Glues and Gelatine

A PRACTICAL TREATISE
ON THE
METHODS OF TESTING AND USE

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PREFACE

This work purports to be a practical treatise on the testing and examination of glue and gelatine. It aims to acquaint the consumer with the methods employed by representative American manufacturers in grading and distinguishing between glues and the considerations governing their valuation. It offers to the chemist, who is too often unfamiliar with these products, although experienced in other lines, test methods chosen with a view to determining the value of a glue for a specific purpose, rather than merely defining its abstract chemical characteristics.

While the subject of glue is by no means unrepresented in technical literature, it has been dealt with chiefly from the standpoint of manufacture; while the intelligent testing of glue — that which must determine its commercial value, and which, furthermore, is the only means by which the manufacturer himself is enabled to assign a grade and a price to his product, has been given scant consideration; the subject being dismissed with brief reference to methods at once obsolete and inaccurate.

The futility of attempting a treatise on the manufacture of glue has long been manifest to the author. Theory and practice differ radically in the production of this article, more so, perhaps, than in the case of any other. It has been the experience of more than one trained chemist to attempt the manufacture of glue, relying for guidance solely upon the chemical principles thought to be involved, and the results have been ludicrous. Tersely stated, the art of making glue consists in knowing what to do and how to do it; and this state of enlightenment presupposes long study under some one who, in turn, acquired the art from an experienced teacher. As certain manufacturing methods, however, leave clues in the finished product that aid in the determination of its commercial value, brief reference has been made to the principles underlying the manufacture of glue and gelatine.

Nor do I enter into any protracted discussion of the probable constitution of glutin or gelatin and allied substances; nor of the chemical changes undergone by the glue-yielding materials in the course of manufacture. As enunciated in the contemporary literature of the subject, these principles are at best premises argued from conclusions — mere opinions that have yet to be substantiated in actual practice. They have absolutely no bearing upon the fitness or unfitness of a glue for a given purpose, nor do they aid either chemist or consumer in determining which of two glues is the better.

Upwards of fifty million pounds of glue, foreign and domestic, are consumed annually in the United States, in such industries as the manufacture of veneers, wall paper, matches, paper boxes, artificial leather, painters' size, patent sizings, woodwork and a host of others. Despite this vast consumption, it is safe to assert that 80 per cent of glue users have but the vaguest conception of its properties and are guided largely by the manufacturer or dealer in the selection of their supply. In the main, their confidence is not abused; but in many instances they are victims of unscrupulous salesmen. Some go through the formality of "testing," employing methods the recital of which would strain the reader's credulity. He who fully understands the nature and properties of the material for which he annually expends many hundreds of dollars is indeed *rara avis.*

To afford the uninitiated consumer a rational means of protection is the chief aim of this work. It is designed, also, to aid the chemist unfamiliar with authentic test methods, whose sole recourse, when appealed to for an opinion respecting glue, has invariably been analysis, which fails absolutely of the desired result. In the interests of the former, I have endeavored to describe the test methods in a manner that will permit of their accurate execution by any one of intelligence. At the same time, I have been at pains not to deprive them of their technical character in order that the chemist may appreciate their adaptability to the requirement of the average commercial laboratory.

The day is not far distant when glue and gelatine will be purchased on specification; and such a trade condition will necessitate the adoption of a uniform system of tests throughout the United States. In the interval, it is the earnest hope of the author that the suggestions herein contained may serve to reduce to the semblance of uniformity the present widely divergent processes for the assay of glue and gelatine.

R.L.F.

PATERSON, N. J.
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CHAPTER I

INTRODUCTORY

1. Nature and Properties of Glue. — 2. Sources of Glue. — 3. Principles of Manufacture. — 4. Commercial Forms.

1. Nature and Properties of Glue. — Through laxity of usage, the term "glue," from "gluere — to draw together" — has been extended to include all solutions of substances exhibiting binding or adhesion. Its legitimate application comprehends only those viscous adhesive bodies resulting from the treatment of animal bones or tissues, as well as the bladders and certain membranes of fish. These products possess the property of absorbing cold water in quantity, which softens them and causes them to swell, when, by the aid of heat, they are rendered soluble in the absorbed water, from which solution they gelatinize or form a jelly, after standing and cooling for a short time.

Of itself, this property of gelatination is not sufficient to distinguish true glues, animal or fish, from the mass of vegetable agglutinants, the solutions of which are often erroneously classified as glue. All starches gelatinize upon treatment with boiling water, the soluble varieties first forming a clear solution from which they subsequently jell, much in the same way as glues. Solutions of Irish moss, agar-agar, "Japanese gelatine" and gelose gelatinize upon cooling, and gum tragacanth will absorb large quantities of water in the cold, forming a gelatinous paste similar to the jelly of a weak glue.

It is in the behavior of the jellies, as well as in the deportment of true glue towards certain chemical reagents, that we find a means of distinguishing the true from the false. Thus, if the glue jelly be dried, we procure practically the original hard glue, which can again be soaked up, melted or dissolved, and from this solution it will gelatinize a second time. This operation may be repeated a number of times. Each treatment, however, so impairs the power of gelatination, that a point is reached where the glue goes into solution but refuses to jell. On the other hand, the products which result from drying out the solutions or jellies of starches and vegetable gums, are dissimilar to the originals; and, while they permit of softening by soaking in cold water, no amount of heating will bring them into permanent solution a second time.

The chief constituent of all glue, that which, in the main, imparts to it the property of gelatination, is GELATIN, or, as it is called by some, GLUTIN. The latter term is somewhat objectionable, as it is synonymous with GLIADIN, the essential principle of wheat and other starches. While it is true that the analysis of purest GELATIN corresponds markedly with that of GLIADIN or GLUTIN, this does not justify the assumption that the nitrogen, carbon, hydrogen, oxygen and sulphur, which both contain in corresponding amount, are *combined* in exactly the same way in each.

According as to the nature of the materials selected for the preparation of the glue, there are associated with GELATIN such substances as CHONDRIN, which is derived from chondrinogen, the characteristic cartilage of young bones and tissues; and KERATIN, from the horns of animals. These substances are more viscous and adhesive than GELATIN, while displaying less gelatinizing power. MUCIN, a slimy substance present in the intercellular structure of cartilages, is frequently found in glue. It has some adhesive, but little or no gelatinizing properties, and its presence must be regarded as the evidence of faulty manufacture.

As the ratio of the GELATIN to the other substances present increases, so does a glue advance in the scale of purity; and those hard, glassy products, ranging in shade from dark through pale yellow to colorless, are the gelatines of commerce. They are refined glues and are prepared from stock known to be rich in those elements yielding chiefly GELATIN and but little else, *i.e.*, the epidermis and carefully selected bones. These undergo special processes with a view to eliminating the other constituents of glue.

It is difficult to define the exact point of transition from glue to gelatine. The two classes of substance possess in common the properties of water absorption and subsequent gelatination. The strength of the jelly is not a determining factor, many glues being far superior in this respect to gelatines. Commercially, the distinction is based largely upon the appearance of the product. Gelatines are usually transparent or at least markedly translucent. Their solutions and jellies are very clear. The *viscosity* of gelatine solutions — that is, their rate of efflux from a vessel of known capacity as compared with that of the same volume of water, is considerably lower than the viscosity of a glue of corresponding strength. This may be ascribed to the fact that the CHONDRIN associated with GELATIN, in glue, imparts to it the added degree of viscosity. The very processes which serve to eliminate the binding and viscous elements of glue stock, thereby producing gelatine, debar the latter from use as glue; and, conversely, the presence of these elements in glue classify it as such. An intermediate product, known as gelatine-glue, displays some of the properties of each and often serves as a gelatine, and, again, finds frequent application where glue is required.

In their deportment towards certain chemical reagents, both GELATIN and CHONDRIN display marked characteristics. These reactions, an account of which will be found under the chapter on Analysis, appeal chiefly to the chemist, in that they furnish some clue to the constitution of these substances. They are of little interest to the general consumer, as they do not enter into the commercial testing of either glue or gelatine. Tests based upon them are found to be inaccurate and, save for alkalinity or acidity, the chemical properties of glue are not factors in rational systems of test.

2. Sources of Glue. — The hides, horns and bones of cattle ; the skins of the sheep, goat and pig, as well as the bones of some of these; the "sounds" or air-bladders and other membranes of fish, constitute the chief stock from which glue is derived. Rabbit skins yield a very strong glue, of unpleasant odor, which was formerly marketed in the form of a jelly, or *size.* Parchment yields considerable glue of high quality. Excepting, perhaps, clippings from old gloves, leather is not available as glue stock, as it is difficult to separate the glue from the tanning materials in combination with it.

Of the above-mentioned hides and skins, only those portions rejected by the tanner as unfit are employed as glue stock. The better portions are converted into the respective leathers, and only the splits and pieces, the ears and head portions, and the muscular tissue contiguous to the skin, known as "fleshings," come to the glue-maker. The epidermis and carefully selected bones comprise stock for gelatine which, in addition, is frequently derived from old buttons and similar horn products.

3. Principles of Manufacture. — In the selection of the stock for glue making, the manufacturer is called upon to exercise considerable ingenuity; and, while the subsequent stages of preparation are no less important, the greatest care in cooking or treating will not overcome the more radical defects of the stock. Glue is not merely the solution of the materials present in the stock, these being greatly modified by the action of boiling water. The exact nature of the change is but little understood, but is assumed to be that of hydrolysis — *i.e.*, the addition, chemically, of a certain number of molecules of water to the glue-yielding elements.

Almost any stock, upon treatment with boiling water, will yield some glue, but very little. To facilitate the extraction and, more particularly, to insure the maximum yield, the stock undergoes treatment preliminary to boiling, varying in character and duration with the nature of the materials selected.

In the manufacture of glue from hides or skins, the first step is LIMING, or treating the stock with weak solutions of lime. Its object is, first, to dehair the hide; secondly, to cause it to swell or "plump," bringing the pores to a condition which insures not only the rapid extraction of the glue, but also the extraction of the maximum amount; thirdly, liming is intended to rid the hide of substances which, if present in the finished glue, impair its value.

The operation is conducted in shallow, rectangular vats of wood. The stock is immersed in the lime solution and stirred from time to time, at which intervals it is examined and the conditions of the pores noted. Some varieties of hide stock require longer liming than others. By far the greater quantity of hide stock has been limed to some extent before reaching the glue-maker. The tanner subjects the skins to the action of lime, because, like the glue-maker, he desires to rid them of all deleterious material and to "plump" them, bringing the pores to a condition where they will properly respond to the action of the various tannins. The tanner's liming process completed, he then rejects those portions unfit for leather, but rich in glue-yielding elements, and hence these come to the glue-maker partially limed. Where tannery and glue factory are in close proximity to each other, the stock is delivered in the wet state. In other cases, it is dried and then shipped.

The glue-maker is under necessity of subjecting the stock to further treatment with lime in order to prepare it properly. Heavy hide pieces, notably those from steers, which are rich in glue-yielding material, frequently undergo six weeks' liming, while sheep stock receives little or no further treatment; this, of course, assuming that it has been delivered from the tannery, as otherwise it receives considerable liming. Goat stock is subjected to the process for a period ranging from twenty-four hours to ten days. In this there is no hard and fast rule, the individual preference of the glue-maker being a factor of considerable importance.

The liming of glue-stock is an operation of great delicacy. In the endeavor to rid the stock of non-gluey material, and to bring the pores to the proper condition, the operation may easily be carried too far and much glue-yielding substance be lost through solution in the alkaline waters. Over-liming creates defects in the stock, which cannot be overcome in the subsequent stages of manufacture, no matter how carefully conducted. The result is that the finished product is inferior and unfit for the majority of usages.

Liming finished, it is the practice of some manufacturers to kill excess of lime by means of sulphuric acid, converting it into insoluble calcium sulphate. Others, again, wash out as much of the lime as possible, permitting the balance to remain. As a result, the finished glue is more or less alkaline in reaction. While moderate alkalinity is of no material disadvantage, interfering in no way with tensile strength, it is preferable to have the glue slightly acid, inasmuch as the bacteria which effect the decomposition of a glue jelly, thrive in an alkaline medium, whereas in an acid one, they have a much harder struggle for existence. Hence the solution and jelly of an acid glue keep better and longer, independent of artificial preservatives, than those of an alkaline glue.

In the course of liming, some of the grease inherent in the stock is converted into insoluble lime soap, the subsequent treatment with acid destroying this; and, while the mineral salts wash out, the separated fatty acids remain in the stock. They have a disagreeable odor and must be removed, else the finished product is too greasy. Their removal is usually effected in the course of boiling, when they rise to the surface of the liquor and are skimmed off.

After liming, the stock is washed. This must be done carefully, lest some glue-yielding material be lost. Washing frees the stock from excess of lime, where treatment with acid has not been resorted to for the purpose. It further serves to remove from the stock substances which have only been softened and not dissolved by the lime. In washing, the stock is subjected to the action of a stream of water, while a roller passes over it, squeezing it out thoroughly. The water employed for washing, as well as for boiling, is the subject of special consideration. It must be free from all salts or chemicals which may interfere with the production of a good glue, or tend to precipitate the glue from solution.

Where bones constitute the glue-stock, the simplest treatment consists in comminuting them in a suitable mill and then steaming the mass to rid it of the bulk of grease. In many instances the grease is extracted by means of some hydrocarbon solvent, special machinery, designed for the recovery of both solvent and grease, being employed. Where selected bones comprise the stock, they are treated with weak alkali to cleanse them and are then leached with acid for a long period. The object of this treatment is manifest, and to understand its operation it is but necessary to recall the experiment of childhood, in which a chicken bone was softened by means of dilute acid, tied into a knot, and once more hardened by immersion in lime-water. Bones consist of the phosphates of calcium and magnesia, supported by a framework of cartilage. The acid dissolves out the mineral salts, leaving the skeleton of cartilage, which is the glue-yielding substance. This, after careful washing, is subjected to boiling. As with hide stock, this washing must be thorough. If the bones have not been previously degreased, some of the fat is converted into acid soaps. The crude treatment of common or "junk" bones, as outlined, results in the ordinary bone glues of commerce; while the product of leached stock is known as "acid-treated" bone glue. Where the stock has been carefully selected and manipulated, bone gelatine is produced.

It is the practice of many manufacturers, prior to boiling, to blend different hide stocks after they have been limed and washed. Herein lies one of the great secrets of making good glue. Sheep stock and goat, of themselves, yield exceptionally strong glues, though rather greasy. Combined with fine ox fleshings, hide pieces etc., the resultant glue is vastly improved in strength and in quality, all other manufacturing factors being equal. As a result, the bulk of hide glue in the market is not "straight" — that is to say, it is not made from any one exclusive hide stock, but from mixtures of two or more. Straight sheep glue is quite common, but straight goat is rarely, if ever, met with.

Many of the cheaper grades of glue consist of mixtures of hide and bone. In preparing these, the respective stocks are not mixed beforehand, but are extracted separately, the resultant liquors combined in different proportions, and the process carried to completion. Similarly, liquors extracted from different hide stocks may be combined before jellying, although it is by far commoner practice to mix the initial dry stocks, as previously pointed out.

In the preliminary treatment, all of the grease in the stock is not converted into soap by lime or acid. Indeed, only a small portion is so modified, and the bulk must be removed by other means. This is usually done in the course of boiling, when the grease and separated fat rise to the surface of the liquor and are skimmed off as closely as possible. Contrary to popular belief, the glue-maker is at especial pains to recover most of the grease. Apart from the fact that its presence, in excess, is hurtful to the finished product, barring it from certain uses, the manufacturer has often to rely upon its recovery and sale to reduce the cost of the glue. Experienced consumers often remark that their favorite grade is at times greasier than at others. We account for this in the fact that at times the price of grease is so low as not to warrant the additional labor-cost attendant upon its recovery. In times of scarcity, however, the manufacturer, by recovery and sale of the grease, realizes an increased margin of profit.

Boiling or Extracting the Stock. — The prepared and washed stock is now subjected to boiling or extraction; and if the initial treatment is of importance in procuring a good product, this is no less so. Here, again, the individuality of the operator asserts itself and, while certain fundamental principles are universally observed, it is safe to assert that no two glue-makers proceed in exactly the same way throughout, each having his little secrets and tricks of the trade.

The stock may either be dried and stored for a time, when it must again be softened prior to extracting, by immersion over night in pure cold water, or else it is at once placed in the boiling vats. These vary in construction from simple wooden vats fitted with a steam coil and vent for discharging the liquors, to complex iron kettles equipped with apparatus for temperature control and agitation, and provided with both jacketed and direct steam. The stock to be extracted is covered with water and the cooking begun. At this juncture, two alternative methods present themselves. The operator may thoroughly extract the stock in one operation and complete the glue from the resulting liquor, or, as is often done, he may produce his glue liquor in "runs"; that is, he begins the cooking using very little water and at the minimum temperature necessary for the extraction of glue; and, maintaining this for a short time, he withdraws the liquor which constitutes the first "run." More water is now added, and the cooking continued at an increased temperature and for a longer time, and so the second run is produced. According to the nature of the stock and the preference of the operator, as many as five runs may be obtained, the last at the maximum temperature, practically that of boiling water, in order to insure complete extraction. Prolonged heating is injurious to solutions of glue, gradually destroying the gelatinizing power, and, for this reason, where glue is produced in runs, the first is the strongest as it contains the bulk of choice material, extracted at a low temperature. Each succeeding run is weaker, the last having but little strength, owing to the conditions under which it is produced.

In the course of boiling or extraction, the preservation of the liquor and thus, ultimately, of the finished glue, receives attention. For antiseptic and preservative purposes a number of substances may be employed with varying degrees of success. Chief among these is carbolic acid, though this, as a rule, is barred because of its characteristic and permeating odor. Formaldehyde is a splendid preservative, but its use, also, is attended by disagreeable features. It tends to precipitate a constituent element of the glue and, while its operation may not be manifest throughout the processes of jellying and finishing, at a later day the consumer, in melting the finished glue preserved by its use, is confronted with the rather startling spectacle of the glue solution separating. Formaldehyde is extensively employed as a temporary preservative of very dilute bone liquors which are to be concentrated by evaporation, during which most of the formaldehyde passes off as vapor, the final preservative being then added to the concentrated liquors. Salicylic and hydrofluoric acids are most useful as glue preservatives, the latter, although difficult to handle because of its corrosive properties, being a powerful germicide. Sulphate of zinc has some preservative properties and is often used in conjunction with other substances.

While still in the form of liquor, the glue may be subjected to the action of bleaching agents, where a very pale finished product is required. The bleaching is usually effected by means of sulphurous acid which is conducted in the gaseous state through the hot glue liquor. From time to time a sample is withdrawn, and the process is terminated when the desired shade has been achieved. The color may be improved by the addition of such substances as zinc white (oxide of zinc), chalk or finely divided barytes or talc. One or more of these is added to produce a perfectly white or "opaque" glue. Again, only a limited amount of these substances may be added, when the resultant glue is described as "colored."

As has been stated, the temperature at which the glue is extracted requires careful regulation. Bone and other liquors are often produced so dilute that they will not jell sufficiently to permit of proper cutting, and must be concentrated by evaporation. Under normal conditions the degree of heat required to effect proper concentration would gradually destroy the gelatinizing power of the glue. To overcome this, the operation is carried out in a vacuum evaporator.

Jelling the Glue Liquor. — The glue liquor, from one run or several, is conducted from the vat into oblong pans or molds with slightly sloping sides and about one foot deep. These are then placed in the cooling room, where the liquor gradually sets to tenacious jelly. These jellies, in the form of oblong blocks, are next conveyed to the cutting room where they are sliced. The simplest device for cutting consists of two uprights permanently fastened upon a long board or runway, to the sides of which are attached boards equal in height to that of the jelly-block to be cut. These prevent the jelly from slipping or swerving. Between the uprights stretch fine wires, the space between which may be increased or diminished at will. The space between the two upper and two lower wires is smaller than that between the others, in order that the top and bottom slices shall be thinner than the rest. The block of jelly is placed in the runway and is firmly pressed against the wires, which traverse it longitudinally, cutting it into sections which average a half inch in thickness. In many plants, more elaborate cutting apparatus, operated by power, is employed; but these complex types are but amplifications of the principles embodied in the simplest.

Drying the Cuttings. — The sections or cuttings are now placed upon nets, made either of galvanized iron wire or fish twine, to dry, in a room set apart for this purpose. This room is heated artificially and fans convey the heated air over the nets. In many instances, the drying is effected by simply exposing the cuttings to natural air currents. In the operation of drying it is possible to undo, through carelessness, much, if not all, of the good accomplished in the previous stages of manufacture. Too much heat, in drying, is as fatal to a good product as in boiling and cooking. On the other hand, if dried too slowly, the cuttings are apt to rot. Some manufacturers rid the cuttings of the bulk of moisture by subjecting them first to artificial drying, and then finish them by exposure to the air. This is thought to "season" the glue. Natural drying in very cold weather is productive of frozen glue, much of which comes into the market at intervals.

The grease which fails to rise to the surface of the liquor in the course of boiling, and so fails of removal by skimming, presents itself in the glue jelly and is to be found chiefly at the top and bottom of the jelly-block. For this reason the top and bottom cuttings are not, as a rule, spread upon the nets to dry, but are set aside and remelted with the next boiling of glue. There are times, however, when they are dried with the rest, and come into the market under the name of Greasy Tops and Bottoms. In the majority of instances where the manufacturer goes to the trouble of drying these greasy sections, he grinds them to be mixed with other ground glues.

4. Commercial Forms. — As taken from the nets when dry, glue is in the form of oblong sheets of varying thickness. The majority of foreign glues come to this market in this form, or as square cakes, the latter very thick. Few, if any, domestic glues are marketed in cake form. Gelatines are for the most part sold in the sheet. Prior to packing in barrels, the sheets of glue are broken into small, irregular pieces known as flakes, and hence this form acquires the designation of FLAKE GLUE. These may be GROUND, or even POWDERED. Certain glue jellies are cut into long, prismatic strips, which, when dry, are slightly twisted and bear a faint resemblance to noodles, whence the name, NOODLE OR STRIP GLUE. Glue jellies are at times so cut as to dry to a strip one inch wide by six long, and from one quarter to one-half inch thick. This form is known as RIBBON GLUE.

Gelatines are met with in the FLAKE, SHEET, STRIP, GROUND, and POWDERED forms. SHRED GELATINE is in the form of fine sections similar to shredded cocoanut.

The bulk of gelatine consumed here is of foreign manufacture, and is in the sheet form.

The form of a glue bears no relation to its tensile strength or working qualities. It is merely a question of individual preference based, perhaps, upon what the consumer has been accustomed to use, that impels one to employ nothing but flake, where another will use only ground or strip. Facility in use is dependent upon the form of the glue. A thin-cut flake soaks up faster than a thick-cut, a ground glue faster than a thin-cut flake, and powdered glue fastest of all. The chief objection to foreign glues is that the majority of cheaper grades are so thick-cut as to require long soaking before they can be melted.

Flake glues are cut in varying thicknesses. The stronger varieties are cut very thin, and where this has been done unskilfully the glue is curled up. To prevent this, the glue liquor is made as dilute as is consistent with proper jellying and rather thick sections cut from the jelly. These consist chiefly of water which passes away in the drying, leaving a thin, dry glue; and as the drying is conducted somewhat slowly, the curling of the edges does not occur. It is readily seen that this method is applicable only to a very strong glue liquor, as otherwise the necessary dilution would interfere with the formation of a jelly sufficiently firm to cut.

Two other forms of glue are produced, Thimble or Teat, which has its origin in the fact that weak glue jellies frequently drip through the interstices of the net, particularly if the drying room become unduly warm. Another, SERRATED GLUE, is produced by forcing the glue jelly through an apparatus similar to a colander, with the result that the dried particles are no longer than a quarter of an inch, and twisted. This latter form is very rare, and Thimble glue is usually promptly ground.

In the trade, the term "opaque" is used with reference to the presence of coloring matters in the glue, rather than as the antonym of "transparent." If the hard glue be white or almost so, it is called "opaque"; and if only whitish, "colored." When materials are added to the glue to produce color, an inspection of the dry piece may fail to reveal their presence; yet the solution will be more or less whitish. The cheaper white glues, much prized by the house-painter, are made from pig stock, to which an inferior quality of coloring material is added. Of this class the Northwestern No. 1, No. 2, and No. 3 are types. High-grade glues are rendered perfectly white or opaque by means of zinc white. This adds to the cost of the product. Not all liquors can be converted into opaque dry glues; only such as have an initial light color receive the treatment and are, in addition, bleached prior to the admixture of coloring agents, in order that only the smallest quantity of the latter need be used. The price of opaque glues is always somewhat higher than that of clear glues of corresponding strength. It is assumed by some that the presence of coloring matter in glue is an aid in drying. Practice fails to sustain this theory.

Of the high-grade hide glues, many are cut very thin and are almost transparent. Others, again, are thicker in section and less flexible. As has been stated, these conditions have no bearing upon the strength of the glues, save within limits hereafter to be defined. As appearance, however, is a material factor in selling, glues are made as nice-looking as possible.

Fish Glues. — With the exception of isinglass, which is prepared chiefly from the swimming-bladder of the Russian sturgeon, and which is marketed in various solid forms such as sheet, purse, lump, pipe, honeycomb, etc., fish glues are in the form of heavy solutions or pastes. They are all powerful adhesives having the characteristic odor of fish, combined with that of the materials used to preserve them in the liquid or fluid state. To offset this, they are perfumed with essential oils (sassafras and wintergreen); but these disguise the natural odors only to limited extent.

Isinglass is a very hard, transparent and practically colorless substance. It is the most powerful adhesive known and is used chiefly by brewers and wine merchants for clarifying purposes. It is to be remarked that pure gelatine, which is chemically the same thing as isinglass, cannot be used for this purpose. Many substitutes for isinglass are offered for sale, but they possess only to a slight degree the excellent properties of the genuine

Similarly, liquid fish glues are extensively imitated. Weak animal glues treated with mineral acids or other agents to destroy their gelatinizing power, and perfumed with various essential oils, are sold as fish glues. They do not and cannot supplant the genuine, as they are deficient in adhesiveness and binding properties. In fact, only very weak animal glues will respond to the necessary treatment, and these, in very cold weather, jell and must be remelted with the aid of vinegar before they can be used. They are properly known as liquid glues; and only such as preserve their fluidity at all times are deserving of the title. The most recent addition to this class is a weak animal glue treated with chloride of calcium which tends to prevent jellying. This is the most spurious of all, as this chemical is markedly hygroscopic and interferes with complete drying.

The "liquid glue" of the paper-box manufacturer contains no glue whatever, being a solution of certain grades of corn dextrine. Flour paste is often added to increase the body of the material and, incidentally, the margin of profit.

The various mending cements are prepared from glue, gelatine and, at times, casein. The glue and gelatine are treated with a view to prevent jellying and mixed with other substances which render the dried material more or less water-proof.

Flexible glue, for book-binders' use and for making pads or writing tablets, comes in the form of oblong cakes, about ten pounds in weight. It is a mixture of glue, glycerine and water, the glue being dissolved in the regular way and the glycerine then added to impart flexibility. Printers' rollers are made in much the same way. Flexible glue is made of white glue or the ordinary shades. That intended for use as padding composition is colored to suit the consumer, fuchsine (magenta) being chiefly employed. Flexible glue is frequently worked up into small toys, such as the grotesque heads displayed for sale by street fakirs.

CHAPTER II

CLASSIFICATION AND TESTING OF GLUES

Preliminary Considerations. — It is obvious that the manufacturer, in assigning a price to the finished glue, must reckon with the cost of stock, labor, etc. Theoretically, he might base the price upon these considerations alone; but, since the most expensive stock may, through faulty treatment, yield a weak or inferior finished product, he cannot, in practice, be altogether governed by the cost of production. In addition to the latter, the *quality* of the product must be considered, and the measurement of quality necessitates the formulation of a system of test. Glue is sold on "test"; that is, the price of the product is governed by its strength and certain other properties, for the measurement of which many divergent tests have been formulated. Some call for the determination of the exact content of GELATIN, since, as a rule, the greater this content, the purer and, in some instances, the stronger the glue. The methods formulated for this assay are faulty and inexact; but, apart from this, the content of GELATIN has absolutely no bearing upon the commercial fitness of the product. Some take note of the amount of cold water absorbed by the glue in a given time. Others, again, are concerned with the breaking strain of the dry glue. It is to be observed that such test methods as are limited to the determination of only one constant or property are deficient in scope. Only by examining for several well-defined constants, can any useful estimate of the general fitness of the glue be formed.

Accordingly, the dry glue must be examined as to color, finish and odor, and, if in the form of flake, sheet, ribbon or strip, as to the nature of the fracture when a piece is broken between the fingers or by other means. The solution must be examined as to odor, acidity or alkalinity, grease, foam and viscosity. The jelly resultant from the solution is tested for strength. The viscosity and jelly strength are compared with those of accepted standards.

Standards. — The constants or measurements of quality in glue-testing are arbitrary and of value only when compared with the corresponding constants of a standard glue. The consumer is frequently at a loss to select the proper standards of comparison. He is usually content, having secured a glue that fully answers his requirements, to compare each succeeding delivery with this. While this doubtless enables him to check uniformity of delivery, it in no wise answers the question with which he is chiefly concerned; namely, was the original purchase which he now uses for a standard, the best quality obtainable for the *price* paid? To possess this degree of protection, he must adopt the identical standards employed by the manufacturer in assigning price.

Manufacturers avail themselves of the Cooper grades as standards of comparison. These are eleven in number, and proceeding from STRONGEST TO WEAKEST, are designated:

A Extra.
1 Extra.
No. 1.
1 X ("one cross").
1¼ ("one and a quarter").
1⅜ ("one and three eighths").
1½ ("one and a half").
1⅝ ("one and five eighths").
1¾ ("one and three quarters").
1⅞ ("one and seven eighths").
No. 2.

These grades were for many years considered the best made, and competing manufacturers sought to produce glues corresponding with them in all respects. Hence they remain the authentic standards of comparison. It must not be inferred that they are the only reliable make of glue. Many manufacturers produce glues far stronger than the A Extra, and the other grades are regularly duplicated.

It will be readily understood that glues are produced which, in strength, fall between the various grades. No manufacturer is so expert that he can proceed with the definite intention of producing a glue of A Extra or 1⅜ or No. 2 strength. He can control the strength of the product only by the careful selection of stock and in the treatment throughout the course of manufacture, as outlined in the previous chapter. Once finished, the glue must be compared with the above standard grades in order that it may be classified and a price assigned to it. Hence the value of their employment by the consumer, if he desires to be enlightened upon the all-important factor of price. Furthermore, the peculiar designations of these grades have become the accepted vernacular of the trade. While defying definition, the term 1½, for example, conveys to the initiated not only the idea of definite strength, but also enables him to form a definite estimate of the limits of price. In addition, the acceptance of the Cooper grades as standards is justified by their unfailing uniformity. While the manufacturers are subject to the same limitations as others in attempting to predetermine the strength of their glues, with the result that they produce many that fall between the various grades, these latter do not come into the market under the manufacturer's name, only those that are up to standard in all particulars receiving their special brand. The result is, that the 1¼ of to-day is identical with that of five years ago.

Test Methods. — The dry glue should first be carefully examined, for, while the appearance of the glue, save in isolated instances, tells nothing in regard to its strength, such examination is often sufficient to warrant the rejection of the glue, without the necessity of further tests. The following points are worthy of consideration:

1. The surface of the piece of glue should be free from bubbles. These may be merely the result of the incorporation of some air with the glue; but, if sizeable and irregular in outline, they are evidence of the fact that the stock from which the glue was made, and hence the glue itself, is in an advanced stage of decomposition. Of such a glue, the jelly will rapidly putrefy and the solution will have a putrid odor, which, in some instances, may be detected in the glue itself, particularly if the sample be slightly moistened.

2. The piece of glue should break with an even fracture. If the fractured edges are splintery, the glue

has not been properly boiled. On the other hand, if a glue breaks under a very slight strain, even though the fracture be even, the glue is either very weak or unduly dry.

3. A good glue should present a velvety or glossy surface, although the absence of this does not always condemn the glue. A "dead" surface may be due merely to the fact that dust settled upon the glue while it was drying upon the nets.

4. The cut of the glue is at times an indication of its strength. If, for example, the glue is cut very thin and is sufficiently flexible to permit of bending almost double without fracture, it is a glue of great strength.

5. If the sample is a flake glue, it is well to compare several pieces in a good light, for even flake glues may be mixed. They are somewhat difficult of recognition inasmuch as the dealer is at great pains in selecting the constituents of such mixtures. Mixed *ground glues* are, of course, frequently met with. Such as are a mixture of foreign and domestic grades may readily be recognized with the aid of a magnifying glass; the particles of the foreign glue being usually lighter in color and more transparent than the domestic. Mixtures of two or more foreign grades may be detected by noting the differences in color exhibited by the particles. In examining ground glues to detect mixture, the observer must not be led astray by slight differences in color, as in all ground glues some particles are finer than others, and hence lighter in shade.

Sampling. — The sampling of the glue preliminary to test is of the greatest importance. The small sample of a few ounces which is usually submitted to the prospective purchaser should be the subject of the above preliminary examination. If it is a flake glue and is seen to be a mixture, a little of each constituent must be taken for test. Where the dealer goes to the extreme of mixing flake glues, he uses a strong glue as a base, and adds enough of a weaker and hence cheaper glue to make the price right. Hence, unless the above precaution is observed in connection with the sampling of a mixed flake, the result of the test is misleading, as the operator may unwittingly select pieces of the stronger glue only, or portions of the weaker alone. It is rare to find more than two constituents in a flake mixture, whereas, with ground glues, as many as four different grades may be mixed together. If the initial sample is a ground glue, even though the preliminary examination reveal no mixture, it is well to shake the package thoroughly before withdrawing the quantity required for test. In the case of mixed ground glues, this precaution must invariably be observed.

Many consumers are content with an examination of the sample and take for granted that the delivery will correspond with it. Such render themselves an easy prey to the unscrupulous dealer. It is manifest that if the consumer is to achieve the full measure of protection, he must test the delivery and note wherein this differs, if at all, from the original sample. Having, furthermore, secured a delivery to his entire satisfaction, he should reserve a generous portion to be used in conjunction with the other standards in future tests.

Whether the delivery consist of a single barrel or a car-load, the sampling should be done systematically. Glue is sometimes stored in a damp place that additional weight may accrue to the barrel. In such case, those portions contiguous to the top and the bottom of the barrel contain more moisture than that at the center. Hence, if the glue is ground, even though the preliminary examination does not show it to be a mixture, samples should be withdrawn from several parts of the barrel, including the center, and should then be mixed well together and the requisite test-quantity withdrawn from this. This applies equally to flake glues, when the several samples should be comminuted in a small mill and, after mixing the ground resultant, the test sample may be weighed off.

Where the test is concerned with a bundle of gelatine, it does not suffice to select only one sheet from the bundle, but small pieces of each sheet should be broken off; and where there are a number of bundles, samples selected in this way should be taken from each.

It may be objected that this sampling consumes too much time. Nevertheless, if the test is to be representative of the delivery, the above precautions must be observed in detail. The writer has been frequently called upon to test a car of glue (sixty barrels), of which no two tested exactly alike. The operator is, of course, at liberty to adopt such methods of sampling as will expedite the test; but he must be sure that the sample he tests is an average one, else the whole test is a waste of time. It will save time if, when the glue to be tested is in the flake, the sample be ground prior to soaking. The writer successfully employs for this purpose a small coffee-mill in which the sample may be ground to varying degrees of fineness. This preliminary grinding of flakes often aids in the development of hidden odors. Inferior grades of glue may betray no undue odor when in the dry piece, but, when freshly ground, these become manifest and are subsequently verified in the solution of the glue.

Before describing the test system as a whole, we shall review the methods applicable to the determination of the individual factors.

1. Odor of the Glue Solution. — The glue having been dissolved to a solution of definite strength (see below), any odors emanating from the *hot* solution should be noted. The solution should be "sweet." This does not mean that it should be free from any odor whatsoever, as even the solution of the purest gelatine will have a characteristic smell. There should be no trace of putrefaction. If the glue is very greasy, this may impart an odor to the solution, and yet the glue be rated sweet. The odor of the solution will vary according to the stock from which the glue is made. Thus, solutions of common bone glues have a marked "beefy" or "soupy" odor, and yet may be excellent glues of their class. Goat and sheep stocks impart a characteristic odor to the glues prepared from them, while glues from skin or epidermis are more or less odoriferous.

It is difficult to describe an "off" odor in glue, but this requires no extended experience to recognize. Frequently a glue that exhibits a disagreeable odor upon going into solution loses this completely as the solution becomes hotter. Care must be taken not to condemn the glue because of smell, without first considering whether this be not due only to the stock. Odors due to partial putrefaction and other radical defects are permanent, and heating the solution does not dissipate them. Acid-treated glues, particularly those from junk bone, are, as a rule, very sweet, though some smell strongly of acid.

2. Alkalinity and Acidity. — Few glues are strictly neutral when in solution, being either acid or alkaline, depending upon the treatment which the stock has received. As previously stated, some manufacturers, after liming the stock, kill the excess of lime by means of a mineral acid. Glues boiled from such stock will be more or less acid in reaction, as will also those prepared by leaching. Where the bulk of the lime has been removed from the stock by simple washing, enough remains to impart to the solution of the finished glue an alkaline reaction.

Sufficient acid or alkali is present to react with litmus, and hence either condition is conveniently determined by dipping, first, a strip of blue litmus paper into the hot solution, and subsequently a strip of red litmus paper. If the glue is acid, the blue litmus strip will be more or less reddened and the red strip unaffected; conversely, if alkali is present, the blue strip will be unaffected while the red strip acquires a blue coloration varying in intensity with the amount of alkali. The test is best carried out by immersing the dry strips in the hot glue solution and, after keeping about one half the strip submerged for thirty seconds, withdrawing and draining the excess of glue solution by wiping both sides of the strip on the edge of the vessel containing the solution. If too much extraneous solution be permitted to adhere to the strip, it is difficult to observe the change of color.

Excess of acid or alkali in glue is of disadvantage chiefly where the glue is to be employed in sizing delicate colors, or insoluble lake pigments ("pulp colors"), as in the wall paper and surface-coated paper industries. Many of these pulp colors, particularly the cheaper grades, are poorly fabricated, the excess of material employed to precipitate the aniline or coal-tar color upon the insoluble base having been only partially washed out. As a result, trouble frequently arises in the wall paper factory, owing to the inter-reaction of the acid or alkali in the glue and the excess of precipitant in the colors. In the same industry, difficulty is at times experienced owing to lack of smoothness in the mixture of glue and clay used for the initial grounds. Excess of acid or alkali in the glue employed for sizing the clay often has a disintegrating effect upon it, the mixed clay and glue solution becoming lumpy and leaving the rollers of the machine in irregular patches instead of with a uniform flow.

Unless acid or alkali is present in large excess, it may be disregarded save as indicating, to a certain extent, the treatment which the stock has undergone. It has already been noted that acid glues keep longer than alkaline ones, as the bacteria of decomposition reproduce far quicker in alkaline media than in acid. If the glue has a rather earthy smell, and the solution turns red litmus deep blue, the stock has been over-limed. Such a glue should be rejected as the excess of alkali in this case will gradually weaken the glue, causing it to rot rapidly. Although the appearance of over-limed glue may frequently give indication of strength, upon test this will be found to be lower than was anticipated, owing to the fact that the lime has already radically weakened the fiber of the glue.

3. Grease. — The presence of grease in glue has always met with strenuous objection, more or less justified, upon the part of the consumer. As a matter of fact, its presence is of material advantage for some purposes and of equal disadvantage for others. In any one make of glue, the amount of grease will vary considerably in the course of, say, a year. As has been pointed out, there are times when the manufacturer relies upon the recovery of the bulk of grease in order to reduce the cost of production. At others, when the market value of the recovered and rendered grease is so low as not to warrant the additional labor-cost attendant upon its complete removal, he permits a goodly proportion to remain in the liquors, and this is subsequently detected in the finished product.

A simple and accurate test for grease is effected by placing upon the corner of a sheet of white paper a few grains of some aniline color such as methyl violet, magenta, or any other readily soluble in water. A clean flat brush, one or two inches in width, the edge evenly trimmed, is dipped in the glue solution, which must be hot (170–180° F.) so as to insure a good flow of the solution, which is apt to cool rapidly upon the surface of the paper. The brush is withdrawn from the solution, hastily drained, and then applied to the color with a stirring motion so as to dissolve all. Without lifting the brush from the surface of the color, it is drawn with a rapid sweep across the paper. Any grease will manifest itself in the form of "eyes" or elliptical spots which soon disappear. Bubbles of air, arising from faulty manipulation of the brush, must not be mistaken for grease spots. The more color used, the better the grease will show. Excellent results may be obtained by keeping the brush always firmly pressed against the surface of the paper in dissolving the color as well as in the subsequent "painting out." The best results of all can be had by using lampblack in place of aniline color; but this has the disadvantage of being insoluble in water and hence it is difficult to clean the brush properly for the next test.

Glue at times contains free fatty acids resulting from the destruction of lime soaps by mineral acids. These impart a more or less acryline odor to the hot solution. Their presence is sufficient to condemn the glue, as they are markedly hygroscopic, absorbing sufficient atmospheric moisture to radically retard drying of the solution.

Of the various glues, that made from sheep stock is the greasiest. Next in order comes glue made from goat; and glues from ox or cow hides are more or less greasy, depending upon the care exercised in the removal of fat. Acid-treated glues seldom exhibit more than a trace of grease.

In the manufacture of "glazed" or surface-coated papers, greasy glue is undesirable, for reasons that are manifest. Since the glue is incorporated as a size or binding medium with the colors, any grease would show upon the surface of the paper just as in the test. For similar reasons, greasy glue is regarded unfavorably by the manufacturer of wall papers. It is claimed that the grease is apt to penetrate the paper, making typical grease spots. The objection is not a good one; as the formation of such spots would presuppose the presence of an enormous excess of grease to penetrate both paper and clay ground. On the contrary, the presence of even a moderate amount of grease is of advantage. It not only prevents the glue from foaming in connection with the clay or colors, but serves to materially brighten the latter even though it may somewhat retard the drying of the printed paper. In the majority of instances where the glue solution is applied to the material to be sized by means of a machine roller, the presence of a small amount of grease assists, rather than hampers, the operation, preventing foam and insuring smoothness of flow from the roller.

4. Viscosity. — As applied to solutions of glue and gelatine, the term viscosity comprehends their rate of flow as compared with that of a standard fluid, viz., water. Just as two solids, two blocks of wood, for example, moving against each other, exhibit more or less friction or resistance to movement, according as their surfaces are smooth or rough, so do fluids manifest friction or resistance to movement, not only towards the solid surfaces over which they flow, but also between their constituent molecules. Viscosity has its origin in the ease, greater or less, with which these molecules pass or roll over one another. It is exhibited by all liquids to a varying degree. If a vessel of water be given a slightly rotary motion, so as to cause its contents to oscillate, it will be observed that with each swing the amplitude of the oscillation becomes smaller, the oscillation gradually ceasing and the surface of the liquid coming to rest. If oil or glycerine be substituted for the water, and the experiment repeated, a much greater resistance to movement will be observed, due to the viscosity or internal friction of the fluids.

The measure of the viscosity of the glue solution is important. It has been adopted by several prominent Western manufactories as the sole means of determining glue strength. Of itself, it is insufficient for this purpose, but, considered in conjunction with jelly strength, it is of great value in grading the glue. It is an arbitrary constant and is of value only when compared with the corresponding measure of a standard fluid. Thus, to say that the viscosity of a glue solution is 35 seconds conveys absolutely no meaning; but from the statement that the viscosity is 35 seconds, when, under the identical conditions, the viscosity of water is 15 seconds, a definite estimate of the "body" or rate of flow of the glue solution, can be formed. Water is advisedly the standard of comparison for viscosity, since it is the medium for extracting the glue stock, and the strength of the glue is in large measure dependent upon the amount of gluey material that has combined chemically with the water. It must not be inferred from this that the higher the viscosity, the stronger the glue. This is true only of certain kinds of glue.

Owing to the importance of determining the viscosities of lubricating oils, several elaborate forms of viscosimeter have been devised, such as the Engler, Sayboldt, Hurst, Coleman-Archbutt, Kunkler and Redwood. These may be employed in the determination of the viscosities of glue solutions; but they supply figures that are inconveniently high and have, furthermore, been standardized by means of oil and not water.

Satisfactory results can be obtained with much simpler apparatus.

The simplest form of viscosimeter consists of a volumetric pipette, of about fifty cubic centimeters capacity. This is shown at Fig. 1. By means of a file, the delivery end is cut off at *a* and the aperture carefully reduced in the Bunsen flame, the object being to procure an instrument that will deliver water from the mark *b* to the aperture *c* in exactly 15 seconds, measured by a stop-watch. Any reliable dealer in chemical apparatus will, at low cost, make such a pipette. Should the operator himself desire to standardize the instrument, he proceeds as follows. Having shortened the delivery tube as directed, the aperture is first slightly reduced by holding it in the flame, giving it a rotary motion so as to preserve the circular perimeter. A trial had best first be made with a piece of glass tubing, in order that the necessary precautions may be studied. The aperture is at first only slightly reduced, when, having cooled, the pipette is filled and adjusted to the mark *b*. In filling a pipette, it is held by the upper tube *bd* between the thumb and middle finger of the right hand, leaving the index finger free to be placed subsequently at *d*. The point *c* is immersed in the liquid and the lips applied at *d*, the liquid being drawn by gentle suc-

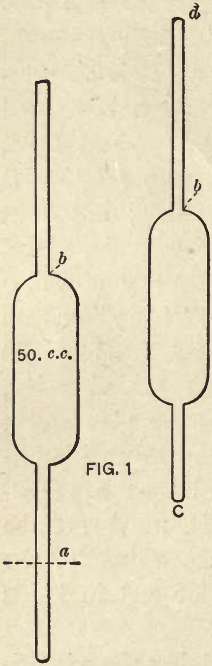

FIG. 1

tion to some point between *b* and *d*. As the lips are withdrawn, the index finger is instantly placed at *d* and pressed firmly against the tube-end so as to maintain the level of the liquid. By gently releasing the pressure of the finger, the liquid will flow to *b* and is held at this point by firm pressure of the finger. The operator now takes the stop-watch in his left hand, using the thumb to release the movement of the watch. With the pressing of the spring, he simultaneously releases the contents of the pipette by removing his finger, and as the last drop of the contents passes *c* he closes the movement of the watch. The time required for the contents (water, free from sediment, at about 180° F., is used for the standardization) to flow from *b* to *c* is registered by the watch. If the operator has proceeded carefully, this will be 12 or 13 seconds on the first trial.

It is now necessary to close the aperture *c* still more. The pipette is thoroughly dried (carelessness in drying will inevitably result in the breaking of the instrument) and the point *c* is held in the flame with the usual rotary motion until it just reddens. Care must be taken not to close the aperture too far as otherwise the point must be broken and the entire operation begun over again. Having cooled, the pipette is filled and adjusted as before, and the time of delivery again noted. On this trial it will be found to be nearly correct — about 14½ seconds. The greatest care must now be exercised in so adjusting the aperture that the time of delivery will be exactly 15 seconds. The pipette is again dried and the point *c* held in the flame a few seconds only at a time, repeated trials of delivery being made between heatings. When the time of delivery between the points *b* and *c* is exactly 15 seconds, the instrument is ready for use.

Much labor may be saved by the inexperienced operator, if he will first study the principles of manipulation by using a piece of glass tubing. In this way he will be able to see just what is necessary in properly reducing the aperture of the pipette. The selection of a pipette of 50 c. c. capacity supplies figures that are most convenient in use. The time of delivery is purely arbitrary, and may be any larger figure than 15 seconds. This, however, is the most convenient. Pipettes of larger capacity, supplying larger figures for viscosity, are awkward to handle and the contents cool perceptibly during efflux, the resulting figures being inexact. By the system recommended, it will be found that the lowest viscosity exhibited by a 25 per cent glue solution is 15½ seconds, or one half second greater than that of water under the same conditions; while the highest will rarely exceed 70.

An improved form of viscosimeter is shown at Fig. 2. The instrument is of 50 c. c. capacity and is provided with a glass stop-cock *s*, which obviates the necessity of controlling the contents with the finger as in the above form. The points of flow are *a*, the lower surface of the stop-cock, and the aperture *c*. The instrument is standardized in the same way as the plain pipette. After filling with the glue solution and adjusting to the mark, the upper tube is firmly clamped to a support, leaving the operator free to release the watch movement and open the cock simultaneously.

Where great accuracy in the determination of the viscosity is desired, the following form of viscosimeter, devised by the author and used by him throughout his tests, will be found to give satisfactory results. The instrument is shown at Figs. 3 and 3*a*. It consists of the viscosity pipette, *A*, and the bath *B* for maintaining the contents of the pipette at constant temperature. The pipette is provided with the stop-cock *S* for controlling the contents, and the time required for the contents to flow from *x* to *c* is exactly 15 seconds.

The bath *B* is made of seamless copper and consists of an outer compartment *D* which serves as a water-jacket, and an inner cylinder in which the pipette *A* snugly fits. This cylinder projects some distance below the jacket *D*, and is provided with a window, *F*, made of thin sheet mica, so that the aperture of the pipette may be clearly seen.

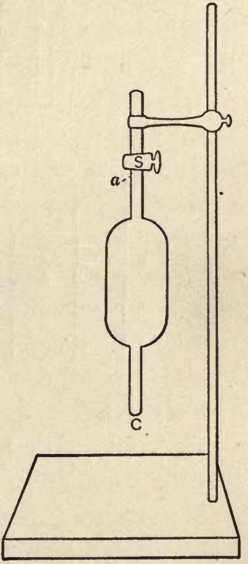

FIG. 2

At Fig. 3*a* the apparatus is seen set up and ready for use. The bath *B* is supported by the ring *G* of the ring-stand. Some distance below is adjusted the ring-burner *E*, by which the water in *D* is brought to the desired temperature recorded by the thermometer *T*. The pipette is shown snugly fitting in the inner cylinder, ready to discharge the glue solution, *y*. The aperture *c* of the pipette is visible through the window *F*. The contents of the pipette are returned to the glass, *H*, in which the glue was originally dissolved.

The pipette having been filled and the contents adjusted to the mark, it is placed in the cylinder and the

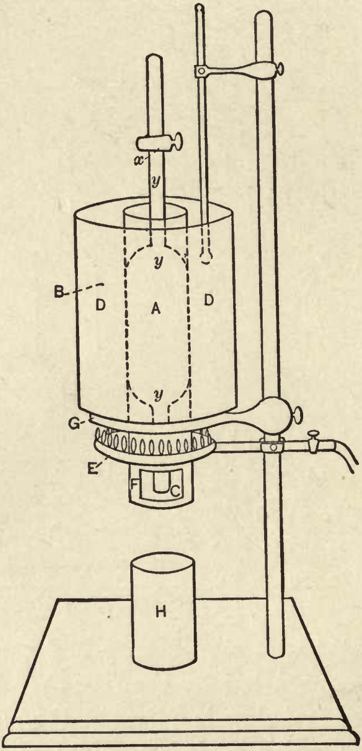

FIG. 3 FERNBACH'S VISCOSIMETER

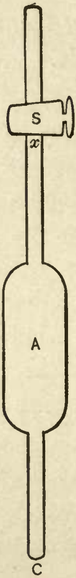

FIG. 3 *a*

water in *D* brought to about 185° F., making the temperature of the contents of *A* practically 180° F. Simultaneous with the release of the contents, effected by giving the stop-cock a sharp turn, the watch, held in the left hand, is started, and the moment the last drop has passed *c* the watch is snapped and the time of efflux between *x* and *c* noted. This is the viscosity of the glue solution, as compared with water, standard = 15. The viscosity may also be expressed in terms of water as unity, by dividing the number of seconds for the glue solution by 15. Thus, if the glue solution has a viscosity of 27 seconds, this may also be expressed as 1.80 referred to water as unity.

Certain precautions are to be observed in taking the viscosity. All the glues to be compared must be at exactly the same temperature (180° F.). Furthermore, they must be of exactly the same strength. It is obvious that two solutions of the same glue, one 10 and the other 25 per cent, will exhibit widely divergent viscosities. During the test, the temperature of the glue solutions should not exceed 180° F., as the protracted heating is apt to decrease the jelly strength. Again, the operator must practise until he is able to release the contents of the pipette and start the stop-watch simultaneously. He must keep his eye constantly directed to the point *c* that he may be prepared to snap the watch the instant the last drop passes that point. Practice for a short time will enable him to execute the test with absolute accuracy.

Value of Viscosity as a Test Factor. — By some, notably Western, producers, viscosity is taken as the ultimate measure of glue strength. This is a grave error. Viscosity is of importance in the glue test as it indicates the treatment the stock has undergone; and is, further, a reliable index of the value of the glue as a sizing medium. It must, however, be considered side by side with other factors. The assumption that the strength of the glue is in direct ratio to the viscosity of its solution is true only of certain glues. Those prepared from the same stock, under identical conditions, may exhibit viscosities varying directly as their strength; but these constitute the exception rather than the rule. The fallacy of rating glues according to viscosity alone, will be readily seen from consideration of the following. It is assumed throughout that the glues are in 25 per cent solution, and that their viscosities at 180° F. are referred to water = 15 seconds.

The viscosities of the Cooper grades seldom vary and then only by a few seconds, the average being:

A Extra	45	seconds.
1 Extra	40	"
No. 1	35	"
1 X molding (opaque)	32	"
1 X, clear	29	"
1¼	27	"
1⅜	25	"
1½	23	"
1⅝	21	"
1¾	19½	"
1⅞	18	"
No. 2	16½	"

It will be observed that the higher grades exhibit greater divergence in viscosity than the lower. Such is the case with the majority of glues.

Assume, now, that the above are being employed as standards, and that the operator relies solely upon the viscosity as the ultimate measure of the glues he is testing. Of four glues on test, he finds, let us say, the viscosities to be 35, 26, 22 and 19 seconds, respectively. His inference is that the first tests No. 1, the second

$1\frac{1}{4}$, the third $1\frac{1}{2}$, and the fourth $1\frac{3}{4}$. If the glues he is testing were made from the same stock and under the same conditions as those in the above table, his inference would be correct; but unless such were the case, his report would be entirely wrong.

Acid-treated bone glues, as well as those from acid-treated hide stock, exhibit viscosities remarkably low in proportion to their jelly strength. Such glues, of A Extra strength, may have as low a viscosity as 30 seconds, and acid-treated glues of $1\frac{3}{8}$ strength, with viscosity as low as 18 seconds, are common. Hence, had any of the above glues on test been derived from acid-treated stock, for example, the one with viscosity of 19 seconds, its jelly strength might be 1 X and not $1\frac{3}{4}$. Now, suppose this glue had been offered at 10 cents per pound. The operator, rating it as a $1\frac{3}{4}$ glue, would at once have decided that the price was ridiculously high; whereas, had he rated it properly as 1 X, he would have realized that he was offered a bargain.

The viscosities of opaque and colored glues are always slightly higher than those of clear glues of corresponding strength (compare 1 X molding with 1 X clear in the above table of standards). Hence, if viscosity is to be taken as the ultimate measure of strength, it is necessary to provide separate standards for comparing opaque or colored glues, separate standards for clear glues, for hide glues, for bone glues, and for acid-treated glues. Even if this were done, the results would not always be accurate, as will be understood from the following considerations.

If the glue stock has been incompletely washed, permitting mucin to be present, or if it has been over-limed, with the result that soaps are present in the finished article, the viscosity will be disproportionately high. The author has seen glues which, while testing only 1⅜, have had as high a viscosity as 30 seconds. Others, testing A Extra, had viscosities ranging from 59 to 69 seconds. These were hide glues from improperly washed or over-limed stock.

The majority of foreign glues, and certain grades of domestic, having been clarified, are low in viscosity. This applies to both bone and hide glues. If the clarification has been effected by means of alum, the viscosity is very high, as alum renders the glue solution stringy. This is to be observed in the case of rabbit glues, the viscosities of which would mislead the observer as to their strength. Gelatines, because of the special stock from which they are made, and the special treatment which this undergoes, are comparatively low in viscosity.

Table I, compiled from the author's laboratory notebook, will convey some idea of the variation in viscosity shown by gelatine, hide glue, acid-treated and regular bone glues, of the same jelly strength.

Table II emphasizes the fallacy of relying solely upon viscosity in rating the glue. It is seen that the gelatine with a viscosity of 49 seconds is two grades stronger than the hide glue with the same viscosity. Similar discrepancies are to be noted throughout.

The manufacturer who manipulates constantly the same stock and whose processes are never altered, might use viscosity alone to rate his product, provided that the standards of comparison were his own glues. He would first have to compare these with the accepted

TABLE I

GLUE SOLUTION = 25 GRAMS IN 100 C. C. WATER.

JELLY STRENGTH	VISCOSITY OF THE HIDE GLUE	VISCOSITY OF THE ACID-TREATED BONE GLUE	VISCOSITY OF THE GELATINE	VISCOSITY OF THE REGULAR BONE GLUE
A Extra	49 seconds	....	32 seconds	....
1 Extra	44 seconds	....	29 seconds	....
No. 1	37 seconds	30 seconds	25 seconds	....
1 X	33 seconds	27 seconds	22 seconds	....
1¼	28 seconds	24 seconds	20 seconds	....
1⅜	24 seconds	21 seconds	19 seconds	....
1½	22 seconds	19 seconds	17½ seconds	....
1⅝	21 seconds	18 seconds	....	21 seconds
1¾	19½ seconds	....	....	19 seconds
1⅞	18½ seconds	....	....	18 seconds
No. 2	17 seconds	....	....	16 seconds

TABLE II

TABLE, SHOWING TESTS OF BONE, ACID-TREATED BONE, HIDE GLUES AND GELATINE, CORRESPONDING TO A CERTAIN VISCOSITY:

WHEN THE VISCOSITY OF THE SOLUTION IS	THE TEST OF THE HIDE GLUE MAY BE	THE TEST OF THE ACID-TREATED BONE GLUE MAY BE	THE TEST OF THE GELATINE MAY BE	THE TEST OF THE REGULAR BONE GLUE MAY BE
49 seconds	A Extra[1]	....	AAA Extra	....
45 seconds	A Extra	....	AA Extra[2]	....
40 seconds	1 Extra	....	A Extra	....
35 seconds	No. 1	1 Extra	A Extra	....
31 seconds	1 X	No. 1	1 Extra	....
27 seconds	1¼	1 X	No. 1	....
24 seconds	1⅜	1¼	1 X	....
22 seconds	1½	1⅜	1¼	....
20 seconds	1⅝	1½	1⅜	1¾
18 seconds	1¾	1⅝	1½	1⅞
16 seconds	No. 2	1¾	1⅝	No. 2

[1] From over-limed stock. [2] Strongly alkaline.

standards, else, outside his own establishment, his grades would be meaningless.

The exact value of viscosity as a test factor will be better understood after the reader has studied the discussion of the test system as a whole, in the succeeding pages.

5. Foam. — Foam, in glue, arises from the incorporation of minute bubbles of air with the solution, when this is beaten rapidly. There may be present in the solution, substances which render the emulsion more or less permanent; or the emulsion may be only temporary, the foam receding and disappearing in a few moments. The same defects which fictitiously increase the viscosity, contribute materially to the foam in glue. Thus, over-limed or poorly washed stock will retain mucin or soaps which make the solution foam badly. Glues from alum-clarified liquors foam, as do also cheap bone glues, because of the impurities they contain. If, however, there is grease present to any extent, it will prevent the foam emulsion from forming. This applies to all makes of glue.

Foam, although undesirable in glues, is often demanded in gelatine, particularly that used for the manufacture of confectionery. In making marshmallows, the solution of gelatine, combined with other ingredients, is beaten rapidly in a special machine.

The test for foam is executed as follows:

The hot solution previously employed for the odor, grease and viscosity tests is transferred to a stout glass vessel, wide enough to accommodate the usual size of rotary egg-beater. This vessel should be neither so thick that the heat of the solution will crack it, nor yet so thin that it is apt to be broken by the egg-beater. On the side, a mark should be placed at the level of the glue solution, and above this three others, a half inch apart. The egg-beater is slowly rotated in the solution for half a minute and the quality as well as the quantity of foam noted. If this is only slight and disappears in a moment, the glue is non-foaming; if somewhat more permanent and reaching the second line, the glue is slightly foamy. If the column of foam reaches the third mark and takes some time to recede, it is moderately foamy; and so on. The operator should agitate the solution neither too rapidly nor too long, as, under these conditions, any glue solution will emulsify. The test conditions should be approximated to those obtaining in actual work. Two revolutions of the egg-beater, per second, will suffice for the test.

6. Jelly Strength. — This is the most important of all the test factors and, unless considered in conjunction with this, the others are of only limited value. The stronger a glue, the greater the resistance offered by its jelly to outside pressure. The statement that a glue tests 1½ means that its jelly offers the same degree of resistance to pressure as the jelly of the standard 1½ glue. Test methods seek to measure this resistance in definite terms.

So many divergent methods for determining glue strength have been formulated, that lack of space forbids their discussion here. Those dependent upon chemical operations are absolutely worthless, as has already been noted. Those involving the use of special apparatus supply results that in no way correspond with the commercial value of the glue. Of these, the test with the so-called "shot machine" is worthy of some notice, although the method is open to considerable criticism.

The shot test was formulated by Lipowitz, whose apparatus, shown at Fig. 4, has since received considerable modification. The test has for its object the determination of the weight sustained by the glue jelly. Upon the surface of the jelly rests a saucer-shaped piece of tin. The iron rod connecting this with the funnel designed to hold the shot passes through and is supported by the tin cap which rests upon the edges of the glass containing the jelly. The combined weight of the saucer, rod and funnel does not exceed half an ounce. Into the funnel, shot is poured until the saucer just penetrates the jelly. The shot is then weighed.

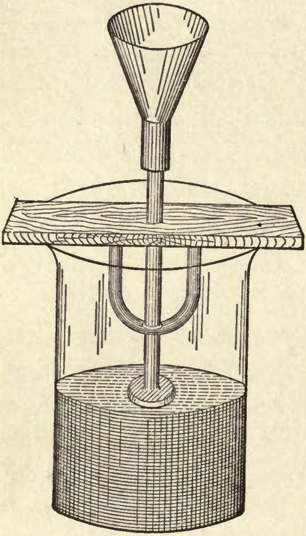
FIG. 4

It will be seen that no account is taken of the friction between the parts of the apparatus, as well as that between the saucer and the jelly. This objection holds better with the more modern forms of shot apparatus in which the rod is permitted to sink through the entire jelly and rest upon the bottom of the glass. Again, the formation of a skin on the surface of the jelly frequently invalidates the test, as the weight determined is really that required to pierce this skin and the jelly, plus that required to overcome the friction between the penetrating rod and the skin and jelly. Lipowitz's apparatus is undoubtedly the best form as it is required just to penetrate the surface of the jelly. For certain classes of glues it is a fairly accurate test. In practice, however, the comparison, by its means of a clear glue and an opaque of identical strength, yields divergent results, as the skin on the opaque glue is slightly tougher than that on the clear.

For practical commercial purposes, there is no better method of measuring the resistance of the glue jelly than by means of the finger. The fourth finger of the left hand is used, as it is the most sensitive of all. In operation, the test is as follows:

The glues, having jelled, are arranged in a single line on the table before the operator. Let us assume that these are nine in number, five unknown glues and four standards, the latter being $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$ and No. 2. The glues are in numbered glasses, the unknown being numbers 1, 2, 3, 4 and 5; and the standards, numbers 6, 7, 8 and 9. They are arranged in numerical order, running from left to right. The operator first assigns a preliminary rating. To effect this, he first presses the finger upon the jelly of No. 1 and then on that of No. 2. Any difference in the resistance of the jellies to the pressure of the finger is at once noted. If No. 2 offers less resistance than No. 1, the glasses remain as they are; but if it is seen that No. 2 is the stronger, it is shifted to the left of No. 1. If the order of the glasses remains unchanged, the operator next compares Nos. 2 and 3; but, if 1 and 2 have changed places, he compares

1 and 3, the stronger jelly always being placed to the left of the weaker, and so down the line. In this way the glasses are finally so arranged that the strongest jelly of all is at the operator's extreme left and the weakest at his right, the intermediate glasses representing successive steps in strength, calculating from right to left.

In the hypothetical case under discussion, we shall assume that, at the end of the preliminary rating, the glasses stood as follows, proceeding from left to right:

No. 5, No. 6, No. 4, No. 7, No. 3, No. 2, No. 8, No. 1, No. 9.

The operator now compares No. 5 and No. 6. He finds, let us say, that these are equal in strength, as they offer exactly the same degree of resistance to the pressure of his finger. Comparing Nos. 6, 4 and 7, he finds that No. 4 is weaker than No. 6 and yet stronger than No. 7, appearing to be exactly half-way between the two. In the same way he finds that No. 3 is half-way between No. 7 and No. 8; that Nos. 2 and 8 are of equal strength, as are also Nos. 1 and 9. Upon consulting the list of standards suggested at the outset it is seen that:

No. 6 = the 1¼ grade.
No. 7 = the 1½ “
No. 8 = the 1¾ “
No. 9 = the No. 2 “

Now, since by careful rating the operator found that the strength of No. 5 is equal to that of No. 6, *sample No.* 5 *must test* 1¼. Since No. 4 was found to be half-way between 6 and 7, that is to say, half-way between 1¼ and 1½, *sample No.* 4 *must test* 1⅜. No. 3 was found to be half-way between 1½ and 1¾. *Hence it tests* 1⅝. Nos. 1 and 9 being equal in strength, *the former must test No.* 2 *grade;* and as No. 2 was found equal to No. 8, it is of 1¾ test.

Doubtless the reader is now able to appreciate more fully the importance of standards in glue testing. If these be incorrect the whole test is worthless, no matter how carefully conducted.

We shall now extend our hypothesis by assuming that the samples, Nos. 1 to 5 inclusive, bear price marks. It is in order to check the price that we have determined their strength. Comparing the test data side by side with the assumed price of each glue:

Sample No. 1, testing No. 2 grade, is offered at 6½ cents per lb.
Sample No. 2, " 1¾ " " " " 8 " " "
Sample No. 3, " 1⅝ " " " " 12 " " "
Sample No. 4, " 1⅜ " " " " 11 " " "
Sample No. 5, " 1¼ " " " " 14 " " "

We cannot here enunciate any set rule governing the price of the various grades. Much depends upon cost of stock, labor, etc.; but if we assume that the above glues were offered for sale at a time when market conditions were normal, several valuable inferences may be drawn from the above hypothesis. In the first place, a 1¼ glue at 14 cents per pound is a luxury; all the more, a 1⅝ glue (four grades weaker) at 12 cents. The prices assumed for the other grades in the table are about right. It is evident that the manufacturer is either endeavoring to impose upon the consumer in the cases of No. 5 and No. 3, or else he is compelled to ask the suggested prices for those glues, owing to the fact that his yield was lower than anticipated while the cost of production was unusually large. We may simplify the entire hypothesis by assuming that the consumer applied to the manufacturer for samples of glues at 12 cents per pound, this being the price he was accustomed to pay for his glue, and that the manufacturer accordingly submitted the above five samples, all quoted at this price. Because of the test, the consumer is speedily enabled to decide upon a choice.

Simple as is this finger test, it may be made, by dint of practice and experience, remarkably accurate. The author has carefully compared the results obtained by it with those furnished by the use of the so-called testing machines, and the verdict is decidedly in favor of the finger test. To insure its success, the operator must, of course, be entirely free from bias. The glasses should all be numbered and the numbers identified only after the glues have been carefully rated. In this way the test is a fair one. Its accuracy, of course, presupposes that all the glues tested have been treated exactly alike. This is essential to the success of any system.

THE TEST SYSTEM AS A WHOLE

A. Apparatus Required.

1. *Glasses.* — The bar glasses commonly known as "sours" are best adapted to glue testing. These may be had of any dealer in hotel or bar supplies, and are much more durable than beakers. Only those having fairly thin bottoms should be selected, and to minimize danger of cracking while in the melting bath, the glasses should first be tempered. This is done by filling them with cold water, placing them in cold water in the bath,

and slowly raising the temperature of the bath to boiling. The glasses are then removed and the contents permitted to cool to room temperature. They are then freshly filled with cold water and the operation repeated, save that this time the hot contents are immediately thrown out and the empty glasses held in a stream of cold water from the tap. Some will break, but those that survive the treatment will seldom crack through alteration of the temperature of the bath, and will be of service for a long time.

2. *Glue Melting Bath.* — This consists of a trough, preferably of galvanized iron, provided with a false bottom resting about two inches above the true, and perforated with one-inch holes. Upon this the glasses rest, and in this way cracking from unevenness of flame is avoided. The sides of the bath should be of such height as to correspond with that of the glasses as they rest upon the false bottom. The bath should accommodate thirty-six glasses.

3. *Scales.* — A fairly accurate balance is required for weighing out the samples. The pharmacist's prescription balance serves nicely, although less expensive forms of apparatus may be employed.

4. *Viscosimeter.* — The different forms have already been described.

5. *Egg-beater.* — This is required for the foam-test. It should be of the rotary form provided with a side wheel. For this test, there is also required a fairly stout glass jar, just wide enough to accommodate the egg-beater.

6. *Brush.* — For the grease test, a flat brush, $1\frac{1}{2}$ inches wide and evenly trimmed, is required. In addition, some aniline color should be on hand.

B. Procedure.

1. *Selection of Standards.* — Extended experience in glue testing will enable the operator to form some preliminary estimate of the strength of the glue to be tested. He cannot say with any degree of certainty what grade it tests, but he can roughly gage the limits within which it lies. In this way, the experienced tester has only to use the minimum number of standards. As a rule, the eleven standards should be placed on test with the unknown samples, be the latter few or many. If the glues submitted be high-priced, it is to be inferred that they are high-grade, and accordingly, such standards as A Extra, No. 1, 1¼, should be selected for the comparison. Where any doubt exists, however, it is safest to employ all eleven standards.

2. *Weighing out the Glues.* — The samples and standards having been numbered, the glasses are numbered to correspond and placed in single file in numerical order, beginning at the left. Twenty-five grams (or one ounce) of each of the samples and standards are then weighed off and transferred to the glasses. If the weighing is done carelessly, the entire test is invalidated. Exactly the same weight of each glue must be taken.

3. *Softening, or Soaking the Glues.* — No hard and fast rule can be formulated as to the time required for this, much depending upon the form of the dry glue. If in the flake, strip, or piece, and very thick, from six to eight hours is required. If ground, one half an hour may suffice. The best way is to let the glues soak over night and melt them for test the following morning.

As the glues are transferred from the scale-pan to the glasses, each glass is provided with a stirring-rod.

One hundred cubic centimeters (or four ounces) of water are measured out with the utmost care and poured over the glue, and the latter stirred with the rod so as to insure uniform immersion. Exactly the same amount of water must be poured on each glue — not a drop more or less.

4. *Melting the Glues.* — When the glues are properly softened, the glasses are placed in the bath. This is then heated, beginning with a small flame. Simultaneously, the flame is started under the viscosimeter bath. Lest any skins form on the solutions while melting, these must be frequently stirred. The formation of a skin will seriously interfere with the test. Further, the solutions must be uniform, else the figures obtained for viscosity will be inaccurate. The temperature necessary to the determination of viscosity has already been noted.

In seeking the various factors, the following order is most convenient:

(*a*) As the glues are melting the odor of the solution is noted.
(*b*) When all are in solution, Acidity or Alkalinity is determined.
(*c*) Next, the grease test is applied to each.
(*d*) By this time the glues are sufficiently hot for the viscosity test.

From now on, care must be taken to prevent skin formation. Where a plain pipette is used for determining viscosity, this must be thoroughly rinsed in boiling water between each test.

(*e*) The viscosity determined, the foam may now be estimated.
(*f*) The glues are now removed from the bath and permitted to jell, when they are rated.

5. *Jelling or Cooling the Glues.* — This requires especial consideration, lest faulty practice invalidate the

test. In the winter time, it suffices to let the glues remain a while in a cool place until jelled. *They must never be allowed to freeze.* The greatest difficulty in jelling the glues is experienced in hot weather, when a small refrigerator may be used. In this, the temperature is about 40° F., which is just right for jelling the glues without interfering with the rating. When the glues have been removed from the bath, they should be stirred *slowly* for a time, and in this way partially cooled. If this is done, the final jelly will have a flawless surface which will aid the operator in the rating.

It were superfluous to state that, throughout the entire test, the glues must be treated exactly alike. Unless this is done, it is useless to go to the trouble of testing them.

C. Recording the Test.

Some record of the test must be kept for future reference. Such records are apt to be cumbersome. In the following system the record is concise and contains full data concerning all points of interest. It serves, among other things, to describe the appearance of the dry glue, long after the original sample has been thrown out. To effect economy of space, the description of all test factors is reduced to a system of mnemonics, to wit:

In describing or defining odor, grease, foam, alkali or acid,

1 = None; 2 = Slight; 3 = Moderate; 4 = Considerable.

In describing the appearance of the glue jelly,

1 = Clear; 2 = Translucent; 3 = Dense.

In describing the form of the dry glue,

1 = Flake; 2 = Ground; 3 = Strip; 4 = Sheet; 5 = Powdered; 6 = Shred; 7 = Ribbon.

In describing the color of the glue,

1 = Light Yellow; 2 = Medium Yellow; 3 = Dark Yellow; 4 = Light Brown; 5 = Medium Brown; 6 = Dark Brown; 7 = Opaque; 8 = Colored; 9 = Colorless.

In describing the cut of the glue,

1 = Very Thin; 2 = Thin; 3 = Medium; 4 = Thick; 5 = Very Thick.

The following is a specimen test record used by the author. The various columns record the name of the sample, viscosity, odor, grease, foam, alkali, acid, appearance of the jelly, and strength. In the last column, the litmus strip which has been used to determine the reaction is pasted by means of the tested glue adhering to it. In the upper left-hand corner of the space for recording the name of the sample are placed small numbers, describing the color, cut, and form of the dry glue. Thus, No. 1, KA, is a dark yellow, ground glue; No. 2, H, is a medium yellow, thin flake. Samples Nos. 6 and 7, which are gelatines, are described as medium yellow, medium thick sheets.

From the complete recorded description of sample No. 3, it is seen that this has a viscosity of little more than 24 seconds, has no odor, is free from grease, foams slightly, no alkali, slightly acid, jelly is fairly clear, and the sample tests 1 X.

25 Grams Glue to 100 c. c.

Date, September 28, 1904. Test Sheet No. 47.

Sample No.	Visc.	Odor	Grse.	Foam	Alkali	Acid	Jelly	Sngth.	Reaction
32 1. KA......	27	1	2	2	1	1½	1½	1 Extra	Acid Strip
221 2. H.........	22	1	2	2	1	1½	1½	1¼	"
3. J. B. No. 1	24+	1	1	2	1	2	1½	1 X	"
4. J. B. No. 2	22	1	1	2	1	2	1½	1¼	"
5. J. B. O...	24½	1	1	2	1	2	1½	No. 1	"
234 6. J. B. "G."	28	1	2	2	1	3	1½	AA Ex.	"
234 7. B. W.....	28¼	1	1	2	1	2	1½	AA Ex.	"
8. Crown....	19¼	1	1	2	1	3	1½	1⅜	"
9. "N. W."..	17¼	1	2	3	1	3	1	No. 2	"
10. B. Sheet..	22½	1	2	2	1	2	1	No. 1	"
11. P. B. No. 1	16½	1	1	3	1	2	1	No. 2	"
12. P. B. No. 2	17+	1	1	3	1	2	1	No. 2	"
13. P. B. No. 3	17¼	1	1	1	1	2	1	No. 2	"
14. P. B. O...	16¾	1	2	3	1	2	1	No. 2	"
15. 1 Extra..	29	...	...	...	...	...	...	1 Extra	...
16. 1¼.......	24	...	...	...	...	...	...	1¼	...
17. 1½.......	21	...	...	...	...	...	...	1½	...
18. 1¾.......	18¾	...	...	...	...	...	...	1¾	...

The value of keeping test records in this form can hardly be overestimated. A year may elapse from the time the operator has tested a certain glue when he is again called upon to test it. By referring to the original test, he may readily compare the two samples. In a separate index, the author notes the number of the test sheet upon which a given glue appears. For example, against the entry J.B.O. is the number 47, which is that of the above test sheet.

Some slight modification of the above test system is to be made in testing gelatines. Here the observer is concerned with the amount of water absorbed by the gelatine, its odor, reaction, grease, and foam. He may omit the determination of jelly strength. On the other hand, this jelly strength is directly proportionate to the amount of water absorbed, and if the sample of gelatine is tested in the same way as glue, the factors are easily determined.

A study of the viscosity column of the above test record will confirm what has already been said relative to the inadequacy of viscosity as the ultimate measure of glue strength. Compare the viscosities of Nos. 6 and 7, which are high-grade gelatines and which test two grades stronger than A Extra, with the viscosity of No. 15, the 1 Extra standard. Had we relied solely upon their viscosities to rate these two, we should have placed their strength at only 1 Extra.

The author has tested more than thirty thousand samples of glue and gelatine, using no other test method than the one here described and relying invariably upon the finger test for the ultimate rating of the glue, in preference to using any test machines. The results have always been concordant. Proceeding carefully, two operators will differ only by two points within a grade, this difference being attributable to personal equation. So long as all the glues are treated alike and the operator is careful to eliminate personal bias, the test is an accurate one, the results agreeing closely with variations in price of the glues.

CHAPTER III

ANALYSIS OF GLUE AND GELATINE

In discussing the methods applicable to the assay of the constituent elements of glue and gelatine, as well as of the impurities they may contain, it must be reaffirmed at the outset that analysis supplies no data as to the strength of the product. For the determination of this, the glue test is essential, sufficing for all practical purposes to acquaint the consumer with the relative merits of his purchase. As his experience in testing increases, he will be able to account properly for all undue characteristics.

Glue is in the main employed as a binding or adhesive medium; and its relative value for such use is comprehensively determined by the test. In the more extended applications of glue and gelatine, however, where, for example, the latter is used for alimentary purposes, or the former for finishing delicate fabrics or for sizing sensitive colors, it may not suffice merely to know the relative economy of the product in actual work. Both glue and gelatine enter frequently into the manufacture of complex products in which they are compounded with chemicals. In such instances the question of *purity* has largely to be considered, the manufacturer having often to purchase the glue and gelatine upon specification. Excesses of grease or soaps, acid or alkali, mucin or foreign mineral matter may all operate to the disadvantage of his processes. It is for chemical analysis to determine these limits; and the results of analysis often serve to amplify and confirm the qualitative observations of the test. Hence, where time permits, analytical data should be collected for such comparison.

The analysis of glue and gelatine comprehends the determination of moisture, ash, acidity, or alkalinity, fat, foreign matter and available glue present. It includes also the qualitative recognition of mucins.

1. **Moisture.** — A good glue contains not less than 8 nor more than 16 per cent of moisture. Moisture in excess renders the finished product more or less pliable and soon causes putrefaction. If too dry, on the other hand, the glue soon becomes brittle and gradually crumbles away. In this condition, it has lost much of its original strength.

To determine the content of moisture, about three grams of the sample, preferably in the ground or powdered state, are weighed out upon a tared watch-glass and dried in the oven at 110° C. to constant weight. The loss in weight represents the moisture which may be calculated to per cent based upon the weight of the sample taken.

2. **Ash.** — The dried sample from the moisture determination is transferred to a weighed platinum crucible. This should be capacious, so that the sample may be distributed over the bottom in a fairly thin layer. Neglect of this precaution will retard incineration.

A small Bunsen flame is now placed underneath the crucible and gradually raised until the bulk of the carbon has been burned off. During incineration the glue swells, the contents of the crucible suddenly bursting into flame. At such times, the Bunsen flame should be withdrawn and the contents be permitted to burn quietly of their own accord. Incineration may be completed over the blast-lamp, although, if proper precautions have been observed, a pure white ash may be obtained with the heat of an ordinary Bunsen flame. Too much heat at the outset produces a form of carbon which is extremely difficult to burn off completely.

After the glue has been reduced to an ash, it should be observed if this has fused or not. This will serve to identify the glue as bone or hide, as the case may be. The ash of *bone glue* fuses and its aqueous solution is neutral, containing traces of phosphates and chlorine. The ash of *hide glue* does not fuse, owing to the presence of traces of lime which render its aqueous solution slightly alkaline. The solution is free from phosphates and chlorides.

In the ash will be found traces of media added to the glue to produce "color," which may be identified by applying the usual qualitative tests. At times such salts will be found, as the carbonate and the sulphate of lead, chromates and the salts of tungsten which have been added with a view to increasing the adhesiveness of the glue or to facilitate the drying of the solution. The presence of such salts as sulphate of barium, carbonate of calcium (chalk), carbonate of magnesia, or zinc oxide or sulphate, must not be construed as adulteration; other salts may properly be so regarded.

The ash will vary from 2 to 8 per cent, according to the quality of the glue. Its examination is of interest as confirmatory of certain test factors. Thus, it has already been pointed out that the viscosities of acid-treated bone glues, or of glues from mixed bone and hide stocks, are disproportionate to their jelly strengths, the latter being higher than the viscosity would indicate. Accordingly, if a given glue display this disrelation between viscosity and jelly strength, and yet the jelly be not sufficiently clear to warrant the assumption that the glue is from acid-treated stock, the examination of the ash will doubtless prove it to be a mixture of bone and hide, the ash partially fusing and its solution showing lime, phosphates, and chlorides.

A very clear glue may have a viscosity much higher than normal and its ash may contain alum. This is proof of the fact that the glue-liquor was clarified by means of alum, or that the alum was added with the deliberate intent of imparting to the solution of the finished glue a fictitious "body." Alum precipitates much of the viscous element (chondrin) of glue, but, if used in excess, the precipitate redissolves and thus the glue solution becomes very "stringy." The use of an excess of alum in clarification invariably produces a foamy glue. These two phenomena are to be observed in rabbit glues, some of which test A Extra, having viscosities of 70 seconds. The ash of these glues is rich in alum

3. Acidity and Alkalinity. — For the determination of alkali, one gram of the sample is dissolved in 500 c. c. of distilled water, so as to form a practically colorless solution. A few drops of alcoholic solution of phenolphthalein are added and the whole titrated with decinormal hydrochloric acid until the pink coloration just disappears.

In the case of acidity, direct titration of the glue solution with standard alkali would supply figures representing the sum of mineral and free organic acids. Hence, for the determination of mineral acidity, 50 grams of the sample are suspended in a flask in 80 c. c. of cold distilled water for ten hours. The flask is then fitted to a condenser and the volatile acids driven over by means of a current of steam, the distillate being collected in a graduted cylinder. When 300 c. c. have come over, the distillation is interrupted and the distillate is titrated with standard alkali. In the presence of sulphurous acid, the cylinder should contain a known quantity of standard alkali added previous to distillation. The figures obtained represent acidity due to hydrochloric and sulphurous acids, which should not exceed 0.2 per cent.

For the determination of *free organic acids* in addition to sulphurous acid, Kalmann proposes the following method:

One gram of the coarsely powdered glue is dissolved in water over the water-bath and then titrated with standard alkali, using phenol-phthalein as an indicator. The liquid is now cooled and, after the addition of some starch solution, is titrated with decinormal iodine until a permanent blue color is established. The amount of iodine used is the equivalent of the sulphurous acid in the sample.

The blue color is now discharged by the addition of a drop of sodium acid-sulphite and again titrated with decinormal alkali and phenol-phthalein. The second volume of alkali indicates the amount of hydriodic acid formed, which should correspond with the result of the iodine titration, showing that this was in no wise affected by the organic matter of the glue.

4. Grease.

(a) *Kissling's Method.* — Twenty grams of the sample are dissolved in 150 c. c. of water containing 10 c. c. of hydrochloric acid, 1.20 specific gravity. The liquid is heated three or four hours under a reflux condenser on the water-bath. The solution is cooled, 50 c. c. of petroleum ether added, and the whole well shaken, when, after standing until clear, an aliquot part of the solvent is withdrawn into a weighed dish, the solvent evaporated, and the residual grease weighed.

(b) *Extraction Method.* — This is by far more convenient of operation than the foregoing.

About five grams of the finely ground or powdered sample are covered with an equal weight of water, soaked up and melted over the water-bath. An absorbent material is now added to remove the water. S. Rideal recommends plaster of paris. The author finds that this seriously interferes with the drying of the mass and uses fine infusorial earth which has previously been well extracted with petroleum ether, and kept in a tightly stoppered bottle. The mass, when dry, is placed in a mortar and carefully reduced to powder. This must be done cautiously, as some is apt to spatter while grinding. It is best first to break the mass roughly on a large sheet of paper and transfer small portions at a time to the mortar, and so powder them.

The powder is now transferred to the capsule of the Soxhlet extraction apparatus, and extracted with petrolic ether for two hours. At the end of this time the flask containing extracted grease and solvent is connected with a condenser and the bulk of the solvent distilled off. The balance is transferred to a weighed dish, the flask rinsed well with the smallest possible quantity of fresh solvent, the washings added to the contents of the dish, and the whole cautiously evaporated over the water-bath. The residual grease or fat is then weighed.

5. Approximate Assay of Constituent Elements.

(a) *Gelatin.* — Gelatin is distinguished from chondrin and mucin by certain characteristic reactions. Its assay in glue is of but little interest, but in ascertaining the purity of commercial gelatine, it is a factor of importance, a good gelatine consisting chiefly of gelatin and little else.

(aa) *Preparation.* — For the purpose of confirming its qualitative reactions, pure gelatin may be obtained as follows:

1. Method of Davidowsky. — Buckshorn is treated with dilute hydrochloric acid for the purpose of dissolving out the calcium phosphate, leaving the glue-yielding material. The latter is treated with milk of lime to free it from fat, washed, boiled and the resultant solution permitted to jell. The jelly is now treated with successive cold waters which serve to extract all coloring matter. This accomplished, the jelly is dissolved, strained and mixed with an equal volume of 95 per cent alcohol, a precipitate of gelatin resulting which may contain phosphates. These may be removed by redissolving the precipitate, acidulating the solution, and bringing it into a dialyser, where the salts and acid diffuse in the water which must be renewed.

A jelly of pure gelatin remains behind. This is evaporated to driness.

2. Method of Allen. — High-grade gelatine is soaked in successive quantities of cold water for several days. This removes salts and coloring matter. It is then dissolved in boiling water and filtered into 90 per cent alcohol, which precipitates the gelatin in white, stringy masses. These are collected, redissolved in hot water and reprecipitated by alcohol. The ash of the product is about 0.6 per cent.

Pure gelatin, in the dry state, is fairly transparent and glassy in appearance. It is somewhat yellowish and free from odor. It is not affected by exposure to the air. When heated, it softens without melting, swells considerably and decomposes with an odor resembling that of burned hair. The ash is blackish and combustible only with great difficulty.

Gelatin is insoluble in cold water, in which it swells and loses its transparency; but in hot water it dissolves with subsequent formation of a strong jelly. This may be re-melted and re-jelled a number of times, but prolonged treatment destroys the gelatinizing property, although this is said to be restored by precipitating the gelatin by alcohol from the final solution. (*Allen.*)

Gelatin is precipitated from aqueous solution by chlorine, alcohol, platinic chloride, tannin, mercuric chloride, picric, phospho-molybdic, and phospho-tungstic acids and acid solution of chromic acid.

When a current of chlorine is passed through a solution of gelatine about one per cent in strength, the liquid remains clear for a time, but after a while froths strongly, each particle of froth becoming encased in a white pellicle. The frothing subsides as soon as the chlorine is in excess, which is noted from the yellow color of the solution, the liquid becoming clear and the gelatin is thrown down in the form of a white, granular precipitate. This, when washed and thoroughly dried, is a fairly white powder insoluble in water or alcohol, but soluble in alkalies.

Addition of a saturated aqueous solution of picric acid to a cold aqueous solution of gelatine produces a precipitate which first dissolves upon shaking, but which becomes permanent upon the addition of an excess of the precipitant. Upon heating, this precipitate is dissolved, but is again formed as a yellowish, sticky mass, as the solution cools. Platinic chloride and sulphate produce much the same precipitate.

Gallotannic acid precipitates gelatin as a fine white powder, which, upon exposure to the air, becomes buff-colored. Once thoroughly dried, this is soluble only in strong alkalies.

(b) *Chondrin.* — The distinction between chondrin and gelatin was first pointed out by Muhlder. These have several reactions in common, but chondrin is precipitated by a number of substances which fail to react with gelatin.

(bb) *Preparation.* — For the preparation of pure chondrin, Davidowsky recommends the selection of the cartilages of the ribs, of the larynx — with the exception of those of the epiglottis, and of the windpipe and bronchi. These are boiled from 24 to 48 hours, the chondrin precipitated from solution by alcohol, re-dissolved in warm water, evaporated, and dried. The product so obtained closely resembles gelatin.

Like gelatin, chondrin is precipitated from aqueous solution by alcohol, tannin, and mercuric chloride. Unlike gelatin, it is precipitated by *mineral acids organic acids, alum, sulphate of alumina, acetate* and *subacetate of lead,* and *sulphate of iron.* All of these precipitates are soluble in excess of precipitant.

Of the precipitates produced by acids, those from *phosphoric, hydrochloric, nitric,* and *sulphuric* are soluble in excess; whereas, those from *pyrophosphoric, sulphurous, hydrofluoric, carbonic, arsenic, tartaric, citric, oxalic, lactic,* and *succinic* are insoluble in excess of precipitant.

(c) *Mucin.* — While this is in no sense a constituent element of glue, it is properly discussed in connection with gelatin and chondrin, since, like them, it emanates from the glue-yielding tissues. Its presence in glue is due to defective liming or faulty washing after liming.

Mucins are slimy substances which mix with water in all proportions without undergoing real solution. They may be precipitated by alcohol or by saturation with common salt, ammonium sulphate and other neutral salts. They are soluble in alkalies and a 10 per cent solution of common salt.

Estimation of Glue Content. — This is at best only approximate, indirect methods of calculation supplying more reliable results than direct. The latter are based upon the precipitation of the gelatin and chondrin by tannic acid, and either weighing the precipitate of "tannate of gelatin," which is assumed to have the composition — tannin 57.26 per cent, gelatin 42.74 per cent; or estimating the nitrogen content of the precipitate and calculating this to gelatin. An optional method is to determine the total nitrogen content of the glue, calculating the result to gelatin.

Rideal has pointed out the complexity of the organic matters of glue. Besides albumoses and peptones, several varieties of gelatin and chondrin may be present, as is evidenced by differences of elementary composition revealed by analysis. Each variety exerts a variable precipitating influence upon the tannin, which, in addition, throws down the peptones and other non-gelatinous matter. Through co-estimation of these with the gelatin and chondrin, the figures obtained are extremely inaccurate. Equally unsatisfactory is the estimation of the nitrogen content of the glue, this being that of all the nitrogenous matters present whether gelatinous or not.

For technical purposes, it suffices to estimate the non-glue, comprising fats, soaps, and extraneous mineral matter, and calculating the available glue by difference. This method fails to take into account such non-gelatinous substances as albumoses and peptones.

Stelling's Method. — Fifteen grams of the sample are placed in a 250 c. c. flask, covered with 60 c. c. water and soaked over night. The following morning, the mass is melted and any loss through evaporation made good. The flask is then made up to the mark with 96 per cent alcohol and the contents thoroughly shaken. After standing for about six hours, from 25 to 50 c. c. of the supernatant liquid are withdrawn, evaporated to driness, and the residual non-glue dried and weighed.

In criticism of the above method, Kissling points out that the non-glue consists of fat as well as decomposition products of gelatin. He also observes that gelatin is not totally insoluble in alcohol of 72 per cent strength. Nevertheless, he considers the method reliable as partially indicating the value of a glue. He found that the non-gelatin varied from 7.6 per cent in the case of a hide glue, to 23.2 per cent in a very inferior bone product.

By Stelling's method, any mucin present is thrown down by the alcohol and hence is not estimated with the non-glue, thus rendering the figure for available glue, obtained by difference, high. This is not a very serious objection inasmuch as, when present in glue, the amount of mucin is quite small, the presence of even this rendering the glue unfit for many uses. Hence its co-estimation indirectly with the true glue occasions no serious error. On the other hand, the substances precipitable by alcohol carry down with them much, if not all, of the media added to the glue to produce color. Hence, in the case of opaque or colored glues, the coloring material must be estimated separately and added to the figure for non-glue. The author does not regard as pertinent Kissling's objection to the co-estimation of fat with the non-glue. True, if much grease be present in the residue of non-gelatinous material it will interfere with accurate weighing because of its hygroscopic nature. For this reason, it is well to extract the grease before estimating the non-glue. In all instances, however, the figure for grease must be added to that for non-glue. Again, the glue should be dissolved in not more than twice its weight of water that the subsequent dilution of the alcohol may not be so great as to permit the return of any of the precipitate to solution. With these modifications, the method yields reliable results; and it will be found that the figures for true glue, calculated by difference, are well in accord with the grading assigned by test.

Foreign Matter. — This includes insoluble organic as well as mineral matter. For the determination, about two grams of the glue are soaked and dissolved in a liter flask with the aid of 200 c. c. of water. The flask is then made up to the mark, care being taken to mix the contents thoroughly. The flask is then kept in a warm place from 24 to 48 hours, during which the insoluble material settles to the bottom. The bulk of the supernatant solution is decanted off, the balance being poured through a tared filter and the residue washed with hot water until free from all glue. The filter, with its contents, is then dried at a temperature not exceeding 100° C. and weighed. The figures so obtained serve to correct the result for available glue.

Both glue and gelatine exhibit characteristic behavior toward certain reagents, the reactions serving to identify them when associated with other substances, and frequently to separate them quantitatively.

Gallotannic acid produces a buff-colored precipitate, known as tanno-gelatin. This is supposed to be the chemical base of leather. The reaction takes place in solutions containing only 0.005 per cent of glue or gelatine.

Added to a neutral or slightly alkaline solution of gelatine, formaldehyde produces a white, stringy precipitate of formo-gelatin. The purer the product, the more readily the precipitate forms, low-grade glues requiring some time to respond to the test.

The bichromates of potassium and ammonium, added to solutions of glue and gelatine, render the product evaporated therefrom insoluble after exposure to sunlight.

When compounded at high temperature with dilute mineral acids, glue loses its power of gelatination. This is restored by the addition of common salt.

A glue solution boiled with slaked lime loses its gelatinizing power; and if the solution be subsequently evaporated, the product is a colorless, gummy mass, soluble in cold water and a solution of common salt.

Potassium or sodium carbonate, neutral potassium tartrate, magnesium sulphate, and rochelle salts coagulate glue solutions by removing the water from them.

Gelatination may be destroyed by the addition of the chlorides of ammonium and barium, nitrate of potassium, and saturation with common salt.

Glue and gelatine are distinguished from albumins in that they yield no precipitate with potassium ferrocyanide or ferricyanide.

Purity of Commercial Gelatine. — For this, Vogel employs a 10 per cent solution of silver nitrate to which has been added enough ammonia to re-dissolve the precipitate which first forms. This reagent is then mixed with an equal volume of the solution under examination. Any impurity is indicated by a coloration varying from yellow to deep brown.

CHAPTER IV

GLUE AND GELATINE SUBSTITUTES

WHERE adhesiveness is the chief end to be attained, proteid substances other than glue, as well as a number of vegetable products, may be used in the place of glue. Certain algæ gelatinize from solution and hence are available as substitutes for gelatine in some classes of work. At times these products are substituted without the purchaser's knowledge; at others, he knowingly selects them in the belief that they are cheaper than glue. It is to be borne in mind that they are available as glue substitutes only for the purpose of adhesion, and even then they are not as economical, in actual work, as glue, although they possess some of the characteristics of the latter. In certain industries, notably in the manufacture of paper boxes, it is desirable to employ an adhesive which, while it binds, does not jell. Hence the use of such agglutinants as "Liquid Glue" and "Boston Gum," both of which may be used cold on the topping-machine. The use of glue substitutes in such case is not open to adverse comment. On the other hand, the abuse of the purchaser's credulity to the extent of offering dextrine or gum crystals as glue is to be condemned.

In the early days of the glue industry, it was a common practice to adulterate ground glues with rosin.

Sand was also used to a limited extent; and it is the recollection of these practices, long since abandoned, that actuates 90 per cent of latter-day prejudice against ground and powdered glue. A more modern attempt at adulteration is the endeavor to combine corn dextrine with ground glue. The dextrine is first dissolved, the solution evaporated to driness, and the resultant product ground and mixed with the glue. In times of glue scarcity, when the price of all grades is abnormally high, the consumer naturally turns to some cheaper product that will answer his requirement; and it is in this way that the majority of glue substitutes have come into use.

Casein. — When the sugar of milk ferments, producing lactic acid, the milk turns sour, and casein, the characteristic proteid of milk, is separated in a coagulated mass. The entire phenomenon is due to the action of the *Bacterium Lactis.* Casein is also produced when acetic acid is added to fresh milk, if this be diluted and warmed. Exact neutralization with acid does not precipitate the casein owing to the interference of the alkaline phosphates present in the milk. An appreciable excess of acid must be employed.

A somewhat modified form of casein is obtained by the treatment of milk with *rennet,* a ferment extracted from the fourth stomach of the sucking calf. This contains the enzyme *rennin* or *chymose,* which coagulates the milk, the casein separating and the milk-sugar, lactalbumins, etc., remaining in solution. The casein so obtained differs from that produced by the addition of acid to the milk, in that the latter form is a precipitate which, under suitable conditions, can again be obtained in solution; whereas the action of the rennet is true coagulation and the casein is insoluble in any media save such as change its chemical constitution.

Commercial casein is purified by alternate solution in alkali and precipitation with acid, the precipitate being thoroughly washed each time. The number of these treatments determines its purity and hence its price. According to purity, the color of the dry product varies from brownish-yellow to almost white. Casein is insoluble in cold water (1 part to 1000), and in hot water swells to a sticky paste without undergoing real solution. It is readily soluble in weak alkalies and weak acids. To facilitate solution, casein is frequently mixed with 12 per cent of borax, the mixture coming into the market under the name Soluble Casein. Caustic alkalies exercise a drastic action on casein, deepening the color of the solution and imparting a disagreeable odor.

The application of casein to the arts is varied. It is useful as a substitute for albumin in calico printing. Upon evaporation from ammoniacal solution, casein is only partially soluble in alkalies, and if the solution of casein in ammonia be treated with milk of lime, the casein, upon evaporation of the solution, is fast to all washing and soaping. Dolfus converts the casein into a nitro-compound, and this is dissolved with the aid of caustic soda, the consistency of the solution being reduced with water. When steamed, this becomes fixed in the cloth, resisting the action of soaping and chlorine.

Casein is applied as the thickener for gold and aluminum bronzes for printing silk. It is far cheaper than gum tragacanth, and yields even better results.

An insoluble compound results from the treatment of casein with slaked lime. This combination is useful as a cement for earthenware, etc. A water-proofing compound is obtained by treating solutions of casein with formaldehyde. A small amount of formaldehyde suffices to produce the desired result, any excess precipitating the casein from solution.

Casein is of service in the preparation of colored micas for printing wall-paper. The aniline color is precipitated upon the mica by some suitable reagent and the addition to the solution (hot) of a small quantity of casein serves to bind the color firmly to the mica. In the same industry, casein may be wholly substituted for glue as the medium for sizing the pulp-colors. Its use for this purpose is attended by difficulty, inasmuch as certain of the colors, when in combination with the casein, cause the latter to ferment, the mixed color and size frequently overflowing the barrel.

Very serviceable insoluble lakes or pulp-colors may be prepared by precipitating casein from ammoniacal solution in conjunction with the color, by means of chloride of aluminium, stannous chloride or acetate.

Egg- and Blood-Albumin. — The albumin of eggs is distinguished from that of blood-serum, etc., by the designation ALBUMEN. White of egg is a nearly pure solution of proteids, the chief of which is egg-albumin or ALBUMEN. Upon evaporation at 60° C., white of egg yields about 14 per cent of albuminous residue. If the white of egg is thoroughly beaten with water, the albumin and salts pass into solution, membraneous material remaining behind. The albumin may be separated from the soluble salts by precipitation with basic acetate of lead, the precipitate decomposed with carbonic acid, and the lead removed with sulphuretted hydrogen. Coagulation occurs upon cautiously warming the liquid to 60° C., the first flakes of albumin carrying down with them the last traces of lead sulphide, leaving the supernatant liquid colorless. This is evaporated at 35° C., when the albumen is obtained in pale yellow scales. (*Allen.*)

Albumen may be obtained in the solid state by cautiously evaporating white of egg at a temperature below 50° C. It is fairly transparent and of a pale yellow color. It is frequently adulterated owing to the fact that it is more valuable than blood-albumin.

Blood- or serum-albumin results from the evaporation of the separated serum of perfectly fresh blood. The evaporation is conducted at about 50° C., when the albumin is obtained in the form of scales or flakes varying in color from grayish to black. Three or four qualities of blood-albumin are known, the purest being a dirty yellow, and the poorest, black.

Both egg- and blood-albumin are applied to the printing of cotton fabrics, when they are rendered insoluble by coagulation with steam, acting as mordants for a number of colors. Egg-albumin is also employed in silk printing as one of the ingredients of the color-thickener. It finds further application in the manufacture of confectionery. Black blood-albumin is not used for printing fabrics, but is useful in sugar-refining and in dyeing with Turkey-red. Blood-albumin may be employed for printing all but the most delicate colors. It is cheaper than egg-albumin and has greater thickening power. Egg-albumin is largely substituted for gelatine in photography in the preparation of sensitive coatings for printing-papers, which consist of albumen treated with silver haloids. The author has frequently been called upon for an opinion respecting "glue," which has turned out to be nothing more than blood-albumin and sometimes egg-. It is difficult to understand how one could be inveigled into the purchase of albumin for glue, the characteristic odor of the former being sufficient to distinguish the two, as well as being so disagreeable as to bar it from many uses to which glue is adapted.

Dextrine Crystals. — Dextrines result from the treatment of the corresponding starches with acids at various temperatures, the duration of the treatment determining the color as well as the solubility of the product. The best are those produced from potato starch, and in order of serviceability rank tapioca-dextrines, corn-dextrines and sago-dextrines. British gum is made from the various starches by simply roasting these for a certain length of time without the aid of acid. Its solution is heavier in body than those of dextrines, and is much lighter in color.

Canary potato-dextrine is of medium yellow color in solution, which, if prepared sufficiently concentrate, yields dark yellow crystals closely resembling the particles of a ground foreign glue of light shade. These require preliminary softening or soaking prior to solution, and this is similar in appearance and characteristics to the solutions of weak animal glue, with the exception, of course, that the dextrine solution does not jell. Solutions of dextrine admirably fulfil the minor requirement of the paper-box maker, as they are as adhesive as weak glue. They have not equal *binding* *strength,* however, nor are they cheaper than glue, as many would believe. They are readily prone to decomposition and molding, unless properly preserved with formaldehyde or carbolic acid.

Gum Arabic. — This gum is too well known to require detailed description in these pages. It is extensively employed in the manufacture of mucilages, in conjunction with dextrines. The poorer varieties are sometimes substituted for glue. The particles of gum require long soaking before applying heat to bring them into solution, and the solution must be prepared very thick to equal in adhesiveness that of a weak glue. Under these circumstances, the gum is more costly than animal glue. The addition of some glycerine is necessary to impart sufficient flexibility to the dried gum.

Japanese Gelatine, etc. — Certain algæ or sea-weeds yield a highly gelatinous substance upon treatment with boiling water. Chief among these is the *Gelideum Corneum,* familiarly known as Chinese Moss or Japanese Gelatine. Its chief constituent is gelose, which has ten times the gelatinizing power of isinglass, setting to a jelly when dissolved in five hundred times its weight of water. It occurs in commerce in bundles of long strips and resembles some forms of isinglass. It swells in cold water and is thoroughly soluble in hot. Upon cooling, the solution sets to a jelly which, although its melting point is higher than that of isinglass, lacks tenacity. The jelly is colorless and translucent, like that of a high-grade gelatine.

Chondrus crispus, Irish Moss, is an alga gathered from the rocks at low tide on the west coast of Ireland, where it constitutes an article of diet. The greater part of the moss consists of the gelatinous substance, carrageenin, somewhat analogous to gelose, though yielding a far darker jelly. The jelly finds application in medicine and is also used in the manufacture of textile fabrics, either as a finishing size or as a thickening medium for printing colors on cotton or silk.

Agar-Agar, the edible sea-weed of Ceylon and other localities, contains a gelatinous principle very similar to gelose.

Gluten. — Starch-tailings, consisting mainly of gluten, or the latter itself, are the basis of the so-called dry pastes which are offered in place of regular flour-paste; and this substance is worthy of some consideration as a possible glue substitute. Wheat flour consists of starch and gluten, the latter containing the two proteids, *glutenin* and *gliadin.* When flour is kneaded in a bag under a stream of water, the starch gradually passes into solution and the gluten remains behind as a brownish, sticky mass. This dries to a grayish, brittle substance which, though insoluble in cold water, is fairly soluble in boiling, the undissolved portions combining with those in solution to produce an extremely heavy, sticky paste. Solution of the dried gluten is facilitated by the addition of a small amount of alkali, and the gray color of the dried product is improved and whitened by the addition of chalk, silver white, and possibly a trace of ultramarine blue.

Though somewhat more troublesome of manipulation than ready-prepared flour-paste, "dry" pastes are far more adhesive, owing to the greater content of gluten. The serviceability of regular flour-pastes is largely dependent upon the proper development of the gluten of the flour. By treatment with a small amount of borax, cooking at a proper temperature, a flour-paste may be produced which is fully the equal, if not the superior, of weak glues in binding as well as adhesion. The author has seen such pastes bind two sticks of wood so that considerable force was necessary to break them apart; in one instance, the wood breaking before the cemented joint gave way. Flour-pastes, well made, regular or "dry," have largely supplanted glue in trunk-making as well as the production of leather novelties, such as bags, belts, and pocket-books. The heavy canvas covering of trunks is often laid on with good paste, which holds just as well as a medium quality of glue, and is far cheaper and easier of manipulation, requiring no preliminary soaking.

Gluten has, of course, its disadvantages in use. It is prone to rapid decomposition and putrefaction, the gases evolved being of the most unpleasant character. The problem of a proper preservative for flour-paste remains unsolved. Mercuric chloride is commonly employed, in solution in hydrochloric acid. Hydrofluoric acid works well as does also formaldehyde, though the pungent odor of the latter is a decided disadvantage.

"Liquid Glue." — This is used in the manufacture of paper boxes, in conjunction with flour-paste, for the lighter work. It contains no animal glue whatsoever, being a solution of British gum and light and dark canary corn-dextrine. To this, flour-paste is at times added with a view to increasing the "body" of the solution. "Liquid Glue" is dark brown in color and dries not unlike a solution of a weak, dark bone glue. Properly prepared, it is fairly adhesive in solution and is preserved with cresylic acid (crude "carbolic" acid), formaldehyde, etc., an essential oil being frequently added to disguise the odors of the preservatives.

Boston Gum. — A solution of dextrines, blackish in color owing to the admixture of crude phenol or cresylic acid as a preservative, is employed by some paper-box manufacturers in preference to "liquid glue." It is extremely useful for "topping," as it may be run cold on the machine for this work. It excels "liquid glue" in adhesiveness and resembles more closely than the latter a solution of weak animal glue. It has also the advantage in that it does not impair the gloss of the paper, as do many preparations of superior adhesiveness and binding power, which are made by bringing starches into solution in the cold with the aid of caustic alkali. These latter invariably dry to a dull coating.

Preparations such as Brightwood gum, envelope gum and similar dextrine pastes or solutions are now used exclusively in the manufacture of envelopes where formerly glue was employed.

Methods of Detection and Analysis. — Not only are some of the above-described products substituted for glue, but several of them are liable to adulteration. This applies particularly to commercial albumin, especially egg, which is hocused to a great extent by the unscrupulous.

In general, casein may be distinguished from albumins and all from genuine glue, by their characteristic odors. The odor of casein, whether dry or in solution, is markedly cheesy — a characteristic never observed in glue. The odor of albumin, while impossible of description, is easy of recognition, and once known is not easily forgotten. Solutions of dextrine are sweet to the taste and smell, unless these characteristics have been destroyed by preservatives. Gluten has an odor, when dry, not unlike that of stale crackers. In the wet state it preserves this same odor and is further recognizable from its consistency and appearance, which resembles that of an exceedingly dirty flour dough.

Casein. — Though casein itself is not liable to adulteration, it may be employed to adulterate glue or albumen. Solutions of casein are not coagulated by boiling, while those of albumins are. The casein may be precipitated from solution by an excess of common salt, magnesium sulphate, chloride of barium, and calcium. It is completely precipitated by the usual reagents for proteids — sulphate of copper, bichloride of mercury, acetate of lead, etc.

When present in conjunction with glue, the casein may be separated by precipitating both with alcohol and boiling the precipitate, which coagulates the casein, rendering it insoluble. The precipitated glue may be then taken up with hot water.

Egg- and Blood-Albumin. — Egg-albumin is usually translucent and of a pale yellow color. It should be free from blisters which are the evidence of imperfect coagulation. All commercial albumen of good quality should be free from any suggestion of the odors of putrefaction and unpleasant taste. On treatment with cold water and constant stirring, it should dissolve without leaving any residue.

Albumin is frequently adulterated with gelatine, sugar, dextrine, and even flour. For its examination, Allen proposes the following method which has yielded the author uniformly successful results:

Five grams of the powdered sample are treated with 50 c. c. of cold water and stirred frequently until all soluble matters are in solution. Pure samples leave no residue. A few drops of acetic acid are added and any insoluble residue filtered off through silk or fine muslin. This may consist of coagulated albumin, casein, starch, or membranous matter. The casein may be dissolved out by treatment with very dilute caustic soda and precipitated by exact neutralization with acetic acid. The aqueous solution of the sample is now boiled, when the albumin is thrown down as a flocculent precipitate which may be filtered off, washed, and weighed; or treated by Kjeldahl's process and the albumin deduced from the ammonia obtained. The filtrate from the albumin is treated with acetic acid and potassium ferrocyanide, to make sure that all the albumin has been precipitated. Any organic precipitate produced by this treatment will consist of casein. Zinc, which may have been added to increase the thickening power, will be thrown down at this juncture as white ferrocyanide. If no proteid remain in solution, gelatin may be precipitated by the addition of tannin, the liquid filtered and concentrated to small bulk, when any gum or dextrine will be precipitated by treatment with alcohol. Sugar, if present, will remain in solution with the alcohol and may be detected by boiling off the alcohol, heating the liquid with hydrochloric acid, and treating with Fehling's solution. Sugar might also be extracted by treating the original dry sample with alcohol.

For the assay of commercial albumin, Ziegler dissolves 20 grams of the sample in 100 c. c. cold water. The solution is strained through a sieve and 10 c. c. of the clarified solution is added to a boiling 20 per cent solution of alum. The appearance and volume of the coagulum is noted, and then it is washed, dried, and weighed. With pure albumin the results are very good and their accuracy is not affected by the presence of dextrine. Gum arabic, however, interferes seriously with the precipitation of the albumin. (*De Koninck.*)

Blood- and egg-albumin may be distinguished from each other by the following reactions:

Solutions of blood-albumin in which are present the ordinary salts are unaffected by agitation with ether, whereas egg-albumin is coagulated. If in dilute solution the precipitate appears at the junction of the layers of ether and water. It is to be observed that if no salts are present this behavior is reversed, the blood-albumin being precipitated while the egg- remains unaffected.

Blood-albumin is readily soluble in concentrated nitric acid, while egg-albumin is only sparingly soluble in this medium.

Dextrine Crystals. — The active constituent of dextrines may be designated as *dextrin.* Chemically, this product is intermediate between starch and grape-sugar. Its empirical formula alone is known, and is $(C_6H_{10}O_5)_n$, that is, some multiple of the starch formula $C_6H_{10}O_5$. If the process of dextrinization, *i.e.*, the treatment of a starch with a trace of nitric acid with the aid of heat, be prolonged, the starch is first converted into dextrin and subsequently into grape-sugar, $C_6H_{12}O_6$. The conversion of starch into dextrin, and, subsequently, of dextrin into grape-sugar, may therefore be assumed to be that of hydrolysis and may roughly be stated by the equation,

$$C_6H_{10}O_5 + H_2O = C_6H_{12}O_6.$$

Commercial dextrine must be regarded as a mixture of unconverted starch, dextrin, and grape-sugar. The further conversion is carried, the more soluble the product, the deeper the shade of its solution, and *the greater the quantity of grape-sugar present.* Dextrines are sometimes produced by the action of malt-infusion upon solutions of starch, the *diastase* of the malt converting the starch first into dextrin and ultimately into the sugar, *maltose.* The temperature of the operation should never exceed 60° F.

Both levulose and maltose reduce Fehling's solution, and hence if the solution of agglutinant be suspected to be dextrine, this may readily be recognized. This test is applicable to the detection of "Liquid Glue" or Boston Gum, although the general appearance and characteristics of these serve to identify them in the majority of instances.

Japanese Gelatine, etc. — These will be recognized by the form in which they appear in commerce, the long, slender strips resembling only a certain form of isinglass, and the difference in the characters of the jelly will soon differentiate them from the latter.

CHAPTER V

FOREIGN GLUES

Comparison of Foreign and Domestic Glues. — A considerable proportion of the glue consumed annually in the United States is of foreign manufacture and, were not the tariff duty on these goods so high as to be almost prohibitive in many instances, it is to be feared that some grades would supplant the corresponding domestic in certain classes of work. The contention, advanced by many, that foreign glues are invariably productive of better results than the domestic goods of equal test-strength, is entirely too broad and sweeping. Yet it must be admitted that there are times when a well made 1⅞ foreign glue will do the work of a poorly made 1½ domestic.

Much uncertainty exists in the minds of the glue-consuming public as to whether the vaunted superiority of foreign glue over our own product is founded on imagination or on fact. The radical difference in appearance between foreign and domestic glues has its origin in the fact that the stock from which the former are made is selected with the greatest care. In addition it is frequently hand-picked, the laborious process of removing physical imperfections of the stock by hand being reckoned as nought compared with the possibility of producing an off-grade of glue through neglect of this precaution. Labor conditions are such in England and on the Continent that it is possible to subject both stock and glue-liquor to operations precluded by the high cost of labor in the United States. Where the European manufacturer can avail himself, at a trifling cost, of the services of the aged and infirm of the locality in which his factory is situate, for the purpose of hand-picking glue-stock, the same labor would command many times the price in the United States and hence the increased cost of production would speedily place beyond the pale of competition the manufacturer who sought to take advantage of such process.

Factors other than the initial treatment of stock operate to create a difference between foreign and domestic glues. The glue-liquors are, as a rule, subjected to processes of clarification or those tending to precipitate the viscous, non-adhesive elements. For this reason, the majority of foreign glues are markedly translucent, if not actually transparent. The viscosity of their solutions is lower than the subsequent jelly-strength would indicate, as is the case with our acid-treated glues.

It is to be borne in mind that glue is glue, the world over, and that the manufacturer, abroad, is subject to the same limitations in production as the manufacturer in this country. The author is not in a position to state whether or not all European manufacturers sell their glue on test. If one is to judge from the contributions of foreign authors to the literature of the subject, each manufacturer employs an individual test-system which certainly must fail of enlightening him as to the commercial fitness of his product, determined by the requirement of the American consumer. This view is materially strengthened by applying the test to various makes and grades of imported glues, when the discrepancies in price between those of identical strength and quality would indicate that the price is governed altogether by cost of production. A German manufacturer will frequently demand a price for a glue testing $1\frac{3}{4}$ for which price an English manufacturer will offer one of $1\frac{1}{2}$ test. Many other examples might be cited in confirmation of the theory that there is not a suggestion of test-uniformity among European manufacturers.

Save with the higher, more expensive grades, the boasted uniformity of foreign glues is largely a myth. For four years the author has tested regular monthly shipments from divers European factories, and there have been frequently variations corresponding to two domestic grades. Even the higher grades vary at times. It may be safely asserted that there is no economy in using a low-grade imported product in preference to a domestic. A foreign glue of $1\frac{7}{8}$ strength will usually cost from eight to nine cents per pound here, when the duty and freight have been added to the quoted price. A clever buyer will procure a domestic glue of at least $1\frac{1}{2}$ strength for the same money.

In certain classes of work, however, particularly where the glue is to be worked in conjunction with unstable chemicals, or for finishing delicate fabrics, the use of foreign glues is of material advantage, if not imperative. All substances tending to affect the chemicals have been removed through the initial treatment of the stock or the very processes of clarification or precipitation before alluded to. Again, their viscosities being low as a result of these treatments, foreign glues are better adapted to sizing work than are many domestic grades.

These exceptions granted, it is an open question whether foreign glues of all grades are more economical in actual work than the corresponding domestic grades. Personally, the writer thinks not. Certain domestic glues, those made by the Michigan Carbon Works, for example, are identical in appearance with some grades of foreign, for the reason that they are made in just the same way. As a result, the price of these products is far higher than that of the regular domestic of the same grade. Thus, the 1⅝ of this make commands a price averaging twelve cents per pound, for which could be obtained a straight hide 1¼ glue. The very fact that such glues are produced in this country bears out the contention that it is not owing to any superiority in skill, but rather to variance in the methods of treating the stock and liquors, that foreign manufacturers produce an article so different in appearance and general working properties from American.

Granting, further, the claim that the 1⅝ glue of the above-mentioned make will do the work of the 1¼ hide obtainable for the same money, the latter is apt to prove much more uniform in the end. While clarification and other processes doubtless render the finished glue better for such purposes as sizing, these processes are apt to deprive the article of much valuable binding material in the endeavor to remove viscous, non-adhesive elements. While conceding the superiority of a foreign glue as compared with a domestic *bone* product of even greater strength, the author holds that if a careful comparison be made between the average foreign and a domestic hide glue of equal strength, in actual work, the verdict will be in favor of the latter, as it is far cheaper and if properly applied will do as good work, if not better. Few, if any, foreign glues equal the domestic A Extras or even the 1 Extras. A foreign glue, testing 1 X, is worth in this market fourteen or fifteen cents per pound, a price which will procure a domestic A Extra superior in every way.

It must not be inferred that all foreign glues are alike. While they have many characteristics in common, such as clearness and extreme hardness, they are in a measure distinguishable according to the country which produces them. The author's experience with foreign glues has been limited to the examination of English, French, Italian, and German of a great variety of makes. The Italian and French correspond in general appearance and behavior. The majority of German are widely different from any other make, while the English may be regarded as most nearly corresponding with some of our domestic product. It would seem that to Russia belongs the credit of first producing opaque or colored glues, since glues of this class are designated Russian even though made in Germany or elsewhere. Similarly, much Scotch glue is manufactured in France, and a grade of Irish glue is produced in Lincolnshire, England. It is thus seen that some of these designations refer to particular brands of glue, rather than indicating the country producing them.

The United States produces but little gelatine of good quality, the bulk of that consumed here being imported. Domestic gelatines lack the purity of the foreign product. They are rather too gluey, and are deficient in strength (water-absorbing quality). Germany and France lead in the production of gelatine applicable to the arts, while England has produced several edible varieties of great merit. French and Italian gelatines, as a rule, are stronger than German. That American manufacturers will, in the near future, produce goods of equal merit, is a certainty. Already the 00 and 000 gelatines of the Michigan Carbon Works are achieving prominence, while some of the Western packing-houses are producing gelatines of great strength. Although the products alluded to are fairly pure and strong there is considerable room for their improvement.

Since foreign glues of every make exhibit certain characteristics in common, it is to be inferred that the higher grades owe their superiority to differences in stock rather than in methods of preparation and boiling. This contention is supported by the fact that at certain factories in the United States, glue-makers are employed whose experience and training have been mainly European, and particularly, German. As a result, the product of these factories is similar in appearance and working properties to foreign-made glue, and differs from it in that it is invariably two or three grades stronger. This added strength can be due only to the superiority of American stock. Thus, an Indiana factory employing a German glue-maker produces a pale yellow ribbon glue well adapted to silk finishing and the preparation of gummed labels. This glue, which is identical with several varieties of German, so far as appearance is concerned, is far stronger than any

German glue that can be bought at the price (nine and one half cents) in this market. The other glues produced at these works are characterized by the clearness of the foreign product with the strength of the average domestic hide glue. Such are superior to the corresponding imported grades in that they are better preserved.

On the other hand, differences characterizing domestic glues are due to variations of process as well as of stock. The problem of a proper stock supply is becoming a serious one with many of our factories. The markets are closely watched by the representatives of many, and stock purchased in every quarter of the country. So great is the demand, that stock of inferior quality is frequently purchased and the skill of the glue-maker depended upon to produce a good article. This will account in large measure for the frequent variations in test of the same grade of glue. It is to be assumed that even a greater stringency exists abroad, where packing industries as well as tanning are not so extensive as in this country. Despite this, stock imported from Europe is at times offered in this market, while that coming from Argentina and other South American countries is commonly employed for glue making both here and abroad. Contrary to popular belief, stock is at as great a premium with the packing-houses operating glue works as with the smaller producer. Since each department of such a concern is conducted as a separate business, it is necessary for the glue department to purchase the stock from the other departments, with the result that it is frequently more profitable to buy in the open market. Ohio, Connecticut, and Massachusetts are almost inexhaustible sources of stock supply. Newark, N. J., a veritable center of the leather industry, furnishes considerable glue-stock, as do the isolated tanneries throughout the country.

So varied is the stock in character, that it is possible for the American glue-maker, through individuality in treatment, to produce a characteristic and distinctive glue. Thus the Baeder Adamson, Armour, Swift, Cudahy, Nelson Morris, American Tanners, Delaney, Anglo-American, Cooper, and Delaware, product exhibit individual characteristics enabling the experienced to identify them with comparative ease. On the other hand, a brown medium-priced foreign glue might readily be the output of any one of a score of European factories, for all that appearance or test tells. Given a specific requirement, almost any imported glue of requisite strength will answer, whether made in Germany, France, England, or Italy. The same rule applies to imported gelatines, so similar are the corresponding grades produced by each country.

It is well known that the modus operandi in almost every European industry is largely governed by tradition. In an industry such as glue making, where the art is frequently transmitted from father to son, tradition plays a most important part and its influence is to be observed even in this country in the manufacture of glue. It is to be inferred that, because of tradition, European glues will continue the same, time without end. The American trained glue-maker, though as a rule conservative, is more prone to experiment than is his European cousin; and since development of any industry is dependent upon experiment, glue making in the United States will doubtless eventually be reduced to almost an exact science.

Lack of space forbids the description of all the varieties of imported glue examined by the author, and hence discussion is limited to such as are typical.

English Glues. — While exhibiting certain characteristics in common with those produced upon the Continent, glues made in England differ somewhat and may be considered as intermediate between domestic glues and those manufactured in Continental Europe. Whether this is due to differences in stock or in treatment is an open question. As it is, some English ground hide glues closely resemble our own higher grades, and certain ground bone glues of English manufacture have their domestic prototypes in the C X glue of Armour & Co. and of other American factories.

Probably the best known English glue in this market is the "Walsall." This appears in the form of fairly thin sheets of good texture, brownish yellow in color and bearing the marks of the net. This may be regarded as the type of high-grade English glue and its merit is attested by the fact that it is extensively imitated. It is applied largely in the manufacture of matches and is also well adapted to joiner-work.

A ground hide glue produced by the Grove Chemical & Fertilizer Works closely resembles American ground hide glues. This concern also manufactures weak bone glues very similar to our own, including a "concentrated size powder," which is regularly duplicated in this country under the less fantastic name of powdered bone glue.

Other types of English glue are the Crown English, Crown No. 1, D. F., etc., made by Duche Freres who maintain extensive works both in England and in France. The "Star and Anchor" glue produced by this concern is typical of either French or English glues of a certain class. It finds an extensive use in this country, particularly in the manufacture of carriages, in which industry there exists a rabid prejudice in favor of foreign glues.

Although some English glues are described by the makers as free from acid or alkali and even grease, such is not always the case. Some show at times as much as 0.5 per cent mineral acidity and appreciable quantities of grease. These facts are not cited with a view to disparaging the product. It is a matter of extreme difficulty to produce a glue absolutely free from alkali, acid, or grease. Others, again, are remarkably beautiful in appearance but extremely weak, testing No. 2. They are pale yellow sheets, very clear and transparent, with high luster. A working trial of these glues is fraught with extreme disappointment. It cannot be stated, with any degree of finality, that their lack of strength is due to the very processes that have contributed to their fine texture and appearance, but it is to be inferred that such is the case.

Irish Glues. — Two grades of Irish glue are very well known in this market — the Block C. and the Block C. L. The former is made in Ireland, while the latter is produced in Lincolnshire England, as the initial, L, denotes. Both are high-grade glues. The Block C. appears in the market in the form of broad, seal-brown sheets, cut fairly thin and prominently marked by the nets. It tests about 1 X on the average and, though considerably clearer, is otherwise identical with a medium, thin-cut, domestic glue, made from straight hide. The Block C. L. is of a somewhat different shade and thicker cut. As a rule, it is very greasy, much more so than any foreign glue examined by the author. Both Block C. and Block C. L. are used in the manufacture of matches, and it is claimed by some that the grease of the latter renders it even more valuable than the former for this purpose. It would seem, however, that this grease is a serious defect in a glue intended for match-composition.

There is a so-called Irish glue, designated "Irish, G. B.," appearing in this market. It bears no resemblance to either of the foregoing grades and, in fact, is not Irish glue at all, being produced in England in an abortive endeavor to imitate the "Walsall" glue. A sample, figuring in a lawsuit, was examined by the author. It is in sheet form, very pale of color, and appears to be made largely from skin-stock. The sample was strongly alkaline in reaction and chromate of lead was present in the ash, resulting from the probable addition of a lead salt to impart factitious weight and a chromate to enhance the drying properties of the glue.

Scotch Glue. — Several samples of this variety of glue have come to the writer's notice, one made in England, another produced in France, and still another of German manufacture. Scotch glue is characterized by extreme darkness of color. Held away from the light, it appears to be almost black; but if held up to the light, the sheet is seen to be of a deep red or claret color. The glue is in the form of sheets, seven to eight inches square and about one-half inch thick. So tough is this glue, that sharp blows with a hammer are necessary to break it, and if one were to judge by the fracture alone, it would be considered of great strength. It seldom tests more than $1\frac{3}{4}$, however, and more often $1\frac{7}{8}$ or No. 2. Scotch glue is of such thickness that it is necessary to soak it twenty-four hours before it will melt properly. Of the samples examined by the author, that of French manufacture was the best. This tested $1\frac{3}{4}$, but owing to the peculiar character of foreign-made glues held a wood-joint so strongly that crushing blows with a hammer failed to separate the two pieces for some little time.

German Glues. — While Germany produces glues in far greater variety than other European countries, her product is, as a rule, inferior in quality. This is doubtless due in part to differences in stock as well as in methods of manipulation. The fact remains, however, that despite the alluring superlatives employed in the description of the product on the printed labels attached to the sheets of each make, a large proportion of German glues is poorly made. It would seem that Germany excels in the manufacture of medium quality bone glues. The hide glues, or the mixed bone and hide, cannot compare with our own product either in strength or in keeping qualities. Those that are at all serviceable cost from seventeen to twenty cents per pound in this market — a price which is ridiculously high.

As has been pointed out, the printed guarantees of the manufacturer are not always substantiated by test. German glues may be roughly divided into two classes, "Superior" and "Extra Superior," and frequently the former are of better quality than the latter. To these adjectives there are added such as "Fett-frei" (grease-free), "Sauer-frei" (acid-free), etc. The glue is also described either as "Leder Leim" (hide glue) or "Knochen Leim" (bone glue). Many of those described as pure hide contain considerable bone liquor, and some described as acid- or alkali-free react strongly with litmus for one or the other of these conditions.

German glues are usually in the form of sheets about five inches long by two wide. In thickness, these vary from a quarter to a half an inch. The poorer grades are usually very difficult of fracture, breaking in long splintery strips. The better varieties are not so thick cut. A chocolate brown is the prevailing color, although the higher grades range through the shades of yellow. Those that can be purchased in this market for seven or eight cents per pound seldom test over 1¾ and are more likely to test 1⅞ and No. 2.

Cologne glue may be regarded as typical of the German product. Originally, this was a very fine article, but of late years has markedly deteriorated owing to extensive imitation in which the original glue formula has been entirely lost sight of. So superior was the quality of this glue and so general its recognition that it has needed but the term "Cologne" to effect the speedy sale of many a spurious grade of glue. The genuine article is in the form of small, square cakes, very thick and extremely hard. It is manufactured from scraps of hide and skin, which, after liming, are bleached; and in order to obtain as clear a jelly as possible, certain portions of the glue-stock are rejected after bleaching and worked into darker glue. The fact that the genuine is characterized by great clearness of jelly has led to its extensive imitation. Bone glues are frequently described and sold as Cologne glue, even by German manufacturers themselves, coming into the market as "Kölnische Knochen Leim." Such characterization is in itself sufficient to warn the prospective purchaser that he is offered a spurious article. Bone glue is not true Cologne glue.

Many of the cheaper grades of German glue lack the necessary keeping qualities to encourage their extensive use in this country. Even some of the higher grades are insufficiently preserved, while over-liming is frequently to be observed in both. This latter defect is noticeable chiefly in glues of great clearness and paleness of color, yielding very clear jellies, and is doubtless due in many instances to the attempt to bleach the stock after liming through the agency of milk of lime. Pale yellow, clear, bone glues owe both clearness and color to treatment of the liquors with sulphurous acid gas. These glues, while very fine in appearance, are extremely weak in test.

French Glues. — Glues of French manufacture are far stronger and better in quality than other European glues obtainable for the same price in this market. The lower grades are of great purity and test from one to two grades (Cooper) higher than the corresponding German or even English product. A peculiarity of French glues is that, save for the cheaper varieties, which are invariably dark in color, they occupy a position intermediate between glues and gelatines. Were they cut thinner, many of the medium grades would pass for low-quality gelatines.

The Jacquet Coignet glues are unquestionably the highest type of French product and, in a sense, of any glues produced. They embody the purity of the average commercial gelatine with all the strength and adhesiveness of a high-class hide glue. A favorite grade, much used by representative cabinet-makers in this country, appears in sheets about eight inches square and a quarter of an inch thick, medium yellow in color. This tests, as a rule, 1 Extra, and is conceded to be without an equal in binding two pieces of wood.

The glues and gelatines produced by Messrs. Tancrede & Cie. are more truly representative of the French product than the above, since the J. Coignet are of such merit as to place them beyond comparison with other makes without too great a disparagement of the latter. Several varieties of glue are produced by Tancrede, the "Colle sans Marque," "Ecossais," "Soleil," and "Medaille."

The "Colle sans Marque" (Unbranded glue) is the weakest of these glues, testing on an average 1⅞, although sometimes running as high as 1¾. This variation in test is due to the fact that at times the glue is shipped fresher than at others. The color of this glue is dark brown and the sheets are from six to seven inches square. The "Ecossais" (Scotch glue) has already been described in the foregoing discussion of glues of this name. The "Soleil" (Sun) and "Medaille" (Medal) glues are in broad sheets of a good yellow color, and fairly thick. They are clearer than the Unbranded and Scotch and exhibit "fiber" to a greater degree. By "fiber" is meant not only the appearance of strength, since this is common to a great number of glues, domestic as well as foreign, which prove very weak on test, but rather a "waviness" in the texture that is an infallible index of strength. Certain forms of cutting apparatus faintly mark the surface of the dried glue with parallel lines, very close together. These must not be mistaken for "fiber." Just as the "grain" in wood indicates soundness as well as careful treatment, so the "fiber" in glue is indicative, not only of good stock, but proper treatment and cooking as well. The Sun and Medal glues average in test 1½ and 1¼ respectively. A characteristic of these glues, worthy of notice, is that the viscosities of their solutions are not as low, proportionately to their jelly strengths, as those of the great number of foreign glues, *although both of these glues are quite clear.* It is evident, therefore, that this clearness has its origin in the preliminary treatment of the stock, rather than in processes aimed to remove by precipitation, the non-adhesive, viscous elements in the glue liquors. It has already been pointed out that such processes are too radical, removing much that is available in the proper working of the glue.

Tancrede & Cie. produce a gelatine that is without exception the strongest that has come to the author's notice. It is in narrow sheets of medium thickness, of a pale yellow color in some lights and almost colorless in others. The test is two grades higher than A Extra and seldom varies. The jelly of a 25 per cent solution, while yellowish and not absolutely clear, is so tough that it is with difficulty pulled to pieces with the fingers. The melting-point of the jelly is rather too high for a culinary article. The solution is decidedly alkaline in reaction and its viscosity averages 35 seconds. The objection is made that this gelatine is in reality too strong for the average work. Despite its peculiar characteristics, it is a true gelatine, the addition of even a few drops of 40 per cent formaldehyde solution producing a change to a tough, elastic mass. In the matter of absorbing foreign odors, it is as sensitive as butter, and if stored for a short time in proximity of crude phenol will soon become impregnated with the permeating odor of the latter. This fact has led to the erroneous conjecture that the product itself is preserved by means of carbolic acid and hence manifestly unfit for culinary applications.

Italian Glues. — While comparatively little glue is produced in Italy, as compared with the output of other countries, the product is of excellent quality, and in many respects similar to the French, being typical of "gelatine-glue" to even a greater degree than the latter product. Two concerns, the "Societa Agricola, etc.," in Milan, and the "Fabrici Torinese di Colla e Cocimo," in Sorrento, produce glues that are worthy of attention. The Societa glue is a cheap grade similar to the Colle sans Marque of Tancrede, testing about the same, but somewhat better adapted to sizing work. This corresponds, also, with certain of the weaker English glues, but is vastly superior to the low-grade German. The Fabrici produces gelatine-glues and gelatines, the former having their exact duplicates in the product of the Michigan Carbon Works, and the latter in the Silver Label, Bronze Label, and Gold Label gelatines of German manufacture. Like the German product, the Torinese high-grade gelatines are in the form of colorless, extremely thin, transparent sheets, testing from 1½ to 1 X. The jellies are remarkably clear and of proper melting-point. Italian glues are a trifle higher in price than the corresponding French, as they are redipped after drying the first time, in order to improve the gloss or luster.

Russian Glue. — From what has been said in regard to Russia as the originator of opaque or colored glues, it must not be inferred that opacity is achieved in exactly the same way as in this country. A considerable quantity of Russian glue is made from bones, the dry product being in the form of brownish-white sheets. The bones are degreased by the usual method, and the customary treatment with hydrochloric acid resorted to, to deprive them of mineral constituents. The acid is permitted to act on the bones until they just become flexible, when the acid is drawn off. As a result of this incomplete treatment, phosphates remain in the cartilage and are incorporated with the finished product which thereby acquires a whitish color. The practice of adding mineral coloring matters to both hide and bone glues originated in the endeavor to imitate Russian glue. It is said that the addition of a small amount of coloring matter does not affect the tenacity of glue, but that an excess tends to weaken it. This does not accord with the contention of numerous consumers of opaque or colored glues that such product is stronger and dries quicker than the corresponding clear.

Some of the opaque or colored glues manufactured in various European countries are genuine Russian, prepared by the above process. Others, again, are made by the same methods as are in vogue in this country, namely, the addition to the glue liquors of various mineral coloring matters.

CHAPTER VI

SELECTION OF GLUE FOR VARIOUS INDUSTRIES

Preliminary Considerations. — While no definite rule can be enunciated relative to the selection of a glue for a specific usage, attention must be paid to certain fundamental considerations. Experience is the safest and surest guide in glue selection; but experience, with glue, is to be acquired only at great pains and expense. Hence the necessity of applying the dicta of common sense to the selection of an article that will answer the requirement of the consumer. It is manifest that stronger glues are required for some purposes than for others, and that common bone glues will not do the work of high-grade hide. It is to be regretted that the average consumer, in selecting glue, is influenced altogether by the question of price. While strenuous competition in all branches of manufacture renders it imperative that raw material be purchased as cheaply as possible, where glues are concerned too little attention is paid to the quality of the material.

Through a lamentable ignorance of its properties and, more particularly, through ignorance of proper methods of application, many a good glue is condemned and frequently an inferior article, at even higher price, substituted. Through this same misconception of the nature and properties of glue, an article is oft chosen that is unfit for the particular requirement. The average consumer proceeds upon the basis that he does not wish to pay more than, let us say, eight cents per pound for the glue, regardless whether the proper glue for his work can be purchased for the money. Utterly failing to consider that a glue at twelve cents is often far cheaper in actual work than one at eight, he tries every make of glue that is offered him at the latter cost and eventually clings to that furnishing the best results. His supply of this cut off, he is at sea regarding further selection, and it is highly probable that he is never successful in obtaining the glue best fitted for his work.

Glues that exhibit palpable defects of stock or manipulation are unfit for any purpose. True, they can be used; but the results will never be entirely satisfactory. As has been previously emphasized, the consumer's only path to safety, no matter for what purpose the glue is intended, lies in the test. It is only through continued testing that he can learn to distinguish glues and arrive at that state of enlightenment that will enable him to select the glue best adapted to his requirement, independent of any and all suggestions on the part of the dealer or manufacturer. Further, in this way alone will he be able to select the proper glue and at the same time protect himself in the matter of price.

Glues for Joiner-Work. — Prior to entering into the discussion of the relative merits of different makes of glue for joining wood, certain axiomatic principles may be enunciated in reference to the method of applying the glue. These once understood, it is not a matter of great difficulty to obtain a good glue for the work, at a satisfactory price.

1. Glue exerts a far greater hold on surfaces of wood that have been cut across the grain than on those that have been split, or cut with the grain.
2. When two surfaces of split wood are laid together, the hold of the glue is the same whether the fibers are laid parallel or crosswise to one another.
3. The value of a wood joint is dependent upon the union of the glue with the fiber of the wood. For glue to be properly effective, it must penetrate the pores of the wood; and the greater this penetration, the more substantial the joint.
4. All other factors being equal, glues that dry slowly are invariably stronger in the joint than those that dry rapidly.
5. Except in the case of veneering, both surfaces of the wood should be properly glued before junction.
6. Do not use thick solutions of glue for joint-work. They congeal too quickly, and hence fail to penetrate the pores of the wood, yielding, as a result, a weak joint. In every case, the glue must be worked well into the wood with a brush, much in the same manner as a coat of paint is applied.
7. If glue is applied to *hot* wood, all the water of the glue solution will be absorbed by the wood, leaving a thin inadhesive coating of glue at the surface of the joint, which, if made in this fashion, will hold only a limited time.

In the fact that thin solutions of glue produce far stronger joints than thick, we find some basis for the contention that foreign glues are superior to domestic for this class of work. Given two solutions, of equal concentration, one of foreign glue and the other of domestic, both glues testing alike, the foreign glue will make the stronger joint for the reason that the viscosity of its solution, owing to clarification, is comparatively lower than that of the domestic glue, and hence penetrates the wood with greater ease. Too much of the domestic glue will lie at the surface of the joint, and hence, despite the fact that it is as strong as the foreign, will not make so strong a joint.

On the other hand, if the comparison be made between a foreign and a domestic glue of equal *price*, the verdict will be in favor of the domestic, inasmuch as a far stronger domestic product can be purchased for a given price. If, now, the domestic glue be brought into solution of viscosity equal to that of the solution of foreign glue, it will be found that the jelly strength of this dilution is practically equal to that of the undiluted solution of foreign glue. As a practical example, let us assume that the glues under discussion are a foreign and a domestic, each costing ten cents per pound. The test of the foreign product is apt to be no higher than 1¾, whereas that of a domestic glue purchasable for this price is likely to be 1⅜. Assuming, further, that in the preparation of the working solution, one pound of the foreign glue is dissolved in two pounds of water, since the domestic glue tests three grades stronger, to make a solution of this equal in viscosity and jelly strength to that of the foreign glue, it is possible to dissolve the domestic product, one pound in three and one half of water. Such solution will equal in penetrating power and binding strength the solution of foreign glue; and it is readily seen that it costs fully one cent less per pound solution. This must not be construed as applying equally to all domestic glues. It is not to be expected that glue made from junk bone will answer as well as hide glue for binding wood. On the other hand, a well made acid-treated bone glue, if properly applied, will make a very strong joint.

Since the *sine qua non* of a good glue for joint-work is that its solution shall properly penetrate the wood, it is important that the cabinet-maker test the viscosity as well as the strength of the glues submitted, before making a selection. While it makes but little difference, for this class of work, whether a glue is alkaline or acid, those exhibiting either of these conditions to excess should be rejected. A glue that has been prepared from over-limed stock (the evidence of which defect is extreme alkalinity), is manifestly unfit for joint-work. Such a glue is constantly weakening, even in the original dry state, and needs but to be brought into solution to promote rapid decomposition. The weakening and decomposition will proceed gradually after the glue has dried in the joint, and the joint in this way gradually weakens. Extreme alkalinity is not always evidence of over-liming; but if this be attended by abnormal viscosity, together with a tendency to foam, the glue-stock has suffered over-liming. A strongly acid glue is likely to have an effect on the wood itself, the fiber slowly yielding to the solvent action of the acid.

Of equal importance to the considerations of acidity and alkalinity of cabinet glues is the question whether the glue has an abnormally high viscosity owing to solution of soaps, alum, etc. Alum-clarified or alum-thickened glues are always to be regarded with suspicion, for, despite the clearness of their solutions, the viscosity is very high in proportion to the jelly strength. It is obvious that, in order to prepare a solution of such glue that will properly penetrate the wood, the solution becomes so dilute as to be radically deficient in glue strength, consisting largely of the salts that are imparting factitious viscosity to the solution. Similarly, hide glues, with solutions of high viscosity owing to the presence of mucin or soaps, are to be rejected for the same reason. In this connection, glues prepared from rabbit skins may be cited as typical of very strong glues that are unfit for joint work. Despite the fact that these seldom test lower than A Extra, the viscosity of their solution is abnormally high, owing to peculiar methods of treatment. The dilution necessary to insure proper penetration of the wood renders the glue very weak. These glues may always be recognized by their peculiar rabbity odor, coupled with great clearness of both dry piece and solution, the latter being very thick owing to presence of alum. Some straight sheep glues, clarified by means of alum, are equally unfit for this class of work.

That domestic glues, of good strength, answer equally as well as foreign for joint-work is evidenced by the fact that many cabinet-makers use the former exclusively. No glue consumer is more conservative and particular than the manufacturer of pianos, who frequently uses several grades of glue, both ground and flake. Some piano-makers will employ none but imported glues; others, again, none but colored and opaque domestic hide glues. No definite data as to the relative superiority of foreign or domestic glues can be obtained from a review of the opinions expressed by individual manufacturers of cabinet work. In the selection of glue for almost every purpose, custom is the controlling factor. Through long and continued use, the consumer becomes accustomed to some particular brand of glue. He has learned its limitations as well as its merits, and hesitates to make a change, even though such change might result in a material saving of money, or the procural of a superior article for the same price he is accustomed to pay, which is an equal saving. While there is considerable justification in the contention of the intelligent cabinet-maker, that one cannot say positively how a glue is going to work until actually tried and the test of time applied, much unnecessary expense may be avoided by a rational preliminary test. It is not sufficient that jelly-strength alone be roughly assayed by noting the "water-taking" properties of the glue. As has been pointed out, the viscosity of the glue solution is of equal importance. By properly testing the glues submitted for his inspection, the consumer will at once be able to distinguish them in a practical way; and, having rejected those manifestly unfit, he may then subject the balance to the test of actual work, confident at least that no work will be harmed through their use, even though they do not supply results of maximum efficiency.

In the manufacture of carriages, imported glues are used almost exclusively, the Star & Anchor being a favorite grade. Long habit in use is responsible for this, as there can be no question but that some domestic grades will work equally well. We must account for this so-called conservatism in the use of glue, in the absence, heretofore, of a reliable system of preliminary test. Having obtained satisfactory results from some one particular grade, it is but natural that the consumer should hesitate to change lest much valuable finished material be damaged. This "conservatism," however, is responsible for much useless expenditure.

Glues for Wall Paper. — In the manufacture of wall papers, glue is employed for applying the clay, paris-white, etc., with which the papers are "grounded," as well as the sizing medium for the ground colors. In some instances the top colors are applied with glue, although it is commoner practice to use dextrine or "color-size" for this purpose. In no other industry has the search for an available substitute for glue been so rigorously prosecuted as in wall paper manufacture. Keen competition, resulting in the production of quantities of papers, selling for a few cents per roll, some printed in as many as twelve colors, with mica and bronze effects, has rendered imperative the purchase of raw material, of which glue is an important part, at rock-bottom cost. Casein is the only available glue substitute for the heavier work, and has been successfully employed in times of glue scarcity and consequent prohibitive price. Sizes made by partially saponifying rosin with caustic alkali, and combining the emulsion with some starch such as tapioca or sago, have been tried without success. Their failure is due to the same causes that preclude the proper working of a number of glues, *i.e.*, they do not work uniformly with all pulp colors, causing a number to "liver." Thus, a sizing compound that may work with reds, greens, and blues may fail utterly with yellows and blacks.

In the selection of the proper glue for sizing the colors, much depends upon the colors themselves. Even the best of these are not always perfect, and the trouble arising from imperfectly or improperly sized colors is too frequently ascribed to imperfections of the glue. The same applies to difficulty arising from lack of union between the clay and glue, in the application of grounds. Difficulties of manipulation experienced at one factory will not obtain at another, for the reason that some manufacturers turn out only a very cheap line of papers, while others produce none but high-grade. It is at the works of the former that the greatest and most frequent difficulty is experienced, inasmuch as only the cheapest raw material is purchased, and cheap pulp-colors, for example, are extremely troublesome.

The importance of the relation between glue, on the one hand, and the colors, on the other, can best be understood from a limited exposition of the methods of manufacture of the latter. In order that the colors shall be at all serviceable in the manufacture of wall paper, they must be in the insoluble or lake form. Otherwise, unless they were sized to such an extent that the mixture would consist of much glue and little color, the latter would "bleed" or spread through the paper and over its surface. Again, it is not sufficient that these colors be lakes, for, were they supplied in the dry state, it would be necessary to incorporate them mechanically with water, before they could be mixed with the glue solution; and this would necessitate the installation of mixing machinery at the wall paper plant, in order that the mixture should be uniform and not gritty. Accordingly, the aniline or coal-tar color, and, in some instances, natural dye-stuffs, are precipitated from aqueous solution upon an insoluble base such as finely divided barytes. The precipitated mass is settled and, after the supernatant fluid is withdrawn, is washed several times to free it from excess of precipitant or unprecipitated color. The mass is then conducted to the filter press and much of the moisture pressed out, or else this is gotten rid of by means of a centrifugal hydro-extractor. The resultant color is in the form of a heavy paste or pulp, and in this state is readily and uniformly sized with glue solutions. Exposed to the air, the pulp colors dry out and may be triturated to an insoluble dry powder, which is difficult of uniform incorporation with water.

Pulp-colors may roughly be divided into two classes — those that are made by first suspending the dry mineral base in the solution of color prior to precipitating the latter, and those that are prepared by precipitating the base simultaneously with the color. The former are poorer in quality and are frequently deficient in color strength. The latter cost more to prepare, but are productive of far better results. As an example of each class, the following formulæ of preparation may be cited. Lemon yellow, a color much used in printing wall papers, either direct or as a reducing agent for other colors, may be made by precipitating a solution of bichromate of potassium with one of lead acetate (sugar of lead). If a quantity of barytes or other suitable mineral base be suspended in the bichromate solution prior to the addition of the lead acetate, the chromate of lead will be precipitated upon the barytes and a pulp-color, of a sort, will result. In order that the whiteness of the base shall be fully hidden as well as that the resultant yellow shall be adequately strong, very concentrated solutions both of bichromate and acetate are required. The resultant precipitate will not stand much washing, as the color is not absolutely fixed upon the base.

Contrast with the above the pulp colors prepared from Ponceaux and Bordeaux reds, nigrosines, eosines, etc., in the following way. Four solutions are prepared, one of calcined soda ash (carbonate of sodium), one of barium chloride, one of magnesium chloride, and one of caustic soda. The color to be precipitated is separately dissolved in water, the amount of color used being subject to the shade desired; and to this solution of color is added a proportion of the above in the order in which they are named. The carbonate of soda does not affect the color, but the barium chloride precipitates it and at the same time reacts with the sodium carbonate to form insoluble carbonate of barium. Similarly, the caustic soda and magnesium chloride react to form insoluble hydroxide of magnesia. The insoluble basic precipitates, being formed simultaneously with that of the color itself, are more finely divided than if corresponding quantities of barium carbonate and magnesium hydrate had first been mechanically suspended in the color solution, and the color precipitated upon them by means of barium chloride. Again, the amended procedure insures the intimate incorporation of precipitated color and bases, which it is otherwise practically impossible to obtain.

This digression from the subject in hand to that of pulp-color manufacture is deemed necessary in order that the working of different glues with different colors may be fully understood. Since so many ingredients enter into the composition of a pulp-color, and the cheaper are poorly fabricated, often containing an excess of precipitant, from what has been said in previous chapters as to the effect of divers chemical reagents upon glue, it is of the greatest importance that the colors be free of all material tending to react with the glue used for sizing them. Conversely, it is of equal importance that the glue be free of substances that may react with any excess of precipitant in the colors. Far greater latitude is to be exercised in the selection of the glue for sizing, than of the colors to be sized. A given shade of color may be obtainable only through the use of certain chemicals, and since this shade may be essential to the requirement, it becomes necessary to adapt the glue to the color and not the color to the glue. For example, it is difficult to prepare Prussian blue lakes that are not greenish, and their manufacture involves the use of a number of chemicals without which the desired shade could not be achieved. Despite the fact that such colors are known to be excessively over-loaded, the wall-paper manufacturer has no alternative save to use this color and find a glue that will work properly with it.

To return to the colors themselves. Since these must cost as little as possible, the manufacturer of them is under necessity of selecting, for the base, such materials as are cheap and heavy. A definite quantity of color is required to produce a given shade, and the color must be of good quality. Hence there is no opportunity of reducing the cost at this end. Therefore, if the color maker is to produce an article of standard shade at low cost, and still make a profit, he must make his colors as heavy as possible. How this is accomplished will be readily seen from the following practical formulas:

1. EOSINE LAKE (TO MAKE 1260 LBS.)

136	lbs.	Soda ash.
200	"	Sulphate of alumina.
350	"	Chloride of barium.
100	"	Lead acetate.
75	"	Eosine.

Exclusive of eosine, the above costs about $1.80 per 100 pounds.

2. Bremen Blue (to make 750 lbs.)

136	lbs.	Soda ash.
200	"	Sulphate of alumina.
350	"	Chloride of barium.
50	"	Barytes.
5	"	Malachite green.
8	"	Tannic acid.

Exclusive of colors and tannic acid, this costs about $1.70 per 100 pounds.

3. Turkey Red (to make 700 lbs.)

75	lbs.	Soda ash.
150	"	Sulphate of alumina.
210	"	Chloride of barium.
200	"	Barytes.
30	"	Scarlet.
30	"	Orange.

Cost of the above, exclusive of colors, $1.40 per 100 pounds.

4. Maroon (to make 1800 lbs.)

150	lbs.	Soda ash.
300	"	Sulphate of alumina.
420	"	Chloride of barium.
10	"	Soap.
300	"	Barytes.
80	"	Scarlet.
14	"	Fuchsine (magenta).

Cost of the above, exclusive of colors, about $1.10 per 100 pounds.

The difference between the sum of the constituent weights and total product, in all of the above, is water. These may all be somewhat cheapened by the substitution of calcium chloride of good strength for the chloride of barium.

It is now seen that the constitution of the average pulp-color is far more complex than its appearance would indicate, and is anything but the simple result of precipitating the color upon a single insoluble base. It is obvious that where so many widely divergent chemicals enter into the constitution of a product, and where, particularly, their proper inter-reaction is dependent upon certain mechanical or physical factors, it is highly probable that they will contain an excess of one or more materials that will either affect the glue or be affected by some substance which it contains. In the case of Bremen blue, for example, if there be any excess of tannic acid, it is not difficult to forecast what will occur when this is brought into conjunction with the glue solution. The insoluble, stringy precipitate of tannate of gelatin, even though small in amount, will be sufficient to "liver" the sized mass. In the case of the maroon, the presence of soap may or may not prove detrimental. This will depend upon what kind of soap is used.

Since the colors, as such, must be accepted and used, the glues for wall paper must be chosen with a view to their possible effect upon the colors, rather than of the possible effect of the colors upon the glue. The glue may be neutral or it may be acid or alkaline. How will either of these latter conditions affect the colors in use? The careful examination of the glue for foam is necessary, not only because of the mechanical difficulties that may arise from this cause, but also to determine if the cause of the foam is some glue substance that will affect the colors. Grease, in excess, unfits a glue for wall-paper work, but not for the usually accepted reason. The ash of the glue revealing chemical salts, the query follows, are these present in sufficient quantity to react to disadvantage with the colors? Each of these contingencies is worthy of individual consideration.

Acidity and Alkalinity. — Were the glue employed for sizing gold or aluminium bronzes, the question of acidity or alkalinity would be entitled to greater consideration than it is. The moderate amount of alkali or acid present in glue is not apt to affect the colors so far as changing the shade is concerned. Once precipitated, colors are not so susceptible to the action of acid and alkali as before precipitation. The chemist has only to view either of these conditions from the standpoint of their possible reaction with substances present in the colors; and, save within the limits previously defined, viz., acidity or alkalinity in excess due to defects of manipulation, these may be disregarded.

Grease. — A popular superstition exists among wall-paper manufacturers, to the effect that greasy glues are to be avoided because of the likelihood of their making grease spots in the paper. That this belief is without foundation is evidenced by the fact that for many years the Baeder, Adamson B4, a markedly greasy glue, was the favorite brand for wall-paper use. It is common practice, even at the best plants, whenever trouble arises through the foaming of glue and clay, or glue and colors, to "kill" the foam by the addition of lard oil, or grease and soda emulsions, to the mass. If the addition of grease itself, in this way, does not result in the formation of grease spots, it is to be assumed that the grease in the average glue never will. An excess of grease in a wall-paper glue is to be avoided chiefly on account of its possible action with the colors. While, on the one hand, grease does much to prevent foam, and very frequently has a brightening effect upon the printed colors, on the other there is always the possibility that there are substances in the colors which will convert the grease into insoluble metallic soaps which will certainly interfere with the uniform flow of the sized colors from the printing machine.

In applying the test for grease in the wall-paper factory, it is advisable to use the ungrounded hanging stock itself for the purpose, and to incorporate the glue solution to be tested with a standard pulp-color. In this way, a glue that might exhibit considerable grease if painted out with a plain aniline color, will in all probability exhibit none at all when a pulp-color is used, as the porous base of the color will absorb it. If, on such test, no grease permeates either color or paper, the glue is not too greasy for use; and it may be added that a glue that fails to qualify under this test is rarely to be found. Unless it is known that the colors contain excesses of material that will be affected by the grease, or affect it, it is wiser to choose a greasy glue in preference to a grease-free, as the grease will promote uniformity in the flow of the color from the roller of the printing machine. Many patent sizings are characterized by the addition of soap to the glue and base, as the former promotes the "slip" of the size. Grease itself will act in much the same way, and is so rapidly absorbed by the porous bases of the colors that it cannot interfere radically with the drying of the printed colors.

Foam in Wall-Paper Glues. — The same considerations limiting the acid, alkali, or grease in wall-paper glues apply to the presence of foam. When trouble arises from this source, it is well to investigate the colors, rather than the glue, unless the latter, on preliminary test, was found to be foamy of itself, in which case it should never have been selected for the work. The chemist at the wall-paper factory will do well to observe the following, in testing glue, apart from determining viscosity and jelly strength. If the glue reacts strongly alkaline with litmus — and by this is meant, if it turns the litmus a very deep blue — the glue should at once be tested for foam, and if found to be foamy should be rejected without further examination. If the glue be only slightly or moderately akaline, the foam test may be relegated to its proper place in the general test scheme. Extreme alkalinity points to over-liming, which means that the glue will foam badly in solution and also that it contains mucin and soaps which will not affiliate with the colors or clay. In certain quarters there exists a prejudice in favor of alkaline glues, based upon the assumption that the alkali brightens the colors. The contention has its origin in the fact that preparations like "Tenacetine," which are powerfully alkaline solutions of starches, certainly brighten the printed colors to some extent. Such preparations are advocated for use in conjunction with the glue solution for sizing the colors, it being claimed that they increase the tenacity of the mass so sized. What has been said in previous pages in regard to glue substitutes applies equally to these preparations.

Viscosity of Wall-Paper Glues. — In the selection of wall-paper glues, certain mechanical considerations claim attention. Since the sized colors are applied from a roller, or, in the case of hand-printed papers, from a block bearing the design, the flow of the glue solution is a factor of considerable importance. The lower the viscosity of its solution, the better is a glue adapted to sizing work. Wall-paper manufacturers usually employ two grades of glue, one comparatively cheap and used with the clay, etc., and the other of better quality, as it is used for sizing the chief colors. The latter is usually from three to four grades stronger than the former, which is, as a rule, a bone glue, but in some instances a hide, like the better quality. The strength of these is of less importance than their facility of flow and surface-covering qualities. True, the stronger these are, independent of abnormal viscosity, the more economical in use, for the same reasons applying to cabinet glues.

In connection with the sizing of pulp-colors, we have again to compare the relative adaptability of foreign and domestic glues to a particular requirement. Foreign glues work exceptionally well in wall-paper work, as the viscosity of their solutions is such that they flow with the utmost readiness. Their serviceability is enhanced by the fact that, owing to clarification, nearly all those substances tending to affect or to be affected by the colors have been removed. Despite this, comparatively little straight foreign glue is used by American wall-paper manufacturers. Some avail themselves of acid-treated bone glues which answer equally as well as the imported. Save such as employ a chemist to examine the raw material purchased, the majority have not the slightest idea what kind of glue they are buying, and the purchasing department bases its verdict upon the opinions of the color mixers. It is obvious that colors will not show to equal advantage, if printed with a cloudy glue, to those printed with clear. Hence it is to the interest of the manufacturer to use clarified glues. These, however, must be carefully selected and examined, for the reasons enumerated above.

In the general testing of wall-paper glues, those with abnormally high viscosities must be rejected, as this peculiarity is due to the presence of substances that will react to disadvantage with the colors. Preferably those glues which, in solution, display viscosities disproportionately low to the jelly strength should be selected. These will give the best results with colors.

The bulk of glue consumed in the wall-paper factory is in the ground form. In no other class of work is thorough and rapid solution of the glue so to be desired. Apart from facility in use, ground glues are of advantage in that two or more grades may be so mixed as to produce a glue fully answering all requirements as to flow and strength.

Attention is directed to the futility of "testing" glues by determining the specific gravity of solutions of equal concentration, the measurement being effected by means of a hydrometer. This practice is altogether too prevalent in our wall-paper factories. The same factors that unduly increase the viscosity, such as soaps, mucin, alum, etc., will increase the specific gravity, and hence this, *per se*, is as little indication of glue strength as is viscosity. Intelligently applied, the specific gravity test may be substituted for the determination of viscosity. Its intelligent application, however, presupposes a thorough acquaintance with the viscosity test; and, as the latter is but little more complicated, its use is to be recommended.

To recapitulate, good wall-paper glue should be of adequate tensile strength, 1⅝ for the grounds, and at least 1⅜ for the colors. The glue to be used with the clay and in the coarser work should preferably be an acid-treated one, provided this is not too acid in reaction. Some clays are in a measure disintegrated by excesses of acid or alkali in the glue. This may or may not cause foaming of the mixture, but is sure to make it lumpy. The viscosity of the glue destined for the work must be normal or sub-normal. Not more than traces of mucin, soaps, and foreign salts must be present. Glues that are slightly colored work to advantage with the grounds. They do not work so well with delicate colors where clearness is desired.

Glues for Surface-Coated Papers. — Much, if not all, of the foregoing is applicable to the selection of glues for surface-coated or glazed papers. It does not follow, however, that any glue adapted to wall-paper work will answer this particular requirement. Exceptions, due to a difference in the result to be obtained, must be considered. Thus, the glue employed in this work must, as a rule, be clearer than that used for wall paper, for not only is a high gloss in connection with the color required, but more glue is used in sizing the colors. Hence any cloudiness of the glue is apt to result in dulness of the coated paper. Again, the glue must be fairly strong, corresponding to the better grade employed by the wall-paper manufacturer. It suffices the latter if the sized color, when dry, yields but a little when rubbed with a sheet of clean paper. With glazed papers, however, the color must be bound with sufficient firmness so as not to rub off at all. As a rule, a better quality of pulp-colors are employed in the manufacture of glazed papers than are in the printing of wall papers. Despite this, the same precautions governing the selection of glue, as to the possibility of its affecting the colors, are to be observed.

Since great clearness of the colored surface is a requisite, foreign glues are extensively used in the preparation of glazed papers. Domestic acid-treated bone glues answer well and are frequently used. A water-proof coating is made by sizing the colors with a solution of shellac in wood-alcohol, crude acetone, or other solvent. Such surface, while water-proof, has not the clearness of the glue-sized surface. Some prepare a sizing medium by dissolving shellac in a strong, aqueous solution of borax. So long as the alkali is present, this cannot be water-proof and has not the clearness of good glue. A far better result is achieved by adding a proportion of potassium or ammonium bichromate to the glue solution, and exposing the coated papers to the influence of sunlight for a time, which renders the coating practically water-proof. This practice is attended with some risk, however, as every glue will not admit of treatment with a bichromate without suffering damage. Again, the colors themselves may not be permanent and the subsequent exposure to sunlight may cause them to fade. The cheaper varieties of surface-coated papers are prepared by coating them with a mixture of unprecipitated aniline color, sized with casein. The use of casein in this connection is subject to the same limitations restricting it as a sizing medium for wall-paper colors.

Glues for Paper Boxes. — While many glue substitutes will answer for paper-box making, a cheap grade of glue is usually employed for the heavier work, and substitutes, such as Boston gum and Liquid Glue, for the lighter. The average paper-box maker seldom pays more than six cents per pound for glue, and at this price only a weak product may be purchased. This usually tests No. 2 and rarely exceeds 1¾ in strength, averaging 1⅞. Ground glues are always used, and these, as a rule, very dirty. The standard grade of paper-box glue is the Swift Box. This is a medium brown, low-grade hide, averaging, in test, 1⅞. Very similar to this is the Nelson Morris No. 92. It must not be inferred that these are the only glues fit for paper-box making. They are merely cited as types.

Almost any glue, weak or strong, that is properly made and sweet in odor will answer for this class of work. Apart from the considerations that an evil-smelling glue is to be avoided and that the boards used for colored boxes are, as a rule, so cheap and poorly colored that alkali or acid in excess is likely to spot them by discharging the color, no particular examination of the glue is required, save to determine whether or not the glue has adequate binding strength. Fully 99 per cent of the trouble experienced by paper-box makers is due to their own carelessness. Owing to a deplorable ignorance of the elemental properties of glue, it is constantly exposed to influences and conditions that cannot fail to impair its efficiency. The melting-pot is exposed to the dust of the work-room and it is a common spectacle to see strips of board, sticks, and other refuse floating in the glue solution. Frequently muddy water is used to dissolve the glue. Intelligent application is essential to the successful working of glue for any purpose; and the fact that the paper-box manufacturer need not exercise the care in the selection of his glue that is demanded of the cabinet-maker, for example, does not warrant the lax methods of treating the glue in vogue at the majority of paper-box factories.

Glues for Sizing Work. — Glue, as a general size, is employed largely by the house painter, either for the treatment of walls before painting or calsomining, or as the binding medium for the calsomine itself. Fairly cheap opaque glues are in great demand for this class of work, custom having decreed their use. These glues, known among the painting fraternity as "shell" glues, since, by a stretch of imagination, they may be said to resemble certain varieties of *laminaria,* are frequently made from pig stock, colored by the addition of very cheap material. Several grades of these are produced, the better testing as high as 1½, while the poorer average 1⅞ to 1¾. That a pale-drying, uncolored glue answers the purpose as well, if not better, is indisputable, the inferior coloring material of these opaque glues often working to disadvantage. Of late years, prepared sizes have come into the market, consisting of mixtures of chalk and glue, clay and glue, whiting and glue, or chalk, clay, whiting, and glue, sometimes with the addition of alum and soap. To prepare these for use, it is but necessary to add boiling water, in the required proportion. The painter frequently desires to prepare these sizes for himself; and in this connection it must be pointed out that the selection of the glue for the size is largely dependent upon the nature of the materials to be sized. To work properly in so strange a combination as the above, it is essential that the glue be comparatively pure, that is, containing no residual salts that are apt to react with the other ingredients of the formula. The selection of glues for these combinations presupposes their careful analysis. Since the flow of the glue is of importance, those with low viscosity in solution are to be given preference. At the same time, the glue must be fairly strong, in order that a minimum may suffice to bind the basic material of the size.

Glue is frequently used as size in the manufacture of cotton batting, and it is customary to prepare a sizing solution such that, when applied to the cotton as it passes into the drying machine, it is absolutely dry as the roll emerges from the machine. Comparatively few glues fulfil this requirement, despite the fact that the temperature of the drying room averages 200° F. The absorbent nature of the material sized is a source of unending trouble, too thin a solution of the glue being totally absorbed, with the result that the material emerges from the drying machine stiff as board. On the other hand, too heavy a solution of the size lies all at the surface, and does not dry with sufficient rapidity, despite the high temperature of the apparatus. To obviate this difficulty, it is customary to treat a very dilute solution of a fairly strong, clear glue with sufficient alum to thicken it. Herein lies a source of danger. Many glues are precipitated with alum, particularly if the mixture of glue and alum remain warm in the kettle for some hours. This precipitate cannot again be brought into solution without the aid of acetic acid, and, while the supernatant fluid has weak sizing properties, it has absolutely no binding strength. Even though the glue is used up before the precipitate has a chance to form in the kettle, the extreme temperature of operation is apt to cause its separation before it dries, and the work becomes "streaky," clear in spots and cloudy or dense in others. It is essential, therefore, if it is intended to thicken the glue with alum, that a preliminary test of the glue be made in the following way: One pound of the glue is dissolved in fifteen of water. To the hot solution is added about 10 per cent of alum, and the mixture is kept hot (without actual boiling) in the kettle over night. If any precipitate forms under these conditions, the glue is not fit to be used as a size in conjunction with alum. If none forms, the glue will work excellently under these conditions.

This applies equally to the selection of glues for use in conjunction with alum and clay, alum and chalk, etc., to which soap is to be added to promote the slip of the size in application. The glue must be carefully tested in the presence of all the ingredients with which it is to be combined, individually as well as collectively, and any adverse result noted. The necessity of great care in the selection of glues for the manufacture of prepared calsomines, particularly the colored varieties, cannot be over-emphasized.

Glue in Textile Manufacture. — In the manufacture of silk, wool, and other fabrics, glue plays an important part, either in conjunction with the dyeing processes or as a finish. It finds considerable application to the manufacture of carpets, as well as special wall-coverings such as burlaps and tapestries. An exception to the rule that glue strength is of the first importance is to be noted in this connection. Since, in all these cases, the glue is used as a size in very dilute solution; and since it is brought in contact with sensitive colors, *purity* is by far a more important consideration than glue strength. Analysis of the glue destined for use in textile manufacture is essential in order that it may be established beyond peradventure of doubt that no deleterious substance is present in the glue. For example, the presence of mineral acids and normal sulphites in a glue renders its use hazardous in the manufacture of woolens, since any notable proportion of these impurities will reproduce light patches on dyed wool. Black woolens owe their color to logwood (hæmatoxylin plus hæmatin) mordanted by the oxidizing influence of a chromium salt. The logwood itself contains considerable glucose, since this is employed to impart the necessary gravity to logwood extracts. It is difficult to combine glucose and solutions of glue. True, the glue solution is applied *after* the logwood, with its constituent glucose, has dried; but it is not to be denied that the water of the glue-size has a solvent action on the glucose of the fiber, the glucose not being affected by the chromium salt. Hence, while the reaction between the finish and the glucose of the fiber may be so subtle as not to be at once manifest, it will nevertheless proceed, and at a later day, long after the shipment of the goods, they may be ruined by spotting, etc.

Silk finishing involves the use of more or less glue, which is used in conjunction with dextrines and starches. That a preference should be expressed for very pale glues is but natural, in view of the fact that these dry with a very transparent coating, especially if applied dilute. At the same time, the use of very pale glues for finishing fabrics of any kind is attended by constant risk. The glue owes its very paleness to the fact that the liquors have been bleached with sulphurous acid, traces, and frequently more than traces of which remain in the glue, as well as salts of sulphurous acid. If these are a menace in the finishing of woolen fabrics, their action is all the more inimical to colored silks, in the dyeing of which far more delicate colors are used. A given shade on silk is produced by the combination of the minimum quantities of several different colors; and a glue used for finishing the silk, if it contain any of the above impurities, is apt to discharge one or more of these, producing spots of the fastest color. Those familiar with the methods of the color-chemist in "discharge work" will have no difficulty in comprehending this phenomenon. A pale blue silk, for example, may be produced by dyeing with a fast red in combination with a blue and a violet. Sulphurous acid will discharge the blue and the violet, revealing the red and causing the silk to be covered, apparently, with red spots.

In many instances, silks, particularly black silks, are treated in the dye-house with glue in conjunction with the finishing emulsion of oil, acid, and soda. As a rule, a good quality of gelatine is used, the object being to correct any hairiness or fuzz of the silk produced by extreme temperatures in the dyeing. Dark imported glues answer as well as gelatine for the purpose and are cheaper than gelatine. It is essential that the glue used in this way, or for finishing purposes, be a clarified one. This assured, the color is of little importance, and it is always safer to use a rather dark glue than a light one, for the reasons above mentioned. A dilute solution of dark clarified glue dries to a remarkably light, transparent coating, and may be used for all save pure white silks. In addition to the regular test preliminary to purchase, the dyer should treat dilute solutions of the glue with all the colors he employs, permitting the mixtures to stand for a day or so that any untoward effects may be noted. The finisher, not having definite data as to how each shade of silk has been produced, should subject the glue or gelatine to rigorous analysis and reject those exhibiting any sulphurous acid and more than traces of other mineral acids and salts.

Glue for Matches. — The manufacture of matches is attended by considerable difficulty owing to the nature of the ingredients used. As to the identity of the individual ingredients, no secrecy exists; the art lies in their proper combination. The general formula for parlor matches is, glue, phosphorus, chlorate of potash, whiting, plaster of paris, and rosin. The glue serves to work these into a hot paste into which the ends of the match-sticks are dipped.

It is readily seen that in so strange a combination of materials, every glue will not work. It is stated upon authority that, unless the customary proportions of the above ingredients are radically modified, none but imported glues will answer. The Irish Block C. and Block C. L., and the Walsall of English manufacture, are the standards of match glues. Domestic glues have been used with success, but are troublesome in operation owing to the necessity of radically modifying the formula.

Glues intended for use in match making should be subjected to careful analysis as well as tested for strength. The function of the glue is not merely as a binding medium for the mineral ingredients. It is largely depended upon to prevent atmospheric oxidation of the phosphorus. Accordingly, it must be certified that the glue contains nothing likely to affect the phosphorus, in addition to exhibiting a fairly water-proof coating when dry.

Comparison of Straight and Mixed Ground Glues. — Although ground glues are invariably regarded with suspicion, much of the popular prejudice against their use is unwarranted. To suggest to some consumers that they are using a mixed glue is to seriously affront them. They at once conceive the idea that the glue is worthless, and that an attempt has been made to defraud them. While it is true that the dealer frequently mixes ground glues for the purpose of cheapening them, his motives in so doing are not always ulterior. Not only are ground glues most convenient in use, as they require but the minimum soaking or softening prior to melting, but they offer many advantages over flake, in that they may be made to conform more nearly to a given requirement. The dealer who is conscientious in the endeavor to sell glue on "test," that is, to match the samples he submits with those submitted to him by the prospective purchaser, has often to mix one or more glues in order to obtain a product conforming in strength and viscosity or other factors with those of the samples submitted to him. It is at times possible to mix two or more grades of flake, with the same object in view. Hence the fact that the dealer submits a sample of mixed glue must not be always construed as an attempt at deception.

Recapitulatory Remarks. — The uses of glue herein enumerated represent but a small proportion of its possible applications. They are cited as typical of the limits of application, by which is meant the least and the greatest that is expected of glue in actual work; and are chosen with a view of impressing upon the glue-user the fact that it is adverse to his interests to regard glue as so much cheese, to be bought, consumed, and the stock replenished. It lies within the power of every consumer, small or large, to control the quality of a material for which he expends considerable in the course of a year. He has but to apply the rules of common sense to its selection and application in order to obviate 90 per cent of his "troubles." Price has often to be relegated to second place in selecting glues, although it must always be considered. For many purposes, an impure glue is dear at any price. In other instances, to spend a few cents more per pound for glue is to effect an ultimate saving, paradoxical as this may seem. He who wittingly fails to test glues prior to purchasing them and to insure that delivery is as per sample, on the ground that his time is too valuable to be devoted to such purpose, is assuredly "penny wise and pound foolish." He is a veritable mark for the unscrupulous salesman, who with glib argument, backed by a minimum of scientific fact, has no difficulty in persuading him that a glue that smells to Heaven has absolutely no odor.

CHAPTER VII

HOW GLUE SHOULD BE USED

It would seem superfluous, after discussing in detail the nature and properties of glue, as well as emphasizing the necessity of exercising the greatest care in its selection, to remark that its success in work will depend in a large measure upon intelligent preparation and application. The normal and logical inference is that this principle is self-evident to him who uses glue constantly; yet a careful study of the situation reveals the fact that a number of consumers are totally indifferent to first principles in the preparation of glue for work, and that many, of seeming intelligence, entrust the melting and distribution to those who are ignorant of its very nature and seemingly regard it as less worthy of consideration than the sweepings from the factory floor. The average dealer in glue is the recipient of so many and varied complaints regarding the product he supplies, the majority without justification, that it becomes necessary, in fairness to him, to call attention to the fact that he is often as little to blame for the difficulties experienced with glue as he is for an unexpected fall of rain. The commonest complaint in regard to glue is that it has a bad odor. Harrowing tales are heard by the dealer regarding the number of employees who were compelled to suspend work owing to the unbearable stench arising from the glue which he has supplied. Quiet investigation reveals the fact that the glue melting-pot has not been cleaned, say for six months, and that there is nothing "off" in the odor of the glue. The author has seen this trouble arise only too frequently in wall-paper factories, where the carelessness of the men in respect to cleaning the melting-pots is proverbial. It is no exaggeration to state that 80 per cent of the difficulty experienced with glue arises from carelessness or ignorance upon the part of the user, and that the remaining 20 per cent may be legitimately ascribed to the glue itself.

The adage, "Cleanliness is next to godliness," has a beautiful and significant application to the preparation and treatment of glue, not only in regard to melting it, but also to its distribution and other factors. Storage under adverse conditions will ruin glue long before it is used. In the matter of assimilating foreign odors, some glues are extremely sensitive and hence should not be stored with odoriferous chemicals, crude carbolic acid in particular. It is the practice of some consumers to store glue in damp and even wet places, and subsequently complain that it contains undue moisture or is moldy. Others, again, unhead the barrels prematurely, exposing the contents to dust and dirt which, when the glue is brought into solution, accumulates at the bottom of the melting-pot, thus contaminating subsequent melts, or, if the solution is heavy, remains suspended therein and soils the work. While the consumer frequently has cause for legitimate complaint, it would redound to his credit if he would but apply the rules of common sense to the treatment of the glue.

Soaking or Softening Glue. — Considerable difficulty in manipulation arises from faulty practice in this respect. Precautions must be observed that will insure the uniform softening of the glue prior to melting. To this end, if in the form of flake, sheet, cake strip or ribbon, it should first be broken into small pieces with a hammer. It is essential that all the glue be immersed in the water. If pieces are permitted to stick out beyond the level of the water, the natural result is that such pieces will be only partially softened. When the melting proceeds, these will slip to the bottom of the kettle, and, in order to melt them, protracted heating at an excessive temperature is required. This means the radical impairment of the strength and adhesiveness of the glue.

In the case of extremely thin-cut, high-testing glues it is often impossible to have all immersed uniformly, unless the melting-pot be capacious. Such glues are very light and hence the required weight frequently represents considerable bulk. The needful quantity of water may fail to cover one half or even two thirds of the glue in the pot, with the result that the uncovered portion is not softened. This difficulty may be avoided at the expense of minimum time and trouble. Thin-cut, high-test glues absorb water rapidly, and hence if the requisite quantity of water is first placed in the melting kettle and the glue added little by little, each portion will soften rapidly and may then be shoved down toward the bottom of the kettle to make room for the addition of the remaining portions. In this way the glue will be uniformly softened.

Even though the pieces are well covered with water, it is necessary that they be stirred in the latter, when it is added, to insure uniform wetting. If this precaution is neglected, pieces will adhere to each other and the center of such masses will be quite hard even though the exterior is well soaked. These partially soaked masses require protracted heating at the expense of the whole solution, in order that they shall melt.

The usual practice in wetting ground glues is to place the glue in the kettle and then pour on the water, stirring the while. No matter how carefully this is conducted, particles of the glue will rise to the surface of the water and float there, and, coming in contact with the sides of the kettle, stick there, giving up any absorbed water with great rapidity and so do not dissolve. This very objectionable feature may be avoided as follows: Put the glue in the kettle and add about half of the requisite quantity of water, stirring the glue with a stick, beginning the stirring before the water is added and continuing until the glue has absorbed as much water as it will. Now add the balance of water, stirring the while. Through the absorption of water from the first portion added, the glue becomes much heavier and when the balance is added there is no possibility of particles floating at the surface.

Melting the Glue. — Two forms of melting-pot or kettle are commonly known, the one jacketed, and the other in which steam is introduced direct or "live." The former is the better. Direct steam is injurious to solutions of glue, the drastic action of the steam rapidly weakening them. If a solution of A Extra be boiled continuously with direct steam for a period of twenty-four hours, the gelatinizing power of the glue will be destroyed. The gelatinizing power of weaker glues is destroyed in correspondingly shorter time. If a solution of glue is boiled with direct steam for one hour, it will lose a grade in strength, and a half-grade if kept at 200° for one hour in a jacketed kettle. It is to be borne in mind throughout the melting of the glue, that no more heat is to be applied than is absolutely necessary. If direct steam is employed, it is folly to boil the water until all is dissolved; besides, it is not necessary to do so. Let the steam pass through the water until the temperature is 180° F. If no thermometer is at hand to measure the degree of heat, this may be approximately gaged by the cessation of the characteristic rattling noise produced by steam when passed, under pressure, into cold water, and is supplanted by a subdued rumbling. When this degree of heat is reached, *cut off all steam* and stir the contents of the kettle until all the glue is uniformly dissolved. If the glue has been properly softened, it will dissolve at a low temperature.

Under no circumstances should hot or even warm water be poured upon dry glue. The heat, so far from facilitating the softening, actually retards it, if not preventing it altogether. We have a parallel phenomenon in the treatment of iron with nitric acid, the action of which is first violent and finally ceases altogether, owing to the fact that a slight film of oxide of iron is deposited upon the surface of the metal undergoing solution. This is repeatedly dissolved and redeposited by the acid. In order to promote the solution of the metal, it becomes necessary to pour off the acid and wash the metal well with pure water.

When the acid is returned, it again attacks the iron violently. The action of the hot water on the glue is to dissolve a little, which, when once in solution, seems to retard, if not altogether prevent, the further absorption of water by the glue. This may easily be verified by preparing a 2 per cent solution of glue and placing in this a piece of glue to be softened. It will be found that a much greater time is required than if the piece had been immersed in pure water.

Where steam is not available for melting the glue, and the direct heat of gas or oil has to be used, the melting-pot must be jacketed, as otherwise the solution will burn and char. The outer jacket is to be filled with water, which, when brought to the boil, will impart sufficient heat to the water of the inner vessel to melt the glue. Once the water in the outer jacket is at the boil, the heat should be withdrawn.

The facility with which glue melts will depend upon its proper softening. If this detail is attended to, there should be no difficulty in obtaining a uniform melt at the minimum temperature. In reply to the oft-emphasized dictum that the glue solution should not be kept continuously at a high temperature lest the adhesiveness and strength of the glue be impaired, it is justly contended that, since the solution must be hot in order to be effective, especially in joining wood, it is imperative that the melt must be kept at a certain degree of heat in order that time shall not be lost by having to stop work to reheat the cooled or jelled solution. Since this continuous heat is maintained to save time in work, it is inevitable that a skin form on the melted glue, which, brushed aside, clings to the pot and dries there, usually beyond the level of the water added for the next melt. How continued high temperature, and consequent formation of skin may be avoided, will be seen further on.

Cleaning the Melting-Pot. — Not only is it essential that the melting-pot be kept scrupulously clean in order that there shall be no gradual contamination of the glue, but much waste of material is avoided through this observance. Dirt enters the melting-pot through the glue itself, the introduction of dirty brushes, or the exposure of the pot to dust, etc. If glue is melted in a dirty pot, the skin forming on the surface of the melt gradually accumulates at the sides of the kettle and slowly decomposes. This may or may not fall into subsequent melts, thus contaminating them. The only way to make sure that it will not do so is to clean the pot.

Much unnecessary waste of glue may be avoided through observance of the following procedure. The contents of the melting-pot exhausted, scraps of dried glue, as well as scraps of partially dried jelly adhering to the sides, should be detached mechanically, as thoroughly as possible, and examined. If clean, they may be replaced at the bottom of the kettle; if dirty, they are to be set aside temporarily. In the first instance, they are covered with the minimum of water necessary to soften them and the sides of the kettle swabbed with a little water in order to soften any glue that has dried and not been detached mechanically. The pot is then gently heated in order to bring the scraps into solution, this solution used in work, and the pot thoroughly washed out with hot water and cooled before soaking a fresh portion of glue. If the scraps have proved dirty, but not sour, they may be re-melted in a separate kettle and the solution kept warm enough to permit the dirt to settle, when the supernatant glue may be used without risk. If sour, they must be thrown away. If the glue pot is properly cleaned, there is no danger of souring, and thus all the glue may be used without waste. It may be contended that much labor may be saved by adding sufficient water for the next melt, and through this means soften all glue adhering to the kettle in conjunction with that added fresh. It will be found, however, that the freshly added glue will absorb the bulk, if not all, of the water, leaving adhering scraps practically unsoftened, which in this way continue to accumulate, interfering with the proper working of the glue.

Distributing the Glue. — The most economical method of handling glue is that adopted at a number of progressive factories where large quantities are consumed. The glue is first softened and melted in a large central kettle, the solution being made very concentrate so that a stiff jelly results. This jelly is then divided into small portions and distributed among the workmen, whose benches are equipped with small melting-pots. The workers have then merely to re-melt the jelly with the addition of water, this re-melting requiring but a minimum temperature. The advantages of such system of distribution are, first, that but a minimum of glue is apt to be damaged in the melting, as this is entrusted to some one who understands what he is about; second, that there is comparatively little or no waste of the glue, the portions of jelly distributed being carefully checked, and it is thus seen that no workman uses more glue than another for a given purpose. Thirdly, the danger of contamination by dirt or partially foul scrap from previous melts is reduced to a minimum, as there is but one large kettle to clean, and the cleaning of the smaller bench-kettles is readily effected. The chief disadvantage of the system arises from the fact that glue, in the form of a jelly or in solution, is far more prone to decomposition than when dry. Unless the system is so regulated that the minimum amount of jelly is prepared and distributed so that it will be rapidly consumed, loss is apt to be occasioned by the souring of the jelly, especially in warm weather. This difficulty may be obviated through the judicious use of any preservative save formaldehyde. The addition of a small amount of pure carbolic acid, for example, will insure against decomposition of the jelly for a day or so, and will not impart sufficient disagreeable odor to affect the work. If the use of preservatives is objected to, the keeping quality of the glue may be enhanced by pouring the solution of glue into small tin boxes to jell. These should be provided with a tightly fitting cover and should always be kept closed save when portions of the jelly are to be withdrawn. Definite quantities of glue jelly may in this way be distributed, as boxes holding one pound, or any other desired quantity, may be selected for the purpose. The atmosphere excluded as far as possible, the glue will keep well. In jelling the glue, the cover of the boxes should be left off until gelatinization sets in.

Davidowsky points out that, while glue is fresh made, every addition of water will, up to a certain point, increase the adhesiveness and elasticity of the glue.

This is true only of glue in the form of jelly, and the fact is largely commendatory of the system of at once converting the glue into a stiff jelly and then distributing this for use. This practice certainly increases the water-taking quality of the glue. Even as glue stock yields more and more glue as water is added up to a certain limit, so glue itself would seem to yield greater strength and adhesiveness to large quantities of water than to small. From this it would seem that glue, as prepared from the stock, is never chemically complete, but requires the addition of water and subsequent treatment with heat in order that the hydrolitic action, to which it owes its very nature, shall be completed. This peculiar behavior of glue jelly would further indicate that gelatinization is attended by partial reversion to the form of the glue-yielding elements of the stock, and that when the jelly is treated with additional water, an increase of actual glue is effected.

CHAPTER VIII

COMMERCIAL AND LEGAL ASPECTS

Trade Conditions Affecting the Price of Glue. — Close study of the glue industry reveals conditions extant in few, if any, other lines of business. The laws of supply and demand, universally recognized as the basic influences affecting the price of any commodity, are here factors of but secondary importance; and, while it is true that the price of glue is subject to the same natural trade influences affecting the majority of manufactured products, such as *cost of production*, which, in turn, is subject to scarcity of stock or lack of economical processes of production, and *scarcity of glue* itself, the glue market is in the main controlled by purely artificial considerations. Few, if any, products require the selling argument necessary to dispose of glue, an argument that draws freely upon the realm of fiction for its presentation.

It is an established and accepted principle, among manufacturers and dealers, that the market price of glue is any price that can be obtained. Under existing business conditions, this applies, to a limited extent, to any manufactured product. The seller of any commodity will take advantage of the credulity of the purchaser in the endeavor to realize an increased profit; but the seller of glue has far greater latitude in this respect, inasmuch as the commodity in which he deals is but little understood and is not subject to sale under specification.

A consumer who is in need of lubricating oils, paint, or other product, the sale of which is subject to specification, even though he know absolutely nothing about the material he contemplates purchasing, has always a limited degree of protection, in that he may consult some authoritative list of prices current, and thereby inform himself, within certain limits, of what he may be called upon to pay. The uninitiated consumer of glue enjoys no such advantage. As a practical demonstration of this lack of data for guidance, the absence, as it were, of any suggestion of a definite market value of glue, we may assume that an individual, A, contemplates the purchase of a lubricating oil. He refers, let us say, to the following list of wholesale prices current:

MINERAL OILS.

Black, reduced,	29 gravity,	25@30 cold test,	10½@11	cents per gal.
	29 "	15 " "	11½@12½	" " "
	29 "	zero " "	16 @17	" " "
	Summer		10½@11½	" " "
Cylinder, light, filtered			18 @19.	" " "
dark "			16 @17.	" " "
extra cold test			22½@29½	" " "
Spindle, No. 1, filtered			15 @16.	" " "
No. 1			12 @13.	" " "
No. 2			11 @12.	" " "
No. 3			10 @11.	" " "
No. 4			9½@10.	" " "

etc., etc., etc.

This is an approximately correct quotation of the market price of oils at a given date, and were A to apply for the individual quotations of a dozen dealers in lubricating oils, he would find that the prices named by them conformed in the main with those quoted above.

Again, let us assume that A is a novice in the purchase of glue. He is about to embark in a line of business entailing the purchase of considerable glue at the outset. Lacking any definite information as to the kind of glue he requires for his particular work, he at once consults a list of wholesale prices current published in some reputable trade journal. This is what he gleans:

GLUES

Extra white	18 @ 24	cents. per lb.
Medium white	14 @ 17	" " "
Cabinet	11 @ 15	" " "
Low grade	9 @ 12	" " "
Foot stock, white	11 @ 14	" " "
" " brown	8 @ 14	" " "
Common bone	7 @ 9	" " "
Irish	13 @ 16	" " "
French	10 @ 40	" " "
German, hide	12 @ 18	" " "
" common	10 @ 11	" " "
Fish glue, liquid, in barrels, 50 gals. each	50 @ 1.20	per gal.

Now, were A a consumer of oils, even though he had never before purchased any, he could readily learn that Spindle oil, for example, will not answer for the lubrication of engine cylinders. He has only to know the particular grade of oil required for his work, Spindle No. 1, for example, when he may form some definite idea as to the cost, which will be 12 or 13 cents per gallon on this day. He may inform himself of this, for the reason that *oils are sold under specification,* and hence the prices quoted are approximately correct. Not so with glue. Were our friend embarking in the manufacture of paper boxes, for instance, he might use with success any of the glues quoted in the above list and thus pay anywhere from 7 to 40 cents per pound. The chances are that he does not know a bone glue from a hide and, upon consulting the above list, might at once conceive the notion that French glue is the best on earth, since it costs more than any other. Two courses of action are open to him. He may either hazard the purchase of a medium-priced glue and eventually, by running the gamut of all the glues offered him, learn that a sweet 7-cent glue will answer as well as one at 25 cents for paper-box work, or he may apply to the nearest dealer for information on the subject. Woe betide him if he does! In event of the prior contingency, his experience will be gained only at the outlay of considerable money. In the event of the latter, the information he would glean in some cases would, if published, contribute materially to the gaiety of nations. The dealer, proceeding upon the established principle that the market price of glue is any price that can be obtained, will at once take advantage of the applicant's credulity to impress upon him the necessity of using a particular grade of glue representing the maximum margin of profit to the dealer, although, possibly, the minimum of efficiency to the consumer. This the consumer will use until another enterprising dealer offers him something cheaper.

That the above list of quotations is of but little value in assisting the uninitiated to form some estimate of the price of glue will be seen from the following considerations. In the first place, Extra White glues are quoted at 18@24 cents per pound. These may range in strength from No. 2 to A Extra *and it is this strength that will determine their cost.* Thus, a good opaque A Extra hide glue may cost 17 cents per pound, whereas an "Extra White" glue for painters' use, which is made largely from pig stock, may cost not more than 10 cents in the same market. Similarly, cabinet glues are of different strengths, and it is this that will determine their cost. The only glues that may be said to have a definite market value, that is, having prices that fluctuate in accordance to universally recognized trade conditions, are imported glues, such as Irish, French, and German, which, in the above list, are quoted with some degree of correctness. There is a fixed duty on these glues, and hence the manufacturer's price, or first cost, is always such as will permit his product, with the addition of the duty, to meet the domestic in competition.

Just as the term "cylinder oil" conveys no information beyond the fact that it is to be used in the lubrication of engine cylinders, and the price will depend upon color, consistency (gravity), flash point, and cold test, so the terminology "cabinet glue" is indefinite unless we specify the strength. Through experience, buyers of glue in large quantities, for any purpose whatsoever, may always inform themselves, to a limited extent, as to what they will be called upon to pay, inasmuch as they are aware that the price will, in the main, be controlled by the strength of the product. If any information is to be gleaned from a list of wholesale prices current, this must be based upon the estimates of a number of leading manufacturers and dealers, and must be tabulated in the following way:

GLUES

A Extra, clear	18 @ 20¢.
A Extra, opaque (white)	18 @ 22¢.
A Extra, colored	18 @ 21¢.
1 Extra, clear	15 @ 19¢.
1 Extra, colored and opaque	17 @ 20¢.
No. 1, clear	14 @ 18¢.
No. 1, colored and opaque	15 @ 19¢.
1 X, clear	13 @ 16¢.
1 X, colored and opaque	14 @ 17¢.
Hide glues, from 1⅝ to 1¼	10 @ 13¢.
Bone glues, common, according to test	6 @ 9¢.
Bone glues, acid-treated, according to test	8 @ 12¢.

The inexperienced buyer has now only to know that glues ranging in strength from 1⅜ to A Extra are cabinet-glues, the particular grade being determined by the nature of the work itself, or that common bone glues are useful for box work, all other factors being equal. Such a list will then assist him in forming some estimate as to the cost of the glue on a given day. As a matter of fact, the glues are so classified by the majority of manufacturers and dealers, who are nevertheless reluctant to apprise the consuming public of this, lest they no longer have an opportunity of realizing increased profits through the inexperience and credulity of the consumer.

Cost of Glue as Affected by Scarcity.—The bogy of a high market, due to scarcity of glue in general and the consumer's favorite brand in particular, is one of the chief selling arguments for glue. The safest remark for a salesman to make, when approached as to the cost of his wares, is, "that the price of glue has advanced, generally." As a rule, the consumer has absolutely no way of informing himself to the contrary and thus the way to an increased margin of profit for the dealer is nicely paved.

At intervals there is a genuine scarcity, not of all glues, but of some particular grades. Nor is this always owing to natural causes, such as decreased production because of temporary scarcity of stock, but simply to the fact that a number of manufacturers may agree, among themselves, to hold back their cheap grades for the time being, in order that there shall be an increased demand for them and in this way a better price realized. Again, some astute jobber may gradually accumulate a vast quantity of low-grade glue, thus creating a genuine shortage on the part of the manufacturers, preventing them from meeting their own goods in competition, when the jobber is able to realize almost any price he may ask so long as his stock holds out, or until manufacturers themselves have once more reached their average production of the glues in question.

It may safely be asserted that there can be no natural scarcity of glue so long as the packing and leather industries are in existence; and these will continue as long as man evinces the desire to eat flesh and wear shoes. Given a number of oxen, sheep, and pigs to be slaughtered daily, there will always be the same number of hides for tanning and hence so much hide stock for glue. So many bones will be obtained from the carcasses, which will produce a given number of knife-handles, buttons, and a definite quantity of bone stock for glue making, with its attendant refuse for fertilizer compost. It is to be remarked that scarcity is usually confined to the low and medium grade bone glues as well as the inferior mixed bone and hide glues produced by our large packing houses. Seldom is the price of high-grade hide glues, produced at independent factories, affected by scarcity; and when this does occur it is legitimately due to lack of stock. These factories are dependent for stock upon the tanner, and, as the latter does not produce a definite quantity of waste or glue stock, the glue-maker cannot rely upon any one tannery for a uniform supply. Again, the tanner may so modify his processes, when dealing with some particular shipment of hides, that the stock coming to the glue boiler may demand totally different treatment than he is accustomed to give; with the result that he produces, for the nonce, a grade of glue different from those hitherto produced by him. In this way a temporary shortage of *some one particular grade of hide glue* is created; but this does not mean the scarcity of hide glues in general.

There is a greater demand, on the whole, for low-grade glues than for high grades, as the former are applicable to the majority of usages and are cheaper than the latter. Hence the tendency to create a shortage of these grades in either of the above-mentioned ways, in order that they may command an advanced price. Were the conditions reversed, *i.e.*, were the demand for hide glues greater than that for bone, endeavor would be directed to the cornering of these.

Position of the Jobber in the Trade. — The jobber of glues occupies a position in relation to the manufacturer and the consumer that is at once advantageous and unique. His are not merely the functions theoretically accorded the "middleman." Eliminate him, and the entire scheme of things, as regards the conduct of the glue industry, would require readjustment. We refer, not to the small jobber whose stock, at any given time, seldom exceeds twenty or twenty-five barrels of glue, but to him who, through resource of capital, enabling him to buy virtually for cash and anywhere he pleases, carries a stock of a thousand barrels of glue at any given time. Many consumers labor under the delusion that they lose money by dealing with the jobber, flattering themselves that they can buy as cheaply as he. Indeed, this is one of the strongest arguments advanced by the manufacturer's representative in approaching the consumer direct. To realize how little truth there in is this contention, the reader has but to bear in mind that, in the purchase of any commodity, he who purchases in large quantities obtains a better price than he who purchases but small packages, and that to every barrel of glue purchased by the consumer, the jobber requisitions twenty. Which, under these conditions, is enabled to buy cheaper? The question is superfluous.

It might seem, at first inspection, that the position of the jobber is a perilous one; that, were manufacturers resolved to shut down on him, he would be compelled to suspend business. This is true of the small jobber, who, through lack of capital, is unable to buy in the open market, as it were, and must confine his dealings to some one manufacturer who is willing to extend to him liberal terms of credit. He can continue in business only so long as the manufacturer who supplies him agrees not to approach his customers. On the other hand, the large jobber enjoys all the advantages and suffers none of the responsibilities of the manufacturer himself. The grades he carries are more varied than those produced at one factory, since he buys from a number. His purchases are uniform. He is very careful to see to that. Again, his resources are such as to enable him to control the output of a number of minor factories, and in this way he becomes virtually a manufacturer himself without having to bother about securing stock. He merely agrees to take the entire output at such and such a price. That the jobber is recognized as an indispensable factor in the glue situation by the manufacturer, despite any arguments he himself may advance to the contrary, is evidenced by the fact that the latter is ever ready to supply the former with vast quantities of glue at a favorable price. Indeed, to refuse to do so would be to antagonize his best interests. As an illustration, we may cite the sale of a carload of glue (sixty barrels) to sixty separate consumers, scattered over a large territory, on the one hand, and, on the other, the sale of a carload, as such, to the jobber. In the first instance, although a far higher price is realized in the sale of the individual barrels, the selling-cost is proportionately high. In the second, a relatively smaller *selling-cost* is entailed, with the paradoxical result that by accepting a lower price the shipper realizes a larger profit. Again, were it not for the jobber who is ever ready to avail himself of favorable offerings of glue, particularly cheap grades, the manufacturer's stock would accumulate to such an extent that it might ultimately have to be disposed of at a loss.

In view of all this, it is seen that the jobber is in relatively better position to supply the trade than any one manufacturer. He handles a far greater variety of glue and, by effecting combinations, comes nearer to selling glue under specification than the manufacturer. He can keep his trade only by selling glue "to match," and when a prospective purchaser submits a sample of the glue he is using, this is carefully tested and a counter-sample submitted practically duplicating the original in color, cut, strength and other test factors. The accomplishment of this presupposes the carrying of a large and varied stock of glue, as it is often necessary to combine two or more glues to match the test factors of another. In this way, the jobber has the advantage over the manufacturer who produces but a limited number of grades and these regularly. Again, the jobber frequently recognizes in the submitted sample a well-known make of glue and may be carrying this in stock. He is thus enabled to offer the manufacturer's own goods in competition with him. Despite the frequent occurrence of this, but few manuacturers withhold their supply from the jobber.

The Consumer's Redress in the Law. — If another argument is needed to impress upon the consumer the necessity of constantly testing his glues, it is embodied in the fact that, unless he does so, he will never be able to recover for losses caused by defective glue. The legal maxim, "Let the buyer beware!" applies with great force to barter in this commodity. An example of the general application of this principle is as follows: If A sell B a horse, and the said horse lacks a tail at the time of purchase, B cannot recover the purchase price, nor could he bring any action for damages on these grounds. It is B's business to note the absence of tail before handing over the money to A. On the other hand, if said horse develop some disease within a few days after purchase, an action against A for the recovery of the money paid will lie, unless it can be proved that said disease was contracted after the horse had passed into B's possession. The law thus creates the distinction between *visible* and *latent* defects.

As applied to glue, this principle operates in the following way: A consumer has received regular shipments of glue of a certain kind; for example, a straight hide glue. In color this was, we shall say, dark brown, and the glue was in the form of oblong sheets. A shipment arrives consisting of flake glue of two colors, one light yellow and the other brown. The consumer uses this in the work, which is thereby ruined. It is evident that the glue is totally different in character from previous deliveries. Despite this he cannot legally refuse to pay the bill, nor is entitled to damages for the ruined work, inasmuch as a *visible* defect existed in the glue. This would apply to taste and odor as well. It is for the consumer to examine the glue on arrival, and, noting the defect, to return it to the shipper or hold it at the latter's disposal. If the latter refuse to take it, the former is not liable for the bill. He cannot, however, use the glue and expect immunity from payment.

Although it is possible to recover for latent defects in glue, it is extremely difficult to prove these. What more difficult to prove, for instance, than that certain chemical conditions existed in the glue which, in combination with outside influences, produced a disastrous result? The testimony of the analyst, however competent, too often demonstrates that the defect was visible and not latent, in the construction of the law.

It would thus seem that the consumer has but little or no redress in the law and must seek protection through other means. He can find it only in the careful testing and comparison of samples and deliveries and the prompt rejection of those that are not as represented.

CHAPTER IX

MANUFACTURING RECEIPTS

THE following working formulæ are all practical, having been tested by the author. A number represent standard formulæ which have been hitherto published in a number of works on glue, having been known for years to investigators. Others, again, are the result of the author's personal experience. Carefully carried out, they will all yield satisfactory results.

Water-proof Glues.

A. *Glues rendered water-proof by mixture with other substances.*

1. Glues may be rendered practically water-proof by the addition of a small quantity (1 per cent) of ammonium or potassium bichromate to their solutions. The glue becomes water-proof only upon exposure to the influence of the sun's rays.

2. The addition of a limited quantity of formaldehyde to the aqueous solution of glue will aid it in resisting the action of water after it has dried for a time.

3. Ten parts of glue are soaked in an equal volume of water and the glue removed before it has lost its primitive form. The swollen glue is then dissolved in about 10 parts of linseed oil, with the aid of heat, until a jelly is formed. This mixture is an effective cement for joining a number of materials and is practically water-proof.

4. Twelve parts of glue are dissolved in 15 of water. Two parts of bleached rosin are added and the heating continued until the rosin and glue are uniformly incorporated. Four parts of turpentine are now cautiously added and the whole stirred until uniform.

B. *Water-proof Substitutes for Glue.*

1. Dammar and other cheap varnishes are sufficiently sticky to fulfil the adhesive requirement of glue, and possess the advantage over the former in that they are absolutely water-proof. These cannot be used as water-proof coatings.

2. Shellac may be dissolved in wood alcohol to the consistency of a heavy solution of glue and may be used as a water-proof glue in the lighter work to which glue is applicable.

3. Marine glues are water-proof cements containing no glue whatsoever. They are admirably adapted to the calking of vessels, whence, in all probability, their name. Jeffrey's marine glue is prepared by incorporating shellac with a solution of 1 part of india-rubber in benzine. Others are combinations of solutions of rubber in refined petroleum (1 part rubber, 12 parts solvent) with 20 parts of asphaltum. The asphaltum is melted separately in an iron boiler and the rubber solution added in a thin stream, the whole stirred until uniform.

Mending Cements. — These comprise numberless preparations of greater or less value. Some few give satisfactory results and are here described.

A. *Cements for Iron and Other Metals.*

1. Marine glue, above described, may be used to advantage in cementing metal to metal.

2. A cement for pipe-joints is prepared by mixing red lead with linseed oil to a thick paste.

3. Diamond cement for metal. Into 40 parts of linseed oil there are slowly stirred the following, in order named: Litharge, 30 parts; slaked lime, 10 parts; whiting, 20 parts; and graphite, 100 parts. The cement is to be applied hot to the slightly roughened surface of the metal.

4. An oil cement for steam-pipes, which is free from lead, is prepared by mixing intimately 1 part of graphite, 3 of heavy spar, 1 of slaked lime, and 1 of linseed oil. The mineral ingredients are first to be mixed well and the mixture incorporated with the linseed oil.

5. Casein, 8 parts; slaked lime, 10 parts; quartz sand, 10 parts. In place of the sand, finely divided silex (silica) such as is employed to "fill" scouring soaps, may be employed to advantage.

6. For uniting metals, a strong cement is made by the addition of good quality whiting (Extra Gilder's will answer) into a solution of silicate of soda (water glass) of 40°. Be. Sufficient whiting is added to form a plastic mass. This cement has the advantage in that it may be colored by the addition of such substances as antimony sulphide for black, cupric carbonate for light green, chromium oxide for dark green, etc.

B. *Cements for Porcelain and Crockery.*

1. White pitch, 9 parts; sulphur, 14 parts; bleached shellac, 2 parts; gum mastic, 4 parts; gum elemi, 4 parts; finely powdered and sifted glass, 14 parts. All ingredients, excepting, of course, the glass, are to be melted together and the glass stirred into the melted mass.

2. Gutta-percha, 1 part, and shellac, 1 part, are cautiously melted together by the aid of indirect heat, preferably by placing the vessel containing them over the water-bath. The melted ingredients should be well mixed and applied hot, having previously warmed the edges of the pieces to be cemented.

3. Casein, 10 parts, is dissolved in silicate of soda, 100 parts, by constant shaking of the mixture. If applied rapidly, this is a most effective cement for mending crockery and glassware that is to be heated.

C. *Cements for Glass.*

1. For mending broken glassware, provided this does not have to be heated, there is no better cement than water-glass itself. This must be carefully applied, special care being taken not to smear the surface of the glass as, once dried, the cement will never come off. It is best used in fairly heavy solution and applied by means of a fine camel's-hair brush which should at once be cleaned by dipping it in boiling water. The fractured edges of glass should be just slightly roughened with a new file (triangular or flat), the cement applied quickly, and the cemented pieces firmly pressed together. Should this procedure squeeze any cement from the joint over the surface of the glass, it should at once be wiped away with a cloth that is just *damp*, not wet. For mending cracked bottles or flasks, these should first be warmed so as to expel the air, immediately corked, and the cement at once applied to the cracks. As the bottles cool, the air will be drawn in through the crack, and in this way the cement will be drawn from the surface into the crack itself, where it will harden.

2. For glass upon glass, dissolve, with the aid of

jacketed heat, 10 parts of shellac in 2 of turpentine, and to this add 10 parts of finely powdered pumice stone, the cement to be used hot.

3. For glass upon metal, melt together 4 parts of rosin, 1 of wax, and 1 of turpentine. Apply hot.

4. For metal upon glass, melt rosin, 40, turpentine, 3, and plaster of paris, 4. Apply hot.

D. *Cements for Leather.*

1. For cementing leather belts, make a solution of good glue (1⅜ test), dissolving 1 part of glue in 4 parts of water. Dissolve, separately, 1 part of tannic acid in 10 parts of water, adding sufficient glycerine to promote solution. Mix the two hot solutions, and heat until the mass is stringy. To apply, have the cement very hot, roughen the edges of the belts with a file, warm them slightly, and the moment the cement has been applied, press them well together by means of a heavy weight and permit them to dry two or three days.

2. Gutta-percha, 6 parts; asphaltum, 6 parts; oil of turpentine, 1 part. The ingredients are to be carefully melted together and the cement applied hot.

3. For cementing strips of very thin leather, cloth to leather, or cloth to cloth, make a solution of elastic bands in benzine. This is best effected by filling a bottle with the elastic bands, pouring in benzine, corking the bottle and subjecting the contents to alternate shaking and rest, until solution has been effected. A better solution may be made by preparing a solvent of 1 part benzine and 2 parts carbon-tetrachloride. Such a mixture is not only a better solvent for the rubber, but possesses the additional advantage that it is *non-inflammable,* refusing to ignite even if a lighted match

is applied directly to it. Chloroform may be used in place of the carbon tetrachloride, in the same proportion, with equally satisfactory results.

4. For the purpose of cementing leather to metal, the cement for leather belts is useful. The surface of the metal should be slightly roughened, and the glue spread upon it, after warming the metal. Do not let the glue chill. The hot tannin solution is spread upon the warmed surface of the leather, which is then pressed down upon the metal and held until dry.

E. *Cement for Wood.*

1. For wood that may not be glued on account of exposure to the air, dissolve shellac with as little wood alcohol as is necessary to effect solution. The cement is to be applied to both pieces, and pressed firmly together.

2. For attaching metal letters to wood, or wood to metal, a solution of glue should be incorporated with some good varnish, turpentine being used in sufficient quantity to effect a proper emulsion.

3. A cement for wood, resisting the action of alkalies and acids, may be prepared by mixing equal parts of rosin, asphaltum, and brick dust, melting these carefully together.

F. *Cements for Bone.*

1. For ivory and bone, melt at a low heat 2 parts of Japan wax, 2 parts of rosin, and, when these are melted, add sufficient turpentine of good quality, to reduce the melt to a syrup consistency.

2. For knife handles, incorporate equal parts of rosin, sulphur, and iron filings. This is to be used hot, and the knife which is to be cemented to the handle should be heated previous to the application of the cement.

Flexible Glue and Padding Composition. — This preparation is indispensable in the binding of books and in the manufacture of writing-pads or tablets. It is used also for the manufacture of certain small toys, such as the grotesque faces vended by street-fakirs. To prepare it, select a strong glue, not less than 1 X in test and preferably A Extra. It is best to have this thick cut, in order that uneven softening may be prevented, owing to the fact that the glue has not been evenly wet.

No. 1. Extra Strong Clear Composition.

A Extra clear glue	30 parts.
Water	50 “
Glycerine (heavy body)	20 “

The glue is to be softened in the water and then melted uniformly at as low a temperature as possible. The glycerine is then well stirred in. The melt is to be cast in shallow pans, from which it may be removed when set. This mixture must be preserved by the addition of pure crystal carbolic acid, dissolved in a little glycerine and water. To disguise the odor of the preservative, perfume with some essential oil such as rosemary, sassafras, or wintergreen.

No. 2. Extra Strong White Composition.

A Extra glue, white (opaque)	30 parts.
Water	50 “
Glycerine (heavy body)	15 “

The procedure is exactly as above. Same materials used to perfume it.

No. 3. Medium Strong Clear Composition.

1¼ clear glue	30 parts.
Water	25 “
Glycerine	15 “

No. 4. Medium Strong White Composition.

1¼ opaque glue	30 parts
Water	25 "
Glycerine	15 "

Nos. 3 and 4 are to be preserved and perfumed with the same materials as above.

Colored Compositions. — Any of the above compositions may be colored to suit by the addition of some aniline or coal-tar color. The white compositions are easiest to color and require less coloring material than the clear.

In use, these compositions may be applied direct, or may be added to regular glue solutions, in proportions to suit.

Liquid Glues.

1.	Glue not exceeding 1¾ strength	30 parts.
	Water	50 "
	Chloride of calcium	17 "

First dissolve the chloride of calcium by boiling in the 50 parts of water. Let this solution become cold, and then put in the glue to be soaked up. When softened, melt the glue and preserve with carbolic acid, perfuming to suit.

2. Prepare a solution of weak glue in its own weight of water. To this add an equal volume of strong acetic acid, heating for nine or ten hours. If properly carried out, this yields a very effective glue for light woodwork, as well as mending china ornaments, etc. The persistent odor of the acetic acid may be partially disguised by the addition of some essential oil.

Box Maker's "Liquid Glue." — This contains no glue whatsoever, being prepared from three grades of corn-dextrine. To make it, dissolve equal parts of light canary corn-dextrine, dark canary corn-dextrine, and British gum in sufficient water to make a paste that possesses medium fluidity. Preserve with formaldehyde. The dextrines are to be dissolved in boiling water, and if the solution is boiled for a couple of hours it will thicken markedly. To effect a solution free from lumps, the dextrines should first be worked into a heavy paste with cold water, the balance of water added, and the whole boiled with constant stirring.

Photo-Library Paste. — This excellent substitute for mucilage in sticking paper and invaluable medium for mounting photographs, is prepared as follows. The white dextrine alluded to is potato-dextrine, known in the market as White E. S. or H White.

No. 1.

White dextrine	20 parts.
Water	90 "
Glycerine	2 "

The dextrine is first worked to a cold paste with a little water, the balance of water added, and the whole heated until perfect solution is effected. The glycerine is now added. Some formaldehyde and a very little purest carbolic acid are used as preservatives, and sassafras or wintergreen as a perfume. The solution is put aside for three or four days, when it sets to a firm paste.

No. 2.

White dextrine	10 parts.
Potato starch	10 "
Water	110 "
Glycerine	3 "

Same procedure as with No. 1.

Starch Pastes. — These may be prepared from wheat, corn, tapioca, sago, or potato starches. Potato starch will yield a paste of heavy body with little adhesiveness, whereas that from tapioca is rather fluid and sticky. Sago yields a very dark, sticky paste. Corn starch is not very useful for paste-making.

In order that the paste be free from lumps, it is essential that continual stirring be applied during boiling. Starches and dextrines should never be boiled by contact with the naked flame. The starch, in all cases, should be first brought into suspension in cold water, the balance of water boiled separately, and the cold emulsion of starch added slowly to this. All starches require careful preserving in solution. Bichloride of mercury, formaldehyde or carbolic acid may be used. Hydrofluoric acid is a good preservative, or any one of its salts, such as ammonium fluoride.

Starch pastes are rendered far more adhesive if the starch be treated with some agent tending to partially hydrolize them. Dilute acids, alkalies, and even chloride of calcium, are useful for this purpose. A very effective paste from tapioca is made as follows:

Tapicoa	20.
Water	100.
Chloride of Calcium	5.

Pastes of this kind should never be boiled with direct steam, as the action of this is entirely too drastic. Jacketed heat invariably produces a heavier paste, with given proportions, than does direct steam. The addition of one fifth of one per cent of nitric acid to the paste while it is boiling will increase its fluidity and stick. Similarly, combined sago and tapioca may be dissolved in the cold, or with a minimum of heat, by the aid of caustic alkalies, to form a very powerful adhesive which is a substitute for rubber cement in lighter kinds of work. This may be prepared as follows:

Tapioca	10.
Sago	10.
Water	100.
Caustic Soda solution, 30° Be.	

The starches are introduced, with constant stirring, into the water, which is at about 80° F. The caustic soda solution is then added little by little, until perfect solution is effected. The mixture is now dark and strongly alkaline. Nitric acid is now added, in small portions at a time, until the mass is just faintly acid in reaction. Stirring to avoid lumps is a most important factor throughout the operation. The action of alkali and acid tends to destroy the gelatinizing properties of the starches, yielding a thickly fluid paste.

Flour-Paste. — Paste made from wheat flour is in great demand among paper-box makers, cigar-box manufacturers, workers in leather goods, etc., who use it either as a label paste, or for the lighter work where glue is not absolutely essential. Good flour-paste is white in color, very sticky, and still possesses the degree of fluidity permitting it to work out smooth. Its manufacture is attended by many difficulties, owing to the fact that it does not suffice merely to boil up the flour in so and so much water, in order to procure a working paste, but the action of certain chemicals has to be depended upon to produce the result. Accordingly, the formulas advocated for the manufacture of flour-paste are legion. The majority are absolutely worthless.

A great defect exists in paste-making machinery. While this is designed to permit uniform agitation of the cooking flour and water by means of a worm agitator, and is even provided with sifting apparatus, which is automatically operated by the main agitator, paste machines are designed exclusively for direct or live steam. This is a great mistake. What has been said in regard to starches producing thicker and stickier pastes if cooked in jacketed apparatus applies equally to flour. So drastic is the action of direct steam, that frequently the paste starts to "go thin" ere all the particles of flour have burst. On the other hand, cooking with direct steam may be inadvertently prolonged, as it is difficult to tell just when the paste is "done," and in this way the paste cools "livery."

Since the paste manufacturer, unless he wishes to go to extra expense in procuring special apparatus, has no alternative save to use the standard form, with the direct steam, he should always observe the following precaution. The paste is best cooked by introducing a full head of steam, and the instant that boiling takes place, as is indicated by the cessation of rattle and the commencement of rumble, the steam should be almost completely cut off. Once a certain degree of heat is achieved (practically 200° F.), the flour needs but little additional heat, in order that the grains shall burst and thus go into solution. Any heat beyond this degree is not only superfluous but is likely to spoil the paste by over-cooking.

If the paste is to be prepared in small quantity for household and office use, cooking is best effected in a double boiler such as is employed for oatmeal and other cereals. Sufficient heat will be established in the inner kettle to cook the flour slowly and uniformly. For such purpose, 15 parts of flour should be cooked with 100 parts of water, which will form a heavy paste. The moment the flour has gelatinized, take the boiler away from the stove, flame, or whatever supplies the heat to the outer kettle, and continue stirring slowly until the paste has cooled.

As to the chemicals used to partially hydrolize the starch of the flour in order to increase the stick of the paste, none answers so well as chloride of calcium, using about 5 pounds to every barrel of paste. If the paste were subjected to jacketed cooking, 10 pounds of flour in 100 of water, plus 3 pounds of chloride of calcium, would produce an extremely heavy and sticky paste, which would, nevertheless, work out smoothly. If borax is intelligently used, a good paste results with a minimum of flour. Such pastes are rather dark in color, however, owing to the action of the alkali upon the gluten of the flour. If too much borax is used, the paste will decay quickly, previously becoming lumpy.

The commonest method of hydrolizing the starch of flour paste is to use hydrochloric acid. In this the necessary quantity of bichloride of mercury, for preservative purposes, is first dissolved. This is then added to the cold mixture of flour and water in the machine, and cooking is begun. For two barrels of paste a pound of acid containing 4 ounces mercuric chloride will answer.

In order that the paste shall not go livery, it is necessary that it be stirred slowly for a while after it is done, to rid it of all excess of steam. It is advisable to let it run in a thin stream from the machine into a tank, equipped with agitator, some distance below. On no account should the paste be stirred rapidly for cooling purposes. This will cause it to go thin.

Paste preservatives are fairly numerous, formaldehyde, carbolic acid, salycilic acid, bichloride of mercury (corrosive sublimate), and hydrofluoric acid answering the requirement. The first two are barred because of their characteristic pungent odors, the second on account of its expense, while the use of the last named is always attended by danger owing to its fearful corrosive properties. It is a good preservative, however, and if carefully handled does good work. On the whole, bichloride of mercury is the best and easiest to use.

No treatise on paste-making could be exhaustive in character. Success depends in a large measure upon experience, and the observance of precautions that are learned only through experience. The above hints, however, should prove helpful.

Gum Tragacanth Paste. — Gum tragacanth possesses the property of absorbing water to many times its weight and is thus converted into a paste. No heat is required in its preparation if ordinary precautions are observed. A serviceable paste may be made by covering 10 parts of good quality tragacanth with 200 parts of water and allowing the gum to swell. The addition of a small quantity of glycerine adds flexibility to the paste, which must also be adequately preserved against decomposition or souring.

Dextrine Mucilage. — A fairly good quality of mucilage may be prepared by simply dissolving certain dextrines in very hot or boiling water. Potato or tapioca dextrines are best adapted to the work. About 30 parts of dextrine, dissolved in 100 parts of water, will make a good thick mucilage. This must be preserved with formaldehyde and carbolic acid, the odors of which may be disguised with a little essential oil.

Dextrine mucilages are usually too dark in color unless a very pale dextrine is selected. The one giving the best results is "canary white" potato-dextrine, which is imported from Germany. Canary-dextrine (potato) yields a somewhat darker shade of mucilage. These mucilages are improved by the addition of about 3 per cent of acetic acid, and some glycerine to impart flexibility and prevent "cracking" of the dried mucilage. Envelope gums are prepared practically upon this principle, either from tapioca or potato dextrines, and at times from mixtures of both.

Gum Arabic Mucilage. — This is usually paler and clearer than dextrine mucilage. A good, clean grade of gum should be selected, as otherwise the product will contain particles of dirt and fine straws. Twenty-five parts of gum arabic are put to soak over night with 75 parts of clean water, in a copper jacketed kettle. When the gum is sufficiently softened, it is dissolved with the aid of heat. About 10 parts of glycerine are added in which has been dissolved 5 parts of pure carbolic acid. When somewhat cool, oil of wintergreen is added to disguise the odor of the carbolic.

Prepared Size. — A size of some sort is necessary to correct distemper of walls before they are calsomined or painted. At times a good glue suffices for the purpose. At others, substances such as chalk, whiting, and even clay are mixed with the glue. To increase the efficacy of the size, soap and alum are frequently added, it being assumed that the soap promotes the "slip" in application. A sample of such size, analyzed by the author, contained:

Chalk	80 parts.
Glue, finely powdered	10 "
Alum	5 "
Soap (in the form of powder)	5 "
	100.

Special Gums. — Certain sizes or gums for stiffening are used in shoe manufacture. Of these, the "box-toe gum" is a prominent example. The following are formulas of preparation:

No. 1.

Light canary corn-dextrine	10 parts.
Talc	10 "
Oxide of Zinc	3 "
China clay	10 "
Water	20 "

No. 2.

Chalk	15 parts.
Ground mica (80 mesh)	15 "
Light canary corn-dextrine	45 "
Water	35 "

In both the above a little more water than is specified should be used to dissolve the dextrine, and into this solution, which is apt to be heavy unless very hot, are worked the other ingredients, a little of each at a time. The result is a paste or gum of great consistency.

CHAPTER X

ANALYTICAL OPERATIONS

While not at all averse to consulting a qualified chemist when need of his services arises, progressive superintendents frequently desire to carry out for themselves the simpler analytical operations, if only that they may thereby better comprehend the import of the chemist's work. In the interest of such, it has been deemed advisable to add to this work a limited exposition of analytical technique. No attempt is made to outline quantitative processes save such few as pertain to the standardization of solutions; nor is it to be expected that the perusal of this chapter will enable the inexperienced to qualify as expert analysts. For the details of specific determinations, the reader is referred to any one of the many excellent works extant upon the subject of quantitative analysis.[1] Since, however, the success of analytical operations is largely subject to the rules of common sense, if the reader will combine the instructions for a specific determination with the suggestions as to technique herein embodied, fairly accurate results should be obtained. All analytical work presupposes the greatest care in execution, lest errors of manipulation creep in to invalidate the result.

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[1] In connection with this chapter and the Appendix, the reader will do well to consult Olsen's Quantitative Analysis.

Apparatus Required. — The following apparatus is essential to the proper execution of the majority of investigations pertaining to glue and gelatine.

1. A good balance for weighing, provided with an accurate set of weights. The balance should be sensitive to at least one milligram (1–28000) ounce. Balances of precision, sensitive to 1–10 milligram, are best. These, as a rule, are costly, and instruments less sensitive will supply results correct within technical limits.

2. A drying oven. This may be of block tin, or better, copper-jacketed.

3. A copper water-bath fitted with concentric rings.

4. Assorted Erlenmeyer and Florence flasks.

5. Two burettes, 50 c. c., graduated in tenths, with glass stop-cocks.

6. Volumetric pipettes, 10, 25, and 50 c. c. capacity.

7. A 100 c. c. graduated cylinder.

8. A 10 c. c. pipette, graduated in 1–10 c. c.

9. Glass funnels of various diameters.

10. Watch- and clock-glasses, assorted sizes.

11. Filter paper, Swedish, 1 F, assorted diameters.

12. Sohxlet extraction apparatus, medium size, complete with flask and condenser, also capsules to fit.

13. Test-tubes, 6 inches long, 1–2 inch diameter.

14. Beakers, Griffith's shape, several nests.

15. Assorted glass and porcelain evaporating dishes.

16. Two separatory funnels, 300 c. c. and 500 c. c.

17. A short piece of platinum wire and a small square of platinum foil.

18. Several Bunsen burners, tripods and ring-stands.

19. Squares of iron wire gauze for tripods.

20. Glass stirring-rods and assorted glass tubing.

21. Volumetric flasks for the preparation of standard solutions. Sizes, 100 c. c., 250 c. c., 500 c. c., and 1000 c. c. (1 liter).

22. Half a dozen porcelain crucibles, Royal Berlin, No. 00, with covers.

23. A platinum crucible, 15 grams.

24. A platinum evaporating dish, 15–20 grams.

25. A desiccator, chloride of calcium variety.

26. A gas blast-lamp, with adequate bellows.

Reagents. — The reageants required are those commonly employed in qualitative work, a list of which will be found in the appendix.

Analytical Processes.

1. *Desiccation.* — The case in which the balance is placed must be kept absolutely dry, lest hygroscopic substances, in the course of weighing, absorb moisture therefrom. Not only this, many substances, previous to weighing, must be heated to expel moisture and then cooled in a perfectly dry atmosphere. For maintaining the balance case in a dry condition, a small glass vessel should be filled with pure, granular chloride of calcium, and this vessel kept constantly in the case. The chloride of calcium must be renewed from time to time. For cooling objects and substances to be weighed, the desiccator is employed. The lower chamber of this is filled with granular chloride of calcium. A partition separating the upper chamber from the lower, which serves also as a platform on which to rest objects, is made by affixing corks of uniform size to the four corners of a piece of wire gauze that has been fitted to the dimensions of the chamber. Holes may be cut in this to accommodate crucibles. The lid of the desiccator should be slightly

greased with vaseline, to insure perfect contact with the ground edge of the upper chamber.

All porcelain apparatus should be heated over the Bunsen flame for at least fifteen minutes before introduction into the desiccator. In many instances it is advisable to subject the object to the blast flame as well. Porcelain requires at least twenty minutes' cooling in the desiccator. Platinum will require ten minutes' heating and fifteen minutes' desiccation.

2. *Weighing.* — That the life and usefulness of the instrument may be prolonged, certain simple precautions are to be observed in connection with the use of a balance. Before any attempt is made at weighing, it should be seen that the instrument is perfectly level. It should rest on a table of such height that the ivory scale is at the level of the eyes when the operator is seated before the table. The balance should never be exposed to direct sunlight nor to the fumes of the laboratory, nor should it be kept in too close proximity of any source of heat lest this cause undue expansion of any of the parts. It should be kept scrupuously clean, the scale-pans being dusted with a fine camel's-hair brush. Under no circumstances should oil be applied to any part of the balance; proper cleaning, from time to time, of the various parts will insure the perfect working of the instrument. In releasing the pan-rests or beam, care must be taken not to jolt the apparatus unnecessarily. Nothing will ruin a sensitive instrument so quickly as the too sudden arrest of its oscillation.

Methods of Weighing. — The importance of accuracy in the use of the balance cannot be over estimated. The slightest error in weighing out the original sample or the final precipitate from which some constituent element of the sample is to be deduced, will invalidate the analysis no matter how carefully intermediate operations may be conducted. Objects to be weighed should be at the same temperature as that obtaining in the balance-case. Hence the desiccator should be kept next to and under the same conditions as the balance. Hot, or even warm, objects should never be placed upon the scale-pan, for, not only will the heat emanating from them cause the expansion of certain parts of the balance, rendering the instrument worthless for the time being, but the objects themselves will increase in weight as they cool.

Even though in apparant equilibrium, the zero or position of rest of a balance is never exactly at the zero mark of the scale. To assume that such is the case, is to sacrifice a degree of accuracy in weighing. The most accurate method of weighing presupposes the determination of the true zero or position of rest, and that weight which will restore this position of rest is the true and final weight of an object.

The method of weighing to be adopted will depend upon the sensitiveness of the balance at hand. If this does not exceed one milligram, it will suffice for all ordinary purposes to weigh by the simple expedient of placing the properly desiccated and cooled object on one pan, and adding weights to the other until equilibrium is restored. If such balance has been correctly set up, and is kept under conditions where it is not affected by vibration or other undue influence, the position of rest will remain practically at the zero line of the scale and any slight deviation will be offset by errors in the weights.

Such a balance will not permit of weighing closer than one milligram or to third decimal place.

On the other hand, if the balance be one of great precision, weighing to tenths of milligrams, the position of rest is far more variable, and cannot be assumed to be at the zero line of the scale unless the needle has been deliberately adjusted to the latter mark. Even then, the position of rest will remain constant but for a short time under the most favorable conditions.

Determination of the Position of Rest. — Each of the ten scale divisions on either side of the dividing line is mentally further divided into tenths. Swings of the needle to the right of the dividing line are arbitrarily designated positive or +, and those to the left, negative or −. The balance is set in motion and the plus and minus swings noted. Let us assume that these are as follows:

+ 10 (to the right of the dividing line).
− 8 (to the left of the dividing line).
+ 9
− 7
+ 8

The first pair of swings indicates that the needle oscillated further to the right than to the left, by two scale divisions. The oscillation would be of the same proportional value, though of smaller amplitude, had the needle started at the dividing line, traveled two scale divisions to the right, and then returned to the dividing line and stopped. Were the balance in equilibrium, this would correspond to a swing of *one* scale division on either side of the dividing line. It will at once be seen that *one* scale division equals *half* the difference between the first two swings. Similarly the half-differences between the remaining swings or oscillations are 0.50, 1, and 0.50. These are designated as positive or +, since the swing to the right of the dividing line was in each instance of greater amplitude than that to the left. Continuing our hypothesis, the tabulated statement of results at this stage is:

$$\begin{array}{rcr}
 & & \text{HALF-DIFFERENCE} \\
+\ 10 & & \\
-\ \ 8 & = & +\ 1.00 \\
+\ \ 9 & = & +\ 0.50 \\
-\ \ 7 & = & +\ 1.00 \\
+\ \ 8 & = & \underline{+\ 0.50} \\
 & 4) & \underline{+\ 3.00} \\
 & & +\ 0.75
\end{array}$$

By dividing the sum of the half-difference by 4, the number of such half-differences, we learn that the position of rest of the balance for this determination is 0.75 of a scale division to the right of the dividing line of the scale. Five such determinations as the above should be made and the arithmetical mean of the result taken as the position of rest.

Extension of the above procedure enables us to determine the *delta* of our balance. This means the milligram equivalent of each scale division. To do this, we determine the position of rest as above. The rider is now placed at the 1 milligram mark on the beam, and the position of rest determined under these conditions. This time it will be negative or −, as the weight causes the needle to swing further to the left than to the right.

Let us assume that the position of rest, as first determined, is +0.75; and that, with the weight, it is −1.25. If we subtract these two algebraically we find the difference to be two scale divisions. That is, the difference of position of rest, due to the milligram weight, equals two scale divisions. Hence the milligram equivalent of one scale division is found by dividing 1 milligram by 2. The figure so obtained, 0.5 mg., is the so-called *delta* of the balance. This changes about once per month, under normal conditions, and more frequently if the balance be exposed to undue influences. The function for the figure for *delta* in weighing operations will be seen from the following.

Weighing by Half-Differences. — In its entirety, the process of weighing by swings necessitates the determination of the initial position of rest, which, let us say, is + 0.75. The object is then placed upon the pan and weights added to three decimal places. Assume that the weight thus far is 9.542. We have now to determine what weight will restore the balance to the original position of rest. To do this, we again determine the position of rest, and this, for example, is found to be +1.25. The difference between this and the original is 0.50 scale division. Since each scale division is equivalent to 0.5 milligram (*delta*), we require the additional weight of 0.25 milligram to restore the balance to the original position of rest. We accordingly add this weight or rather 0.3 milligram (since our balance does not weigh to hundredths) and once more determine the position of rest. If this proves to be + 0.75, the final weight of our object is 9.5423 gram.

It may be objected that the process of weighing by swings consumes too much time, and the latter is assuredly a factor in chemical analysis. True, the novice will find the method tedious, until he has had considerable practice. At the same time, the importance of accustoming himself to accurate methods of weighing cannot be too strongly urged, provided he has equipped himself with a sensitive instrument.

Less troublesome and tedious is the method of weighing by *half-differences*, a method that presupposes that the position of rest of the balance is always at the zero or dividing line of the scale. That such is not the case with an instrument of great sensitiveness has already been pointed out, and the reliability of the method will depend, first, upon the maintenance of the balance under strictly uniform conditions, and, secondly, upon the adjustment of the needle to the zero of the scale each morning before starting work. This done, it will be necessary to let the balance rest for an hour before attempting to use it, in order that conditions of temperature, etc., become normal. Before attempting this adjustment, it should be first seen whether any deviation from the adjustment of the previous day has taken place. If not, there is no need of readjustment. These precautions observed, the method of half-differences becomes satisfactorily reliable and possesses the advantage over the complete oscillatory method, in that it consumes far less time, a weighing being accomplished in five minutes with reasonable practice. In operation, the method is as follows:

An object is being weighed, and the operator has already placed upon the pan 9.542 gram. The balance is now set in oscillation and the swings to right and left of the dividing line noted. These, let us say, are 8 scale divisions to the right and 6 to the left. The difference, + 2, shows that the weight is still deficient. The weight required is that which will cause the needle to swing *one scale division* on either side of the dividing line. One scale division is seen to be half the difference between the swings + 8 and − 6. We have already determined that the milligram equivalent of our hypothetical balance is 0.5 milligram. Hence, if this weight be added by means of the rider, we shall find that the balance is restored to equilibrium, oscillating equidistantly on either side of the dividing line. The final weight of the object is thus 9.5425.

The novice is at times troubled by the failure of the needle, when the beam is first released, to oscillate on both sides of the dividing line. This difficulty may be overcome by causing a gentle draft to impinge on the right pan by *gently* waving the hand toward this pan. It is well to adopt this practice at all times, disregarding the first pair of oscillations and relying on the third for the reading. Thus, if after stimulating the motion of the balance as suggested, the swings are

$$\begin{array}{ccc} +9 & +7\frac{1}{2} & +7 \\ -6 & -5\frac{1}{2} & -5, \end{array}$$

we take the half-difference between the third pair, viz., one scale division for our calculation, and multiply this by the *delta* to determine the final weight required to restore the balance to equilibrium.

Preparation of Samples for Weighing. — Substances to be analyzed are, as a rule, dried prior to weighing out the initial sample or samples. Save such as would lose water of crystallization by crushing, they are first reduced in a mortar to an impalpable powder and then placed in the oven until all moisture has been expelled. The temperature of drying will depend upon the nature of the substance. Much importance attaches to the method of transferring the dried substance to the weighed container in "weighing out." The practice of first weighing crucible or other container and, as this rests upon the scale-pan, introducing the substance by means of a spatula, is a simple and convenient one, but requires great care lest any substance be spilled onto the pan with the result that the sample in the crucible, etc., is less than the weight recorded. It were better for the novice, once he has weighed the container, to remove this from the balance and, placing it on a clean sheet of paper, introduce the substance and proceed to the second weighing. The removal and replacement of the container must be effected by means of a pair of tongs. Under no circumstances should contact of container with the hand be permitted.

Where the sample is to be placed in containers either too large or too heavy for the balance, the following method of weighing out will be found convenient. As the substance is drying in the oven, a test-tube, fitted with a smooth, tight cork should be dried at the same time and the substance subsequently introduced into the tube. This is then corked and placed in the desiccator to cool. Before weighing, the tube is permitted to rest in the balance case for fifteen minutes. The container, into which the sample is to be weighed, is placed near at hand upon a sheet of black glazed paper.

The tube plus cork and contents is carefully weighed, then uncorked and a little of the contents shaken into the container. A piece of bibulous paper is employed to handle the tube and cork to avoid contact with the hand. The tube is recorked, permitted to rest a few minutes in the balance case and again weighed. The difference in weight represents the sample taken. If, inadvertently, any particles of the sample have fallen upon the paper, these may readily be added to the main portion within the container. Two samples require but three weighings by this method. The weighings are best noted as follows:

$$\begin{array}{rcl} \text{Tube} + \text{cork} + \text{substance} & = & 10.8976 \\ \underline{\text{Tube} + \text{cork} + \text{substance}} & = & \underline{10.6543} \\ \text{Sample taken} & = & .2433\ \text{gram} \end{array}$$

This is better expressed as 243.3 milligrams. For a second sample, we might then have

$$\begin{array}{rcl} \text{Tube} + \text{cork} + \text{substance} & = & 10.6543 \\ \underline{\text{Tube} + \text{cork} + \text{substance}} & = & \underline{10.4321} \\ \text{Sample taken} & = & 222.2\ \text{mgs.} \end{array}$$

It is advisable always to express the weights taken in milligrams and to base all subsequent calculations on milligrams.

In order that the results may be controlled, it is customary to run duplicate samples and these should approximate each other in weight. Where the analyst has at his command a sensitive balance, large samples should never be taken for analysis. A large sample means subsequent bulky precipitates awkward to handle and entailing mechanical loss in washing. On the other hand, it must be remembered that, with a small sample, each loss through faulty manipulation counts more than with a large sample. The analyst must regulate the sample taken through his knowledge of the properties of the substance sought. Where he suspects a constituent which he knows will yield a bulky precipitate, the minimum working sample should be weighed out; and *vice versa,* since there is added safety in large samples.

Weighing out Liquids. — For this, a weighing bottle, provided with ground stopper, should always be employed. It will save time if a lead counterpoise is made for this bottle and subsequently used to tare the bottle in weighing.

In weighing potash bulbs of any description, they must be permitted to rest for a time in the balance case that the contents may acquire the temperature obtaining therein. This applies equally before and after absorption of carbon dioxide.

Calcium chloride tubes that have been employed for the absorption of moisture should be accorded the same treatment.

Filtration. — Separation of filtrates and precipitates entails certain precautions, neglect of which will seriously hamper the operation. In selecting funnels, only those with long, narrow stems and flawless sides should be accepted. Such will permit of rapid and uniform filtration. Some precipitates, because of their fineness, require *double* filters. In preparing the filter, the paper is folded in half, and this again in half, taking care that the edges are even. It is now a quadrant. Opening the filter again to semi-circular form, a small piece is torn from one end of the diameter. This subsequently serves, after moistening with alcohol, to detach any particles of dry precipitate adhering to the funnel itself, in which case it is incinerated with the main filter.

After detaching the portion of paper, the filter is once more folded to a quadrant and inserted into the perfectly clean and *dry* funnel, conforming its shape to that of the latter by pressing, care being taken not to rupture the point. One side of the filter represents a single thickness of paper and the other three thicknesses. If a double filter is required, a second paper is prepared in the same manner as the first and introduced into the funnel superimposed upon the first paper in such way that both sides of the complete filter represent four thicknesses of paper. Whether single or double, the filter, after conforming its shape to that of the funnel, is moistened with boiling water and firmly pressed into the funnel to expel all air bubbles between it and the surface of the funnel. Let boiling water pass several times through the filter, and note if the stem of the funnel holds the column of water, free from air bubbles. A well-made filter is in reality a miniature air pump. Filtration will never proceed rapidly nor efficiently unless the stem of the funnel holds the column of water.

In filtering precipitates, a glass rod is held against the lip of the beaker, the end of the rod directed to the center of the filter. Under no circumstances should liquids for filtration be poured onto the filter direct. The filter should never be filled to its capacity, as in this way much precipitate collects at the edges and difficulty in washing ensues. The bulk of the precipitate is washed from the beaker down the rod, into the funnel.

Washing Precipitates. — Before drying, precipitates must be washed free of the precipitating medium, else this dries with them, augmenting the weight and producing a fallacious result. Save in certain specific analyses, the washing is effected with distilled water, which is delivered from a wash-bottle equipped with a fine-pointed nozzle attached to the main delivery tube by a short piece of rubber tubing, enabling the operator to direct the stream at will. Care must be taken to wash the edges of the filter, it being customary to wash the precipitate down from the sides of the filter towards its apex. It must be remembered that many precipitates are not wholly insoluble in water and hence only a minimum of wash-water may be employed. Nevertheless, washing must be complete.

In many instances, filtration is effected by holding back as much of the precipitate as possible, by means of the rod, and washing the precipitate in the beaker, bringing the washings and a little of the precipitate each time on the filter and washing the latter in between. The bulk of the precipitate is finally brought upon the filter by means of a stream from the wash-bottle, aided, perhaps, by a trimmed feather or rubber "policeman," and the filter given a final washing. This method is known as "washing by decantation."

Certain precipitates attach themselves to the sides of the beaker, and are difficult of removal. For detaching these, a trimmed Guinea fowl feather is most useful. The feathers are stripped *in toto* from one side of the shaft, and the balance cut down short with a scissors. Where a feather of this description is employed, it must be rinsed thoroughly lest precipitate adhere to it and loss thus occur. Another aid in rinsing beakers of precipitates is the "policeman." This consists of a short piece of rubber tubing, of the same diameter as the stirring rod to which it is attached by slipping over the end of the rod. One end of the rubber tube is firmly sealed. To be at all serviceable the "policeman" must be perfectly smooth.

Drying Precipitates. — The washed precipitate is now dried. The funnel, still retaining the wet filter, is covered so as to exclude dust and placed in the drying-oven, the temperature of which should not exceed that of boiling water.

Incineration of Filters. — Before the dried precipitate can be weighed, it must be detached from the filter and the latter burned to an ash. The weight of this ash (which is usually recorded on the package of filter paper) is then deducted from the total. The entire operation is one of great nicety. The crucible, in which the precipitate is to be placed for incineration and weighing, is itself desiccated, cooled, weighed, and then placed upon a sheet of black glazed paper. The funnel containing the filter with dried precipitate is uncovered, the filter removed and inverted upon a clean watch-glass. By gentle tapping, the bulk of the precipitate is freed from the paper. If any has adhered to the funnel, the strip of paper originally torn from the filter is moistened with alcohol, and the funnel wiped with this, which is subsequently incinerated with the main filter. The precipitate detached from the filter as far as possible, the latter is folded, the apex placed in the flame until it is ignited and the whole rapidly introduced into the crucible which is supported on a triangle. The ignited filter is permitted to burn of its own accord, and as soon as it smolders a small flame is placed beneath the crucible. If this causes the half-burnt paper to burst into flame again, remove the Bunsen flame until the former has again died out. As soon as the filter is thoroughly charred, and no longer burns of its own accord, replace the Bunsen flame beneath the crucible and gradually raise the flame until all carbon is burned off, leaving a good white ash. The crucible is now cooled, and the bulk of the precipitate is added, care being taken to brush the surface of the watch-glass, as well as that of the glazed paper, with a feather, any particles of precipitate adhering to either being transferred in this way to the crucible. The precipitate is now ready for simple ignition or prolonged blasting, as the conditions demand.

Volumetric Processes. — Volumetric processes involve the use of graduated flasks, cylinders, pipettes and burettes. The success of such processes depends upon consistency in reading the instruments, as well as upon their preservation in the utmost state of cleanliness.

(a) *The Pipette.* — A description of the use of this instrument for a specific purpose will be found under the discussion of Viscosity, in Chapter 2. The pipette is most convenient for delivering definite quantities of liquid, but its proper use presupposes certain precautions. As remarked, the instrument must be scrupuously clean, lest globules of the discharged liquid adhere to the glass. The last drop may be discharged by placing the index finger of the right hand over the aperture of the upper tube, holding the body of the instrument in the palm of the left hand, when the natural heat of the hand will cause the air to expand, driving out all liquid. Unless this practice is observed, the full capacity of the pipette is not delivered and an ultimate error of analysis results.

(b) *The Burette.* — Many substances are analytically determined while in solution or "volumetrically" rather than gravimetrically — *i.e.*, by precipitation and weighing. For example, if the strength of an acid solution be known, — that is, if we know the exact amount of acid contained in each cubic centimeter, and if, further, 10 c. c. of this solution are required to neutralize x c. c. of an alkali solution of *unknown* strength, from the data at hand we may readily determine the strength of the alkali solution. Such analytical process is termed "Titration"; and in the above instance, we speak of titrating the alkali against acid.

The instrument employed for titration is the burette, which consists of a stout, long glass tube, provided at one end with a glass stop-cock or a rubber tube fitted with a pinch-cock. The tube is graduated up to 50 c. c., each subdivided into tenths. The correct reading of a burette presupposes considerable practice. The meniscus, or heavy stratum of liquid at the top, common to all columns of liquids, is the guiding point, where no "float" is at hand to assist the reader. The meniscus will be seen to consist essentially of three distinct lines, upper, lower, and a very dark line between. Any of these may be employed as the guiding line in the reading; but it behooves the operator to read from the same point throughout any one titration or set of titrations.

As in gravimetric, so in volumetric analysis, duplicates are run for the purpose of checking the results. Duplicates must be titrated under identical conditions of temperature and concentration, if concordant results are to be obtained. Each should contain the same amount of indicator.

The flow of solution from a burette should be so regulated that 10 c. c. are discharged per minute, or the entire contents of the burette in five minutes. If discharged with greater rapidity, some drops of solution tend to adhere to the upper portions of the tube, and unless the operator waits for these to flow down to the level of the column before taking the reading, this will be incorrect.

(c) *Graduated Cylinders.* — The correct reading of a column of water contained in a graduated cylinder is dependent upon the identical principles obtaining with the burette. The cylinder is not reliable for measuring liquids in analyses presupposing quantitative accuracy.

(d) *Volumetric Flasks.*— These flasks, usually of 100, 250, 500 and 1000 c. c. capacity are accurately graduated and are most useful, not only for the preparation of standard solutions, but for measuring liquid samples, for which latter purpose they should always substitute the graduated cylinder. In adjusting the contents to the graduated mark on the neck of the flask, the operator has to observe the same precautions governing the reading of the burette. Liquids, while hot, must never be adjusted to the mark, as shrinkage occurs through cooling.

Cleaning Volumetric Apparatus. — A solution of alcholic potash is an excellent medium for cleaning all glassware. This need not necessarily be concentrated and may be prepared by dissolving about 10 grams of dry, chemically pure caustic potash in 100 c. c. of 80 per cent alcohol with the aid of heat. The solution should be kept in a dark bottle sealed with a tuft of cotton in preference to a cork, and may be used repeatedly for cleansing purposes until exhausted. The apparatus cleansed by its use should be subsequently rinsed with pure, distilled water and inverted to drain.

Equally efficacious, and less expensive, is a solution of potassium dichromate in concentrated sulphuric acid. Such solution may be prepared either by making a concentrated aqueous solution of the dichromate and cautiously adding an excess of concentrated sulphuric acid, or dissolving the salt in the acid direct. Its use is governed by the same precautions applying to alcoholic potash.

It is at times inexpedient to rinse burettes and pipettes with water, since, unless the apparatus be subsequently dried, the strength of a standard or other solution will be altered by admixture with the water remaining. Burettes, when not in use, may be kept filled with distilled water and well corked to exclude dust. When it is desired to use the apparatus, this water may be run off and the instrument rinsed with about 20 c. c. of the solution with which it is to be filled. This is then run off and the main solution added.

Pipettes and volumetric flasks, after cleaning, rinsing and draining, may be dried by rinsing with alcohol to remove the balance of water, then with ether to remove the alcohol. The ether is then removed by suction, either of the lips or pump.

APPENDIX

The following are the reagents required for the general qualitative and quantitative operations:

Ammonium acetate. — To 500 c. c. *aqua ammonia,* add 600 c. c. *glacial acetic acid.*

Ammonium carbonate. — Dissolve 50 grams of the salt in 250 c. c. water and add 25 c. c. *aqua ammonia.*

Ammonium Chloride. — Make a 10 per cent solution.

Ammonium hydroxide. — Mix equal parts of concentrated *aqua ammonia* and distilled water.

Ammonium molybdate. — Dissolve 25 grams of the salt in 100 c. c. water with the aid of heat. Prepare a mixture of 300 c. c. concentrated *nitric acid* and 200 c. c. water. Mix the two solutions with constant stirring.

Ammonium oxalate. — Make a ten per cent solution.

Ammonium sulphide. — Pass *sulphuretted hydrogen gas* through *aqua ammonia* until the latter is saturated and add an excess of *aqua ammonia.*

Ammonium sulphide (yellow). — To some *ammonium sulphide* as prepared above, add sufficient *sulphur* to impart a decided yellow color when thoroughly dissolved.

Ammonium sulphate. — Make a 10 per cent solution.

Barium chloride. — Make a 2 per cent solution.

Barium hydroxide. — Make a 5 per cent solution.

Calcium hydroxide. — Stir 10 grams of *burnt lime* in 100 c. c. of water for several hours. Let settle and pour off the supernatant solution.

Ferric chloride. — Make a 10 per cent solution.

Ferrous sulphate. — To a 20 per cent solution add 2 per cent *sulphuric acid* and a few tacks.

Lead acetate. — Make a 10 per cent solution and add 1 per cent *acetic acid.*

Magnesia mixture.—Dissolve 40 grams *magnesium chloride*, and 100 grams *ammonium chloride* in 500 c. c. water. Add 25 c. c. *aqua ammonia*.

Mercuric chloride.—Make a 5 per cent solution.

Potassium acetate.—Make a saturated solution.

Potassium chromate.—Make a 10 per cent solution.

Potassium ferricyanide.—Make a 2 per cent solution.

Potassium ferrocyanide.—Make a 2 per cent solution.

Potassium sulphocyanide.—Make a 10 per cent solution.

Silver nitrate.—Make a 5 per cent solution.

Silver sulphate.—Make a saturated solution.

Sodium acetate.—Make a saturated solution.

Sodium carbonate.—Make a 25 per cent solution.

Sodium hydroxide.—Make a 10 per cent solution.

Sodium phosphate.—Make a 10 per cent solution.

Sodium sulphide.—Pass *sulphuretted hydrogen* through a 10 per cent solution of *sodium hydroxide*, and to each liter of solution add 50 grams of *sulphur*.

Acid acetic.—Add 2 parts of water to 1 part *glacial acetic acid*.

Acid nitro-hydrochloric (aqua regia).—Mix 3 parts concentrated *hydrochloric acid* with 1 part *nitric acid*.

Acid hydrochloric.—(a) *Concentrated*, specific gravity 1.12; (b) *Dilute*. Mix 1 part concentrated acid with 4 parts water.

Acid nitric.—Two solutions required, one *concentrated* and one *dilute* (1:4).

Acid sulphuric.—Two solutions required, one *concentrated* and one *dilute* (1:4).

Acid chloroplatinic.—Make a 10 per cent solution.

Hydrogen sulphide (sulphuretted hydrogen).—This reagent may either be kept in the form of a saturated aqueous solution of the gas, or better, the gas may be freshly evolved as required.

The special reagents pertaining to the analysis of glue and gelatine will be found under the specific determinations outlined in Chapter III.

Quality of Reagents. Traces of metals presumably in the substance and determined in the course of analysis may often be traced to the reagents employed. A "c.p." (chemically pure) label is in no sense a guarantee of the purity of any reagent. For example, "c.p." ammonium oxalate frequently contains traces of lime. Accordingly, reagents should be purified by recrystallization from their concentrated aqueous solutions, rejecting large crystals, as these are apt to contain too much of the mother liquor. These may, in turn, be recrystallized. The operator has, of course, to predetermine whether his work demands the highest accuracy or not. Upon his decision will depend the further purification of the reagents employed for analytical work.

Standard Solutions. — Standardized solutions of hydrochloric acid, potassium hydroxide, and potassium permanganate are at almost all times required in the laboratory and should be prepared in quantity.

(a) **Hydrochloric acid** (approximately decinormal).

Forty grams of the chemically pure acid, specific gravity 1.12, are accurately weighed into a clean liter flask. This is then carefully made up to the mark, mixing the contents thoroughly. Ten such liters should be prepared and the whole mixed well in a bottle of ample capacity and well stoppered.

To standardize this solution, proceed as follows: From a burette, run duplicate samples of 40 c. c. each of the acid solution, taking the reading carefully. To each sample add 20 c. c. nitric acid, and bring to incipient boiling. Add silver nitrate solution to each until no more precipitate forms, and stand the beakers in a dark place over night for the precipitate to settle. During the precipitation, it is well to exclude direct sunlight. Prepare two double filters, and pass the filtrate through, holding back as much of the precipitate as possible. Wash the filters well with boiling water containing 10 per cent of nitric acid, and with the same medium bring the precipitate onto the filters, washing the latter well between additions of precipitate. Rinse the beakers thoroughly of all precipitate and then wash filter and precipitate with *plain* boiling water until the washings are no longer turbid when treated with a drop of hydrochloric acid.

Dry the precipitates upon the filters in the oven at 100° C. (212° F). Prepare two porcelain crucibles, incinerate the filters as directed in the foregoing chapter, add the bulk of precipitate to the crucibles and warm with a small Bunsen flame. Gradually raise the flame until the precipitate of silver chloride *just fuses at the edges.* Place the crucibles in the desiccator and weigh the silver chloride.

Calculate as follows:

$$\left\{\begin{matrix}\text{Molecular}\\ \text{weight of}\\ \text{silver}\\ \text{chloride}\end{matrix}\right\} : \left\{\begin{matrix}\text{atomic}\\ \text{weight of}\\ \text{chlorine}\\ \end{matrix}\right\} :: \left\{\begin{matrix}\text{the weight}\\ \text{found of}\\ \text{silver}\\ \text{chloride}\end{matrix}\right\} : \left\{\begin{matrix}\text{weight of}\\ \text{chlorine}\\ \text{in it.}\\ \end{matrix}\right\}$$

$$\frac{\text{The weight of chlorine}}{\text{No. c. c. HCl taken}} = \text{the mgs. chlorine in 1 c.c. of acid.}$$

(b) **Potassium Hydroxide** (approximately decinormal.) Weigh out as closely as possible 7 grams pure caustic potash (precipitated by alcohol in sticks) into a clean liter flask, dissolve in a minimum of water, and make up to the mark, mixing well. About ten such liters should be prepared and mixed in a bottle of ample capacity.

To standardize:

(1) *Against Oxalic Acid.*

Weigh out two portions, not more than 100 milligrams, of chemically pure oxalic acid that has been previously well powdered and dried to expel all water of crystallization. The samples are placed in beakers of 250 c. c. capacity, and dissolved by stirring in 150 c. c. cold water. To each solution is added two drops of phenol-phthalein as indicator. The burette is now filled with the alkali solution, adjusted to zero, and the solution run into the oxalic acid drop by drop as the latter is stirred, until a pink coloration just appears. The reading is then accurately taken.

Calculation:

$$\left\{\begin{matrix}\text{Molecular weight}\\ \text{of oxalic acid}\end{matrix}\right\} : \left\{\begin{matrix}\text{Twice the molecular weight}\\ \text{of potassium hydroxide}\end{matrix}\right\} :: x : y,$$

where $x =$ the weight of oxalic acid taken,
and $y =$ the weight of potassium hydroxide required to combine with x.

Then y, divided by the number of c. c. of potassa solution taken = the number of milligrams of actual *potassium hydroxide* (KOH) in 1 c. c. solution.

(2) *Against Standard Acid.*

Fill two clean burettes, one with the standard acid solution, and the other with the unknown alkali. Select two Erlenmeyer flasks of about 250 c. c. capacity. Run into each 20 c. c. acid and add a few drops of litmus solution. Now run in the alkali, drop by drop, until the color of the solution in the flask turns from red to reddish blue, or violet. Boil the contents of the flask until all *carbon dioxide* is expelled, and add a few drops of alkali until the color of the solution is a true blue, without reddish cast. Note readings of both burettes.

Calculation: Assume, for example, that 30 c. c. alakli are required to neutralize 20 c. c. acid; whence, 1 c. c. alkali = $\frac{2}{3}$ c. c. acid. Assume further that each c. c. standard acid = 3.65 milligrams HCl. Then each c. c. of alkali is equivalent to 2.43 milligrams *hydrochloric acid*. Since the reaction taking place is expressed

$$HCl + KOH = KCl + H_2O,$$

we have,

$$\text{mol. weight HCl : mol. weight KOH :: 2.43 : } x,$$

x = milligrams *potassium hydroxide* in each c. c. solution

(c) **Potassium permanganate.**

Weigh out 5 grams of chemically pure *potassium permanganate* into a clean beaker, and cover with cold water, stirring well. Permit the undissolved salt to subside and pour off the solution into a dark bottle, taking care that no undissolved portions are transferred with the solution. Again treat the salt in the beaker with water and again pour off, repeating the operation until all has been dissolved. The total solution should not exceed 4 liters.

To standardize: Secure some fine piano wire, which is virtually 99.6 per cent pure *Iron*. Clean this of any rust, by means of emory paper, and weigh out two portions of about 100 milligrams each. Place these in small beakers, add 20 c. c. concentrated *hydrochloric acid*, and heat cautiously until complete solution is effected. Cover the beaker with a watch-glass during the operation and subsequently rinse the glass into the beaker. Now add to the contents of the beaker a minute crystal of *potassium chlorate* and again warm until the solution assumes the characteristic yellow color of *ferric iron.* Transfer the contents of the beaker to a 250 c. c. Erlenmeyer flask, rinsing the beaker well. Support the flask so that it inclines at an angle of 45°, and let the contents boil gently until all *oxides* of *chlorine* have been expelled. In the interval, weigh out about 5 grams chemically pure *zinc* spelter, selecting only thin, flat pieces. Add these cautiously to the contents of the flask. When the liberation of *hydrogen* subsides, add 40 c. c. concentrated *sulphuric acid* to dissolve all residual zinc. The contents of the flask are now transferred to a capacious beaker, the flask rinsed into same and the solution made up with 400 c. c. additional water.

Fill a burette with the solution to be standardized. None but glass-stoppered burettes may be used for *potassium permanganate* solutions. Owing to the opacity of these solutions, they are extremely difficult to read without the aid of an Erdmann float. The *permanganate* is adjusted to the mark and run into the beaker drop by drop, with constant stirring, until a faint pink color is permanently established. The reading is then taken, and the weight of iron wire originally taken, divided by the number of c. c. permanganate solution run in, is expressed as *the number of milligrams of iron, oxidized from the ferrous to the ferric state, by* 1 *c. c. permanganate.*

It is to be noted that too much time must not be allowed to elapse between the reduction of the ferric iron to ferrous, and the titration with permanganate, else the solution is atmospherically re-oxidized to the ferric state and the reading of permanganate consequently low. It should be seen that all zinc is dissolved before transferring the contents of the flask to the beaker for titration, else these particles will reduce the solution as fast as it is oxidized by the permanganate. The results of the duplicate titrations should be fairly concordant, differing by not more than one part in 500.

Comparison of English and Metric Weights

1 milligram =	.001 gram =	.0154 troy grain =	.00003 avoirdupois ounce
1 centigram =	.01 gram =	.154 troy grain =	.0003 avoirdupois ounce
1 decigram =	.1 gram =	1.540 troy grain =	.003 avoirdupois ounce
1 gram =	1.0 gram =	15.40 troy grain =	.03 avoirdupois ounce
1 decagram =	10.0 gram =	154.0 troy grain =	.3 avoirdupois ounce
1 hectogram =	100. gram =	1543.0 troy grain =	3.520 avoirdupois ounce
1 kilogram =	1000. gram =	15432. troy grain =	35.20 avoirdupois ounce
1 kilogram =	2.2 pounds avoirdupois.		

1 Liter = 1000 c. c. = $1\frac{1}{7}$ quarts approximately.
500 c. c. is approximately 1 pint.
250 c. c. = approximately 8 oz.
125 c. c. = approximately 4 oz.

Comparison of Thermometers.

To convert degrees Fahrenheit into degrees Centigrade, subtract 32 and multiply by $\frac{5}{9}$.

Example: Convert 212° F. into degrees C.

$212 - 32 = 180.\quad 180 \times \frac{5}{9} = 100.$ *Ans.*, 100° C.

To convert degrees Centigrade into degrees Fahrenheit, multiply by $\frac{9}{5}$ and add 32.

Example: Convert 15° C. into degrees Fahrenheit.

$15 \times \frac{9}{5} = 27.\quad 27 + 32 = 59.$ *Ans.*, 59° F.

EQUIVALENT OF DEGREES BEAUMÉ, AMERICAN STANDARD, AND SPECIFIC GRAVITY AT 60° F.*

(*a*) For Liquids *HEAVIER* than Water, Beaumé $= 145 - \frac{145}{\text{Sp. Gr.}}$

Degrees Beaumé	Specific Gravity	Degrees Beaumé	Specific Gravity	Degrees Beaumé	Specific Gravity
0	1.0000	24	1.1983	48	1.4948
1	1.0069	25	1.2083	49	1.5104
2	1.0140	26	1.2185	50	1.5263
3	1.0211	27	1.2288	51	1.5426
4	1.0284	28	1.2393	52	1.5591
5	1.0357	29	1.2500	53	1.5761
6	1.0432	30	1.2609	54	1.5934
7	1.0507	31	1.2719	55	1.6111
8	1.0584	32	1.2832	56	1.6292
9	1.0662	33	1.2946	57	1.6477
10	1.0741	34	1.3063	58	1.6667
11	1.0821	35	1.3182	59	1.6860
12	1.0902	36	1.3303	60	1.7059
13	1.0985	37	1.3426	61	1.7262
14	1.1069	38	1.3551	62	1.7470
15	1.1154	39	1.3679	63	1.7683
16	1.1240	40	1.3810	64	1.7901
17	1.1328	41	1.3942	65	1.8125
18	1.1417	42	1.4078	66	1.8354
19	1.1508	43	1.4216	67	1.8590
20	1.1600	44	1.4356	68	1.8831
21	1.1694	45	1.4500	69	1.9079
22	1.1789	46	1.4646	70	1.9333
23	1.1885	47	1.4796		

* Chemical Annual.

EQUIVALENT OF DEGREES BEAUMÉ, AMERICAN STANDARD, AND SPECIFIC GRAVITY AT 60° F.*

(*b*) For Liquids *LIGHTER* than Water, Sp. Gr. $= \dfrac{140}{130 + \text{Be.}^\circ}$

Degrees Beaumé	Specific Gravity	Degrees Beaumé	Specific Gravity	Degrees Beaumé	Specific Gravity
10	1.0000	34	0.8537	58	0.7447
11	0.9929	35	0.8485	59	0.7407
12	0.9859	36	0.8434	60	0.7368
13	0.9790	37	0.8383	61	0.7330
14	0.9722	38	0.8333	62	0.7292
15	0.9655	39	0.8284	63	0.7254
16	0.9589	40	0.8235	64	0.7216
17	0.9524	41	0.8187	65	0.7179
18	0.9459	42	0.8140	66	0.7143
19	0.9396	43	0.8092	67	0.7107
20	0.9333	44	0.8046	68	0.7071
21	0.9272	45	0.8000	69	0.7035
22	0.9211	46	0.7955	70	0.7000
23	0.9150	47	0.7910	71	0.6965
24	0.9091	48	0.7865	72	0.6931
25	0.9032	49	0.7821	73	0.6897
26	0.8974	50	0.7778	74	0.6863
27	0.8917	51	0.7735	75	0.6829
28	0.8861	52	0.7692	76	0.6796
29	0.8805	53	0.7650	77	0.6763
30	0.8750	54	0.7609	78	0.6731
31	0.8696	55	0.7568	79	0.6699
32	0.8642	56	0.7527	80	0.6667
33	0.8589	57	0.7487		

* Chemical Annual.

To Convert Specific Gravity into Degrees Twaddle.

Multiply by 1000, subtract 1000, and divide by 5.

Example: Convert 1.250 sp. gr. into degrees Twaddle.

$$\begin{array}{r} 1.250 \times 1000 = 1250 \\ \underline{1000} \\ 5\overline{)\underline{250}} \end{array}$$

Ans. = 50° Tw.

To Convert Degrees Twaddle into Specific Gravity.

Multiply by 5, add 1000, and divide by 1000.
Example: Convert 125° Tw. into specific gravity.

$$\begin{array}{r} 125 \times 5 = \quad 625 \\ \underline{1000} \\ 1000\overline{)\underline{1625}} \end{array}$$

Ans. = 1.625 specific gravity.

TABLE OF INTERNATIONAL ATOMIC WEIGHTS

		O=16	H=1			O=16	H=1
Aluminium	Al	27.1	26.9	Molybdenum	Mo	96.0	95.3
Antimony	Sb	120.2	119.3	Neodymium	Nd	143.6	142.5
Argon	A	39.9	39.6	Neon	Ne	20.0	19.9
Arsenic	As	75.0	74.4	Nickel	Ni	58.7	58.3
Barium	Ba	137.4	136.4	Nitrogen	N	14.1	13.9
Bismuth	Bi	208.5	206.9	Osmium	Os	191.0	189.6
Boron	B	11.0	10.9	Oxygen	O	16.0	15.8
Bromine	Br	79.9	79.3	Palladium	Pd	106.5	105.7
Cadmium	Cd	112.4	111.6	Phosphorus	P	31.0	30.7
Cæsium	Cs	133.0	132.0	Platinum	Pt	194.8	193.3
Calcium	Ca	40.1	39.8	Potassium	K	39.1	38.8
Carbon	C	12.0	11.9	Praseodymium	Pr	140.5	139.4
Cerium	Ce	140.0	139.0	Radium	Ra	225.0	223.3
Chlorine	Cl	35.5	35.2	Rhodium	Rh	103.0	102.2
Chromium	Cr	52.1	51.7	Rubidium	Rb	85.4	84.8
Cobalt	Co	59.0	58.5	Ruthenium	Ru	101.7	100.9
Columbium				Samarium	Sm	150.0	148.9
(Niobium)	Cb	94.0	93.3	Scandium	Sc	44.1	43.8
Copper	Cu	63.6	63.1	Selenium	Se	79.2	78.6
Erbium	E	166.0	164.8	Silicon	Si	28.4	28.2
Fluorine	F	19.0	18.9	Silver	Ag	107.9	107.1
Gadolinium	Gd	156.0	155.0	Sodium	Na	23.1	22.8
Gallium	Ga	70.0	69.5	Strontium	Sr	87.6	86.9
Germanium	Ge	72.5	71.9	Sulphur	S	32.1	31.8
Glucinum				Tantalum	Ta	183.0	181.6
(Beryllium)	Gl	9.1	9.0	Tellurium	Te	127.6	126.6
Gold	Au	197.2	195.7	Terbium	Tb	160.0	158.8
Helium	He	4.0	4.0	Thallium	Tl	204.1	202.6
Hydrogen	H	1.008	1.0	Thorium	Th	232.5	230.8
Indium	In	114.0	113.1	Thulium	Tm	171.0	169.7
Iodine	I	126.8	125.9	Tin	Sn	119.0	118.1
Iridium	Ir	193.0	191.5	Titanium	Ti	48.1	47.7
Iron	Fe	55.9	55.5	Tungsten	W	184.0	182.6
Krypton	Kr	81.8	81.2	Uranium	U	238.5	236.7
Lathanum	La	138.9	137.9	Vanadium	V	51.2	50.8
Lead	Pb	206.9	205.3	Xenon	X	128.0	127.0
Lithium	Li	7.1	6.9	Ytterbium	Yb	173.0	171.7
Magnesium	Mg	24.4	24.1	Yttrium	Yt	89.0	88.3
Manganese	Mn	55.0	54.6	Zinc	Zn	65.4	64.9
Mercury	Hg	200.0	198.5	Zirconium	Zr	90.6	89.9

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