applied to the yarn. The sizing machine is sometimes supplied with size by the attendant who draws off, at intervals as required, the hot size into a vessel, and pours it into the size-box of the machine.

This practice is, however, for various reasons attended with several disadvantages. For example, it demands the frequent personal attention of the operative sizer to keep the size-box replenished with size, as this is absorbed by the yarn; each fresh supply of size is liable both to reduce the temperature and to increase the density of that contained in the size-box. Also, the practice is both a wasteful and an uncleanly one. Therefore, in order to avoid the disadvantages of supplying size to the sizing machine by hand, the supply is in many instances effected automatically in combination with an auxiliary size-boiling apparatus, of which there are many different types. By means of these devices the raw size is pumped from the last mixing beck and forced along a service pipe terminating in the size-box of the sizing machine.

§93. In conjunction with the size-boiler there is also a contrivance for controlling the supply of size to the size-box automatically, and in a measure corresponding exactly with the demand.

One of the earliest inventions to accomplish this object successfully is that illustrated in Fig. 7, which represents Eastwood's tubular-coil size-boiler operating in conjunction with Kenyon's device consisting of a floating roller for regulating the supply of size to the size-box, of which a rear sectional view is shown in the diagram.

From the last mixing beck the raw size passes along a service pipe A, which is coupled to a copper pipe B, of

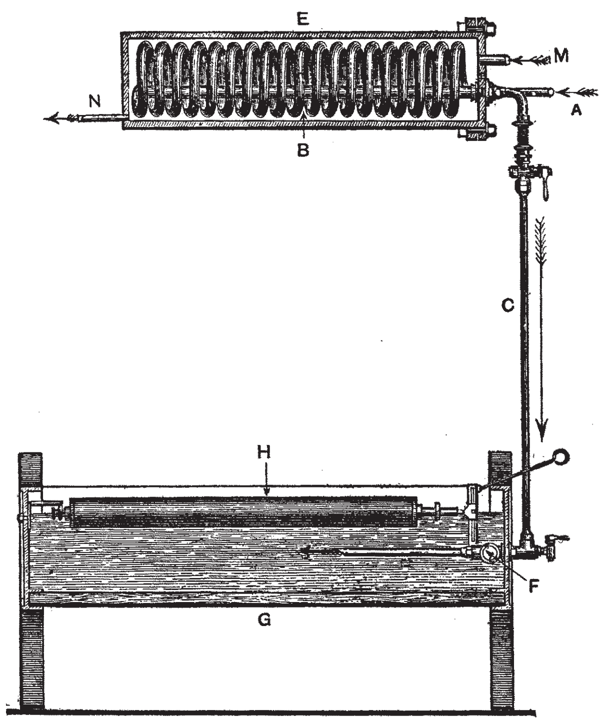

Fig. 7.

which a length of about 60 ft. is coiled spirally and enclosed within a cylindrical steam-chest E, suspended above the size-box G. The steam-chest is heated with high-pressure steam which enters it through a pipe M fixed at one end, whilst the condensed steam escapes through a pipe N at the opposite end of the chest. After circulating the coiled piping, in which it is boiled, the size returns and then flows downward along a pipe C,

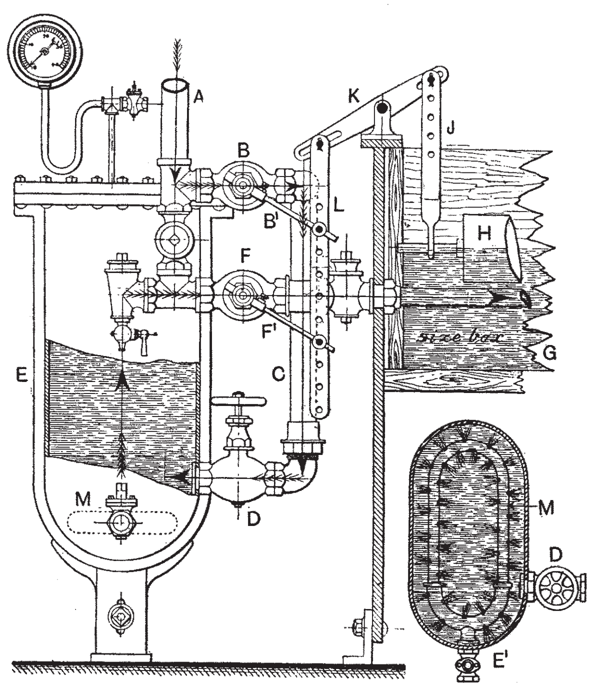

Fig. 8.

thence through a controlling valve F, and into the size-box.

The inflow of size is regulated automatically by the vertical movement of a hollow copper roller H, which floats on the size, and through the medium of suitable connections controls the inlet valve F, so as to maintain the size at an approximately constant level throughout. Precaution is also taken to safeguard against the risk of the service pipe bursting from abnormal pressure in the event of the regulating valve F cutting off the delivery of size to the size-box when this is full, although the pump may continue working. This object is effected by means of a safety valve which is attached to the pump, and allows all the size which is delivered in excess of that required in the size-box to return again, in its unboiled state, to the raw size in the last mixing beck.

§94. Another and later type of size-boiling apparatus is that of Briggs and Taylor's, illustrated in Fig. 8. This device consists of a steam boiler E (shown in part section), which is attached to one end of the size-box G, also shown in part section, and broken short. As the raw size is pumped from the last mixing beck, it passes downward along the service pipe A, thence through a controlling valve B, along a pipe C, and through a stop-valve D, where it enters the boiler E, whence it emerges through a second controlling valve F, into the size-box G of the sizing machine, as indicated by arrows.

The size is boiled by injecting high-pressure steam through a perforated steam-pipe M, placed internally around the bottom of the oval-shaped boiler, as indicated in the plan E^1, shown on a reduced scale, and detached. The size-box G is provided with the usual floating roller H, which, through the medium of a connecting link J, a lever K, a bar L, and rods B^1 and F^1, controls both the valves B and F, thereby regulating the supply of raw size to the boiler and of boiled size to the size-box simultaneously, and in a corresponding volume, whereby the size is maintained at a constant level in both the boiler and size-box.

CHAPTER IV

DATA FOR SIZE-MIXING RECIPES. ALSO USEFUL FORMULÆ AND DATA RELATING TO SIZING INGREDIENTS. SIZE MIXING, AND SIZE-MIXING APPARATUS

DATA FOR SIZE-MIXING RECIPES

§95. It has been stated previously that the character and variety of sizing ingredients are such variable factors that it is impracticable to give exact data respecting the selection and proportion in which they may be employed in order to meet specific requirements, unless these are definitely known. The accompanying data, therefore, is compiled merely for general guidance respecting the character of ingredients to employ, and the approximate proportion in which they may be combined in the preparation of size paste to add various percentages of weight to the yarn. The items are not prescribed for any special purpose, but may be modified, according to the technical knowledge and practical experience of the size mixer, to meet special requirements. Also, the volume of water employed may, within certain limitations, be regulated so as to vary the density of the size paste according to the percentage of size required to be applied to the yarn:—

TABLE OF DATA FOR SIZE RECIPES

Object and Character of Sizing Material	Grade and Percentage of Sizing				
	Pure, to Add up to 10%	Light, to Add 10 to 20%	Medium, to Add 20 to 50%	Heavy, to Add 50 to 100%	Extra Heavy, to Add from 100%
1. Adhesive	280lb. = 95%	280lb. = 90%	280lb. = 75%	280lb. = 60%	280lb. = 30%
2. Softening	15lb. = 5%	23lb. = 7·5%	28lb. = 7·5%	47lb. = 10%	117lb. = 12·5%
3. Antiseptic ($ZnCl_2$)	—	3·1lb. solid (= 0·4gal. solution at 100° Tw.) = 1%	7·5lb. solid (= 1gal. solution at 100° Tw.) = 2%	18·7lb. solid (= 2·6gals. solution at 100° Tw.) = 4%	46·6lb. solid (= 6·4gals. solution at 100° Tw.) = 5%
4. Deliquescent ($MgCl_2$)	—	4·66lb. solid (= 0·52gal. solution at 60° Tw.) = 1·5%	11·25lb. solid (= 1·3gal. solution at 60° Tw.) = 3%	28lb. solid (= 33·2gals. solution at 60° Tw.) = 6%	70lb. solid (= 8·1gals. solution at 60° Tw.) = 7·5%
5. Weighting (china-clay)	—	—	47lb. = 12·5%	117lb. = 25%	420lb. = 45%
6. Water (gals.)	From 150	160 to 120	130 to 80	120 to 60	To 80

E

USEFUL FORMULÆ AND DATA RELATING TO SIZING INGREDIENTS. SIZE MIXING, AND SIZE-MIXING APPARATUS

§96. If the R.D. (relative density) or sp. gr. (specific gravity) of a solution differs from that at which it is usually employed, the disparity may be counterbalanced by proportioning the volume of solution so that it will contain the same weight of solid substance in solution as that contained in a prescribed volume at the usual density. The relative volumes of the respective solutions of the same substance at a different density necessary to contain the same weight of solid material in solution vary in a ratio inversely proportionate to the number of degrees indicated by the scale of Twaddell's hydrometer. This rule may be formulated thus:

$$\frac{D \times V}{d} = v,$$

if

D = degrees (Tw.) of solution at the usual density;
V = volume (known) ,, ,, ,, ,,
d = degrees (Tw.) of solution at any other density;
v = volume (required) ,, ,, ,, ,,

Example:—If the prescribed volume of a solution at 72° Tw. (R.D. 1·36) is 4 gals., it will require a volume of 4·5 gals. of a similar solution at 64° Tw. (R.D. 1·32) to contain the same weight of solid substance in solution; thus:

$$64° \text{ Tw.} : 72° \text{ Tw.} :: 4 \text{ gals.} : 4{\cdot}5 \text{ gals.};$$

$$\text{or, } \frac{72° \text{ Tw.} \times 4 \text{ gals.}}{64° \text{ Tw.}} = 4{\cdot}5 \text{ gals.}$$

Per contra, if it is required to vary the volume of any solution, and maintain the same weight of solid material in solution, the number of degrees Tw. may be found by employing the value of the required volume, as the divisor, when the quotient will give the required number of degrees Tw., thus:

$$\frac{D \times V}{v} = d,$$

because $$D \times V = d \times v.$$

§97. CAUSTIC SODA, in a solid state, has a R.D. of 3 : 1. Water and caustic soda combined in an equal proportion by weight, or in a volumetric ratio of 3 : 1, respectively, produce a saturated solution having a R.D. of $1{\cdot}5 = 100°$ Tw. At this density, 1 gal. of solution weighs $1{\cdot}5 \times 10 = 15$ lb., and consists of 7·5 lb. water and 7·5 lb. soda. Therefore, the volume of such a solution necessary to contain 1 lb. net caustic soda =

$$\frac{1 \text{ gal}}{7{\cdot}5 \text{ lb.}} = \tfrac{2}{15} \text{ gal.},$$

or a little more than 1 pint.

The volume of caustic soda solution at any specified density necessary to contain a prescribed weight of soda may be calculated from the above formula and data.

§98. CHLORIDE of MAGNESIUM, in a solid state, has a R.D. of 1·53 : 1. Water and magnesium chloride combined in the proportion of 1 to 2 by weight, or in a volumetric ratio of 13 : 17, respectively, produce a saturated solution having a R.D. of $1{\cdot}3 = 60°$ Tw. At this density, 1 gal. of solution weighs $1{\cdot}3 \times 10 = 13$ lb., and consists of $4\frac{1}{3}$ lb. water and $8\frac{2}{3}$ lb. magnesium. There-

E*

fore, the volume of such a solution necessary to contain 1 lb. net chloride of magnesium =

$$\frac{1 \text{ gal.}}{8\frac{2}{3} \text{ lb.}} = \frac{3}{26} \text{ gal.},$$

or a little less than 1 pint.

§99. CHLORIDE of ZINC, in a solid state, has a R.D. of 3·125 : 1. Water and zinc chloride combined in the proportion of 1 to 2 by weight, or in a volumetric ratio of 16 : 25, respectively, produce a saturated solution having a R.D. of 1·825 = 165° Tw. At this density, 1 gal. of solution weighs 1·825 × 10 = 18·25 lb., and consists of 6·08 lb. water, and 12·16 lb. zinc. Therefore, the volume of such a solution necessary to contain 1 lb. net chloride of zinc =

$$\frac{1 \text{ gal.}}{12{\cdot}16 \text{ lb.}} = \frac{6}{73} \text{ gal.},$$

or about $\frac{2}{3}$ of a pint.

§100. The "*per-centage of sizing*," as applied to yarn, indicates the RATIO OF SIZE PASTE TO THAT OF YARN; and *not* the ratio of size to the combined weight of size and yarn. Thus:

25 *per cent. sizing* signifies that 25 lb. size is applied to 100 lb. yarn, which therefore becomes 125 lb.

Ex. 1: If an unsized warp weighing 120 lb. receives 30 lb. size, it becomes 150 lb., and is stated to be sized 25 per cent., thus:

120 : 100 :: 30 : 25 PER CENT. SIZE;

$$\text{or,} \quad \frac{30 \times 100}{120} = 25 \text{ PER CENT. SIZE.}$$

Ex. 2: If a sized warp weighing 150 lb. has been sized 25 per cent., it contains 30 lb. size, thus:

$$125 : 150 :: 25 : 30 \text{ LB. SIZE};$$

$$\text{or,} \quad \frac{25 \times 150}{125} = 30 \text{ LB. SIZE.}$$

Ex. 3: If an unsized warp weighing 120 lb. is sized 25 per cent., it becomes 150 lb., thus:

$$100 : 120 :: 125 : 150 \text{ LB. SIZED WARP};$$

$$\text{or,} \quad \frac{125 \times 120}{100} = 150 \text{ LB. SIZED WARP.}$$

Ex. 4: If a sized warp weighing 150 lb. has been sized 25 per cent., the warp, before sizing, weighed 120 lb., thus:

$$125 : 150 :: 100 : 120 \text{ LB. YARN};$$

$$\text{or,} \quad \frac{100 \times 150}{125} = 120 \text{ LB. YARN.}$$

§101. The R.D. (relative density) of any substance represents the ratio which a given volume of that substance bears to a corresponding volume of distilled water at a temperature of 60° F. $= 15\frac{5}{9}$° C.

One gallon of water at a temperature of 60° F. = 10 lb. Therefore, since the R.D. of water at that temperature represents unity, the R.D. of any solution, multiplied by 10, indicates the weight, in pounds, of a gallon of that solution.

§102. The capacity of a RECTANGULAR VESSEL is ascertained as follows:—

Length × Width × Depth = Cubic units of measurement. If these are cubic feet, then—

Cubic Feet × 6·232 = Gallons.

Ex.: A vessel 5ft. long × 3ft. wide × 3ft. deep = 45 cub. ft., and would hold $45 \times 6{\cdot}232 = 280$ gallons.

The capacity of a ROUND OR CYLINDRICAL VESSEL may be ascertained by either of the following alternative methods:—

(1): $\text{Radius}^2 \; 3{\cdot}1416 \times \text{Depth} = $ Cubic units of measurement employed.

Ex.: A circular vessel 2ft. 6in. dia. × 3ft. 6in. deep $= 1{\cdot}25^2 \times 3{\cdot}1416 \times 3{\cdot}5 = 17{\cdot}15$ Cubic Feet, and would hold $17{\cdot}15 \times 6{\cdot}232 = 107$ gallons (nearly).

(2): $\text{Diameter}^2 \times 0{\cdot}7854 \times \text{Depth} = $ Cubic units of measurement employed.

§103. The Diameter of a Circle × 3·1416 = the Circumference.

The Diameter of a $\text{Circle}^2 \times 0{\cdot}7854 =$ the Area.

The Diameter of a Circle × 0·8862 = the Side of an Equal Square.

The Side of a Square × 1·128 = the Diameter of an Equal Circle.

A Sack or Peck of Flour = 280 lb.

A Sack or Bag of China-clay = 224 lb. = 2 cwt.

Water boils when it is raised to a temperature of 212° F. = 100° C.

§104. TO CONVERT THE FOLLOWING FACTORS:—

(1): Relative density to degrees Twaddell:—

(R.D. × 1000)—1000 ÷ 5 = Deg. Tw.

Ex.: (R.D. 1·25 × 1000)—1000 ÷ 5 = 50° Tw.

(2): Degrees Twaddell to relative density:—

(Deg. Tw. × 5) + 1000 ÷ 1000 = R.D.

Ex.: (Tw. 50° × 5) + 1000 ÷ 1000 = R.D. 1·25

(3): Degrees Fahrenheit to Centigrade:—

$(\text{Deg. F.} - 32^\circ) \times 5 \div 9 = \text{Deg. C.}$

Ex.: $(60^\circ \text{ F.} - 32^\circ) \times 5 \div 9 = 15\tfrac{5}{9}^\circ \text{ C.}$

(4): Degrees Centigrade to Fahrenheit:—

$(\text{Deg. C.} \times 9) \div 5 + 32^\circ = \text{Deg. F.}$

Ex.: $(15\tfrac{5}{9}^\circ \text{ C.} \times 9) \div 5 + 32 = 60^\circ \text{ F.}$

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