SCIENTIFIC SECTION, AMERICAN PHARMACEUTICAL ASSOCIATION

SOLVENTS IN PHARMACY.*

(Continuation of "Precipitates in Fluid Extracts," 1885.)

BY JOHN URI LLOYD.

Introduction.—In 1879 to 1885 (inclusive) the writer contributed to the American Pharmaceutical Association a series of papers entitled "Precipitates in Fluid Extracts." This cosmopolitan text enabled him to enter into any desired phase of plant pharmacy manipulation, the study chiefly concerning physics, as applied to or involved in pharmacy. Publication was suspended in 1885, though research based upon this study proceeded. Most entrancing was this continuation of the published study, although seemingly not directly connected with pharmacy as an art.

In 1890, the writer began to issue a series of printed contributions titled *"A Study in Pharmacy."* This was intended for private distribution only, the intent being to present therein the results of experimentation subsequent to 1885. Recently, the evolution of thought and action, in pharmacy, physics and chemistry, has led to a kindlier opinion of investigations such as these. The writer, therefore, encouraged by several friends, and especially by Dr. Wolfgang Ostwald, presumes to present the accompanying paper as a continuation of the series suspended in 1885 (very few changes being made in the old manuscript), in the hope that it will not be a burden. It may also be considered as a part of the aforenamed *"Study in Pharmacy,"* following the chapter titled *"Reference to Capillarity."*

The enthusiastic interest our late member and friend, Dr. Martin I. Wilbert, took in these researches, with which he was so conversant and so urgent that they be not lost, leads the writer to hope that it may be proper to consider this contribution as a belated recognition of his requests, and to present it as an offering to his memory.

PART I.

Menstruum. A "Menstruum" in plant pharmacy is a liquid solvent intended for use in the making of a pharmaceutical preparation, its primary object being the abstraction of a body or group of substances, in perfect or partial solution, from a vegetable tissue. At first thought such an achievement seems a simple matter, as it would be, were it not that in plant structures many substances other than those desired are always therewith associated, both mechanically and in textural combination. If, for instance, a vegetable tissue were composed of pure linen fiber or porous ligneous pulp, embedded in which a definite alkaloid existed intact, it would be comparatively easy to ascertain the proper solvent for this alkaloid or resin. This having been determined, we could then, theoretically, use an appropriate solvent as the abstracting medium, separating the substances desired without dissolving any of the fiber containing the same.[1] But the writer recalls no instance of such simplicity in natural drug

* Presented in abstract before Scientific Section, A. Ph. A., Indianapolis meeting, 1917.

[1] We are neglecting the force of physical attraction, or mass affinity, in which apparently inert materials often possess powerful attractives. For example, picric acid is soluble in water, in which such substances as wool and horn are insoluble, yet, it is impossible to wash picric acid by means of water out of the finger nail, wool or horn. Not less pronounced are some plant extractives in their adhesive affinities for textural fibers.

texture. Simple, therefore, as at a cursory glance the matter of solvents appears, the selection and adaptation of a suitable menstruum that will first abstract and afterward preserve the abstracted therapeutic constituents[2] becomes a perplexing problem, even when, according to authoritative standards, but one constituent of accepted therapeutic value is contained therein. To the writer, indeed, it seems that galenic pharmacy at this date (1885) embraces no subject more essential than is the experimental consideration of menstrua and connected manipulation, in their own relationships, as well as to materials manipulated. In its entirety, connecting therewith such phases of the problem, as the drug, the menstruum and the product, there is presented a field for investigation that cannot be disregarded, and must not be underrated.

So far as the writer is aware, this subject has, as a separate feature in the field of pharmacy, been considered so unimportant, or at least it has been so neglected that not even the courtesy of a single chapter in any work devoted to pharmacy has been restricted exclusively to menstrua and connected phenomena. Manipulations have, as a rule, been instituted and directed without mention of the influences exerted by the selected medium, or reasons offered for its preference over others that might have been used, or that had been previously suggested or employed for the same purpose. Many solvents of very decided characteristics have also been utterly neglected in pharmaceutical print.

To the writer this seems due, largely, to the blanket system of classification of pharmaceutical preparations that has prevailed, from time gone by to the present, and which yet dominates pharmaceutical thought and action. Also, satisfaction with the inherited processes of the past (involving in pharmacy chiefly alcohol and water as menstrua) is responsible for the neglect of opportunities in outside directions. Surely, in a time to come, very many of the galenical preparations now included among the Pharmacopeial "Tinctures" and "Fluid Extracts" must, if pharmacy credits itself, give way to carefully studied natural plant *separates*. Galenical processes, instead of beginning and ending with simple percolation, or infusions and decoctions, will utilize such methods as these merely as a first, or introductory, step to perfected products (liquid pharmaceuticals), the products being subsequently worked, where desirable, by means of differentiating solvents, without the application of destructive chemical processes. This can be accomplished in such a manner as rationally to exclude inert materials, overcome subsequent decomposition and precipitation, and produce permanent solutions that are representative of desirable parts of natural plant structures.

When, therefore, a systematic effort is made to pass beyond present crudities of galenical pharmacy, a preliminary study of menstruums, both as concerns their qualities and relationships, will be found to be the first essential. Applied plant pharmacy of the future must, before it can accomplish its object, embrace a systematic consideration of the far too long neglected nature and solvent attributes of solvents and their compounds, from a *physical side* (accepting that solutions are physical), which is of not less importance than are the chemical and physical relationships of the drug manipulated. The physician deserves, and in the very

[2] The problem is not restricted to therapeutics, but this paper centers thought on pharmacy.

near future will demand, better medicines than the present crudities known as "Extracts" and "Tinctures," and if they are not supplied, legitimate pharmacy must surely suffer. In this thought, let us repeat, pharmacists must soon awaken to the fact that in the evolution of a finished plant product, a crude percolate is *but the first step*, and that discriminative research in the direction of solvents as excluders and abstracters, may be one feature that will yet make the art of pharmacy a recognized science. Does not our "Study of Precipitates in Fluid Extracts" (1879–1885) warrant us in making these statements and this prediction?

The subject having thus been touched, briefly and in a general manner, the writer believes that, in the progress of pharmaceutical art, next in order comes a study of a selected group of possible solvents. As a preliminary necessity, let us then (superficially) consider some features of the general phenomena connected with this problem.

Attraction. This term expresses, in a general way, the property that substances possess, of being mutually drawn toward each other. In magnetism, some features of electrical phenomena, and in gravitation as well, this influence is exerted without actual contact of the bodies; but in cohesion, adhesion and capillarity, the substances concerned must be in actual contact. Bodies so acted upon may, after their coalition, without known chemical alteration, present attributes more or less different from those originally possessed, as separates.

Cohesion. This force unites the integral particles (molecules) of a homogeneous body. Thus, the molecules of a liquid (and of some phases of solids) are in apparent contact, and are held together by cohesion, which exerts its influence only on particles of matter at insensible distances from each other. For example, by cohesion the globule of mercury assumes its mass form.

Mass Action[3] or Structural Affinities. is a term I use to apply to the attractive force that holds the surfaces of different substances against each other. It is a mass influence, possibly molecular in some directions, exerted by bodies in contact. Like cohesion, it acts only at insensible distances. Under its influence, liquids and even gases adhere to solids, or solids may attach themselves together, without the structure undergoing any internal alteration. In some cases, bodies that under one condition attract each other, are under other conditions repellant. For example, crystals of hydrastine will stick together under certain influences, while under other conditions they fly apart. Such variations as these, and similar exhibitions of mass movements seem chiefly to depend on electrical phenomena. It is difficult, in our present study, to draw a distinct line between the phenomena exhibited by the forces of cohesion, attraction and mass action, and more difficult to differentiate them from what is known as capillarity, which in the writer's opinion, in its many outreaches, employs them all. Such phenomena are all-important to the pharmacist.

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[3] I should to-day (1917) use the term *Adhesion* instead of mass action. Indeed, I shall occasionally replace it in the text that follows.—J. U. L., 1917.

Capillary Attraction. embraces, as a chief feature, the united influences of cohesive and mass attraction. The force "cohesion" is thought to produce a surface tension of the superficial film of a liquid. This results, when a tube is held in a liquid, in an upward movement to the liquid's edges, and its surface as well, due to the surface of the liquid within the tube and the tube's surface attracting each other. The surface of the uplifted liquid then becomes concave (Fig. 1). When the surface of the container and the liquid repel each other, a downward movement of the liquid results, its surface becoming convex (Fig. 2). The weight and attraction of an

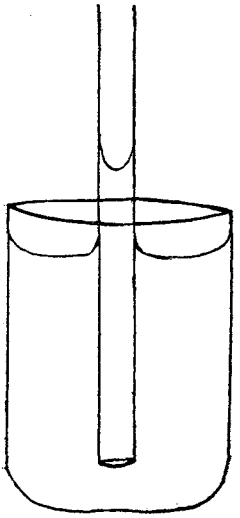

FIG. 1.

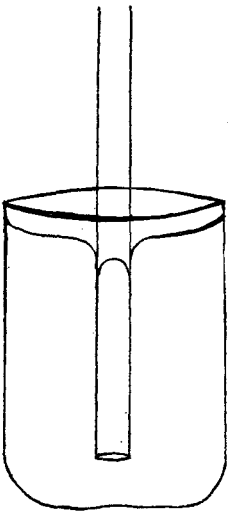

FIG. 2.

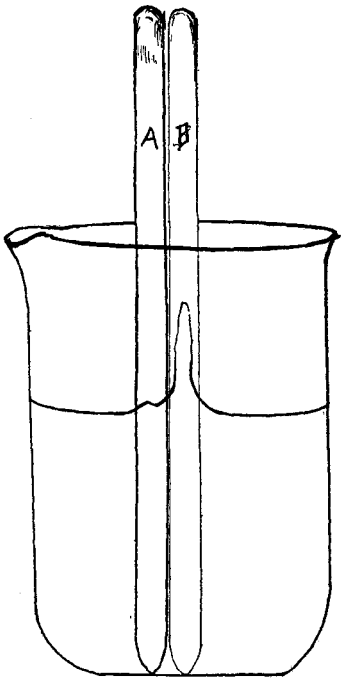

FIG. 2*a*.

A. Glass rod coated with paraffin.
B. Clean glass rod.
Beaker of Water: Water attraction above surface in vessel shown on *B*.

overlying gas, or the weight and capillarity of an overlying liquid, as well as the affinity or repulsion of each for the surface of the container, are important factorsin such phenomena.[4]

The term "capillarity" is often restricted to the phenomena exhibited when liquids rise in hair-like tubes, but the same influence produces the meniscus at the edges of liquids in large vessels, and (when no solid deposited from the solutions exerts its influence) causes liquids to creep upward on the surface of solids. The nearer parallel surfaces approach each other, as in parallel panes of glass, or the smaller the tubes, the higher the liquid rises in tubes of mutual attraction. An example is shown in the placing of a glass rod near the side of a beaker of water and gradually moving it from the glass.

In 1709 Hanksbee, an English experimenter, first made accurate experiments in capillary attraction, and since that date many conspicuous scientists have given

[4] These phenomena, together with experimental illustrations, have been a source of great interest to this writer. They are part of another section of this study, and are there liberally illustrated.

the subject close attention. Long since (Dr. Jurin, 1718) it was established that the rise of a liquid is inversely in proportion to the radius of the tube. We believe that this investigator used glass vessels, and that his results apply to glass only, other surfaces varying in their attractions.[5] Theories explanatory of the observed phenomena have since been worked out with mathematical exactness by such men as Newton, Laplace, Thomas Young, and others conspicuous as scientists. The phenomenon of capillarity depends on the combined influences of:

1. Gravity (the resisting force).

2. The mutual attraction (cohesion) that the neighboring molecules of a liquid exert on each other, which produces the surface tension of the liquid. (Include Mass Action here.)

3. Temperature.

4. The nature of the overlying substance (including gases), as concerns its affinity for the liquid and its container.

5. The container, that furnished the surface of contact.

Notwithstanding the exhaustive investigations that have been made in the study of capillarity during a period of more than two hundred years, little, if anything, has as yet been accomplished to assist those who propose to study the comparative capillarity and connected influences and attributes of different solvents on different drugs used by pharmacists.[6] This fact, and the paucity of printed results in our field, is an excuse for the burdening of this paper with these introductory remarks, as well as other features apparently irrelative to pharmacy.

Reagents or Solvents. The solvents herein employed are all neutral. Those official stand the tests of the Pharmacopeia of the United States, 1880. It is not practical, in pharmaceutical manipulations, to employ reagents of an absolute state of purity, nor is there any necessity, in practical pharmacy, for "painful" exactness, when the contaminating agent is unobjectionable, therapeutically. Indeed, an occasional admixture may be sometimes beneficial, as when chloroform contains a little alcohol. Official ether also contains some alcohol; alcohol contains some water; methyl alcohol may contain traces of acetone, and other official liquids may bear similar minor complications. Considerable latitude should be allowed in pharmaceutical processes for variations in result, occasioned by conditions surrounding

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[5] This is proven by experiment Fig. 2, in which a paraffined glass tube reverses capillarity of water. Immerse a clean glass rod and a glass rod coated with paraffin, side by side, in a beaker of water. Capillary attraction of the two glass surfaces is shown by *A*, the paraffined rod by *B*. Fig. *2a*. This feature is a part of this study and is illustrated in its bearings on connected problems.—J. U. L.

[6] "*References to Capillarity*," Lloyd Library Bulletin No. 4, 111 pages, gives the bibliography of capillarity research to 1900. This was made by Dr. Sigmund Waldbott in order that it might be established whether research herein named had been accomplished. From the preface we reproduce as follows: "Since brief reference only is made to this phenomenon in our pharmacal works, and as in none of them do we find citations that assist us in the study of this neglected section of pharmacy, before entering into more detailed review of the subject embraced under the blanket term capillarity, it seems proper to present reference to such connected literature as has been consulted in the production of this résumé. With this object, an endeavor will be made to begin with the earliest reference and end with the current year."

individual operators, as well as for the "personal equation" of operators. Thus, in general "drug store" work, it is impossible to govern temperatures exactly, and decided changes in temperature are often followed by somewhat different returns, even in experiments in seemingly purely *physical* directions. In the domains embraced by this study of solvents, no endeavor is made to go into the minuteness of exact scientific research, which might defeat the very object of the work. Still, the reagents employed by the writer were the purest obtainable, and the details were repeated more than once, some of them being recently verified by another person.[7] The benzol and benzin[8] used were supplied by Dr. Charles Rice. In like manner, the reagents employed by Miss Van Guelpen in the review work (1917) (excepting the petroleum benzin) were the purest possible to obtain, being guaranteed "chemically pure" by the house of E. R. Squibb and Company, Brooklyn, from whom they were obtained, under the personal selection of Dr. Virgil Coblentz. In order to parallel exactly the experiments of 1885, alcohol of the specific gravity (0.820) in use at that date was employed in 1917.[9] In addition to neutral solvents, liquids that exert chemical alterations may be mentioned, as follows:

Acidulated Solvents. Concentrated sour acids cannot be used, undiluted, as plant menstrua. Diluted with some of the neutral liquids recognized in the U. S. Pharmacopeia as solvents, the sour acids impart qualities distinct from those commonly observed. For example, they increase the power of water as a solvent for most alkaloids, and decrease the solvent power of alcohol, with the exception, perhaps, of acetic acid—most alkaloidal acetates, so far as the writer's experience extends, being more or less soluble in alcohol. The sour mineral acids, excepting sulphuric acid, when added to water increase its capacity for the phosphates of calcium and magnesium, and excepting the calcium compounds, for mineral salts generally. Since many plants contain structures capable of liberating considerable amounts of these inorganic bodies, percolates containing such acids are often heavily charged therewith.

Most, if not all the sour acids, are insoluble in carbon disulphide, chloroform, benzol and benzin; hence these liquids cannot be acidulated, excepting by vapor of the volatile acids, or by mechanical agitation, which produces physical admixtures. Salts of many alkaloids may be easily made by passing the vapor of acetic, nitric or muriatic acids through their solutions in appropriate menstruums, most alkaloidal *salts* being insoluble in such as these. Appropriate acids added to

[7] Miss Eda Van Guelpen (1917), in the writer's laboratory, repeated a few of those most important.

[8] "Benzin" of commerce was then, and is now, exceedingly unsatisfactory. In the experiments of Miss Van Guelpen (1917), petroleum benzin having the following general qualities was used. It had a gravity of 0.764 and a boiling point of 125° centigrade. That of 1885 had a gravity of 0.670, boiling point not determined. Were the study to be now instituted, benzin would be excluded as a solvent.

[9] The writer desires herein to express to the firm of Edward R. Squibb and to Professor Virgil Coblentz his sincerest thanks for the pains taken to help him in these investigations. Not only did they (1917) donate free of all expense the liquid reagents, but they took special pains to prepare some of them for his special use.

aqueous, alcoholic or hydro-alcoholic menstrua, from this view alone, produce solvents far superior to either alcohol or water, for abstracting an alkaloidal product from certain natural alkaloidal drugs. It may be safely accepted that when acids are used as a part of an abstracting menstruum, the liquid should, as a rule, be decidedly aqueous.

Unless the alkaloid is in small amount, it is detrimental to add to undiluted alcohol any acid excepting acetic acid. The artificial alkaloidal salts of the sour acids are, as a rule, much less soluble in alcohol than are either the natural salts, or the free alkaloid. An error of this description was made in the Pharmacopeia of 1890, where tartaric acid was used in "Abstract of Aconite," the first pharmacal preparation named in that work, as well as in "Fluid Extract of Aconite," in both of which the menstruum used was alcohol.[10] Had the menstruum employed been *diluted* alcohol, the addition of the acid named might have been more rational, although it would have been superfluous, since the natural salt of aconitine is perfectly soluble in either alcohol or diluted alcohol. This error was corrected in the Pharmacopeia in 1890. Acid solvents are theoretically of no value in abstracting substances from plant tissues other than alkaloids and mineral salts, although in practice, it is accepted that diluted acetic acid is desirable in making the preparation of squill known as "Vinegar of Squill."

In this connection, it should be mentioned that while acetic acid may be of immediate benefit as an addition to a menstruum designed for the abstraction of alkaloidal drugs, other considerations may prevent its employment in some other phases of vegetable pharmacy. If this acid menstruum be a part of the final product, the finished preparation will carry the odor of acetic acid. This operates against the employment of any plant remedy, regardless of its therapeutic value, for it leads many physicians to fancy that the preparation has "soured." Such an experience has been, in several instances, that of the writer, label explanations seeming not to be noticed, or perhaps not remembered. In this connection, members of the pharmaceutical profession will perhaps recall that the U. S. P. 1860 formula for making Fluid Extract of Ipecac, demanded acetic acid. This resulted in a torrent of complaints from physicians. A further objection may be that some alkaloidal acetates in water solution lose their energies and "wear out," owing, perhaps, in part, to animalculae,[11] or minute organic life actions.

The "sour smell" problem may be overcome by using an odorless vegetable acid. Citric acid, for example, is very sour and of a marked acid nature, but yet it is not identical with lemon juice. As a plant abstracter, a menstruum made by macerating sliced lemon in an appropriate aqueous or hydro-alcoholic liquid, seems preferable to solutions of either citric or tartaric acids. Better still, in some directions, is a menstruum made by macerating sliced stems of garden rhubarb in alcohol, which may be used as a solvent for both alkaloids and alkaloidal drugs, the nature of the drug and its alkaloid establishing the proportion.

The study of acidulated menstrua for alkaloidal abstraction in finished pharma-

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[10] In revising the old notes, several opportunities occur for such injected sentences as these, which are self-apparent.—J. U. L.

[11] Had these notes been written at a later date, the term "animalculae" would have been replaced by "bacteria," a word not then employed.

ceutical preparations, is well worth the attention of pharmacists; but to the present time it seems to have been much underrated.

Alkaline Solvents. When an alkaloid-bearing plant is moistened with an alkaline solution, the natural plant alkaloidal texture is broken, the alkaloid being liberated in the vegetable tissue. It can afterward be more easily abstracted by alcohol, but less readily by water. In this manner, the (insoluble in water) alkaloids of plant structures can be washed with water and also freed from other substances, such as gums, many fats and oils, and water-soluble extractives. If the alkaloid be thus liberated, the powdered drug washed by percolation with water, and then, after drying, the drug be percolated by a menstruum having an affinity for the alkaloid, the alkaloid can be obtained in the cleanest possible manner as concerns percolation. A like process may be applied to other drugs, the use of some appropriate menstruum, such as benzol, benzin, chloroform or ether, being often available in the line of a grease or fat separator. Such as these are stepping agents to pharmaceutical perfection.

It should be borne in mind, however, that the products obtained represent, *not the drug itself*, nor the alkaloidal *texture of the drug*, but an energetic (alkaloidal) fraction, a product of the drug, more or less modified by the heroic process. The material obtained is a chemically altered, manipulative *product*, and not a naturally abstracted, *textural educt*.[12]

In other cases than with alkaloidal drugs, alkaline menstrua may be used to advantage, but for a different purpose. Some vegetable acids are not as soluble in either water or alcohol as are their salts, and in such cases an alkaline menstruum acts kindly. For example, the official menstruum employed in making Fluid Extract of Senega contains ammonia water (introduced to the U. S. P. 1880), because it has been found that polygalate of ammonia is very soluble, while polygalic acid is much less soluble. This principle can be carried to advantage, elsewhere. Glycyrrhizin is soluble in dilute ammonia, hence an ammoniacal menstruum (introduced U. S. P. 1880) is used in making Fluid Extract Glycyrrhiza.[13]

Still a third point may be made in the direction of alkaline solvents acting on plant tissues. Alkalies render most mineral salts insoluble, or decrease their solubility in alcohol, and if as a preliminary step a drug be percolated with alkaline alcohol, the percolate will be comparatively free from such compounds as calcium sulphate and phosphate.

By a judicious application of the foregoing principles, as yet altogether neglected in very important plant manipulation directions, a field in individualizing galenical pharmaceutical products, not as yet cultivated, may be developed.

Sugar and Glucose. In some cases, syrup acts admirably as a menstruum, and was at one time recognized as an official solvent. The U. S. P. formula, 1860, for making Compound Fluid Extract Sarsaparilla contained sugar, and those who have used that formula

[12] Bear in mind that this alkaloidal product is altered from its natural condition.

[13] In connection with this subject I investigated the making of Extract of Licorice in Smyrna and the Valley of the Meander, Turkey. An attempt was made to liberate the glycyrrhizin, previous to percolation. This extract failed to give satisfaction, likewise, pure glycyrrhizin was rejected by the tobacco manufacturers.—J. U. L.

will remember how admirably (admitting the desirability of such bodies) it held in solution the extractive constituents that neither water, nor water and alcohol, would assimilate and hold in solution. It contained too much alcohol, however, which induced subsequent crystallization of the sugar. In many places a little sugar in a menstruum furnishes an exceptional extractor, and it is not unlikely that in a time to come sugar, now practically abandoned, will be used more frequently as part of the menstruum, for either its solvent or its preservative powers. In this connection should be noted the preservative action of sugar on iodide of iron, lactate of iron, carbonate of iron, and many other bodies, and its solution qualities in the direction of calcium salts.

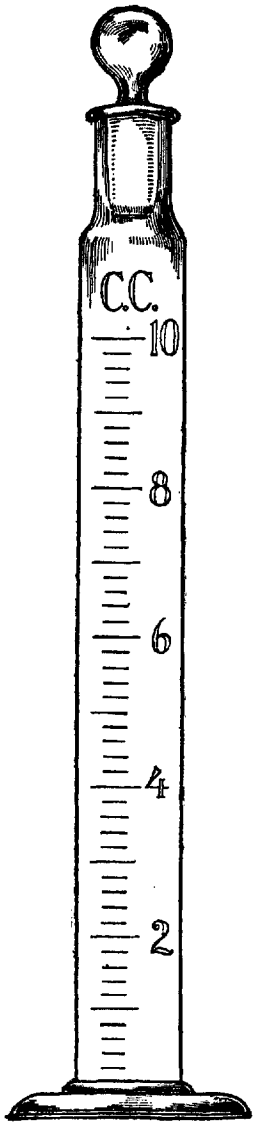

FIG. 3.

Citrate of Potassium. Mr. Creuse[14] recently introduced a solution of this substance as a medium for uniting tannates and iron salts, but its further application to organic mixtures as a solvent creator has been overlooked. Although not directly used as a solvent in galenical pharmacy, it is recognized, to a limited extent, as a beneficial admixture with a few finished products. In our opinion, however, its use could be greatly enlarged. For example, the addition of citrate of potassium, or citrate of ammonium, is of value as a component of aqueous or hydro-alcoholic menstrua, in the percolation or maceration of astringent plants, such as colombo and gentian, such drugs parting more readily with their astringents under this influence, the dissolved product remaining in more permanent solution than is the case with purely hydro-alcoholic menstrua. The products have another advantage, for such preparations, if in correct proportion, mix more freely and even mix clearly with iron salts, not forming therewith objectionable black solutions or precipitates. In such directions, many opportunities are offered for compound solvents.

Apparatus. For the series of experiments with solvents, herein presented, a suitable form of apparatus is found in the ordinary small glass cylinder of 10 Cc. capacity, shown in Fig. 3. This cylinder answers admirably our present purpose, though the results obtained may not be as exact as could be established by the use of apparatus especially devised for the purpose. It is easily cleaned, is not expensive, and it can be readily procured from any dealer in chemical ware.

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[14] Editor of the *Druggists' Circular*.

Special Forms of Apparatus. Occasionally, where it cannot well be avoided, special apparatus is designated. Our work, however, being restricted (as previously stated) to the field of the pharmacist or laboratory student it is better to sacrifice ultra exactness than to employ processes that render the study impracticable for persons having only ordinary laboratory facilities.

Exceeding Cleanliness Necessary. All utensils, including cylinders and tubes, must be perfectly clean and free from grease, especially when glycerin and water are manipulated. In this object, no care must be spared. Excepting where water is used as one of the solutions, the apparatus must be dry. Cleanliness is necessary in all pharmaceutical manipulations, but in no place, perhaps, is it so necessary that the absence of even *traces* of grease or resin be assured, as in the experiments that follow. Every implement employed must be cleaned after each manipulation. first with distilled water, and then with alcohol, and it should finally be dried in a clean, air desiccator. When liquid petrolatum has been used, chloroform or ether should be employed as a rinse after the alcohol has seemingly cleansed the vessel. These brief generalities seem necessary as preliminary to "a study of solvents," adapted to pharmaceutical problems.

(Part II, later.)

TRADE COMMITTEES OF NATIONAL COUNCIL OF DEFENSE TO BE REORGANIZED.

It is clearly evident that every industry should be represented on the trade committees of the National Council of Defense. At all times, and more so now, it is highly important to the Government that every business be protected against destruction, for the financial support of all industries is essential. Due to the complexity of the drug business, druggists are not only affected by shortage of supplies and increased prices but also by many provisions of the tax measure. The alcohol situation is a recent example and also the limitation of sugar supply. Counsel E. C. Brokmeyer, of the N. A. R. D., has brought the latter inconvenience to the attention of the food administration.

The U. S. Chamber of Commerce in advocating the prompt and representative selection of these war-service committees, emphasizes the following:

"All branches of the industry should be represented on the committee, whether members of a trade organization or not.

"It is important that the committee should include representatives of some of the smaller units of the industry, as well as the larger.

"To be in a position to render efficient service, the committee should not necessarily be made up of the presidents of the largest units of the business, or of the best known men, but should contain men of recognized ability who have a thorough knowledge of the important details of the industry, particularly costs, specifications and volume of production. Where the industry is widely scattered and different problems exist in different sections, it is important to have the different sections of the country represented, but effort should be made to appoint a committee which can be readily assembled for committee meetings.

"Sub-committees of the important branches of the industry should be appointed to cooperate with the war service committee wherever possible.

"These committees should be ready at all times to meet any of the departments of the government whenever their advice is desired, to discuss questions affecting the industry raised by the war needs of the government. The committees might also, on their own initiative, present to the government questions which call for consideration, and might from time to time suggest on behalf of the industry how orders and material can be distributed to the best advantage, and with the least disturbance to existing or prospective conditions."
